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SECOND WORLD-WIDE STUDY ON THE PETROCHEMICAL INDUSTRY: PROCESS OF RESTRUCTURING *

prepared by the secretariat of UNIDO

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Abreviations

1. Organizations terminologies

CMEA – Council for Mutual Economic Assistance

CPE – Centrally Planned Economy

DMEC – Developed Market Economy Country

ECWA – Economic Commission for West Asia

EEC – European Economic Community

GOIC – Gulf Organization for Industrial Consultancy

NIC – Newly Industrialized Country

OAPEC – Organization for Arab Petroleum Exporting Countries

OECD – Organization for Economic Cooperation and Development

OPEC – Organization of Petroleum Exporting Countries

UNCTAD – United Nations Conference on Trade and Development

UNCTC – United Nations Centre for Transnational Corporations

UNIDO – United Nations Industrial Development Organization

2. Economic and technological terminologies

DMT – Dimethyl teraphthelate

EG – Ethylene glycol

EO – Ethylene oxide

GDP – Gross domestic product

GND – Gross national product

HDPE – High density polyethylene

Ipc – Major independent petroleum-chemical company

SBR	-	Styrene butadiene rubber
TPA	-	Teraphthalic acid
VCM	-	Vinyl chloride manomer
VGA	-	Vacuum gas oil
LDPE	-	Low density polyethylene
LLDPE	-	Linear low density polyethylene
LNG	-	Liquified natural gas
LPG	-	Liquified petroleum gases
Mc	-	Major chemical company
Mp	-	Major petroleum company
PP	-	Polypropylene
PS	-	Polystyrene
ROI	-	Return on investment

Introduction

The recommendations of the First Consultation served as the bases for this Second World-wide Study on the Petrochemical Industry[1]. The study undertook the objective of avoiding any repetition of what has been discussed in the first study and thus it approached the industry's development where the first study has left. The approach to this study is basically an analytical one which attempts to identify the basic elements of the restructuring process which have been taking place at an increasing pase since 1973, and then proceed to propose an integrated network of actions to be taken that would facilitate the future development of the industry to the mutual benefits of the world community and to each and every party concerned.

Two important points should be noted when considering the study as a whole. First, since the main objective of the study was to identify the principal forces affecting the development of the industry, very fine accuracy in the presentation of the data was not of main concern since the tracing of the overall trends would help achieve this objective in just the same way. However, this should, by no means, cast any doubt on the accuracy of the data presented, which were based on a wide spectrum of resources. Second, it should be noted that not too much elaborate attention was paid to the question of future projection. The situation being so fluid in the industry that any such attempt would claim as much success as tens of other projections, which have been and are being prepared all the time, including the projection model presented in the First World-wide Study. Capacities for the 16 petrochemical products until 1987 were based on existing projects, projects under construction and those with firm planned commitments. Demand projections were extended to 1990 only, with few occasional exceptions, and based principally on figures given by the Working Group with whatever adjustment UNIDO considered to be appropriate.

The competitiveness of petrochemical production in developed and developing regions was extended to six locations, three developed and three developing regions. The choice of each country was based on the choice of a typical location, particularly for producers from developing countries and should in no way be taken as exclusive to that country, for example Qatar was chosen to represent the Gulf region and Indonesia to represent a Far-Eastern location.

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[1] Report of the First Consultation Meeting of the Petrochemical Industry, ID/227 (ID/WG.291/9/Rev.1) 22/3/1979. In particular points 2 (c,f,g,h, i,j,k,p).

It should be further noted that all the developing countries' locations are related to oil and natural gas producing countries which is in compliance with the recommendation of the First Consultation (para i).

The elaborate analysis of investment cost, production cost, shipping charges and tariffs imposed on petrochemical products exported from developing countries to developed countries' markets shows that developing countries could be competitive in most of the chosen petrochemical products to producers from the developed countries in their own markets (Chapter II). This conclusion is re-inforced by the analysis of the feedstocks situation and prospects (Chapter IV), tendency in trade (Chapter III) and the petrochemical technology prospects (Chapter V). The restructuring process of the petrochemical industry is examined closely (Chapter VI) identifying the role of the various operators in this process and the possible results of their actions. The integrated analytical approach used in the study leads to the vital final conclusion that the on. alternative to the present and expected disruption and chaos in the petrochemical industry is long-term North/South co-operation based on the principles of collective management of interdependency.

To facilitate the reading of the Study by readers with various interests, summaries are provided at the end of each chapter, as well as an overall summary. To relieve the main body of the Study from excessive statistical information and at the same time to make this information available to the reader a Statistical Annex is provided as a second volume to the Study.

The Study is the result of close co-operation between the UNIDO Secretariat and a number of United Nations, regional, intergovernmental and private organizations as well as specialists from various countries working as consultants for UNIDO in their personal capacities.

Special acknowledgement should be attributed to the following organizations and persons who contributed, in one way or another, to the study:

1. The permanent working group established by the First Consultation who provided information on capacity/production/demand for the period 1979-1985 for 16 petrochemical products included in the study;

2. United Nations Conference on Trade and Development (UNCTAD) which provided computer run data for trade in petrochemicals;

3. United Nations Centre for Transnational Corporations (UNCTC) who provided studies on the chemical and the refining industry;

4. Economic Commission for West Asia, Joint ECWA/UNIDO Industry Division for providing a staff member who worked on Chapters IV and V.

5. Gulf Organizations for Industrial Consultancy (GOIC) who provided data on methanol, locations factors and petrochemical marketing strategy;

6. Stanford Research Institute (SRI) whose data on production costs in 1980 and 1985 for the petrochemical products in Chapter II were used.

7. Chem-Systems International whose work was used freely in Chapters III, IV and V.

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I. WORLD DEMAND FOR AND SUPPLY OF PETROCHEMICAL PRODUCTS. 1975-1990

Demand for petrochemicals

Demand for petrochemicals will continue to grow at a fast pace in developing countries, with demand for thermoplastics growing by over 11 per cent per year and synthetic fibres and synthetic rubbers by 7 per cent per year.

Demand for thermoplastics will reach 22 million tons in 1990, compared to 6.7 million tons in 1979. Two thirds of this volume will be accounted for by the most widely used plastics LDPE and PVC.

Demand for synthetic fibres will reach 5 million tons in 1990, compared to 2.5 million tons in 1979. Demand for polyester fibre, the most widely used synthetic fibre, will exceed 3 million tons in 1990.

Demand for synthetic rubbers will reach 2 million tons in 1990, compared to 0.8 million tons in 1979.

Demand for basic petrochemicals will increase faster than demand for these final products. Demand for ethylene will reach almost 14 million tons in 1990, compared to 2.7 million tons in 1979. Demand for propylene will reach 4.5 million tons in 1990, compared to 1.2 million tons in 1979. Demand for xylenes will reach 3 million tons in 1990, compared to 0.8 million tons in 1979.

Demand for final products in industrialized countries is expected to grow less rapidly than in the past and about half as fast as demand in developing countries, i.e. thermoplastics by 5 per cent per annum, synthetic fibres by 3 per cent per annum, and synthetic rubbers by 3.5 per cent per annum.

Demand for basic petrochemicals in industrialized countries is expected to grow at about half the rate in developing countries, i.e. ethylene by 5 per cent per annum, propylene by 5 per cent per annum, benzene by 4.5 per cent per annum and xylenes by 4.5 per cent per annum.

Supply of petrochemicals

Supply of petrochemicals in developing countries is growing by about 15 per cent per year. By 1987, 27 developing countries will have established plants to manufacture ethylene, compared to 13 countries with plants in existence in 1979; 16 of these countries will also produce propylene and 11 will produce butadiene.

The biggest increase in capacity to produce basic petrochemicals will come after 1984, e.g. ethylene capacity will increase from 3.4 million tons in 1979 to 7.9 million tons at the end of 1984 and an estimated 14.5 million tons at the end of 1987. Production capacity for propylene and butadiene, benzene and xylenes is also expected to increase three times in the period 1979 to 1987.

The growth of capacity to produce basic petrochemicals will be matched by increased output of intermediate and final products. Capacity to produce thermoplastics will increase from 4.7 million tons in 1979 to 10.6 million tons in 1984 and above 14 million tons in 1987. Local production in 1984 will supply 70 per cent of demand, compared to 60 per cent in 1979.

Capacity to produce synthetic fibres will increase from 2.2 million tons in 1979 to 3.2 million tons in 1984 and about 4 million tons in 1987. The proportion of demand supplied by local production is already high, about 80 per cent, and will not increase much further in this period. However, developing countries rely heavily on imports of synthetic fibre and intermediates (0.9 million tons in 1979) and some progress will be made in the period 1979 to 1984 in increasing local production of these intermediates, namely acrylonitrile, caprolactam, and DMT or TPA.

Production of two synthetic rubbers is expected to increase from 0.5 to 0.9 million tons in the period 1979 to 1984, leaving the proportion of demand satisfied by local production unchanged at 64 per cent. Most of the new production capacity is for SBR.

The industrialized countries, with the exception of the U.S.S.R. and Eastern Europe, are planning for a slower expansion of capacities in the 1980s. Between 1979 and 1984 production capacity for thermoplastics is expected to increase from about 46 million tons to 57 million tons, for synthetic fibres from 9.8 million tons to 11.3 million tons and for synthetic rubbers from 7.4 million tons to 8.7 million tons.

The growth in capacity to produce basic petrochemicals will also be slower than in the past, namely from 43 million tons in 1979 to 53 million tons in 1984 for ethylene and from 22 million tons to 25 million tons for benzene. Methanol is an exception to this trend with capacity expected to increase from 12 million tons to 20 million tons in the period 1979 to 1984.

Share of developing countries in total world production

World production of plastics is expected to double from 40 million tons in 1979 to 80 million tons in 1990. World production of synthetic fibres is expected to increase from 10 to 15 million tons in this period and world production of synthetic rubbers is expected to increase from 6.4 to 10 million tons in this period.

The developing countries' share of total world production in 1990 is expected to be between 22 and 27 per cent for thermoplastics, between 30 and 34 per cent for synthetic fibres and between 15 and 20 per cent for synthetic rubbers.

World production of ethylene is expected to almost double from 38 million tons in 1979 to 70 million tons in 1990 and the developing countries' share is expected to be 20 per cent in 1990. For other basic petrochemicals, the developing countries' share in 1990 is expected to be less than 20 per cent, except for xylenes, which are used extensively for synthetic fibres.

Thus, the study estimates that the developing countries' share of total world petrochemical production should reach between 15 and 20 per cent by 1990. To reach the 20 per cent level, developing countries would have to become self-sufficient in the production of the five main plastics, two synthetic fibres and two synthetic rubbers, and they would also have to produce 10 per cent of the world output of the other chemicals which comprise the petrochemical industry. However, the 15 per cent share could be achieved if imports of the main plastics, synthetic fibres and synthetic rubbers in 1990 were no higher than in 1984, or if exports reach a level which off-set the higher level of imports.

Interdependence in the petrochemical industry

The study concludes that developing countries should aim to bring about a better balance in international trade in petrochemicals in the 1980s. The capacity of developing countries to export basic petrochemicals and their derivatives should be significant by 1987, when ten export-oriented plants will be in production. However, most of these plants will produce either ethylene derivatives or methanol. It is therefore suggested that a more diversified range of products be produced by developing countries for export.

The chapter further shows that although sufficient new capacity has been planned in the industrialized countries to supply demand up to 1984, there will be a requirement for additional capacities, including 20 new ethylene plants of 500,000 tons per annum for each, in the period 1984-1990. So far, tentative plans have been announced for only ten ethylene plants. The need to establish other plants in industrialized countries could be reduced by the building of more plants in the developing countries.

II. TRENDS OF PRODUCTION COSTS AND PRICES FOR PETROCHEMICALS

During the 1960s, the domestic wholesale price for chemicals either dropped or rose only slowly compared to rising industrial prices as a whole. This largely reflected strong downward trends in production costs (see below). Lower costs were also influential in international prices, but the relationship was not direct. Keen competition meant a greater fall in export than internal prices (2.1.0).

Pricing generally reflects the monopoly character of the internal and international chemical markets (2.1.0). There has been little change since 1973 when the ten largest chemical TNCs accounted for 70 per cent of world chemical exports. The practice of price leadership in national and international trade meant that the chemical industry was last among all industrial sectors in terms of frequency and extent of price changes (2.1.0).

Monopoly pricing has meant in practice that prices actually fell much less in the post-war period than productivity improvements would have allowed. Output per worker in the United States chemical industry rose by a factor of 2.4 compared to 1.8 for all world industry (2.1.0).

Beginning in 1973-74, the energy crisis triggered rapid rises and broadened ranges of national petrochemical prices (2.1.0). They subsequently fell back but rose gradually to the peak 1974 levels in mid-1979.

International prices followed a similar pattern, but, because they moved more slowly than energy prices, the ratios vis-à-vis petrochemical raw materials changed radically: in 1970 one ton of ethylene equated to six tons of crude oil, four tons of naphtha and 8,000 cubic metres of gas. In 1980 it bought only three tons of oil, two tons of naphtha and 5,000 cubic metres of gas. This process is considered irreversible.

Production costs account for 75 to 80 per cent of national wholesale price of basic chemical products. It was thus the reduction in chemical production costs that was responsible for the dramatic downtrend in the prices of the basic product groups in the 1950s and 1960s.

Raw materials are particularly important for fertilizers, resins, plastics and organic chemicals; less so for industrial alcohols, black, certain synthetic fibres and inorganic chemicals. Raw material outlays represent 60 to 80 per cent of manufacturing costs for fertilizers, 45 to 75 per cent for plastics and 50 per cent for synthetic fibres. In petrochemicals over-all they accounted for 40 to 60 per cent of primary raw materials costs and 20 to 30 per cent for derivatives costs (2.5).

Fluctuations in production costs of primary petrochemicals, intermediate and final products are directly related to price fluctuations in oil and gas used as raw material, fuel and energy sources: a 10 per cent rise in natural gas price, rises ethane price by 3 to 4 per cent and ammonia by 5 to 6 per cent. A similar increase in ethylene price raises VCM price 6 to 7 per cent, polyethylene 5 per cent, styrene and benzine 6 per cent and polystyrene 6 to 7 per cent. As a result of pricing prices for oil and gas, increases in rising raw material fuel and electrical energy costs for chemical production have been considerable and the ratios of the individual cost components have changed considerably (2.5).

With respect to energy, the early post-war policy of fixing prices in relation to extraction and recovery costs (2.1.0) has been succeeded by an era in which price levels rose towards levels reflecting the cost of developing future alternative sources - new exploitable reserves as well as synthetic alternatives such as liquid fuel from coal, shale, etc. (2.2.1). Development of these alternatives will not lead to cheaper oil, however, and further increases in energy costs will further drive up raw materials, fuel and energy costs for the petrochemical industry.

The industry is responding to this with feasibility studies on alternative sources of hydrocarbons. Examples include aromatics, methanol and acetylene from coal, shale and residual gas from the steel industry. At present costs are high, e.g. 20 per cent higher for coal-based ammonia in the Federal Republic of Germany than for using oil and gas. Thus oil and gas remain the petrochemical industry's basic hydrocarbon source for the decade ahead and petrochemical production costs will follow movements in oil and gas prices.

Second to raw materials in the production cost-price structure, is the investment-related expenditures (2.2.2, 2.4.1). Of these, depreciation charges vary in importance with the newness of the technology. When technology changes rapidly, e.g., inorganic chemicals, plastics, synthetic fibres, obsolescence not physical wear and tear determines the cyclic renewal of capital equipment. At the same time, energy price rises increased the cost of chemical equipment and industrial construction, while tougher environmental standards mean larger over-all outlays.

In the past, increasing equipment and raw material costs have frequently been offset by scientific and technological advances (2.1.0). Today, however, substantial modernization of technology or development of radically new low-cost production methods is unlikely (2.2.3). This means new plants will lack any appreciable advantages over old ones. Much heavier investment costs mean petrochemicals would have to be sold at higher prices. (If new highly efficient processes were developed, they would take many years to make a serious impact on the market because of existing investment in traditional technology.)

The prospect of rising production costs means that international trade (2.3) in petrochemicals will continue to grow (2.1.0) as developed countries close unprofitable plants and rely on imports. In securing their long-term supply needs, industrialized countries are interested in constructing plants near hydrocarbon sources. Lower production costs in developing countries (see below) will thus stimulate petrochemical growth - a large part of which will be exported.

Two trends evident in the plans of the respective groups add up to a new international division of labour, replacing the traditional raw material/manufacturing relationship. Developing countries are concentrating on production and export of mainly unsophisticated, low-cost petrochemicals - there are few instances of vertical integration yielding a full range of petrochemicals.

Industrialized countries are increasingly specializing in complex, capital-intensive plants needing a high degree of processing. This development is not necessarily permanent. Developing countries are increasingly capable of absorbing technology and marketing experience. Co-operation between them will enhance their situation. A still higher division of labour will emerge with developing countries gaining mastery over general purpose chemical products and industrialized countries specializing still further in high technology specialty products.

The changing cost structure (2.5) noted above has a direct influence on the competitivity of petrochemical production in developing countries. Many have low-cost raw materials with which to offset higher capital costs (2.4.1) and shipping charges (2.9). The key factors determining their production cost trends are capital costs (2.4.1.1) and location factors (2.4.1.3), working capital, plant size (2.4.1.2) and choice of process, feedstock prices and by-product credits. When used in competitivity calculations, location factors must truly reflect the cost of building petrochemical plants in the country. Developing countries should direct attention to infrastructure investments that will bring down high location factors (2.5.1).

The importance of large plant size and the choice of process (2.5.1) depends on the product. Where process economics demand very large units and access to particular technology, help in running them may be obtained via co-operation agreements with industrialized country partners. Feedstock availability, often a strong point for developing country producers (2.5.1.4), is most effective with upstream operations, e.g. ethane cracking. A good local market for by-products (2.5.1.5), usual in industrialized countries but still rare in developing countries, does much to offset high feedstock prices.

Analysing the sensitivity of production costs to all these factor inputs (2.6) shows the relative importance of each in the final production cost. Capital-related charges are significant at all locations. Dropping ROI expectations for ethylene crackers from 25 per cent to 5 per cent can reduce ethylene costs in developing countries by 35 to 60 per cent. The analysis underlines the importance of reaching high load factors as quickly as possible and the inherent advantages in some developing countries of being able to sell small quantities of product at very substantial discounts.

Comparing production costs of selected petrochemicals in representative developed and the developing countries, the analysis indicates (2.7.1) it is cheaper to make nearly all of them in developing countries. Exceptions are where the low feedstock costs assumed for developing countries cannot offset higher capital costs. This occurs where plants suffer abnormally high location factors, e.g. 2.1 in the Far East, and/or where the advantages of low feedstock costs are fully absorbed in upstream units, e.g. DNT units supplying PET plants in the Middle East. The economics of PVC production in developing countries depend entirely on by-product values for caustic soda in the associated chlor-alkali unit.

Excluding shipping costs and other market entry charges, the three developing countries studied could have sold profitably (i.e. with better than 25 per cent ROI) in 19 out of 57 combinations of product and market, and in 40 out of 57 with better than 5 per cent return. "Profitability" is taken to mean production costs below the cost of local production in comparable, i.e. newly built, plants in industrialized countries.

In practice, low market prices in the industrialized country markets would have clouded this picture. In many cases these prices were even too low to justify new investment by industrialized country producers.

Repeating this exercise for 1985 (2.7.2) conditions, the picture improves considerably if it is assumed that prices rise sufficiently to justify new investment at either set of locations. Under these conditions, the developing countries could compete in their nearest industrialized country market with a 25 per cent ROI in 48 out of 57 product-market combinations, and in all of them if the expected return was only 5 per cent.

Looking further ahead, the structure of production costs will continue to change with feedstock-related charges growing at the expense of capital charges (2.8). This is to the benefit of developing countries disposing of feedstock sources. Capital charges may be further reduced with the introduction of catalysts that increase yield and permit processing under milder conditions. It is important, however, that these technological improvements are equally available to developing as well as developed country producers.

Transportation costs for petrochemicals produced in developing countries are built up for 1980 and 1985 (2.9) assuming shipment by sea from a portside production plant to a destination terminal in each industrialized country market. This demonstrates the importance of such costs in determining competitivity. In the Middle East, for example, the cost of reaching major markets exceeds 10 per cent of production costs for ethylene and polyethylene, ammonia, methanol and urea. For the three last, freight charges amount to 20 to 40 per cent of production costs.

A true indication of competitivity is given by combining production costs, freight charges and tariffs to give a landed cost in each major market in 1980 and 1985 (2.10). This permits three conclusions:

1. Geographically well-placed countries could land oleofins and oleofin derivatives at lower prices than those expected from such plants in industrialized countries. In some cases, a relatively low rate of return, e.g. 5 per cent versus the industrialized countries' 25 per cent return, might have to be accepted. Conversely, developing countries not geographically well placed or suffering penalties of high capital costs would find it difficult to export finished products to distant markets;

2. This position could radically change inside a few years if industrialized country market prices rise and by-product values in the developing countries improve, e.g. by 1985;

3. The tariffs on petrochemicals, while modest for intermediates such as ethylene, are a major item on finished products, often equalling or excelling shipping costs. They are high enough to reduce profitability of developing country operations, but not high enough to protect inefficient industrialized country producers. This is an issue for Government negotiation.

III. INTERNATIONAL TRADE IN PETROCHEMICALS

The chemical industry is one of the most dynamic sectors in the industrialized economies and within this sector the petrochemical industry is the fastest growing sector. This fact is accentuated even more so in international trade. During the period 1950-1970 the world export of chemicals increased tenfold whereas the total world export increased by half as much during the same period. Among the chemical exports organic chemicals (1950-1970) increased 24-fold (in value), of which the export of plastics grew 32 times. Due to the continuous decline in the unit value of organic chemicals - as a result of cheap oil prices, technological development, and increasing economy of scale - the volume of the world export of plastics increased 76 times, synthetic fibres 55 times and synthetic rubber 28 times.

The pattern of trade flow in petrochemicals reflected, to a great deal, the patterns of their production, i.e., high concentration in the developed regions of the world; Japan, the United States and Western Europe (see annex III.A) the largest amount of trade flow being affected within Western Europe. Only lately have some developing countries realized some exports, mainly fertilizers and natural gas derivatives.

The petrochemical market is closely integrated between oil refineries and olefines and aromatics producers. The movement of basic, intermediates and final petrochemicals are often achieved by short pipelines across the fence between the various producers or in a pipeline grid system as in North Western Europe and the Gulf Coast of the United States.However, due to the sheer size of the market there is a merchant market. Ethylene, propylene, butadiene, benzene and para-xylene are products traded mostly between relatively few large producers/sellers under 3-5 year contracts whereas styrene and orthoxylene trade is more fragmented. Nearly 80 per cent of traded petrochemicals are based on long-to medium-term contracts while the other is left to the spot market. Long-term supply contracts are essential to the chemical producers in order to keep the operation of their huge plants at maximum level, since the lowering of the plant loading factor would drastically increase the units cost of production (see sensitivity analysis in chapter II). The adjustment of contracts of the prices are reviewed on the basis of changes in basic production and overhead costs and the spot prices here act as a price "leader".

The role of the merchant traders which flourished during the sixties is continuously shrinking and they have little to play in the role of basic chemicals. However, in some cases and for particular type of companies or commodities, trading companies with experience, know-how and contacts conserve several useful functions. It is important for new suppliers of petrochemical products wishing to enter new markets to recognize these facts when determining their marketing strategy.

Cross-continental trade in ethylene is relatively small and is carried out in refrigerated ships, mainly from non-European development market economies. However, 22 per cent of the total export to developed regions originated from developing countries, mainly Algeria, Mexico and the Republic of Korea. Other olefins are traded in larger quantities: the United States annually imports some 300,000 of butadiene; both the United States and the EEC import appreciable quantities of propylene, mainly from other development market economies. Aromatics are more freely traded between all producing regions, particularly xylenes. While the United States is a net exporter of xylenes it is a net importer of benzene. The flow of gas-based derivatives are mainly from developing countries and centrally planned economies involving the export of methanol and considerable quantities of ammonia. In the case of ammonia the major trend in Japan, the United States and Western Europe is to rely more on imports, a fact which has led to the closure of considerable ammonia producing capacities in these regions.

World trade in intermediate petrochemicals has not been significant and it is concentrated mainly within the developed regions, with styrene moreover being the most widely traded. It is expected, however, that a major shift in intermediate trade will occur during the 1980s when production capacities in Saudi Arabia and other oil producing countries come on stream in the middle of the decade. In the area of polymers, plastic resins, synthetic fibres and synthetic rubber, the developing countries are major importers from the developed regions with little trade occuring among themselves. South East Asia developing countries export small quantities of polymers, mainly PVC, to developed regions. A shift in the historic trade pattern is expected in the 1980s in polymers originating from oil producing developing countries to developed regions and to other developing countries - PVC and polyethylenes -.

Considering the economic recession, the uncertainty due to inflation and feedstocks, a shift in the patterns of world production and trade in petrochemicals is expected to take place during the late 1980s. The United States which has so far enjoyed a high surplus in petrochemical trade, is expected to lose some ground in the 1980s caused by the lifting of oil and gas control of the prices. This results in diminishing exports and increasing imports due to increasing competitiveness of other producers, particularly hydrocarbon exporting countries. West European producers will face increasing pressure from East European and Middle East producers in the mid-1980s. Japan will be in the weakest position among the two other developed regions to resist the pressure of cheaper petrochemicals (particularly basics and intermediates) coming from the hydrocarbon producing developing countries. However, except for some producers from Western European countries, the general trend would be for the petrochemical producers in these developed regions to seek some kind of association (mainly joint ventures) with oil producing developing countries in the fields of basic and intermediate petrochemicals production facilities. Other trends would be the increasing share of newly industrialized countries, Canada, China and the USSR and some East European countries in world capacities of petrochemicals and its subsequent influence on the shift in the would trade pattern. Other factors influencing international trade in petrochemicals are expected to emanate from greater mergers between giant companies, formation of new trading blocks and expected increase in per capita consumption of petrochemicals in East European countries and in some of the developing countries.

Prospects for increasing exports of petrochemicals from developing to developed countries, which account at present for 9 per cent of the latter's total imports and for about 1/4 of 1 per cent of their consumption, is expected to meet increasing resistance under conditions of reduced demand and over-capacity. However, the rising prices of feedstocks and energy which constitute at present some 80 per cent of over-all production cost (see chapter II) would force some petrochemical producers to shut down their plants and resort to the import of cheaper basic and intermediate petrochemicals from developing countries.

Examination of the existing structure of tariff barriers in developed countries against petrochemical products shows that the tariffs imposed are so construed as to encourage the import of basic petrochemicals and to discourage the imports of intermediate and final petrochemicals. In general, of the 88 possible tariff rates on basic petrochemicals, 56 are zero or less than one per cent; 8 are 5 per cent or less and 10 are between 6 and 7 per cent; only 14 are higher than 7 per cent and half of these involve a single product - methanol - and five of them applied in a single country - Austria - .

In contrast, the tariff rates which apply to the intermediate petrochemical products are significantly higher; of the 66 possible rates only 19 are zero or less than one per cent and involve synthetic rubber or are applied by Finland or New Zealand. High tariff rates ranging from 9 to 37½ per cent are applied to the other intermediates, with considerable differences in their application to different groups of countries. A casual examination of these tariffs would imply that the exporter in developing countries have quite good access to the markets of the developed countries for basic products.

As regards intermediates, these rates would rise substantially to between 10 and 17 per cent. However, a more careful examination of the theory of tariffs reveals that the protective effect of a tariff is often much higher than indicated in the nominal tariff rate. Effective protection rates have been calculated for five intermediate petrochemicals (table 3.6). With the exception of SBR these figures indicate that, on the average, foreign exporters to the markets of developed countries must improve their local processing cost by 23 per cent for basic petrochemicals when converted into intermediates in order to be competitive in the markets; the efficiency differential is 68 per cent higher on the average than the price wedge imposed by the tariff (table 3.6).

In addition a number of other restrictions are imposed on imports such as quota, health, safety and environmental standards, imports licensing schemes, government purchasing scheme, custom valuation practices, etc. Moreover, the high degree of concentration of the market in the developed countries would limit the penetration of the exporters from developing countries to these markets.(see table 3.7). This indicates that developing countries which are moving into the petrochemical field must be aware of the dominance of Western markets by a relatively small number of large companies.

Whereas under existing conditions it would be possible to carve out a small niche in the large market, it would be very difficult to export products to these markets in large volumes unless through long-term arrangements the developing country productive capacity is taken into consideration by these large companies which have developed an ogopolistic market structure. Another possible problem facing the new suppliers from developing countries may come from competition from suppliers from other developing countries, particularly those linked to traditional suppliers to the developed countries through joint ventures, buy-back agreements, territorial marketing arrangements, etc.

Conditions imposed on markets and on product mix and specifications may hamper the development of the industry in the developing countries but it would only delay a historial process with unnecessary sacrifices.

IV. PETROCHEMICALS FEEDSTOCK

The issue of feedstocks for the petrochemical industry constitutes one of the most important elements for its future development. This element was not evident during the earlier stage of the industry's development due mainly to the limited demand for feedstocks in the total energy pool, on the one hand, and the extremely low prices they commanded, on the other. However, with the sharp increases in the price of oil and its derivatives, the principal sources of raw material and energy for the petrochemical industry since 1973 have changed the situation completely. Whereas in the era of cheap oil, the resource pattern of energy in general and of petrochemical feedstocks, in particular, has moved away from coal to oil, after the year 1973 serious thoughts and actions were given to a counter-move towards coal utilization and other possible energy sources in order to reduce dependence on crude oil and its derivatives. The industry was not sure any more of obtaining its feedstock and energy requirements at the right price and quantity and still [illegible] to operate with a reasonable profit margin.

The energy crisis of the 1970s compounded the general and prolonged economic recession and the petrochemical industry was not able to transfer the increases in the cost of its inputs to the prices of its output (products) without affecting a steeper drop in demand. The viability of the industry being highly sensitive to economy of scale would be endangered by any significant decline of its operation load factor, since this would add further cost to that imposed by the increase in feedstocks and energy cost to the unit cost of the final product.

To complicate the matter further, the tight supply of crude oil and subsequently naphtha, the main feedstock in Western Europe and Japan, has created a state of possible competition/conflict between the two main sectors using naphtha, i.e. the motor fuel sector and the petrochemical industry. Such a situation intensified the search for alternative sources and greater feedstock flexibility which would make possible the shift from one source to another depending on availability of supply and price differentials.

Chapter IV of the Second World-wide Study on the Petrochemical Industry analyses in detail the feedstock situation within the context of the energy balance on a global scale in general and in the major regions of the developed countries (Japan, United Sates, Western Europe) in particular.

Various projections of the world energy balance until the end of the century show that there will not be any serious shortage of supply. However, the increase in oil prices and the expected increases in the price of natural gas and a general tendency towards parity, on the basis of the energy equivalence in the prices of different energy sources, would shift the emphasis created during the era of cheap oil from oil and gas to alternative sources. Though crude oil and natural gas are expected to register considerable increases in the quantity of supply during this period, its share in the total energy supply would nevertheless be reduced from around two thirds of the total energy supply in 1973 to about less than half of that total in the year 2000 (see table 4.3 and 4.4). In the meantime, coal and nuclear energy would increase their respective share in the total energy supply.

In the United States the share of oil and gas in world energy consumption is expected to decline from 75 per cent in 1975 to 62 per cent in 1990, with the share of coal and nuclear energy increasing from 22 to 34 per cent in the corresponding periods. But oil and gas imports will increase nonetheless. In Western Europe the share of oil and gas is expected to decline from 79 per cent in the mid-seventies to 66 per cent in 1990, while Japan's dependence on imported oil and natural gas is expected to decline from 74.5 per cent in 1975 to around 50 per cent in 1990.

The conclusion is that the main sources of energy and feedstock for the petrochemical industry until the end of the century will still be oil and natural gas due mainly to the high risk involved in the investment into alternative resources and the time period required to develop these resources.

Being resource-oriented, the petrochemical industry has developed historically in the United States on the basis of natural gas while in Japan and

Western Europe it was mainly naphtha-based. However, with the expected decline in natural gas resources in the United States and the greater intensity of cracking, an increasing trend towards the utilization of naphtha is seen inevitable. In all three regions, Japan, United States and Western Europe, the introduction of feedstock flexibility is becoming a standard practice. Such flexibility is directed to the lighter end of the crude oil barrel due to economic reasons and greater supply availability, for example, LPG supply from the Middle East and Africa is expected to increase from 7.8 mmt in 1978 to 33.4 mmt in 1990.

The feedstock outlook in developed regions (Japan, United States and Western Europe) is expected to depart from its existing pattern and take a different trend due to (i) the expected decline of its share in the world capacity of building blocks (ethylene and aromatics) and intermediates, (ii) technological development allowing the production of certain intermediates directly from syngases and methanol and (iii) the increasing cost of investment in new plants.

In the USA the new trend in feedstocks is towards greater use of naphtha (and middle distillates) which will result in a significant shift in the petrochemical spectrum. Greater quantities of by-products from naphtha-based olefins plants will result, for example, in the shut-down of dehydrogenation facilities for butadrene production and perhaps present refining facilities producing aromatics. Naphtha-based ethylene production is expected to increase from 27 per cent in 1975 to 54 per cent in 1985 while the share of etham and refining gases is expected to decline during the same period from 46 per cent to 29 per cent and propane from 25 to 8 (see table 4.19). The same trend is also apparent for other olefins (propylene and butadiene) as can be seen from Tables 4.20 and 4.21).

This shift in feedstock supply will have a profound effect on the level of integration between oil refiners and petrochemical producers in the United States brining it closer to the existing pattern in Western Europe i.e. a very nigh level of integration. The increasing share of olefins from naphtha-cracking will also be reflected on the production of the source of aromatics (benzene and xylene).

In Western Europe, where the petrochemical industry is primarily naphtha-based, a different trend to that of the United States is emerging.

The prospects of greater availability of natural gas liquids (NGL) and LPG from the North Sea and from imports from the Middle East and Africa and the increasing quantities of gas-oil resulting from new refinery configuration (higher share of catalytic and thermal cracking) will decrease the dependence of the petrochemical industry on naphtha (see Table 4.23) and at the same time, reduce the feedstock/fuel conflict. The demand of the petrochemical industry on naphtha supply in Western Europe which was nearly 26 per cent in the mid-seventies is not expected to change much; however, by 1990, the share of synthetic naphtha (non-virgin) in the total supply is expected to increase from 10 to 26 per cent. The very high level of integration between oil refiners, olefins and aromatics producers that exists in Western Europe is expected to be maintained and intensified in the future, with the oil majors increasingly moving towards control over the production of basic and intermediate petrochemicals.

In Japan the feedstock situation is expected to develop on the same lines as that of Western Europe, only without the advantage of North Sea resources enjoyed by the European producers and with a lesser level of integration.

The availability of huge hydrocarbon resources in the oil-producing developing countries, particularly natural gas (both associated with oil production and free) and their ambitious plans for the development of their refining capacities would put these countries in a highly advantageous position for the production of basic and intermediate petrochemicals. Other developing countries with huge vegetation production areas and/or with coal, tar sand and shale oil resources will indeavour to develop these resources and reduce their dependence on imported oil for the supply of their feedstock and energy requirements. Newly industrialized developing countries would work towards establishing closer contacts with oil exporting countries to guarantee the security of their supplies on a long-term basis.

Examination of alternative sources for feedstocks shows that crude oil (as a raw material) and natural gas will remain to dominate the sources of supply for the petrochemical industry. The close relationships between the prices of various sources of supply shows that at the prevailing level of oil prices, oil and gas-based feedstocks are still the cheapest among all alternative resources. The development of synthetic gas from coal would provide a strategic long-term alternative to oil-based natural gas feedstock but would not acquire prominence before the turn of this century. The other promising alternative which is being developed at present is the production of ethanol and methanol from biomass, to be used as a fuel (gasohol) or as a petrochemical intermediate. Some developing countries are actively involved in the biomass fermentation, notably Brazil.

V PETROCHEMICAL TECHNOLOGY: STRUCTURE AND PROSPECTS

The technological structure of the petrochemical industry in this chapter is examined in two time-periods, 1950-1973 and post 1973. During the first period, after the Second World War, the petrochemical industry was superimposed on an organic chemical industry which was largely based on the by-products of the coking industry. The development of the industry assumed different patterns in the three main developed regions: Japan, United States and Western Europe, as a consequence of different raw materials becoming available to them from the petroleum refining industry. In the United States large volumes of butane and propylene were produced in association with high octane gasoline whereas ethane was produced in surplus as a result of natural gas utilization in the energy industry. Thus major feedstocks for ethylene, butadiene and polypropylene were made available in large quantities at low prices. In Europe and Japan, the refineries, with different configuration to that of the United States, yielded large quantities of naphtha, the predominant petrochemical feedstock especially for ethylene as well as propylene, butadiene and pyrolysis gasoline.

The US engineering companies which were associated with the design and construction of large and complex petroleum refineries of the United States were the main contributors to the development of the present day naphtha cracker. Technological innovation in downstream products, particularly of the petrochemical intermediates, is the contribution of both the United States and Europe. Major petrochemical technologies for HPE, Acetaldehyde from ethylene, vinyl acetate monomer, suspension grade PVC, polypropylene, polyesters, LDPE, methanol, ammonia, synthesis gas, aromatics, ethylene oxide, ethanol, acetic acid and cumene/phenol are essentially of European origin whereas acrylonitrile, nylon, ethylene glycol, propylene oxide, styrene-butadiene rubber, etc. emanated from the United States.

These technological innovations, particularly ethylene, propylene, butadiene and the intermediate products (except acrylonitrile) were widely diffused throughout the developed regions for various reasons. However, an entirely different situation prevails for further downstream products as specialty plastics, pesticides, pharmaceuticals and the like, where inventor companies have extremely strong proprietory positions in patent and trade-mark which makes these technologies extremely difficult to obtain. The possession of such technologies thus becomes the source of differential (monopoly) profits to these companies.

This period, 1950-1973, witnessed the extreme concentration of petrochemical productive capacities in the market economy developed countries with the active support of their governments. There was also a clear demarkation between the activities of the major oil companies, specializing in upstream production (naphtha, ethane and propane) and the major chemical companies which were primarily involved in downstream petrochemical production. This kind of concentration and interdependency between the two major groups of companies seems to have excluded the possibility and feasibility of moving some production facilities towards cheaper hydrocarbon sources in the developing countries.

The period following the increase in oil prices since 1973 did not affect the viability of the petrochemical industry nor did it disrupt its operation as happened to the gasoline and heating oil markets. Most of the attention was directed towards greater intervention in the energy industry - energy conservation, replacement of oil and gas by nuclear energy or coal, ... etc. The profound effect on the petrochemical industry caused by the increase in oil prices and the long recession period was the decline in demand and a subsequently decline in profitability and cash flow resulting in the preoccupation of the industry with the process of restructuring in order to secure feedstock supplies, avert a fuel/feedstock conflict and ralionalize the industry's operational structure. The main emphasis in technology development was directed towards developing alternative feedstocks, feedstock flexibility, energy saving measures and improvement of existing processes.

The new situation asserted the role of governments in the industry, particularly in West European countries where government-owned chemical-oil companies (as ENI in Italy, CdF Chimie in France, Veba in the FRG, etc.) assumed greater importance in the industry. In the meantime, the major oil companies emerged as the biggest beneficiaries from the post 1973 situation. By virtue of their control over hydrocarbon supply and their high cash-flow position they were able to buy downstream plants, enter into joint ventures with the major chemical companies which were seeking feedstock security, enter into joint ventures with oil-producing countries, and establish their own new production facilities, all in the field of downstream operations, mainly basic, intermediate and some commodity petrochemicals.

The results of the restructuring process that was accelerated after 1973 are so far as follows: major oil companies, government-owned chemical-oil companies in some West European countries and new producers in developing countries concentrating in basic, intermediate and general commodity petrochemical productions; major chemical companies and government-owned chemical-oil companies in some West European countries moving up more and more into specialty petrochemical products. The trends in research and development in the future would follow this new structure.

A very important characteristic of the petrochemical technology is that while specific innovating firms have had patent protection in respect of their technologies, essential process and catalysts patents, there exists a plurality of technology sources in individual products. Thus competitive technologies exist in HDPE, LDPE, VCM, PVC, and so on. Basically, these technologies are owned by producing companies and thus it is the presence (in products) of the competitive market that has been the principal motive force for diversity of technology ownership. Thus the diffusion of technology in the market economy countries has mostly been through the imitative development (self-generation) rather than through licensing. A good example of this is the latest development of LLDPE. This characteristic is very important, since it enables each developer of the same product (or nearly the same) to add some superior qualities to it and thus capture certain customers or segment of the market. It is this characteristic of the industry which leads to large markets for "narrow specification" products, which in turn makes it very difficult for broad specification products, as those produced or to be produced in developing countries, to break through in these established markets. Furthermore, the technical services provided to the client of these products is considered more or less as part of the technological development process. Thus technological choice confronting new producers from the developing countries has to be weighed with great care with regard to choice of markets and partners and their future (long-term) prospects.

In spite of the plurality of technology (in chemical intermediates, particularly) and the possibility of its choice on the basis of lowest cost, it is well recognized that its transfer to developing countries is usually associated with high fees, inadequate transfer of technology skills, restraints on license organization on rights to markets and inflexibilities with respect to expansion, product diversification and geographic distribution.

Such practice emanates from the desires of the major producers in developed countries to maintain their power position in the world markets. For this purpose they have established a defensive mechanism which is steadily expanding, supported by a sophisticated infrastructure that surrounds the chemical industry - large refining capacities, ethylene distribution grids. Such a defensive mechanism which also includes the "producer-engineering company" linkages, and the "producer-equipment supplies" associations, is aimed at discouraging prospective producers in the developing countries from venturing into this industry.

In forecasting technological developments, it is necessary to associate it with expected growth in demand since demand is the major motive for technological innovation. It is, however, believed that the period of growth from innovation/substitution has passed and the industry has reached maturity and consequently the rate of change of technology has slowed down. In the main products, the change to ethylene, propylene benzene and synthesis gas as the basic building blocks is largely complete. Over the medium term, the technology to produce most of these petrochemical building blocks is not expected to change either in feed-stock used, process technology or scale of plant. Competitiveness may be more related to catalyst improvements, utility savings, integration and utilization rates, rather than to the latest plant design. However, research and development will step up in preparation for the expected changes in the 1990s when escalating oil and natural gas prices lead both to the use of alternative feedstocks and to processes which will avoid the current building blocks entirely.

It is not anticipated that any new basic polymers will be developed which could revolutionize the petrochemical industry as did polyethylene, polystyrene and polyesters in the 1950s and 1960s. Although some significant process changes are still occurring in a few bulk products - PP, EG, PO and LLDPE - no major breakthrough is expected.

It should also be noted that the large-scale development of alternative feedstocks from coal, sand tar and shale oil will not be so much tied with research and development tools or the creation of research and development infrastructures as with the level of investments required for scale-relevant production and sources of financing production plants. Investment in each such production facilities is expected to be in the order of 2-3 billion, which is beyond the capabilities of the largest corporation. Equally, the engineering design load is expected to be in the order of 6-7 million manhours per production of each production facility. Thus the physical implementation of such projects would most likely be on a multi-agency basis, with perhaps government participation. A situation of this sort would leave the question of ownership and protection of technology (patents) open and would most probably delay the commercialization of these technologies which have already been adequately tested at the pilot scale. Moreover, the products of new technology would have to make use of the existing infra-structural facilities in the developed countries: pipelines, terminals, tankers and marketing and distribution linkages which have been built at a relatively low cost during a cheap energy era. This situation also requires that products of new technologies be with the physical characteristics of present-day fuel, energy and chemical materials.

The most outstanding new development in technology is the conversion of methanol to olefins, aromatics and gasolines. Having such a wide spectrum of possible utilizations and of possible sources for its production, methanol has caught the equal interest of oil-oriented and chemical companies as well as developing countries.

In addition to the improvements in process technology over the past twenty years, there have been gradual improvements in the mechanical performance of equipments and materials which have allowed both improvements in process performance and increases in the scale of plant. The overall result has been a greatly improved efficiency in production. A good example of the marriage of mechanical performance and process technology includes: improved furnace design in olefins production permitting much higher conversion of feedstock to ethylene; the use of large centrifugal compressors in ammonia olefins production and the use of bi-metalic catalysts and moving beds in aromatics production.

Examples of technological developments in the derivative products of large volume are: linear low density polyethylene (LLDPE) which is expected to capture a large share of the polyethylenes market by 1990 and propylene oxide which ushered in the direct oxidation route. Examples of future technology developments which would be considered as a break-through are expected in catalystic conversion at high pressure which would reduce the expensive cracking/furnace area of conventional olefins plant, and reduce or even eliminate compression of cracked gas and in the area of ammonia production the elimination of carbon "carrier".

It is expected that leadership in research and development will be concentrated in the future in the hands of the major oil companies and the major chemical companies while the role of universities, engineering companies and government-supported agencies will acquire less prominance.

VI GLOBAL CO-OPERATION IN THE PETROCHEMICAL INDUSTRY: ANALYSIS OF THE PRESENT SITUATION AND FRAMEWORK FOR FUTURE CO-OPERATION

It has been shown in the preceding chapters that the structure of the petrochemical industry, like the industrial structure in general, has developed historically in such a way that production, consumption, trade, and technology are all concentrated in the developed countries. Only very few developing countries are involved in this industry and when they are, it is mostly in conjunction with multinational corporations of the developed countries in the pursuance of their global policies to get and maintain sizable markets for their product and/or to take advantage of raw materials or other favourable factor inputs. However, the conditions under which the petrochemical industry was operating during the 1950s and 1960s have undergone drastic changes with the increase in oil prices in 1973 and the general and prolonged economic recession of the 1970s and beginning 1980s. Chapter VI of the Second World-wide Study analyses the restructuring process that is taking place in this industry and the role of the different operators involved in this process. The period of observation, 1976-1983/84, though short, is nonetheless highly indicative of the type and nature of the changes and of the possible ultimate direction the industry has taken.

Because the petrochemical industry is concentrated mainly in Japan, the United States and Western Europe, the analysis of the structural changes within these regions has been carried out in greater detail. The major groups of operators in the industry are distinguished as the major oil companies (M_ps), the major chemical companies (M_cs), and the less concentrated independents (I_{pc}s). The representativity of these groups of companies and therefore the rank they occupy with regards to possible approaches to long-term agreements, the investment decisions and financial control policies at different stages of the petrochemical production, are indicative of their power positions. Analyses for the periods 1976, 1980 and 1983 show that these major groups have great financial control over basic, intermediate, and final petrochemical production in the EEC region and the USA. It also reveals that the degree of concentration of the industry in the EEC is much higher than it is in the USA.

In 1983, the oil majors (M_p) in the EEC will be controlling 43.5% of the ethylene capacities (46.2% in 1976), 61.3% of butadiene (61.3% in 1976), and 43.0% of benzene (44.5% in 1976). Whereas the share of the oil majors (M_ps) has thus generally declined in basic petrochemicals, a different situation is to be noticed in final products where their shares will be in 1983: for LDPE, 32.6% (30.1% in 1976), HDPE 25.1% (21.9% in

1976), PVC 21.3% (15.3% in 1976), and for PP 27.8% (22.3% in 1976). This is particularly evident in the case of Exxon, Shell and BP. In the two major petrochemical intermediates, the M_ps have substantially increased their share in ethylene oxide (from 20.8% in 1976 to 30.4% in 1982/83) but less so in styrene (from 32.4% to 33.3%) over the same period.

The chemical majors of the EEC, on the other hand, have been adjusting their policies by gradually restricting their control over basic and intermediate petrochemicals as well as plastics (see Table 6.2). The greatest drop of their share is noted in ethylene oxide (from 67.2% to 47.0%), LDPE (from 48.1% to 34.5%), polypropylene (from 71.5% to 55.7%) and HDPE (from 62.5% to 50.9%) while a modest decline was registered for PVC and styrene, with no change for ethylene and a modest increase in their share of benzene production. The significant changes in the policies of the M_cs in the EEC are characterized by the drive of some to get a foot-hold in hydrocarbon resources on the one hand, and to diversity their activities in fine and specialty chemicals, on the other.

The less concentrated independents (I_{pc}s), which have been formed in the EEC with the assistance of state capital, have adopted an aggressive policy in the fields of intermediates and plastics (see Table 6.3). With the exception of benzene, their share has increased in all petrochemical products considered here, particularly so in PP (from 6.2% to 16.5%), EO (from 11.9% to 22.6%), HDPE (from 15.6% to 24.0%) and styrene (from 15.1% to 20.0%). The I_{pc}s are characterized by: their lack of cash-flow in their chemical activities which is balanced by their success in hydrocarbons (DSM, ENI and ELF), government support, and their external activities; the development of their own technologies with which they are able to compete with the M_ps and M_cs and their independence from the oil majors for the supply of their needs in crude oil and gas.

In the United States and unlike in the EEC, the oil majors exercise greater control over basic petrochemicals and the number of joint ventures in steam-cracker capacities is limited and there exists a large non-captive ethylene capacity. The share of the US M_ps in ethylene has increased from 42.5% in 1976 to 53.8% in 1983, while in benzene it will decline slightly. In the meantime, their share in plastics has increased from 22.5% to 27.6% for LDPE, 21.9% to 32.6% for HDPE, and from 47.4% to 52.2% for PP.

The chemical majors in the United States are losing ground in their activities to the oil majors and their share in ethylene, HDPE and PP has declined by some 17% while in LDPE it has marginally declined by nearly 1%. It should be noted however that the three largest US petrochemical companies (Dow, Union Carbide and Hercules) continue to pursue an aggressive investment policy. Also to be noticed at the same time, is that all US M_cs are diversifying in fine chemicals, electronics, electro-metallurgy, etc., as well as in acquiring direct access to hydrocarbon resources. It is to be noted that chemical majors of the EEC are increasing their investments in the United States.

The internal changes that have taken place during the study period indicate that:

the oil majors (M_ps) have taken advantage of the economic and energy crises to assert their presence in the petrochemical industry;

the chemical majors (M_cs) have redirected their investment policies to reduce the effect of competition in "mature products" and to ensure new basis for their cash-flow;

and finally the independents (I_{pc}s) have become a clear partner in the industry through state support. Thus the restructuring process has disrupted the dynamic balance between the M_ps and M_cs which prevailed during the 1960s.

The "seven sisters" among the oil majors have established the strongest presence in the petrochemical industry during this period, 1977-1983, taking 40% of the new steam-cracker capacities and 83% of the expanded LDPE capacities. Among the most important factors favouring the integration of M_ps in petrochemicals, the following can be mentioned: to appreciate the value of naphtha to compensate higher costs of cracking heavier oils and meet the evolutionary demand for refined products; to appreciate the value of ethylene in the profitable operation of new steam-crackers and the need of the industry to recoup the higher prices of ethylene used directly or indirectly in the production of LDPE, HDPE and PP, in order to guarantee full capacity utilization and cover most of the fixed cost of these units. As a result of this policy, the oil majors contribute through their action to the creation of large production surpluses, particularly in the EEC and the USA. The emerging structure of the M_ps, "Refinery-steam-crackers-final plastic products", thus constitutes an efficient approach to obtain differential profits from this chain of integrated activities. The strongest leverage in the hands of the oil majors lies in their control over naphtha which they have so effectively used since 1974/75. Faced with such a situation, the position of the chemical majors (M_cs) and the independents (P_{pc}s), pressed to accept a long-term price increase in energy and the role being played by the oil majors, are such that either they accept to be dependent on the oil majors or modify/diminish this dependency through direct contact with hydrocarbon-exporting countries and/or invest directly into petroleum industry (see Table 6.7).

The relations between the M_cs and I_{pc}s and the downstream industries is another area of conflict contributing to an accelerated rate of restructuring for the chemical/petrochemical industry. Most outstanding here is the synthetic fiber crisis in the EEC and to a lesser degree in the USA. The end-users (converters) of petrochemical products cannot so easily transfer the high prices demanded by petrochemical producers to the consumers particularly when they are faced with foreign competition, so they look for lower prices which they can get from imports. As such, the profitability of the downstream industry is subjected to the contradictory effects of increasing prices for petrochemical feedstocks and international competition. Subsequently, it is confronted with a total transfer of revenues due to feedstock suppliers (i.e. oil majors) and pressured to such an extent that the only alternative is to redeploy the capacities/activities in the developing countries which enjoy cheaper factor inputs so as to improve their competitive position in export markets against other petrochemical producers.

Turning to petrochemical producers in the developing countries, one could say that due to the limited capacity of the private sector to finance such projects the governments of these countries are strongly involved in this industry, particularly in basic petrochemicals, leaving a limited role to be played by the private sector in downstream products, usually with foreign multinationals. These countries could be divided into three major groups: the newly industrialized countries (NICs), hydrocarbon-exporting countries with low population and the other developing countries. Each of these groups of developing countries has its own distinctive policies towards the petrochemical industry, emanating from its special conditions.

The main concern of the NICs is: to substitute imports with national production and to develop their markets according to the pattern of national production; to integrate basic products with downstream products, petrochemicals with capital goods and petrochemicals with engineering; to improve their technological capacities and to obtain new forms of financing in order to reduce their debt burden. However, some of these groups of countries are confronted with additional worries, namely, to guarantee their hydrocarbon supplies through direct relations with OPEC countries such as Brazil, India, the Republic of South Korea and Yugoslavia, and to have access to export markets. It should be noted however that the progress of the NICs is part of a historical process which started in the mid-1960s and, although it may be delayed for some time, could never be stopped. The objective factors favouring this process are: the fact that arrangements between the major operators in the industry on certain products, markets and cross-licensing are precarious and constantly challenged; that large chemical companies of the developed market economy countries (DMECs) seem to lose their efficiency under conditions of extreme competition; and that the economic recession in DMECs forces the authorities to export products of their capital goods industry, according to technology transfer agreements and helped by public Western European petrochemical companies (I_{pc}s).

To obtain a guarantee of hydrocarbon supply, the NICs try to reduce their dependence on the oil majors for the supply of crude oil and naphtha and try instead, to establish direct contacts with OPEC and Mexico for the supply of oil and to obtain agreements on joint refineries. Moreover, they work on the development of their own hydrocarbon or other alternative resources -gasohol in Brazil and ammonia from coal in India.

The hydrocarbon exporting countries with small population who have the financial possibilities and political will to valorize their hydrocarbon resources are mainly concerned with getting access to international petrochemical markets and to technical mastery over their plants. They concentrate, at present, on the development of their crude oil refining capacities, on the production of methanol, ammonia, ethylene and its first derivatives (LDPE, styrene, ethylene glycol, ethylene dichloride,..) The impact caused by products of these countries on the markets of the developed countries is expected to hasten the pace of the restructuring process of the petrochemical industry helped by government intervention in developed countries and by M_cs and M_ps who choose to collaborate wuth these oil exporting countries as Shell, Mobil, Dow Chemical and Mitsubishi have done in Saudi Arabia. The final evolution of the position of oil exporting countries with small population would, however, depend on: the possible consequences of the development of state to state (or group of states) agreements on: the delivery of crude oil and refined oil products; the decline in the role of the oil majors (M_ps) as intermediaries between oil exporting and oil importing countries and the development of co-operation between this group of countries and other developing countries under the impulse of the energy crisis.

The common objectives of the other developing countries who are in a position to establish their own petrochemical industry (or who have already done so) are to secure financing for projects on their territories and to guarantee external marketing for their products if need be. The development of their industry will also be dependent on: the future of the export-oriented projects of the OPEC countries; co-operation in the fields of energy and industry between OPEC countries and other developing countries; their external debt position and the availability of appropriate technology.

The analysis of the on-going restructuring process in the petrochemical industry and the role of the main operators in this process indicates that the 1990 image of the industry will be influenced by actions and choices being taken now by the main operators, namely: the major chemical and oil companies, states of the developed countries and of the oil exporting countries. A strong possibility exists for international co-operation between the different partners in this industry to safeguard the interest of each and every one while, at the same time, adapting to the new economic situation and to the evolution and the implication of the energy problems.

Chapter VI of the study indicates that international co-operation in the petrochemical industry is relatively recent, and has emerged from the economic crisis of the 1970s with two distinct major international negotiations concerning the compensation agreements between Eastern European countries and developed market economy countries, and the international multi-fibre agreements between developed and developing countries. However, the petrochemical industry in the developing countries has not benefited from these agreements or from any other form of international co-operation. The essential contribution of the developed countries to the development of petrochemicals in developing countries were confined to: direct investments in few countries, and recently, some joint-ventures there; transfer of technology agreements based on traditional terms and "normal" credits for the export of capital goods. Only 5 newly industrialized countries were active in basics, intermediates and plastics in 1978, as a result of direct foreign investment. Between 1979 and 1984, only very few petrochemical operations will be based on macro-economic co-operation (see Table 6.10). It is thus to be noted that the micro-economic co-operation has achieved very little in the last fifteen years, while macro-economic co-operation (at broader economic level) has not acquired priority as yet as a principal instrument of co-operation in petrochemicals, nor, to this end multilateral co-operation.

A number of constraints are limiting the partners in the petrochemical industry to adopt new means and approaches to international co-operation. Such constraints are to be found in the various policies of the developing countries related to the management of their hydrocarbon resources and the establishment of their petrochemical industry, on the one hand, and the various strategies of the petrochemical operators in the developed countries, on the other. In the first case, the OPEC countries want to exercise their legitimate rights for the preservation of their hydrocarbon resources which may affect the supply situation of the petrochemical industry. The developed countries will be confronted with less oil and gas export, heavier oil, greater export-oriented petrochemicals and greater amount of refined oil products. Such a situation should modify the role of the oil majors and should favour a global approach tending to integrate energy and petrochemicals, production and marketing and direct relations between developed and oil exporting countries. Furthermore, it should raise the serious question of the location of new steam-crackers on the basis of North-South negotiations.

The plastic industry in the developing countries is expected to grow by a minimum of 3.5 million ton/year during the period 1980-1986/1987. The injection of such huge quantity in the world market should have a definite destabilizing effect. Only an international approach to industrial co-operation could provide an equitable solution to this situation. Such an approach will have to be based on international negotiations between the parties concerned on the fundamental issues related to the restructuring of the petrochemical industry.

The first point would have to deal with the replacement of old steam-cracking capacities in the developed countries and the cash-flow problem facing the M_Cs and I_{PC}s for their renovation or the building up of new ones. A choice has to be taken within the framework of the international approach to co-operation and interdependency, taking into consideration the new steam-crackers to be built in the developing countries. Moreover such an approach would have to take into account the social consequences of replacing these old steam-crackers of the developed countries.

The second point to be considered in the context of the approach to interdependency is the export of petrochemical engineering components from the developed to the developing countries which would have to include other counterparts agreements in order to maintain a high level of trade flow between the partner countries.

The preceding analysis leads to one of two choices: either the old and dominant international petrochemical structures are going to break down under the influence of the new factor impulses analysed before or these structural relations are to be reconsidered in the light of collective administration of interdependencies by the international community on medium and long-term bases to the mutual benefit of all concerned. This would imply a consensus on a number of considerations concerning: the legitimacy of the development of the petrochemical industry in the developing countries; the legitimacy of the developed countries to control the pace of expected changes in their petrochemical industry; the specific role of government to government relations in adopting ways and means (of changes) to the mutual benefits of their respective economies and finally to recognize the specific role of public enterprises in the implementation of the government to government agreements.

Since international co-operation implies intervention by the state authorities, the governments of developed and developing countries have to play a substantial role in the implementation of the co-operative approach to interdependency. The objectives of government interventions would be: to prepare the pace of changes; to adopt suitable steps for handling the issues related to collective management such as bilateral agreements, global negotiations, regional programmes and economic groupings and to mobilize the necessary means and the required operators for the conclusions of final agreements. The suggested approach to collective management of interdependency in the production of basic petrochemicals would have to take the following issues into consideration: gradual opening of the developing countries markets to refined oil products and petrochemicals from oil exporting countries; redeployment of certain petrochemical capacities to developing countries and participation of developed countries in new projects of oil exporting countries; security of supply (price and quantity) to steam-crackers in developed countries; participation of hydrocarbon importing developed countries in investments aimed at developing new hydrocarbon resources in developing countries and joint investments with oil exporting countries and other developing countries in research and development aimed mainly at conserving hydrocarbon and at refining heavy fuel technology; finally the setting up of mechanisms to allocate state funds and to offer risk guarantees to entire groups of projects (enterprises).

Regarding the approach to finished and specialty products, it should comprise the following points: gradual opening of developed countries markets to products exported from developing countries; adequate policy adjustments to cope with the conditions under which petrochemical projects are to be established in developing countries, on the basis of collective management of interdependency approach within an agreement framework as applied to regions or countries groupings, counter-trade and buy-back agreements and trade agreements between national enterprises of the countries concerned.

The future of petrochemical development in the non-oil-exporting developing countries will depend on the evolution of the energy crisis. By 1987, no more than 35 developing countries are expected to be in the petrochemical production business, about one third will be entering it for the first time. The objectives of the petrochemical-producing developing countries with no hydrocarbon resources are: the security of their supply; improved conditions for the entry into the industry and improved conditions for export. The proposed approach to meet the above objectives are: regional and inter-regional agreements with OPEC and Mexico for direct access to oil, joint-venture refineries, and hydrocarbon exploration technology; increasing funds made available for development purposes; opening of developed countries markets; funds for research and development; and the establishment of regional groups of buyers.

The procedure for initiating such a global approach to co-operation would have to take into consideration a transitory phase where first all parties are allowed to express very freely their ideas, positions, projects, and interests, followed by in-depth studies and evaluations of the various experiences of the past in the field of co-operation. Then studies on various alternatives of possible agreements are made in the areas outlined in this chapter as a prelude to reach a concrete framework of agreements. Two approaches are proposed here: first to convene a meeting of policy-makers from OPEC and from other developing countries and second, a meeting between the developed and developing countries. Alongside these two meetings, it is also proposed that regional meetings take place to pin-point the needs and possibilities of each region for the implementation of the proposed approach to the future development of the petrochemical industry. It is also proposed that two working groups be established to deal with issues related to the meetings proposed above, i.e. a working group on relations between OPEC and other developing countries and another on relations between developed and developing countries.

I. WORLD DEMAND FOR AND SUPPLY OF PETROCHEMICAL PRODUCTS 1975 TO 1990

Introduction

The petrochemical industry produces hundreds of different products. The estimates of world demand and supply made in this Second UNIDO World-Wide Study concentrate on those final intermediate and basic petrochemical products suggested by the First UNIDO Consultation on the Petrochemical Industry convened in Mexico City in March 1979.2/

The final products considered in this Study are five thermoplastics, three synthetic fibres and two synthetic rubbers which account for about 40 per cent, 12 per cent and 10 per cent of world petrochemical production, respectively.

The basic petrochemical products considered in this Study are the major olefins and aromatics - namely ethylene, propylene, butadiene, and benzene, para- and ortho-xylene and toluene.

UNIDO estimates of capacity (1975, 1979, 1984) production (1975, 1979, 1984) and demand (1975, 1979, 1984 and 1990) at world and regional levels are provided in the Statistical Annex, and the way in which they were compiled is described in the introduction to the Annex(I.A-I.P)

The purpose of this Chapter is to analyse and interpret the information given in the Statistical Annex so as to describe the main trends affecting the development of the petrochemical industry in the world and in particular, the development of this industry in the developing countries.

The Chapter has been written in four parts:

Growth of the industry in developing countries, 1975-1990;
Growth of the industry in industrialized countries, 1975-1990;
The share of developing countries in world petrochemical production;
Interdependence between developing and industrialized countries in the industry.

2/ The First Consultation suggested that a Working Group be established by UNIDO to prepare estimates of demand for and supply of the following petrochemical products at the world and regional levels: 10 basic petrochemical products: ethylene, propylene, butadiene, benzene, paraxylene, orthoxylene, toluene, methanol, ammonia, acetylene; intermediate and final petrochemical products: acrylonitrile, caprolactam, dimethyl terephthalate (DMT), terephthelic acid (TPA), styrene, vinyl chloride, polyvinyl chloride (PVC), high and low density polyethylene, polypropylene, polystyrene, styrene butadiene rubber (SBR), acrylic, polyamide and polyester fibre.

The Statistical Annex to this Chapter reports on the decisions of the Working Group and presents estimates of world demand and supply for 16 of those 25 products. The products omitted are the intermediate products, toluene and ammonia.

1.1 Growth of the petrochemical industry in developing countries: 1975 - 1990

1.1.1 Capacity to produce basic petrochemicals

The petrochemical industry in developing countries is growing by 15 per cent per year. The progress is best measured by their plans to establish plants to manufacture basic petrochemicals. As of April 1981, 27 developing countries had announced plans to establish ethylene plants compared to the 13 plants in existence in 1979; of those 27 producers, 16 will also produce propylene and 11 will produce butadiene. The new ethylene producing countries are Qatar, Libya and Singapore in the period up to 1984; after 1984, the new producers are to be found in Africa (Egypt, Nigeria), Middle East (Kuwait and Saudi Arabia), Asia (Iran, Indonesia, Pakistan and Philippines) and in Latin America (Bolivia, Ecuador and Peru) (see Table I.4). Capacity in developing countries to produce the three olefins (ethylene, propylene and butadiene) is estimated to increase eight-fold in the period 1975 to 1987, with the biggest increase in capacity coming after 1984 as shown in Table I.1.

Table I.1 Developing countries' capacity to produce olefins (million tons)

Capacity at years end	Ethylene	Propylene	Butadiene
1975	1.40	0.74	0.28
1979	3.38	1.52	0.54
1984 1/	7.90	3.05	1.04
1987 1/	14.50	4.36	1.38

1/ Based on plans reported as of April 1981.

A total of 17 developing countries have made plans to establish plants to manufacture aromatics (benzene, xylenes, toluene) compared to plants in existence in 8 countries at the end of 1979 (see Table I.5). The other basic petrochemical considered in this study - methanol - was produced in only 8 developing countries in 1979; but there will be 16 producing countries by 1987. Aromatics are generally required in smaller quantities; but since aromatics can be produced by modifying petroleum refineries, many other developing countries are expected to become producers by 1990. Capacity to produce benzene and xylenes in developing countries is estimated to increase six-fold between 1975 and 1987 and methanol by 5 times between 1979 and 1987 as shown in Table I.2.

Table I.2. Developing countries' capacity to produce aromatics and methanol
(million metric tons)

Capacity at years end	Benzene	Xylenes 1/	Methanol
1975	1.05	0.21	0.27
1979	1.60	1.03	1.40
1984	3.15	2.29	3.35
1987	4.92	3.09	6.80

1/ Para-xylene and ortho-xylene.

1.1.2 Capacity to produce final products

The establishment of capacity to produce basic petrochemicals is needed to supply downstream units manufacturing intermediates and final products. Production capacity to manufacture 5 thermoplastics (LDPE, HDPE, Polypropylene, PVC and Polystyrene), 3 synthetic fibres (acrylic, polyamide, polyester) and 2 synthetic rubbers (SBR and CIS-polybutadiene), which together account for more than 60 per cent of the volume of all petrochemicals produced in the world, is expected to increase four-fold in developing countries in the period 1975 to 1984 or by over 15 per cent per year, see Table I.3 below.

Table I.3 Production capacity in developing countries for 10 final products: 1975-84
(million metric tons)

	5 THERMOPLASTICS			3 SYNTHETIC FIBRES			2 SYNTHETIC RUBBERS		
	1975	1979	1984	1975	1979	1984	1975	1979	1984
AFRICA	-	-	0.04	0.03	0.06	0.08	-	-	-
N. AFRICA	-	0.11	0.65	0.02	0.03	0.07	-	-	-
W. ASIA	-	0.90	0.95	0.07	0.11	0.11	0.03	0.02	0.03
ASIA	0.61	1.83	3.92	0.86	9.13	1.45	0.10	0.15	0.33
CHINA	0.37	0.85	1.40	0.02	0.09	0.57	0.03	0.04	0.15
LATIN AMERICA	0.90	1.86	3.61	0.50	0.74	0.97	0.26	0.45	0.68
DEVELOPING COUNTRIES	1.88	4.74	10.57	1.55	2.16	3.25	0.42	0.67	1.19

1.1.2. A Production capacity for 5 Thermoplastics

The same 27 developing countries that will produce ethylene and propylene by 1987 are the principal producers of thermoplastics. The production of five thermoplastics in developing countries is expected to increase from 4.7 million tons in 1979 to 10.6 million tons in 1984; the proportion of total demand (the level of self-sufficiency) supplied by local production is estimated to increase from 60 per cent in 1979 to 70 per cent in 1984. Information on the capacity to produce 5 different types of thermoplastics in developing countries is provided on a country-by-country basis in Table I.6.

Although many developing countries will complete new plants in the period 1985 to 1987, there is a need to begin planning for the additional thermoplastics capacity that will be required to satisfy demand which is expected to double from 10.6 million tons in 1984 to 22 million tons in 1990. The main thrust of the expansion is needed to meet demand in Asia (expected to reach 10 million tons in 1990) and demand in Latin America (expected to reach 6 million tons in 1990).

1.1.2. B Production capacity for 3 synthetic fibres

The production of three synthetic fibres in developing countries is expected to increase from 2.2 million tons in 1979 to 3.2 million tons in 1984, thus raising the proportion of demand supplied by local production from 78 per cent in 1979 to 80 per cent in 1984.

Synthetic fibres are produced in a wide range of developing countries and it has been difficult to obtain complete information on the volume of production. The information obtained on developing countries is shown in Table I.7. Some countries in Asia are already very important producers on a world scale. However, the exports of textiles from some of these countries to industrialized regions is not expected to increase so rapidly after 1987; further increase in the production capacity of synthetic fibres after 1984 is expected to supply increases in domestic demand rather than exports.

1.1.2. C <u>Production capacity for synthetic fibre intermediates</u>

Demand for synthetic fibres has reached a level in 10 developing countries where some of the synthetic fibre intermediates - acrylonitrile, caprolactam, DMT or TPA and ethylene glycol - will be produced locally (see Table I.8). The only major producers in 1979 were Turkey, India, Republic of Korea, Other Asia (NES) , Brazil, Colombia and Mexico. Other developing countries are likely to accelerate their plans to manufacture these intermediates in view of the rising costs for imported intermediates.

1.1.2. D <u>Production capacity for 2 synthetic rubbers</u>

Developing countries use more natural rubber than industrialized countries. In 1979, they used 1.1 million tons of synthetic rubber and 0.9 million tons of natural rubber. However, as increased supplies of natural rubber are unlikely to be available in the early 1980s, synthetic rubber's share is expected to increase from 55 per cent in 1979 to 58 per cent in 1985 and 62 per cent in 1990; that is unless increased supplies of natural rubber become available in the late 1980s, stimulated by the recent increase in the price of both synthetic and natural rubber.

Eleven developing countries plan to be producing SBR by 1987 and 7 countries producing polybutadiene (see Table I.9). The number is expected to grow as other developing countries initiate production to supply their local tyre industry, the main user of synthetic rubber. Production of two synthetic rubbers is expected to increase from 500 thousand tons in 1979 to 900 thousand tons in 1984, thereby raising the level of self-sufficiency from 61 per cent in 1979 to 64 per cent in 1984. If the level of self-sufficiency is to be increased in the future, there is a need to start planning now the new capacity needed in the period from 1984 to 1990 when demand is estimated to increase from 1,400 to 2,000 thousand tons.

Table I.4 Production capacity of 30 developing countries in three basic petrochemicals (olefins) (thousand metric tons)

	Ethylene			Propylene			Butadiene		
	1979	1984	1987	1979	1984	1987	1979	1984	1987
AFRICA									
Nigeria	-	-	280	-	35	35	-	-	-
N. AFRICA									
Algeria	120	120	120	-	-	-	-	-	-
Egypt	-	-	140	-	-	-	-	-	-
Libya	-	330	330	-	50	50	-	60	60
Morocco	-	-	-	-	-	-	-	-	-
W. ASIA									
Bahrain	-	-	-	-	-	-	-	-	-
Iraq	30	160	160	-	-	-	-	-	-
Kuwait	-	-	300	-	-	-	-	-	-
Qatar	-	280	280	-	-	-	-	-	-
Saudi Arabia	-	-	1600	-	-	-	-	-	-
Turkey	60	360	360	40	100	100	30	30	30
U. Arab Emirates	-	-	-	-	-	-	-	-	-
ASIA									
India	240	240	920	120	120	220	50	50	70
Indonesia	-	-	350	-	-	-	-	-	-
Iran	30	30	300	15	15	125	-	-	25
Malaysia	-	-	-	-	-	-	-	-	-
Pakistan	-	-	100	-	-	-	-	-	-
Phillipines	-	-	250	-	-	-	-	-	-
Rep. of Korea	150	850	1200	80	450	630	25	125	175
Singapore	-	300	300	-	165	165	-	-	-
Thailand	-	-	150	-	-	-	-	-	-
Other Asia	570	920	920	290	410	410	80	120	120
CHINA	540	950	1810	230	410	950	100	130	220
LATIN AMERICA									
Argentina	170	250	550	80	100	240	40	40	120
Bolivia	-	-	160	-	-	80	-	-	-
Brazil	740	1220	1220	410	650	650	170	240	240
Chile	60	180	180	-	-	-	-	-	-
Columbia	20	120	120	10	10	10	-	-	-
Ecuador	-	-	100	-	-	-	-	-	-
Mexico	440	1440	1940	150	450	450	150	150	250
Peru	-	-	250	-	-	150	-	-	70
Venezuela	150	150	500	90	90	90	-	-	-

Table I.5 Production capacity of 30 developing countries in three basic petrochemicals (aromatics and methanol) (thousand metric tons)

	XYLENES 1/			BENZENE			METHANOL		
	1979	1984	1987	1979	1984	1987	1979	1984	1987
AFRICA									
Nigeria	-	-	-	-	20	20	-	-	-
N. AFRICA									
Algeria	-	40	40	-	-	-	110	110	110
Egypt	-	-	-	-	-	-	-	-	-
Libya	-	-	-	-	-	-	330	330	330
W. ASIA									
Bahrain	-	-	-	-	-	-	-	330	330
Iraq	-	-	-	-	-	-	-	330	330
Kuwait	-	-	140	-	-	280	-	-	-
Qatar	-	-	-	-	-	-	-	-	-
Saudi Arabia	-	-	-	-	-	-	-	-	1400
Turkey	-	200	200	-	150	150	-	100	100
U. Arab Emirates	-	-	-	-	-	-	-	-	-
ASIA									
India	40	100	160	150	210	310	-	60	60
Indonesia	-	-	240	-	-	370	-	-	330
Iran	-	-	120	-	-	350	-	-	100
Malaysia	-	-	-	-	-	-	-	-	330
Pakistan	40	40	40	-	-	-	-	-	-
Phillipines	-	-	-	-	-	-	-	-	-
Rep. of Korea	50	400	400	110	250	250	390	390	390
Singapore	-	-	-	-	-	-	-	-	-
Thailand	-	-	-	-	-	-	-	-	-
Other Asia	260	400	400	200	340	440	120	190	190
CHINA	30	210	400	400	500	800	260	400	800
LATIN AMERICA									
Argentina	65	65	65	230	230	290	40	40	40
Bolivia	-	-	-	-	-	100	-	-	-
Brazil	160	230	230	270	390	390	140	140	140
Chile	-	-	-	-	-	-	-	-	-
Colombia	60	60	210	40	40	90	-	-	-
Ecuador	-	-	70	-	-	140	-	-	-
Mexico	110	410	710	120	720	720	180	1000	1820
Peru	-	-	20	-	-	120	-	-	-
Venezuela	-	-	50	-	-	100	-	-	330

1/ Para-Xylene and Ortho-Xylene

Table I.6.A. Production capacity of 30 developing countries in five thermoplastics (thousand metric tons)

	LDPE			HDPE			Polypropylene		
	1979	1984	1987	1979	1984	1987	1979	1984	1987
AFRICA									
Nigeria	-	-	110	-	-	70	-	35	35
N. AFRICA									
Algeria	48	48	48	-	-	-	-	-	-
Egypt	9	90	90	-	40	40	-	-	-
Libya	50	50	50	50	50	50	70	70	70
Morocco	-	-	-	-	-	-	-	-	-
W. ASIA									
Bahrain	-	-	-	-	-	-	-	-	-
Iraq	-	60	60	-	30	30	-	-	-
Kuwait	-	-	130	-	-	-	-	-	-
Qatar	-	140	140	-	70	70	-	-	-
Saudi Arabia	-	-	680	-	-	160	-	-	-
Turkey	25	175	175	-	40	40	-	60	60
U. Arab Emirates	-	-	-	-	-	-	-	-	-
ASIA									
India	112	112	N.E.	30	30	N.E.	30	30	N.E.1/
Indonesia	-	-	180	-	-	60	37	37	-
Iran	-	-	100	-	-	60	-	-	50
Malaysia	-	-	-	-	-	-	-	-	-
Pakistan	5	5	65	-	-	-	-	-	-
Philippines	-	-	100	-	-	35	-	-	-
Rep. of Korea	70	320	N.E.	70	140	N.E.	125	205	N.E.
Singapore	-	120	120	-	80	80	-	100	100
Thailand	-	74	74	-	-	-	-	-	-
Other Asia	215	215	N.E.	50	170	N.E.	50	185	N.E.
CHINA	280	340	860	35	35	35	120	200	440
LATIN AMERICA									
Argentina	33	228	N.E.	-	30	N.E.	-	40	N.E.
Bolivia	-	-	40	-	-	95	-	-	40
Brazil	320	570	N.E.	110	170	N.E.	100	150	N.E.
Chile	36	36	36	-	-	-	-	-	-
Columbia	20	60	60	-	-	-	-	-	-
Ecuador	-	-	60	-	-	35	-	-	40
Mexico	100	340	N.E.	100	200	N.E.	-	100	N.E.
Peru	-	-	90	-	-	-	-	-	-
Venezuela	56	110	110	-	60	60	-	-	-

1/ N.E. - no estimate

Table I.6.B Production capacity of 30 developing countries in five thermoplastics (thousand metric tons)

	PVC			Polystyrene		
	1979	1984	1987	1979	1984	1987
AFRICA						
Nigeria	-	-	145	-	-	-
N. AFRICA						
Algeria	35	35	35	-	-	-
Egypt	-	80	80	-	-	-
Libya	-	80	80	-	-	-
Morocco	25	-	-	-	-	-
W. ASIA						
Bahrain	-	-	-	-	-	-
Iraq	-	60	60	-	-	-
Kuwait	-	-	-	-	-	-
Qatar	-	-	-	-	-	-
Saudi Arabia	-	-	-	-	-	-
Turkey	52	152	152	15	N.E.	N.E.1/
U. Arab Emirates	-	-	-	-	-	-
ASIA						
India	132	187	N.E.	24	24	N.E.
Indonesia	40	40	150	-	-	-
Iran	-	-	150	-	-	-
Malaysia	25	25	-	7	-	-
Pakistan	5	5	55	-	-	-
Phillipines	50	50	N.E.	13	13	N.E.
Rep. of Korea	200	300	N.E.	50	200	N.E.
Singapore	-	-	-	-	-	-
Thailand	20	50	N.E.	15	23	N.E.
Other Asia	400	1000	N.E.	80	120	N.E.
CHINA	400	800	800	20	20	20
LATIN AMERICA						
Argentina	53	147	N.E.	57	57	N.E.
Bolivia	-	-	-	-	-	-
Brazil	311	511	N.E.	185	200	N.E.
Chile	15	N.E.	N.E.	4	N.E.	N.E.
Columbia	-	30	30	-	10	10
Ecuador	-	-	20	-	-	10
Mexico	120	260	N.E.	98	148	N.E.
Peru	-	-	60	-	-	36
Venezuela	45	45	90	36	36	54

1/ N.E. - no estimate

Table I.7 Production capacity of 30 developing countries in synthetic fibres (thousand metric tons)

	ACRYLIC			POLYAMIDE			POLYESTER		
	1979	1984	1987	1979	1984	1987	1979	1984	1987
AFRICA									
Nigeria	-	-	-	-	-	-	-	20	20
N. AFRICA									
Algeria	-	-	-	-	-	-	-	-	-
Egypt	-	-	-	-	1	1	-	25	25
Libya	-	-	-	-	-	-	-	-	-
W. ASIA									
Bahrain	-	-	-	-	-	-	-	-	-
Iraq	-	-	-	-	-	-	-	-	-
Kuwait	-	-	-	-	-	-	-	-	-
Qatar	-	-	-	-	-	-	-	-	-
Saudi Arabia	-	-	-	-	-	-	-	-	-
Turkey	50	75	75	20	40	40	70	90	90
U. Arab Emirates	-	-	-	-	-	-	-	-	-
ASIA									
India	16	16	16	40	44	141	27	89	149
Indonesia	6	6	6	8	8	8	55	80	80
Iran	-	20	20	-	16	16	-	-	-
Malaysia	-	-	-	-	-	-	36	36	36
Pakistan	-	-	-	6	6	6	13	40	40
Phillipines	-	-	-	15	15	15	30	50	50
Rep. of Korea	114	114	114	91	180	180	100	250	250
Singapore	-	-	-	-	-	-	-	-	-
Thailand	-	-	-	-	-	-	56	56	56
Other Asia	91	190	240	111	130	130	333	500	500
CHINA	10	60	60	10	60	60	15	430	430
LATIN AMERICA									
Argentina	15	15	N.E.	37	37	N.E.	23	23	N.E. 1/
Bolivia	-	-	-	-	-	-	-	-	-
Brazil	23	23	N.E.	89	89	N.E.	125	125	N.E.
Chile	-	-	-	6	-	-	6	-	-
Colombia	-	18	18	35	35	75	30	60	120
Ecuador	-	-	-	-	-	-	-	-	-
Mexico	69	69	105	49	49	100	146	250	-
Peru	-	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	-	-	-	-	-

1/ N.E. - no estimate

Table I.8 Production capacity of 20 developing countries to produce synthetic fibre intermediates (thousand metric tons)

	Acrylonitrile			Caprolactam			DMT/TPA			Ethylene Glycol		
	1979	1984	1987	1979	1984	1987	1979	1984	1987	1979	1984	1987
AFRICA												
Nigeria	-	-	-	-	-	-	-	-	-	-	-	33
N. AFRICA												
Libya	-	-	-	-	-	-	-	-	-	-	52	52
W. ASIA												
Kuwait	-	-	-	-	-	-	-	-	-	-	-	135
Saudi Arabia	-	-	-	-	-	-	-	-	-	-	-	500
Turkey	-	70	70	25	25	25	30	70	70	-	70	70
ASIA												
India 1/	24			20			-			-		
Indonesia	-	-	-	-	-	-	-	-	120	-	-	-
Iran	-	-	-	-	-	-	-	-	60	-	-	-
Pakistan	-	-	-	-	-	-	-	-	50	-	-	25
Phillipines	-	-	-	-	-	-	-	-	-	-	-	-
Rep. of Korea	75	75	75	80	180	180	100	200	200	-	80	80
Singapore	-	-	-	-	-	-	-	-	-	-	100	100
Other Asia	132	132	132	100	100	100	200	350	350	100	225	225
CHINA	50	50	50	-	-	60	-	220	450			
LATIN AMERICA												
Argentina	-	-	-	-	35	35	14	14	14	-	-	-
Brazil	60	60	60	40	40	40	165	165	165	-	-	-
Chile	-	-	-	-	-	-	-	-	-	-	-	-
Colombia	-	-	-	35	35	75	-	-	120	-	-	-
Ecuador	-	-	-	-	-	50	-	-	-	-	-	50
Mexico	75	125	175	50	50	110	235	330	330	60	180	180
Peru	-	-	50	-	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	-	-	-	-	-	-	-	-

1/ For India, no information available on plans for production in 1984 and 1987.

Table I.9 Production capacity of 13 developing countries to produce two synthetic rubbers (thousand metric tons)

	S B R			POLYBUTADIENE		
	1979	1984	1987	1979	1984	1987
AFRICA						
-						
N. AFRICA						
Libya	-	-	60	-	-	-
W. ASIA						
Turkey	32	32	32	-	-	-
ASIA						
India	30	30	30	20	20	20
Iran	-	-	40	-	-	-
Rep. of Korea	50	100	100	-	50	50
Other Asia	50	90	90	-	42	42
CHINA	30	110	270	-	-	50
LATIN AMERICA						
Argentina	60	60	60	-	-	-
Brazil	200	300	300	40	80	80
Colombia	-	-	30	-	-	10
Mexico	90	200	200	20	20	20
Peru	-	-	60	-	-	25
Venezuela	-	-	40	-	-	-

1.1.3 Demand for petrochemicals in developing countries

In developing countries, the start of local production improves the availability of petrochemicals and helps to create demand. Until such time as local production is developed, difficulties in obtaining imports may restrict demand[3/]. Thus, in preparing estimates of demand for developing countries, it has been assumed that new plants will soon produce at 80 per cent of capacity and that there will be a demand within the region for the entire production. Hence, high rates of growth of demand for petrochemicals in developing countries can be expected in the 1980s even though prospects for their economic growth are perhaps less bright than in the 1970s.

1.1.4 Demand for basic petrochemicals

The demand for basic petrochemicals is derived from the demand for final products. Thus, ethylene demand is expected to grow sufficiently to supply all downstream plants including those producing LDPE, HDPE and PVC which account for about 60 per cent of ethylene demand in industrialized countries. The estimated rates of growth of demand for basic petrochemicals are as follows:

Table I.10 Estimated annual rate of growth of demand for basic petrochemicals in developing countries (per cent per annum)

	1975-79	1979-84	1984-1990
Ethylene	24.0	17.6	14.9
Propylene	26.0	15.1	10.8
Butadiene	14.7	10.0	8.7
Benzene	12.8	15.6	10.8
Xylene	41.4	17.6	8.8

3/ For example, Jose Juca Bezerra Neto, a Director of Brazil's State Petrochemical Company, PETROQUISA, is reported as estimating that Latin America's 300 million inhabitants would consume 4 million tons per year of plastics instead of the actual consumption of 2 million tons per year if supply were not restricted by limits on production and and imports. Reported in Chemical Week, January 28, 1981, page 46.

Demand for the most important 5 basic petrochemicals is expected to increase ten-fold from 2.8 million tons in 1975 to 28 million tons in 1990. The contribution of each region to demand is summarized in Table I.11 below.

Table I.11 Demand for basic petrochemicals in developing countries in 1975 and 1990 (million tons)

Regions	Ethylene		Propylene		Butadiene		Xylenes		Benzene	
	1975	1990	1975	1990	1975	1990	1975	1990	1975	1990
Africa	-	0.30	-	0.06	-	0.06	-	0.10	-	0.05
N. Africa	-	0.80	-	0.10	-	0.05	-	0.10	-	0.05
W. Asia	-	2.65	-	0.16	0.01	0.06	-	0.30	0.02	0.15
Asia	0.25	3.80	0.20	1.80	0.08	0.50	0.05	1.20	0.20	1.60
China	0.30	1.40	0.07	0.85	0.04	0.33	-	0.30	0.28	1.40
Latin America	0.60	5.00	0.20	1.50	0.08	0.60	0.15	1.00	0.30	1.75
TOTAL	1.15	13.95	0.47	4.47	0.21	1.60	0.20	3.00	0.80	5.00

1.1.5 Demand for final products

The estimated rates of growth of demand for the 3 groups of final products are as follows:

Table I.12 Estimated annual rate of growth of demand for 10 final products in developing countries (per cent per annum)

	1975-79	1979-84	1984-1990
5 Thermoplastics	19.5	11.7	11.1
3 Synthetic Fibres	12.0	7.0	6.7
2 Synthetic Rubbers	14.0	8.7	5.9

1.1.5. A Demand for thermoplastics

Demand for the 5 thermoplastics in developing countries is estimated to increase by 11 to 12 per cent per annum from about 7 million tons in 1979 to 22 million tons in 1990. The contribution made by each region is expected to be as follows.

Table I.13 Demand for 5 thermoplastics in developing countries (million tons)

	1975	1979	1984	1990
Africa	0.10	0.15	0.30	0.60
N. Africa	0.19	0.26	0.40	0.80
W. Asia	0.35	0.48	0.90	1.80
Asia	1.20	2.85	5.00	10.00
China	0.34	0.80	1.40	2.80
Latin America	1.10	2.20	3.70	6.00
TOTAL	3.28	6.71	11.70	22.0

The thermoplastics most widely used in developing countries are LDPE and PVC. In the 1980s, demand for polypropylene is expected to grow slightly faster than demand for the other plastics.

Table I.14 Demand for 5 thermoplastics in developing countries 1979-90

	Volume (million tons)			Proportion (per cent)		
	1979	1984	1990	1979	1984	1990
LDPE	2.21	3.75	6.95	32.9	32.0	31.6
HDPE	0.84	1.44	2.72	12.5	12.3	12.4
Polypropylene	0.85	1.52	3.04	12.7	13.0	13.8
PVC	2.11	3.85	7.20	31.5	32.9	32.7
Polystyrene	0.70	1.14	2.09	10.4	9.8	9.5
	6.71	11.70	22.00	100.0	100.0	100.0

1.1.5 . B Demand for synthetic fibres

Demand for 3 synthetic fibres in developing countries is estimated to increase by 7 per cent per annum from about 2.5 million tons in 1979 to 5.1 million tons in 1990. The contribution of each region is expected to be as follows:

Table I.15 Demand for 3 synthetic fibres in developing countries (million tons)

	1975	1979	1984	1990
Africa	60	100	140	200
N. Africa	60	90	120	200
W. Asia	100	130	160	220
Asia	800	1150	1550	2050
China	80	320	500	1000
Latin America	460	680	1000	1430
TOTAL	1560	2470	3470	5100

The demand for each type of synthetic fibre expected in 1984 and 1990 is shown in the following Table. The share of polyester fibres is expected to increase at the expense of polyamide (nylon) fibres, whilst the share of acrylic fibres stays the same.

Table I.16 Demand for 3 synthetic fibres in developing countries 1979-90

	Volume (million tons)			Proportion (per cent)		
	1979	1984	1990	1979	1984	1990
Acrylic	0.39	0.55	0.81	15.8	15.8	15.8
Polyamide	0.62	0.81	1.15	25.1	23.4	22.6
Polyester	1.46	2.11	3.14	59.1	60.8	61.6
Total	2.47	3.47	5.10	100.0	100.0	100.0

1.1.5. C Demand for synthetic rubbers

Demand for the 2 synthetic rubbers in developing countries is expected to grow by 8 per cent per annum from about 0.8 million tons in 1979 to 2.0 million tons in 1990. The shares of SBR and polybutadiene in the total demand are expected to remain stable at 83 per cent and 17 per cent, respectively, in the period from 1979 to 1990. The contribution of each region is expected to be as follows:

Table I.17 Demand for 2 synthetic rubbers in developing countries (1000 tons)

	1975	1979	1984	1990
Africa	10	40	50	70
N. Africa	10	30	40	50
W. Asia	20	40	40	50
Asia	220	340	470	590
China	30	90	190	300
Latin America	250	380	610	920
TOTAL	540	820	1400	1980

Table I.18 summarizes estimates of the rate of growth of demand for all the basic and final petrochemical products covered in this Second Study for industrialized countries and the world as a whole as well as for developing countries. From this Table, it can be seen that demand in developing countries is expected to grow 2 to 3 times as fast as in the industrialized countries in the period 1979 to 1990.

Table I.18 Growth of demand for selected petrochemical products (per cent per annum)

Petrochemical Product	World Total			Industrialized Countries			Developing Countries		
	1975 -1979	1979 -1984	1984 -1990	1975 -1979	1979 -1984	1984 -1990	1975 -1979	1979 -1984	1984 -1990
Basic Petrochemicals									
Ethylene	11.2	6.2	6.0	10.4	5.8	4.3	24.0	17.6	14.9
Propylene	11.8	5.2	6.4	8.7	4.4	5.9	26.0	15.1	10.8
Butadiene	8.8	5.0	4.6	7.8	3.7	3.6	18.9	16.4	10.0
Benzene	11.0	5.7	4.9	10.8	4.7	4.0	12.8	15.6	10.8
Xylenes	11.8	7.1	5.6	9.3	5.1	4.5	41.4	17.6	8.8
Methanol	10.7	9.6	7.0	10.1	11.4	6.3	22.9	17.6	12.0
Thermoplastics									
LDPE	10.3	5.1	5.8	11.3	3.6	3.9	19.1	11.1	10.8
HDPE	17.9	6.5	6.1	16.9	5.5	4.9	24.4	11.4	11.2
PP	20.4	8.5	8.6	19.0	7.7	7.6	28.7	12.3	12.2
PVC	11.4	6.2	6.3	10.6	4.6	4.6	16.1	12.7	11.0
PS	11.9	5.4	5.9	11.2	4.7	4.9	18.1	10.2	10.6
AVERAGE	13.6	6.1	6.4	12.6	4.8	5.0	19.6	11.7	11.1
Synthetic Fibres									
Acrylic Fibres	10.3	2.8	3.6	9.4	2.1	4.0	14.1	7.1	6.6
Nylon Fibres	7.2	2.8	2.4	6.6	2.8	1.3	8.2	6.3	5.5
Polyester Fibres	9.9	5.1	3.7	8.7	4.1	2.3	13.0	7.6	6.9
AVERAGE	9.0	4.1	3.5	8.1	3.0	3.2	11.9	7.4	6.4
Synthetic Rubber									
SBR	7.2	4.2	3.7	6.6	3.5	3.2	14.3	8.3	6.0
Polybutadiene	7.8	6.3	3.2	7.0	5.6	2.8	13.7	16.7	5.8
AVERAGE	7.5	5.8	3.6	6.6	3.9	3.1	14.1	8.7	5.9

/

1.2 Growth of the Petrochemical Industry in Industrialized Countries - 1975 - 1990

1.2.1 Demand for petrochemicals in industrialized countries

Most observers expect a much slower rate of growth in the demand for petrochemicals in industrialized countries in the 1980s than they did in mid-1977 when the estimates of the First UNIDO Study were prepared. The main reasons are as follows:

- the prospects are for slower economic growth and slower growth of major consuming industries such as automobiles and textiles;
- demand for petrochemicals has reached a mature stage where substitution opportunities are largely exhausted.

1.2.2 Demand for final products

Estimates of the growth of demand for final products in industrialized countries are summarized in Table I.19. They are lower than in the First UNIDO World-Wide Study when demand for all plastics was expected to grow at 11.5 per cent per annum, demand for man-made fibres at 6.2 per cent per annum and demand for all types of rubber at 5 per cent per annum. Demand in 1975 and 1990 by region is shown in Table I.20.

Table I.19 Growth of demand for final products in industrialized countries 1973-1990 (per cent per annum)

Product Groups	Actual 1973-1979	Forecast 1979-1984	Forecast 1984-1990
5 Thermoplastics	3.6 a/	4.8	5.0
3 Synthetic fibres	3.2	3.0	3.2
2 Synthetic rubbers	2.7	3.9	3.1

a/ Growth rate of the period 1974 - 1979.

Table I.20 Demand for 10 final petrochemical products in industrialized countries in 1979 and 1990 (million tons)

	5 Thermoplastics		3 Synthetic Fibres		2 Synthetic Rubbers	
	1975	1990	1975	1990	1975	1990
Japan	2.94	6.64	0.64	1.27	0.45	0.92
W. Europe	8.20	19.05	1.57	2.30	1.06	1.32
N. America	7.23	22.81	2.42	4.08	1.25	2.30
USSR + E.Europe	2.35	8.20	0.80	2.15	1.40	3.25
Other Countries	0.60	1.30	0.08	0.22	0.07	0.18
Total	21.32	58.00	5.51	10.02	4.23	7.97

1.2.2. A Demand for 5 thermoplastics

In the period 1974-1979, demand for the 5 thermoplastics in industrialized countries increased by 3.6 per cent per annum; it is expected to increase by 4.8 per cent in the period 1979-1984 and 5 per cent in the period 1984-1990, that is from 34 million tons in 1979 to 58 million tons in 1990. The annual rate of growth of demand in the 1980s is expected to be 7.7 per cent per annum in the USSR and Eastern Europe, 6 per cent in North America, 4 per cent in Western Europe and less than 2 per cent in Japan. The annual growth rates for the five different plastics in the 1980s are estimated as follows: LDPE 3.7 per cent, HDPE 5.2 per cent, Polypropylene 7.6 per cent, PVC 4.6 per cent and Polystyrene 4.8 per cent.

The expected demand for the five different thermoplastics in 1979 and 1990 is shown in Table I.21 below. The most significant developments in the 1980s will be the growing share of polypropylene and the emergence of LLDPE (Linear Low Density Polyethylene) which is expected by Chem Systems to take 25 per cent of the United States polyethylene market and 13 per cent of the West European market by 1990.

Table I.21 Demand for 5 thermoplastics in industrialized countries

PRODUCT	Demand million tons		Share of Total per cent	
	1979	1990	1979	1990
LDPE	10.03	15.04	29.2	25.9
HDPE	4.84	8.44	14.2	14.6
PP	4.14	9.29	12.1	16.0
PVC	10.03	16.42	29.2	28.3
PS	5.25	8.81	15.3	15.2
Total	34.29	58.00	100.0	100.0

1.2.2. B Demand for 3 synthetic fibres

Demand for 3 synthetic fibres in the industrialized countries increased by 3.2 per cent per annum in the period 1973-1979. Demand is expected to increase by 3.0 per cent from 1979-1984 and by 2.2 per cent from 1984-1990. The growth of demand is expected to be highest in the USSR and Eastern Europe (8 per cent). Very little increase in the demand for synthetic fibres is foreseen in North America, Western Europe and Japan except for further penetration of the market by polyester fibres in North America where demand is expected to increase from 1.75 million tons in 1979 to 2.35 million tons in 1990. The assumption is that the increase in demand for textiles made from synthetic fibres will be satisfied by imports from developing countries; however, this will depend on such an expansion of exports from developing countries not being restricted by the present trade barriers and other restrictive arrangements.

The substantial volume of imports and exports of textiles and clothing make it difficult to assess the relative shares of synthetic and natural fibres in the total demand for fibres in the industrialized countries. The share of the three main synthetic fibres in total demand for synthetic fibres is expected to change very little in the 1980s as shown in Table I.22 below.

Table I.22 Demand for 3 synthetic fibres in industrialized countries

	Demand million tons		Share of Total per cent	
	1979	1990	1979	1990
Polyester Fibres	3.48	4.89	46.0	48.8
Polyamide Fibres	2.66	3.29	35.2	32.8
Acrylic Fibres	1.42	1.84	18.8	18.4
Total	7.56	10.02	100.0	100.0

1.2.2. C Demand for 2 synthetic rubbers

Synthetic rubber supplied 75 per cent of the industrialized countries' requirements for all rubbers in 1979 compared to 55 per cent of the developing countries' requirements; this proportion is expected to rise to 78 per cent by 1990. The USSR and Eastern Europe relied on synthetic rubber for 85 per cent of their total rubber requirements in 1979, the United States for about 75 per cent and Western Europe and Japan for about 65 per cent.

Of the two types of synthetic rubber used in large volume - SBR and Polybutadiene -, SBR accounted for 58 per cent of demand for all synthetic rubbers in 1979; the level is expected to drop to 56 per cent by 1990. Polybutadiene accounted for 13 per cent in 1979 and is expected to reach 14 per cent in 1990. The following other types of rubber accounted for the remaining proportion of total synthetic rubber used in 1979: Butyl (6.6 per cent), Ethylene/Propylene (5.6 per cent), Polychloroprene (4.8 per cent), Polyisoprene (4.1 per cent) and Nitrile (4.3 per cent).

The growth of demand for all types of synthetic rubber in industrialized countries between the two years of peak demand 1973-1979 was 2.7 per cent per annum. The demand for synthetic rubbers in the industrialized countries is expected to increase from 7.8 million tons to 11.4 million tons or by 3.6 per cent per annum. Motor tyres are a major end-use. Demand in Japan, Western Europe and North America is expected to grow by 2.7 per cent per annum because the vehicle population will increase only a little in the 1980s and the size of motor tyres required is expected to be smaller on the average. In the USSR and Eastern Europe, demand is expected to increase by over 5 per cent per annum, as the region aims to reduce reliance on imported natural rubber still further from 14 per cent in 1980 to 7 per cent in 1990.

1.2.3 Demand for basic petrochemicals

The rate of growth of demand for basic petrochemicals was summarized in Table I.18 on page 18 above. Estimates of the demand for five basic petrochemicals in 1975 and 1990 in industrialized countries are summarized in Table I.23 below.

Table I.23 Demand for basic petrochemicals in industrialized countries in 1975 and 1990 (million tons)

Region	Ethylene		Propylene		Butadiene		Benzene		Xylene	
	1975	1990	1975	1990	1975	1990	1975	1990	1975	1990
Japan	3.40	6.20	2.30	3.30	0.47	0.80	1.48	2.50	0.65	1.14
W. Europe	7.90	16.60	4.10	10.00	0.81	1.65	3.26	7.00	1.09	2.04
N. America	9.80	23.60	4.40	15.00	1.50	2.50	3.74	10.00	1.32	3.32
USSR and Eastern Europe	2.00	8.60	1.20	3.50	0.45	1.50	2.15	6.00	0.60	2.25
Other Countries	0.25	1.50	0.12	0.60	0.10	0.25	0.08	0.30	0.02	0.10
TOTAL	23.35	56.50	12.12	32.40	3.33	6.70	10.71	25.80	3.68	8.85

1.2.3.A Demand for ethylene and other basic petrochemicals

The downstream uses for ethylene are shown in Table I.24 below.

Table I.24 Downstream uses for ethylene in some industrialized countries (per cent)

Downstream Uses	United States		W. Europe		Japan
	1979	1990	1978	1985	1977
LDPE	44.0	50.0	37.8	37.0	26.7
HDPE			13.7	15.2	14.6
Polystyrene	7.5	7.4	5.8	5.8	8.7
PVC	12.5	10.7	17.6	17.2	15.7
Ethylene oxide	16.4	17.8	6.1	5.5	13.5
Ethylene glycols			6.1	5.8	
Other derivatives	19.6	14.3	12.9	13.4	9.2
Acetaldehyde					11.5
TOTAL	100	100	100	100	100

For all industrialized countries, ethylene demand is expected to grow by 5.8 per cent per annum from 1979 to 1984 and 4.3 per cent per annum from 1984 and 1990. For the USSR and Eastern Europe, ethylene demand increased by 10.7 per cent in the period 1975-1979 and is expected to grow by 10 per cent per annum in the period 1979-1984. The rate of growth of demand for ethylene in the period 1974-1979 was 2.7 per cent per annum in Japan, 3.0 per cent in Western Europe and 4.1 per cent in the United States; for the period 1979-1984, the estimates used are those made for the Working Group, namely 1.7 per cent in Japan (where two acetic acid plants will switch from ethylene to methanol as a feedstock), 2.6 per cent in Western Europe and 5.9 per cent per annum in the United States; for the period 1984-1990, the growth rates estimated by UNIDO are 3.0 per cent in Japan, 3.0 per cent in Western Europe and 4.0 per cent in the United States.

Similar trends apply to propylene, butadiene, benzene and xylenes and full details are given in the Annexures on these products in the Statistical Annex. The pattern of downstream uses for ethylene, propylene, benzene and some of their derivatives in Western Europe are given in Chart A. For propylene, a study of downstream uses is given in Table I.25.

Table I.25 Downstream uses for propylene in some industrialized countries (per cent)

	United States		Western Europe	
	1979	1990	1979	1990
Polypropylene	28.3	32.6	23.2	31.4
Acrylonitrile	16.6	15.1	19.9	18.0
Propylene oxide	13.8	13.8	10.4	10.3
Isopropanol	11.0	8.2	8.2	7.2
Cumene	11.0	11.9	9.1	7.9
Oxo-alcohols	} 19.3	18.3	16.1	13.9
Other derivatives			12.9	11.4
TOTAL	100.0	100.0	100.0	100.0

Chart I.A Downstream uses for selected petrochemical products

Estimates for Western Europe by Chemical Age, 10 April 1981

ETHYLENE	LDPE	40 per cent	HDPE	15 per cent
	EDC (for PVC)	19 per cent	Ethylene oxide	13 per cent
	Ethylbenzene	7 per cent	Other uses	6 per cent
PROPYLENE	Polypropylene	26 per cent	Acrylonitrile	17 per cent
	Oxo alcohols	17 per cent	Propylene oxide	12 per cent
	Cumene	8 per cent	Other uses	20 per cent
BENZENE	Ethylbenzene	49 per cent	Cumene	18 per cent
	Cyclohexane	11 per cent	Nitrobenzene	7 per cent
	Other uses	15 per cent		
ETHYLENE OXIDE	Ethylene glycol	45 per cent	Ethoxylates	21 per cent
	Glycol ethers	11 per cent	Ethanolamines	8 per cent
	Other uses	15 per cent		
ETHYLENE GLYCOL	Polyester	50 per cent	Antifreeze	35 per cent
	Other uses	15 per cent		
LD POLYETHYLENE	Film	74 per cent	Injection Moulding	7 per cent
	Coatings	6 per cent	Cables	4 per cent
	Pipes	3.5 per cent	Blow Moulding	3 per cent
PROPYLENE OXIDE	Polyether polyols	65 per cent	Propylene glycol	25 per cent
	Other uses	10 per cent		
POLYPROPYLENE	Moulding	45 per cent	Fibre	37 per cent
	Film	10 per cent	Other uses	8 per cent
PVC	Pipes and fittings	28 per cent	Rigid profiles	12 per cent
	Wires and Cables	10 per cent	Flexible films	10 per cent
	Rigid Foil	8 per cent	Bottles	7 per cent
	Floor coverings	6 per cent	Coated fabrics	5 per cent
STYRENE	Polystyrene	65 per cent	SB/SBR	13 per cent
	ABS	10 per cent	Polyester	8 per cent

1.2.3.B Demand for Methanol

Demand for methanol is difficult to forecast because new end uses are expected to become increasingly important in the 1980s. Demand for methanol in industrialized countries is expected to increase 50% between 1979 and 1984 and a further 50% between 1984 and 1990, that is from about 11 million tons in 1979 to 16 million tons in 1984 and 24 million tons in 1990. However, the estimates for 1990 could be much too low if methanol begins to be used as a fuel in power stations and it is used in gasoline blending on a larger scale than forecast below in Table I.26, which estimates the expected pattern of demand in 1985 and 1990 in Western Europe, United States and Japan.

Table I.26 Demand for methanol in various end uses in Western Europe, United States and Japan - 1979, 1985 and 1990 (thousand metric tons)

	Western Europe			United States			Japan		
	1979	1985	1990	1978	1983	1990	1978	1983	1990
Traditional End-Uses Established before 1974									
- Formaldehyde	1,590	1,840	2,080	1,306	1,709	2,260	631	768	-
- D M T	160	185	200	135	157	160	43	42	-
- Methyl Methacrylate	110	130	150	141	205	307	53	64	-
- Methyl halides	110	145	175	270	405	400	32	38	-
- Methyl amines	155	180	210	160	219	226	32	38	-
- Miscellaneous	807	990	1,170	762	1,005	-	279	330	-
TOTAL	2,932	3,470	3,985	2,774	3,700	5,303	1,070	1,280	-
New End-Uses Established after 1975									
- M T B E	70	180	240	-	451	758	-	-	-
- M T B E blending component	30	75	100	-	-	-	-	-	-
- Gasoline blending	200	200	200	74	138	1,138	-	-	-
- Acetic acid	25	260	550	206	471	871	-	100	-
- Single cell protein	2	160	550	-	-	-	-	-	-
TOTAL	327	875	1,640	300	1,060	2,767	-	100	-
TOTAL	3,259	4,345	5,625	3,074	4,760	8,070	1,070	1,380	2,120

Source: UNIDO and OOIC estimates based on estimates of Chem. Systems International and Stanford Research Institute.

1.2.4 Capacity to produce petrochemicals in industrialized countries

Estimates of the 1979 and 1984 capacity in industrialized countries to produce the six basic petrochemicals and ten final products considered in this study are given in Table I.27. They confirm that further growth in the petrochemical industry is expected but at a slower rate than in the past.

Table I.27 Estimates of capacity to produce selected petrochemicals in industrialized countries (million tons)

Petrochemical Products	Japan		W. Europe		N. America		USSR + E. Europe		Other Countries		Total	
	1979	1984	1979	1984	1979	1984	1979	1984	1979	1984	1979	1984
Basic Petrochemicals												
Ethylene	6.00	6.00	14.70	17.60	18.00	22.2	3.90	6.50	0.60	1.00	43.20	53.30
Propylene	4.30	4.30	8.10	9.70	10.00	12.90	2.00	3.00	0.28	0.41	24.68	30.31
Butadiene	0.80	0.80	2.13	2.25	2.40	2.60	0.50	1.00	0.12	0.12	5.95	6.77
Benzene	3.00	3.00	6.60	7.20	8.60	9.60	3.30	5.00	0.20	0.30	21.70	25.10
Xylenes	1.11	1.11	1.98	2.11	3.05	3.25	0.90	1.70	0.04	0.09	7.10	8.26
Methanol	1.30	1.30	3.70	5.00	4.15	8.00	3.00	4.85	0.12	1.35	12.28	20.50
Thermoplastics												
LDPE	1.57	1.57	5.70	6.50	4.20	6.00	1.40	2.15	0.28	0.38	13.15	16.60
HDPE	0.90	0.90	2.10	2.60	2.70	4.26	0.36	0.93	0.13	0.19	6.19	8.88
PP	1.16	1.16	2.20	2.60	2.33	3.10	0.24	0.60	0.07	0.12	6.00	7.58
PVC	2.08	2.08	5.20	5.60	3.58	4.87	1.85	2.90	0.35	0.40	13.06	15.85
PS	1.39	1.39	2.80	3.10	2.56	2.98	0.60	0.80	0.09	0.11	7.44	9.24
Synthetic Fibres												
Acrylic Fibres	0.40	0.40	1.00	1.05	0.38	0.38	0.20	0.40	-	0.03	1.98	2.26
Nylon Fibres	0.33	0.34	0.97	0.91	1.47	1.80	0.60	0.75	0.04	0.05	3.40	3.85
Polyester Fibres	0.69	0.74	1.04	1.06	2.17	2.40	0.50	0.80	0.05	0.08	4.45	5.08
Synthetic Rubbers												
SBR	0.93	0.95	1.60	1.60	1.80	2.00	1.60	2.40	0.07	0.13	6.00	7.08
Polybutadiene	0.23	0.23	0.36	0.36	0.50	0.60	0.25	0.40	0.03	0.03	1.37	1.62

The potential supply of petrochemicals needs to be examined in relation to demand. Table I.28 therefore considers the expected increase in demand from 1979 to 1990 and the additions to capacity planned for the years up to 1990. For all but two products (propylene and polystyrene), there will be no excess capacity available in 1984, if operation at 80 per cent of nameplate capacity is considered a minimum requirement.

This means that considerable additional capacity will be required in the 1984-1990 period. The largest requirements are in ethylene, propylene, benzene and methanol among the basic petrochemicals, PVC and polypropylene among the plastics, polyester fibre and SBR.

Table I.28 Planned increase in production capacity for selected petrochemicals in industrialized countries, 1979-1990. (million tons)

	Estimated Increase in Demand 1979-1990	Estimated Increase in Capacity 1979-1984	Excess Capacity Available in 1984 1/	Additional Capacity Required in 1984-1990
Basics				
Ethylene	21.8	10.1	-	11.8
Propylene	14.0	5.6	1.3	7.1
Butadiene	2.2	0.8	-	1.4
Benzene	9.6	3.4	-	6.2
Xylenes	3.5	1.3	-	2.2
Methanol	13.2	8.2	-	5.0
Plastics				
LDPE	3.0	3.4	-	-
HDPE	3.6	2.7	-	0.9
PP	5.2	1.6	-	3.6
PVC	6.4	2.8	-	3.6
PS	3.5	1.8	0.6	1.1
Fibres				
Acrylic	0.41	0.28	-	0.13
Polyamide	0.63	0.45	-	0.18
Polyester	1.41	0.63	-	0.82
Rubbers				
SBR	1.95	1.08	-	1.87
Polybutadiene	0.56	0.25	-	0.31

1/ Assuming plants operate at 80 per cent capacity.

1.2.4.A Production capacity for ethylene

There will be an increase of 10 million tons in capacity to produce ethylene in all industrialized regions between 1979 and 1984 and capacity will be sufficient to satisfy demand in all regions in 1984. Between 1984 and 1990, an additional 15 million tons will be required, including 10 million tons in Japan, Western Europe and North America, as demand will increase by a further 13.5 million tons in this period.

Tentative plans for additional ethylene capacity announced so far in the industrialized countries for the period after 1984 are in Alaska (1.0 million tons), in Canada (1.0 million tons), in the United Kingdom (1.0 million tons) and in Scandinavia (1 million tons). Therefore, there appears to be a need for additional new sources of supply for at least 5 million tons of ethylene, that is 10 ethylene crackers in the period 1985 to 1990.

Market opportunities for the ethylene and derivatives produced by the 10 export-oriented plants already announced by developing countries (see Table I.36 on page 36) with a capacity of 2.8 million tons can be viewed in this context.

1.2.4.B Production capacity for methanol

The increase in methanol capacity between 1979 and 1984 in industrialized countries shown in Table I.29 is sufficient to meet the increase in demand in all industrialized regions except Japan, where imports from Saudi Arabia are planned starting in 1983. After 1984, the demand for methanol in Western Europe, North America and Japan will increase by a further 8 million tons by 1990, but plans for new capacity announced so far are for only 2.7 million tons, even when new plants based on coal rather than petroleum feedstocks are included.

Table I.29 Additions to capacity to produce methanol
(thousand tons)

	1979 - 1984	After 1984
Japan	-	-
Western Europe	1,300	2,000
North America		
United States	2,400	
Canada	1,500	700
U.S.S.R. and Eastern Europe		
U.S.S.R.	1,650	
Eastern Europe	200	
New Zealand	400	
South Africa	825	
Total industrialized countries	8,275	2,700

1.3 The share of developing countries in world petrochemical production

1.3.1 Share of developing countries in world demand

The share of developing countries in world demand for petrochemicals will increase substantially over the period 1979 to 1990. By 1990, developing countries will account for 28 per cent of total world demand for the 10 final products (5 plastics, 3 fibres, 2 synthetic rubbers) considered in this study and shown in Table I.30 below.

Table I.30 Share of developing countries in world demand for selected petrochemical products

	World Total (million tons)		Developing Countries (million tons)		Developing Countries Shares (percentage)	
	1979	1990	1979	1990	1979	1990
5 Thermoplastics	41.0	80.0	6.7	22.0	16.3	27.5
3 Synthetic Fibres	10.0	15.0	2.5	5.1	20.0	34.0
2 Synthetic Rubbers	6.4	10.0	0.9	2.0	14.0	20.0
Total 10 Products	57.4	105.0	10.1	29.1	17.6	27.7

Table I.31 measures the developing countries' share of the increase in world demand between 1979 and 1990 for 16 petrochemical products. The developing countries' share is about 50 per cent for synthetic fibres, 46 per cent for thermoplastics, 28 per cent for synthetic rubber and 30 per cent for 6 basic petrochemicals.

1.3.2 Share of developing countries in world production

The estimated share of developing countries in world petrochemical production for the 6 basic petrochemicals and 10 final products considered in this Study is shown in Table I.32 For the year 1990, the production of developing countries has been calculated for two cases:

- Case 1: where the level of imports in 1990 is assumed to remain at the same level as in 1984.
- Case 2: where production of developing countries is sufficient to meet 100 per cent of their demand.

Table I.31 Share of developed and developing countries in the increase in world demand for selected petrochemicals

Petrochemical Products	Increase in Demand 1979-1990			Share of Increase 1979-1990	
	World Total	Developed Countries (million tons)	Developing Countries	Developed Countries per cent	Developing Countries
Basic Petrochemicals					
Ethylene	33.0	21.8	11.2	66	34
Propylene	17.3	14.0	3.3	81	19
Butadiene	3.4	2.2	1.2	65	35
Benzene	13.3	9.6	3.7	72	28
Xylenes	5.8	3.6	2.2	62	38
Methanol	16.0	13.2	2.8	82	18
Thermoplastics					
LDPE	9.7	5.0	4.7	52	48
HDPE	5.5	3.6	1.9	65	35
PP	7.3	5.1	2.2	70	30
PVC	11.5	6.4	5.1	56	44
PS	5.0	3.6	1.4	72	28
Synthetic Fibres					
Acrylic Fibres	0.8	0.4	0.4	50	50
Nylon Fibres	1.1	0.6	0.5	55	45
Polyester Fibres	3.0	1.4	1.6	47	53
Synthetic Rubbers					
SBR	2.8	2.0	0.8	71	29
Polybutadiene	0.8	0.6	0.2	75	25

Table I.32 Share of developing countries in total world production of selected petrochemical products

Petrochemical Product	World Production (million tons)				Developing Countries Output (million tons)					Developing Countries Share (per cent)				
	1975	1979	1984	1990	1975	1979	1984	1990 Case 1	1990 Case 2	1975	1979	1984	1990 Case 1	1990 Case 2
Basic Petrochemicals														
Ethylene	24.4	37.6	50.3	70.4	1.15	2.73	6.15	14.0	14.00	4.7	7.2	12.4	19.8	19.8
Propylene	12.6	19.7	25.3	36.9	0.47	1.19	2.41	4.47	4.47	3.7	6.0	9.5	12.1	12.1
Butadiene	3.4	5.0	6.2	8.3	0.20	0.40	0.90	1.60	1.60	5.8	7.9	14.4	19.3	19.3
Benzene	11.3	17.2	23.0	30.8	0.68	1.18	2.62	4.85	5.00	6.0	6.9	11.4	15.7	16.2
Xylenes	3.8	6.1	8.6	11.9	0.16	0.66	1.69	2.82	3.00	4.2	10.8	19.7	23.8	25.3
Methanol	7.5	11.6	18.9	27.6	0.25	1.20	2.90	3.55	3.55	3.3	10.3	15.3	12.9	12.9
Thermoplastics														
LDPE	7.5	12.2	15.6	22.0	0.5	1.1	2.6	5.8	6.9	6.1	8.9	16.6	26.4	31.6
HDPE	3.2	5.8	7.9	11.2	0.1	0.3	1.0	1.3	2.7	2.6	5.0	12.3	11.6	24.4
PP	2.3	5.0	7.3	12.6	0.05	0.3	1.0	2.5	3.0	2.1	7.1	14.1	19.8	31.7
PVC	7.6	12.2	16.4	23.6	0.7	1.6	3.2	6.6	7.2	8.8	13.1	19.6	28.0	30.5
PS	3.8	5.9	7.5	10.9	0.2	0.4	0.7	1.7	2.1	5.0	7.1	9.2	15.6	19.2
TOTAL	24.4	41.1	54.8	80.3	1.45	3.7	8.5	17.9	21.9	6.0	9.1	15.5	22.3	27.4
Synthetic Fibres														
Acrylic Fibres	1.3	1.9	2.3	2.7	0.17	0.30	0.45	0.69	0.81	13.0	16.0	20.0	26.0	30.6
Nylon Fibres	2.5	3.2	3.8	4.4	0.30	0.44	0.61	0.95	1.15	12.3	13.3	15.9	21.4	25.9
Polyester Fibres	3.5	4.9	6.2	7.9	0.70	1.06	1.76	2.79	3.14	20.0	21.8	28.3	35.2	39.6
TOTAL	7.3	10.0	12.3	15.0	1.17	1.80	2.92	4.43	5.10	16.1	17.9	23.4	29.5	33.6
Synthetic Rubbers														
SBR	4.1	5.2	6.4	8.0	0.27	0.40	0.70	1.18	1.63	6.6	7.7	10.8	14.7	20.3
Polybutadiene	1.0	1.2	1.6	2.0	0.07	0.10	0.20	0.30	0.35	7.0	8.4	12.6	15.6	18.2
TOTAL	5.1	6.4	8.0	10.0	0.34	0.50	0.90	1.48	1.98	6.9	7.8	11.2	14.9	19.9

Case 1 Assumed imports of Developing Countries in 1990 are at the same level as in 1984.
Case 2 Assumed Developing Countries' production in 1990 is 100 per cent sufficient to meet domestic demand.

The estimated share of developing countries can be summarized as in Table I.33 below.

Table I.33 Share of developing countries in world production of selected petrochemical products

Product	1979	1984	Case 1 1990	Case 2 1990
5 Thermoplastics	9.1	15.5	22.3	27.4
3 Synthetic Fibres	17.9	23.4	29.5	33.6
2 Synthetic Rubbers	7.8	11.2	14.9	19.9
Ethylene	7.2	12.4	19.8	19.8
Xylenes	10.8	19.7	23.8	25.3

The 5 thermoplastics, 3 synthetic fibres and 2 synthetic rubbers represent about 60 per cent of world petrochemical production. For the remaining 40 per cent of world production of final petrochemical products, the developing countries are likely to produce, say, 5 per cent to 10 per cent of the world total output. Their share of total world petrochemical output in 1990 is therefore likely to be approximately as shown in Table I.34

Table I.34 Estimated world production of petrochemicals in 1990 (million tons)

	Total World Production	Developing Countries' Production		Developing Countries' Share (%)	
		Case 1	Case 2	Case 1	Case 2
				per	cent
5 Thermoplastics	80	18.0	22.0	22	27
3 Synthetic Fibres	15	4.4	5.1	30	34
2 Synthetic Rubbers	10	1.5	2.0	15	20
All Other Final Products	70	3.5	7.0	5	10
Total	175	27.4	36.1	15.6	20.6

Hence, a broad estimate might be that developing countries will produce between 15 and 20 per cent of world petrochemicals output by 1990. This order of magnitude is confirmed by the estimate that they will produce 17 per cent of the six main basic petrochemicals by 1990.

1.4. Interdependence of developing and industrialized countries in the petrochemical industry

1.4.1 Imports and self-sufficiency in developing countries

Although the developing countries made considerable progress in establishing their own petrochemical industry in the 1970s, they still relied heavily on imports of final products in 1979 and are likely to continue to do so in 1984. In Table I.35 below, net imports in 1990 are assumed to be the same level as in 1984 (case 1) or zero (case 2).

Table I.35 Dependence of developing countries on imports (million tons)

PRODUCTS	DEMAND	PRODUCTION	IMPORTS	SELF-SUFFICIENCY per cent
5 Thermoplastics				
1975	3.20	1.6	1.6	50
1979	7.0	4.2	2.8	60
1984	12.0	8.5	3.5	70
1990 Case 1	22.6	19.1	3.5	85
1990 Case 2	22.6	22.6	0	100
3 Synthetic Fibres				
1975	1.70	1.25	0.45	74
1979	2.49	1.78	0.71	72
1984	3.66	2.91	0.75	80
1990 Case 1	5.20	4.45	0.75	86
1990 Case 2	5.20	5.20	0	100
2 Synthetic Rubbers				
1975	0.54	0.34	0.20	63
1979	0.82	0.50	0.32	61
1984	1.40	0.90	0.50	64
1990 Case 1	1.98	1.48	0.50	75
1990 Case 2	1.98	1.98	0	100

Case 1 Imports in 1990 same volume as in 1984
Case 2 Zero net imports in 1990

Even to maintain the same volume of imports from industrialized countries in 1990 as in 1984 (case 1), the developing countries would have to increase production of thermoplastics, synthetic fibres and synthetic rubber between 1984 and 1990 by 2.32 times, 1.53 times and by 1.64 times, respectively. To achieve zero imports in 1990 (case 2), production would need to increase between 1984 and 1990 by 2.66 times for thermoplastics, 1.78 times for synthetic fibres and 2.2 times for synthetic rubbers.

The thermoplastics and synthetic rubber production in most developing countries has so far been based on locally produced basic and intermediate petrochemicals. However, for synthetic fibres, the intermediates are manufactured in only a few developing countries; 40 per cent reliance on imports of intermediates makes the figure of 80 per cent self-sufficiency in 1984 an exaggeration of the benefits of local production. In the remaining groups of products, namely other plastics, fibres and rubbers, solvents and other organic chemicals, the volume required by developing countries is smaller and the dependence on imports much greater. For this 40 per cent of total petrochemical requirements, developing countries probably import most of their requirements. Thus, developing countries are likely to remain importers from the industrialized countries on a substantial scale.

1.4.2 Increased exports from developing countries

International trade between developing and industrialized countries is likely to become better balanced in the late 1980s when developing countries bring on stream the 11 export-oriented petrochemical plants or complexes producing ethylene derivatives, propylene derivatives, benzene, xylenes and methanol listed in Table I.36 on the following page.

Table I.36 Capacity of export-oriented plants planned by developing countries (million tons)

COUNTRY	DATE	ETHYLENE	PROPYLENE	BENZENE	XYLENES	METHANOL
Libya	1979	-	-	-	-	330
Qatar	1980	280	-	-	-	330
Libya	1984	330	50	-	-	330
Bahrain	1984	-	-	-	-	330
Singapore	1984	300	165	-	-	-
Kuwait	1985	300		280	140	-
Saudi Arabia	1985-86	1600	-	-	-	1400
TOTAL		2810	215	280	140	2720

In addition to these plants, Iraq, Iran, Indonesia, Republic of Korea , another Asian country , Brazil, Mexico and Venezuela are likely to have significant quantities of production available for export, at least for some years after a large new complex has come on stream.

There should be no difficulty in absorbing the petrochemicals made available by these developing countries for export in the period up to 1990. The world market for each product is growing and the quantities available for export amount to a small share of the increase in demand, except for ethylene (12 per cent) and methanol (27 per cent). Further more, as discussed in Chapter VI , some old plants in developed countries will need to be replaced by new capacities.

Table I.37 World market for exports from developing countries 1984-1990 (million tons)

Products	Increase in Demand 1984-1990			Supply available from planned export-oriented plants in developing countries after 1984	
	Industrialized Countries	Developing Countries	World Total	Minimum	Maximum
Ethylene and derivatives	13.0	7.8	20.8	2.5	3.5
Propylene and derivatives	9.5	2.0	11.5	0.15	0.25
Benzene	5.4	2.3	7.7	0.25	0.35
Xylene	2.0	1.2	3.2	0.10	0.20
Methanol	7.4	1.7	9.1	2.5	3.3

Indeed, given growth in the market and the need to replace plants, there appears to be scope to establish a greater number of export-oriented plants in the period 1986-1990 in developing countries. It appears that more attantion could be given to producing the other olefins (propylene and butadiene) and aromatics as well as those products most frequently chosen so far. The products may then be exported as basic petrochemicals or as intermediates or final products.

The developing countries will need to continue importing many petrochemicals as well as special grades of some products they produce themselves. Therefore, interdependence will mean not so much a reduction in their imports from industrialized countries but rather a more balanced trade in which the developing countries export petrochemicals to the industrialized countries on a substantial scale for the first time.

There will also be a trend for the more advanced petrochemical producers in developing countries to replace industrialized countries as suppliers of importing developing countries. In 1979, industrialized countries supplied 2.8 million tons of thermoplastics, 700,000 tons of synthetic fibres and 900,000 tons of synthetic fibre intermediates and 300,000 tons of synthetic rubbers to the developing countries. Some countries in Asia and Latin America have already begun to replace traditional suppliers with their own exports and this trend should accelerate in the 1980s.

I.5 Summary and conclusions

Starting with a very low per capita consumption of petrochemicals and with an expectation of higher growth rate of GDP than developed countries, the developing countries are expected to register a higher growth in demand on all major petrochemicals for the period 1979-1990 than the developed countries. Thus, the developing countries' demand for final products is estimated to grow annually at 12.6 per cent for thermoplastics, 4.5 per cent for synthetic fibres and over 9.2 per cent for synthetic rubbers, thus increasing from 6.7 million tons in 1979 to 22 million tons in 1990 for thermoplastics, from 2.5 to 5 million tons for synthetic fibres and from 0.8 to 2.0 million tons for synthetic rubbers. In the meantime, demand for ethylene in the developing countries is expected to increase from 2.7 million tons in 1979 to 14.0 million tons in 1990, for propylene from 1.2 million tons to 4.5 million tons and for xylene from 0.8 million tons to 3.0 million tons.

The annual growth of demand in the developed countries is expected to be at a much slower rate: 5.4 per cent for thermoplastics; 2.8 per cent for synthetic fibres; 3.8 per cent for synthetic rubber; and 4.8 per cent for ethylene, benzene, propylene and xylenes.

Indigeneous petrochemical supply in developing countries is expected to grow at a higher rate than demand and the number of petrochemical producers will grow for ethylene from 13 in 1979 to 27 in 1987, of which 16 will also produce propylene and 11 butadiene. By 1987, the production capacity in developing countries will reach 14.5 million tons for ethylene, 14.0 million tons for thermoplastics and 4.0 million tons for synthetic fibres. In spite of these growth figures, the developing countries will remain dependent upon developed countries for meeting part of their demand for intermediate and final product petrochemicals. No major production of speciality and performance petrochemicals is expected to develop in the developing countries during this period.

Industrialized countries, with the exception of the USSR and East European countries, are planning a slower growth rate of their already high capacities for basic and intermediates petrochemicals, thermoplastics, synthetic fibres and synthetic rubbers. Increases in annual capacity during the period 1979-1984 are expected to be: from 43 to 53 million tons for ethylene, 22 to 25 million tons for benzene, 12 to 20 million tons for methanol, 46 to 57 million tons for thermoplastics, 9.8 to 11.3 million tons for synthetic fibres and 7.4 to 8.7 million tons for synthetic rubbers.

The share of developing countries in world production in 1990 is expected to be 22-27 per cent for thermoplastics, 30-34 per cent for synthetic fibres, 15-20 per cent for synthetic rubbers, 20 per cent for ethylene and less than 20 per cent for other basic petrochemicals, except xylenes. The share of the developing countries in total world production of petrochemicals by 1990 will be between 15 and 20 per cent.

It is also evident that after considering all planned additions to capacity in industrialized countries for ethylene up to 1984, there is still a need for an additional 10 million tons by 1990.

II PRICES AND COSTS ANALYSIS OF THE PETROCHEMICAL INDUSTRY

2.1 Trends of prices and products costs for chemicals

2.1.1 A historical overview.

In the period of the 1950s and 1960s the radical improvements in the economics and technology of production as a result of the conversion of the organic as well as of many inorganic chemicals to an inexpensive oil-gas raw material basis, and the building of increasingly large automated enterprises resulted in a substantial rise in labour productivity and a lowering of production costs and prices.

The application of new technology led to the use of oil and gas refinery products as basic raw materials for chemical production. This not only expanded the branch's raw materials basis, but also made it considerably less expensive. By the end of the 1960's oil and gas raw materials were costing chemical manufacturers approximately 50 per cent less than coal. These economic advantages were responsible for a steady increase in the share of oil and gas in the sector's over-all raw materials balance and a rise in the proportion of petrochemicals in industry output, reaching 50-70 per cent in the industrially developed countries by 1970. In 1972, 92 per cent of all organic chemicals in the European OECD member countries, 95 per cent in the United States of America and 96 per cent in Japan were produced from oil and gas. 4/

At the present time, coal accounts for less than 20 per cent of total raw material consumption in the chemical industries of the developed countries.

This changeover in the industry's raw materials infrastructure led to a sharp drop in chemical production costs. In a large measure this was due to the fact that, during nearly the entire post-war period, the

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4/ L'Industrie Chimique, OCDE, 1972, p.27

chemical branch had operated with cheap oil obtained at monopolistically low prices from developing countries, a factor which had contributed to accelerated technological advances in the chemical industries of the developed countries.

The expansion of large-scale production and the higher optimal capacities of individual production facilities have had a marked effect on lowering current and capital expenditure per unit of production as well as operating and management costs. In the 1960s the increase in the capacity of ethylene plants from 50,000 to 450,000 tons a year had the effect of reducing average unit capital investment from 220 to 90 $ per ton, while production costs declined by 55 per cent; increases in plant capacity from 36,000 to 180,000 tons a year dropped ammonia production costs by 25 per cent and unit capital investment by 35 per cent, and so on.

As a result of the increase in the unit capacities of production facilities, manufacturers succeeded in lowering their unit investment costs by 25-65 per cent and their production costs by 14-55 per cent (Table 2.1). In fact, there are grounds for believing that the decline in investment and production cost was even greater. For most products the plant capacity figures given in the table refer to the mid-1960s. As the trend towards larger plants continued over subsequent years (till the beginning of the 1970s), this - together with improvements in technological processes - contributed to a further reduction of production costs.

These aspects of the scientific and technological revolution were responsible for a substantial reduction in production costs - by a factor of 2 to 3 in the case of the most essential products (chiefly organic chemicals) - which in turn had a covering effect on the movement of prices in the chemical market during the postwar period.

During the 1960s alone, the domestic wholesale price level for chemicals in the major producing countries (the Federal Republic of Germany, Japan and the United States) dropped by 2 to 12 per cent while at the same time that it increased by only 5 to 11 per cent in other countries (France, Italy and the United Kingdom). During the same period, for industrial production as a whole this level rose by 9 per cent in the Federal Republic of Germany, 10 per cent in Japan, 11 per cent in the United States, and by more than 20 per cent in the United Kingdom. This downward trend in prices was particularly typical of the chemical industry's relatively new

Table 2.1 **The effect of plant capacity on capital investment and production costs in the chemical industries of the developed countries in the 1960s**

Production designation	Capacity, thousands of tons / year	Unit capital investment: US dollars per ton	Unit capital investment: %	Production costs: US dollars per ton	Production costs: %
Ammonia[a] (from natural gas)	36	139	100.0	46.0	100.0
	102	108	77.7	38.0	82.6
	180	89	64.0	34.0	74.0
Butadiene[a]	10	600	100.0	239.0	100.0
	20	450	75.0	202.0	84.5
	40	338	56.0	178.0	74.4
Carbamide[a]	33	85	100.0	64.0	100.0
	82	63	74.0	59.0	92.0
	165	50	59.0	54.0	84.0
Black[a]	10	300	100.0	130.0	100.0
	25	208	70.0	104.0	80.0
	50	106	35.3	90.0	69.0
Ethylene[b] (by-products based on the price of the chemical raw material)	50	150	100.0	94.8	100.0
	100	120	80.3	70.3	74.1
	150	100	66.6	66.1	69.7
	300	90	60.0	47.2	49.8
	454	77	51.0	42.8	45.1
High pressure polyethylene[c]	25	468	100.0	328.0	100.0
	50	400	85.5	296.0	90.2
	75	372	79.8	280.0	85.3
	100	356	77.0	272.0	82.9
Polyvinyl chloride[a]	6	285	100.0	290.0	100.0
	20	170	60.0	250.0	86.2
	40	129	46.0	239.0	82.4
Styrene[c]	12	275	100.0	180.3	100.0
	48	162	58.9	149.6	83.0
	96	116	42.1	140.0	77.8
Polystyrene[c]	10	278	100.0	235.0	100.0
	40	181	65.3	210.0	89.0
	80	156	56.3	202.0	86.0

a/ Calculated on the basis of documents produced at the Seventh Petroleum Congress of Arab Countries held in March 1970 in Kuwait.

b/ Study of Feedstock and Process in the Petrochemical Industry, UNIDO, 1969, page 252.

c/ Studies in the Development of the Plastics Industries (United Nations Publication, Sales No. E.69.II.B.25) pages 43-49.

subsectors. For example, against the background of a general 2 per cent decrease in wholesale chemical prices in the United States during the 1960s, prices for plastics and synthetic resins dropped by more than 15 per cent, while in Japan the mean annual decline in chemical prices during the period 1960-1969 was 1.3 per cent, but approximately 6 per cent for plastics. In the industrially developed countries the internal price level for basic petrochemical produts dropped by the following average amounts during the period from 1950 to 1955: ethylene, methanol - 35 per cent; phenol, polystyrene, ammonia - 50 per cent; ethylene oxide, vinyl chloride, styrene - 55 per cent; polyethylene, polyvinyl chloride, carbamide - 60-65 per cent.

At the same time, there was an increase in the average price level for inorganic chemicals, for example, by 14 per cent in the United States during the period from 1957 to 1969. The explanation for this lies in the fact that the production of inorganic chemicals had long been well established in the market economy developed countries and no major changes had taken place in manufacturing techniques. Unlike the situation in the organic chemistry production sector, inorganic chemical producers were not confronted with the same massive change-over in product lines or the same variety of basic raw-material sources. Growth rates in the production of inorganic chemicals were moderate: during the 1960s output rose by less than a factor of 3 (as opposed to one of 6-8 for organic chemicals). In addition, the manufacture of inorganic chemicals is characterized by a higher degree of concentration and the existence of a restricted number of "established" firms.

2.1.2 Cost/price relationship

Cost as the decisive pricing factor carries over as well into the foreign economic relations of the market economy developed countries. The conditions of domestic production in the exporting countries and their domestic prices play a central role in determining chemical prices in international trade. However, this relationship between domestic production conditions (and domestic costs) and the domestic prices based on them, on the one hand, and world prices, on the other, is not a direct and immediate one, since a number of factors act to set apart national markets from the world market. Nevertheless, although internal chemical prices, reflecting as they do domestic production conditions in individual countries, do not fully explain the real prices charged in foreign trade transactions, they are useful in suggesting how starting levels are fixed and prices evolve in international trading, inasmuch as domestic bulk wholesale prices represent the point of departure in the setting of foreign trade prices.

Long-term trends in internal and export prices prove the coincidence of their development. According to UN figures, the average level of export prices for chemicals for 1950-1970 has fallen by approximately 20 per cent, as against 27 per cent rise for all commodities.

Against the background of periodically recurring crises of overproduction and increasingly keen competition in international markets there has been a greater fall in foreign trade prices for the basic petrochemical product groups than in the internal prices of the individual countries.

Trade of export prices (1963 = 100)

	1950	1960	1965	1968	1969	1970
All goods	89	100	103	103	107	113
Chemicals	120	108	100	94	94	97

Source: Monthly bulletin of statistics for the years in question.

2.1.3 Price control

Pricing in the chemical industry is substantially affected by monopolistic regulation of market and price control. The chemical industry is one of the most highly monopolized branches of the economy. In the United Kingdom, for example, Imperial Chemical Industries accounts for more than 30 per cent of the business in this branch, in Italy Montedison for about 40 per cent, in France Rhone-Poulenc for 30 per cent, while in the Federal Republic of Germany the "Big Three" - Hoechst, Bayer and BASF - together control more than 60 per cent of the market. At the present time the chemical industry is one of the leaders in terms of the number of giant companies.

Far-reaching monopolization is also characteristic of the international trade in chemicals. In today's world, the extent of monopoly control over the external market is determined not only by direct export, but also by the sales of the companies' foreign production outlets. Taking these factors into account, in 1973 the ten largest multinational corporations accounted for 70 per cent of world chemical exports. There is ground for believing that this is valid for the present.

The commanding economic position of a limited number of major companies provides the objective conditions for temporary agreements in the pursuit of concerted market policies, including the area of pricing. During the period from 1960 to 1972 the average export prices for nitrogen fertilizers declined by 25-50 per cent as a result of the sharp reduction in production costs and the emergence of a number of new exporting countries. This drop in prices would have been even greater were it not for the actions of the international nitrogen cartel Nitrex and the Japanese association of exporters of this variety of fertilizer. An even higher degree of monopolization can be found in the case of the potassium fertilizer market, which is shared by a consortium of North American producers and the West European potassium syndicate. A similar situation also exists in the chronium compound market, which is controlled by four firms. As a result, the price structure in both domestic and international chemical trading is largely specific in nature, a fact which is reflected in what is known as "price leadership" and also in the relative constancy and uniformity of the posted reference prices for chemicals over extended periods. Of all economic sectors in the developed countries, throughout the most part of the postwar period the chemical industry has occupied the last place in terms of frecuency and extent of changes in the posted prices set by the major companies. However, at a time of increasing monopoly power, price competition has become a less effective instrument than it was before and the compensation is carried out mainly in the field of production.

In their studies, economic analysts make much of the fact of the downward trend in monopoly prices for chemicals during the postwar period. Analysis indicates that in reality these prices have fallen far less than have production costs as a result of higher labour productivity. Output per worker (in man-hours) in the United States chemical industry rose from 1948 to 1968 by a factor of 2.4 (and from 1900 to 1969 by a factor of almost 9) in comparison with a 1.8 world average increase for all industry (the figure being 4.5 for the period from 1990 to 1969)[5/]. This indicates that there was an increase in monopoly prices in comparison with the dynamics of labour productivity and that, through their pricing policies, the major chemical companies realized a higher rate of profit.

5/ Chemistry in the Economy, Washington, 1973 pp. 516-518.

2.1.4 Post-1973 prices

Beginning in 1973-74, the movement of domestic and foreign-trade chemical prices has contrasted starkly with the trends of former periods. Everywhere in the chemical markets the distinguishing feature has been an unprecedently sharp increase in the prices of basic chemicals, intermediate and finished products. In 1974 the prices for internationally traded basic petrochemical products were three to four times higher than their 1970-1972 level.

The energy crisis, which in 1973-74 triggered a sharp rise in the cost of fuel and energy for the chemical industry also represented, in a large measure, a raw materials crisis, since the bulk of the output of this industry is based on oil-and-gas raw material. The increase in the price of oil and other energy sources meant that the chemical industry's raw material fuel and energy basis had become more expensive, resulting in a dramatic escalation of production costs. In conjunction with a market situation in which demand considerably exceeded supply, the end effect was a major rise in the price of internationally traded chemicals.

During 1973 and the beginning of 1974, with chemicals in short supply, a wide range of prices were offered for the same products. The prices under long-term supply arrangements were considerably lower than the prices charged for spot deals, small lots of available goods, or goods on immediate delivery. For example, in the beginning of 1974, for styrene they were US $ 600 against 1200-1700 per ton respectively.

However, the peak prices charged at the beginning of 1974 were not only a gauge of the true extent of the shortage of chemicals and their increased production costs, but were also very largely speculative in nature. The rise in prices was greater than might have been expected on the basis of the increase in production costs. Beginning in the middle of 1974, the improved situation with respect to deliveries of oil-and-gas raw material for the chemical industry and the decline in the demand for chemicals by the major consumer branches led to a fall away from the peak prices of the beginning of the year. In 1975, export prices for many product types, e.g. plastics, had dropped by 15-25 per cent in the Federal Republic of Germany and by 18-30 per cent in the United States.

Table 2.2 Trends of export prices for specific chemical products, oil, naphtha and gas

(US dollars per ton)

Product	1970	1972	1974	1975	1976	1977	1978	1979	1980
Ethylene	70-90	80-90	260-285	260-330	240-330	295-315	286-370	310-590	410-740
Propylene	45-90	50-90	185-220	185-200	185-220	185-200	200-230	370-410	400-420
Ammonia	35-50	38-45	135-150	150-230	105-123	100-120	95-110	120-160	140-200
Methanol	60-90	50-70	100-250	100-150	100-130	90-135	120-130	150-175	200-240
Acrylonitrile	250-270	250-270	590-660	490-550	480-580	450-560	540-590	590-860	680-750
Glycols	100-190	100-170	340-450	430-470	340-440	330-395	330-340	550-700	600-800
Benzene	58-65	60-65	315-350	250-300	230-280	200-240	245-255	490-560	490-560
High-density polyethylene	290-370	270-340	700-790	615-660	620-680	630-660	580-700	770-1000	950-1200
Low-density polyethylene	230-300	250-300	680-740	550-600	550-600	500-560	515-560	840-950	980-1150
Polyvinyl chloride	290-330	220-380	650-760	510-570	520-610	510-580	580-700	840-950	870-1100
Oil a/	13.31	18.19	85.41	85.01	91.25	100.72	100.72	102.80	
Naphtha b/	16.08	20.02	123.25	109.73	130.69	125.12	146.14		
Natural gas c/ (for 000 m^3)	11.05 9.37	12.33 10.81	20.12 18.31	31.02 39.20	36.05 60.39	47.02 64.80	57.20 76.79	66,57 87,16	102 d/ 156

a/ Persian Gulf, Arabian light (Ras Tannura) 34.0-34-09° APK. 1970-1978 Platt's Oil Price, Handbook and Oilmanual from 1979, Platt's Oilgram Price Report.

b/ European Bulk, Italy.

c/ Export prices of the Netherlands and Canada

d/ Preliminary figures

The movement of internationally traded chemical prices in the years since that time has been unstable. The gradual revival of demand and rallying of chemical prices which began towards the end of 1975 gave way in the second half of 1976 to a softening in the prices of many product types which continued through 1977 and the first half of 1978. By the middle of 1978 foreign trade prices for essential product types were considerably lower than during the first half of 1974, but on the average 2 to 3 times as high as the 1970-72 level. At the end of 1978 and during the first six months of 1979 the chemical - and, above all, the petrochemical - market was marked by a sharp upturn in prices, which was basically the result of further substantial increases in the cost of oil and gas and the measures introduced by the major chemical companies to regulate production.

By mid-1979 the foreign trade prices of certain petrochemical products had moved beyond the record level of 1974 (aromatics, some types of plastics).

In the second half of 1979, amidst a generally worsening economic situation in the developed countries, market prices for chemicals tended to remain stable at the high level attained during the first half of the year or, in the case of a number of petrochemical products, to decline slightly.

In early 1980 higher oil cost caused the rise in prices of petrochemicals (an average of 10-15 per cent). Reflecting the continuation of the economic recession in developed countries, prices for petrochemicals began to decrease in the second and third quarters, specially spot prices (by 20-40 per cent). At the end of 1980-beginning 1981 the rise in prices for the majority of petrochemicals began to emerge.

2.1.5 <u>Petrochemicals, energy and feedstocks price ratios</u>

The deepening of the energy crisis in the 1970s resulted in the rise of the absolute level of chemical production costs, for a variety of petrochemical products had risen by a factor of 2-4 over their level at the beginning of the 1970s. This nearly caused the same increase in the level of prices in the international trade of chemicals. During this same period, the price of oil rose by a factor of 8, of naphtha by a factor of 9, and of natural gas by a factor of 5.5-8.2 (the lower figure representing the mean export price from the Netherlands, the higher from Canada).

During the 1970s the price system on the international chemical market underwent major changes in the form of both substantive increase in the general price level and a considerable acceleration in its rate of growth. Along with these changes new proportions in the exchange of chemical products for oil and gas began to emerge in international trade.

With oil-and-gas raw materials rapidly growing more expensive, new price ratios came into being in international trading. In 1970, in line with the price level of that period, one ton of ethylene - the basic raw material of the petrochemical industry - corresponded to approximately six tons of oil, five tons of naphta, and 8,000 cubic metres of gas, while the equivalent figures for one ton of the most essential plastics were 22 tons, 18 tons and 27,000 m^3, respectively. In 1978, one ton of ethylene was internationally traded, on the average, for three tons of oil, two tons of naphta, and 5,000 m^3 of gas; one ton of plastics bought six tons of oil, four tons of naphtha and 9,000 m^3 of gas. What this indicates is that new exchange ratios as between chemical products and the principal oil-and-gas raw materials have begun to emerge in international trading. These ratios are primarily based, in our opinion, on long-term factors whose effect, is to bring energy resource prices into conformity with increasing production costs and to take into account the growing shortage of these resources. It may be assumed that this process is largely irreversible.

Table 2.3 **Exchange ratios in the international trading of chemical products and oil and gas raw materials in the 1970s, on the basis of the foreign-trade price level**

(tons/ thousands of m^3 of oil and gas per ton of chemical products)

Product	1970			1978		
	Oil	Naphtha	Gas	Oil	Naphtha	Gas
Ethylene	5.3-6.8	4.4-5.6	6.9-8.8	2.8-3.7	1.9-2.5	4.3-5.5
Propylene	3.4-6.8	2.8-5.6	4.4-8.8	2 -2.3	1.4-1.6	3.0-3.4
Ammonia	2.6-3.8	2.2-3.1	3.4-4.9	0.9-1.1	0.7-0.8	1.4-1.6
Methanol	4.5-6.0	3.7-5.0	5.9-7.8	1.2-1.3	0.8-0.9	1.8-1.9
Acrylonitrile	18.8-20.2	15.5-16.8	24.4-26.4	5.4-5.9	3.7-4.0	8.1-8.8
Glycols	7.5-14.2	6.2-11.8	9.8-18.6	3.3-3.4	2.3-2.3	4.9-5.1
Benzene	4.4-4.9	3.6-4.0	5.7-6.4	2.4-2.5	1.7-1.7	3.7-3.8
Vinyl chloride	7.9-11.2	6.5-9.3	10.3-14.7	2.7-3.9	1.8-2.7	4.0-6.0
Polyethylene, high-density	21.8-27.8	18.0-23.0	28.4-36.2	5.8-6.9	4.0-4.8	8.7-10.4
Polyethylene, low-density	17.3-22.5	14.3-18.7	22.5-29.4	5.1-5.5	3.5-3.8	7.7-8.4
Polyvinyl chloride	21.8-24.8	18.0-20.5	28.4-32.3	5.8-6.9	4.0-4.8	8.7-10.4

Source: Author's calculations based on the movement of the foreign-trade prices of the products in question.

2.2 Prospects for production cost and price development

2.2.1. Impact of raw materials and energy on price development.

Pricing in the chemical market is subject to the combined influence of a set of interrelated factors. From the point of view of long-range price forecasting, critical importance is attached to changes both in overall production costs and in their essential components, since these costs are directly related to full product cost and act as a price-regulating factor.

It is precisely the reduction in chemical production costs that was responsible for the downward trend in the prices of the basic product groups in the 1950's and 1960's. As a major price component, production costs have a definite effect on the level and movement of prices, with which their development trends actually coincide over the long term.

Analysis of the structure of wholesale prices for basic chemical products reveals that production costs account for 75-80 per cent of the price. Therefore, in price forecasts based on production costs it is advisable to take into account their major components: the cost of the raw materials, fuels and energy investment costs; wages and salaries. The movement of these indicators - and therefore ultimately the price - is subject to the corrective effect of advances in technology and increases in labour productivity.

Raw material outlays are the decisive component in the industry's production costs, representing 60-80 per cent of these costs in the manufacture, for example, of the basic varieties of fertilizers, 45-75 per cent in the manufacture of plastics, and more than 50 per cent in the manufacture of synthetic fibres. This fact predetermines the high proportion of raw material costs in the prices of most chemical products, accounting on the average for 50 per cent. Accordingly, the following rule of thumb may be used to calculate the likely price level on the basis of expenditures for raw materials: a chemical's price is approximately double the cost of the raw materials used to produce it. The list below indicates the approximate share of material costs in the total production costs of a number of basic chemical products in market economy developed countries at the end of the 1960's and beginning of the 1970's (the figures represent percentages of total costs).

Ammonia	30-40	Polyvinyl chloride	70-75
Nitric acid	50-60	Styrene	60-65
Phosphorous	35-40	Polystyrene	65-70
Phosphoric acid	70-75	Caprolactam	45-55
Chlorine	20-25	Titanium dioxide	40-50
Hydrogen	70-80	Acetylene	70-75
Carbamide	60-65	Butadiene	30-35
Superphosphate	70-80	Isoprene	30-35
Polyethylene:		Methyl alcohol	25-30
High-density	45-50	Phenol	30-40
Low density	48-55		
Acrylonitrile	40-45	Ethanol	40-45
Dimethyl terephthalate	50-55	Maleic anhydride	40-45
Benzene	50-55	Phthalic anhydride	50-60
Vinyl chloride	70-80	Glycerin	40-45
		Acetic acid and anhydride	70-75

The raw material factor plays a particularly important role in the costs and prices of mineral fertilizers, synthetic resins and plastics, and organic chemicals. For example, for most plastics material consumption is greatest during the initial manufacturing stages - the production of the intermediate products and monomers, which require 2-4 tons of hydrocarbon raw material for every ton of production; in the final production phase, monomer consumption is no more than 1-1.5 tons per ton of plastic. Conversely, the raw material factor is less significant in the production costs of industrial alcohols, black, certain kinds of synthetic fibres (polyacrylonitrile), and some inorganic chemical products (chlorine, calcium carbide, etc.).

In the production of intermediate and final chemicals there are relatively well established standards for the consumption of raw materials so that it is possible to estimate the ratio of raw material costs to total production costs. (Annex D).

The chemical industry uses large amounts of heat energy, steam and also water for technological processes and cooling. On the whole, raw material, fuel and energy outlays represented by far the largest component of chemical production costs at the beginning of the 1970's (over 60 per cent). This circumstance takes on special significance in the light of the situation with respect to raw materials and fuel at the present.

Table 2.4 The structure of the production costs of specific chemical products (in percentages of total production costs)

Product	Raw and auxiliary materials	Fuel and energy costs	Wages a. salaries	Investment costs (depreciation, routine repair a. eq. maintenance, etc.)	Approx. level of production costs	
					end of 60s a. beginning 70s (US$/ton)	1977-78
Methyl alcohol	27	1.5	10	45	25-35	150-140
Acrylonitrile	45	11	3	40	150-190	400-500
Terephthalic acid	60	5	9	25	200-300	
Benzene	55	11	3	30	50-70	
Ethyl benzene	73	11	4	11	70-90	
Styrene	60	20	4	13	120-180	
Polystyrene	65	7	4	20	200-220	
Vinyl chloride	70	7	4	18	120-150	300-380
Polyvinyl chloride	70	4	2	18	270-290	500-550
Low density polyethylene	48	10	6	30	230-270	550-600

There is a direct relationship between fluctuations in the prices of the oil and gas used as raw materials, fuel and energy sources in the chemical industry, on the one hand, and the production costs of raw chemicals, intermediate and final products, on the other. Estimates that have been made indicate that a ten-per-cent increase in the price of ethylene triggers an increase in the production costs of basic petrochemical products (at plants of comparable capacity) of approximately the following order of magnitude: vinyl chloride monomer (assuming a constant price for hydrogen chloride), 6-7 per cent; polyethylene, up to 5 per cent; styrene (in combination with a similar price increase for benzene), 6.0 per cent; and polystyrene, 6-7 per cent. Given a ten-per-cent increase in the price of natural gas, the production costs of ethane increase by 3-4 per cent, and of ammonia by 5-6 per cent. The result of rising prices for oil and gas has been a substantial increase in raw material, fuel and electric energy costs in chemical production. There has also been a shift in the ratios of the individual cost components making up the total production cost, with raw materials, fuel and energy accounting for an increasingly large share.

The post-war policy of price fixation has led to a disruption of the principle of the determinative role of costs with respect to the prices of fuel and energy products as a whole, namely: the average level of production costs for these interchangeable goods (and, on that basis, their prices) should be established under the effect of the costs of producing a unit of hypothetical fuel depending on the energy content of its various varieties and taking into account the possibilities of satisfying general energy needs in the future.

The sharp increase in oil prices in the 1970's is largely a reflection of the reaffirmation of the principle mentioned above and is basically the result both of the production costs associated with the energy sources currently in use and of the expense involved in seeking future alternative sources in the light of the lack of easily accessible and cheaply workable oil and gas reserves and the non-renewability of these resources. At the same time, the effect on prices of the production costs of alternative energy sources is acquiring increasing importance. The energy crisis has created a problem of how to meet increasing requirements that will be difficult to solve in the short term. Actually, the world faces no energy shortage; what it does face is a lack of developed energy resources that are here and now ready for delivery. In the long term, the limits of economically exploitable reserves can be expanded to keep pace with growing demand. The limiting factors here are not the physical size of energy resource reserves, but the costs of their extraction and refining. The effect of the introduction of such alternatives as synthesized liquid fuel from coal, shale and bituminous sand will not, in all likelihood, be significant because of the heavy capital investments required and the need to solve a number of difficult scientific and technical problems. In addition, it is obvious that even when alternative raw material and energy resources are developed, this will not lead to cheaper oil, since existing estimates indicate that these alternative sources will require a very high level of expenditure. For this reason there is every reason to expect further increases in average production costs per unit of hypothetical fuel, which in turn will tend to drive up raw material, fuel and energy costs in the chemical industry.

In response to these sharply increased prices for oil and gas, the developed countries have undertaken careful studies of the feasibility of using other hydrocarbon sources for the production of chemicals. Research is being conducted into the possibility of expanding the output of aromatic hydrocarbons, methanol and acetylene from coal, shale and the gases released in iron- and steel-making processes. A reversion to coal, however, has been found to involve significantly increased production costs. In the Federal Republic of Germany, for example, production costs for coal-based ammonia have been 20 per cent higher than when using oil and gas (in respect of the mid-1974 price level). This is also true of methanol, the production of one ton of which requires three tons of coal, whereby the raw material costs alone are three to four times greater than the total production costs using natural gas at a typical plant (having a capacity of 360,00 tons/year); acetylene production costs using oil and natural gas are, respectively, 80 and 70 per cent lower than the same costs using coal. What is more, the exacerbation of the energy crisis raises the question of the chemical industry's priority as a consumer of an oil-and-gas resource, unique in its chemical composition, which can be replaced by other sources for the generation of energy. Accordingly, it is fair to assume that, despite shortages and high prices, oil and gas will remain - at least through the decade ahead - the chemical industry's basic source of hydrocarbon raw material. 6/

Accordingly, changes in the raw material and fuel components in chemical production costs will be determined basically by the movement of oil and gas prices and will, for the most part, mirror the changes in the price of oil and gas. At the same time, the situation in the chemical industry is characterized by relatively stable technological standards governing the consumption of raw materials as well as by a direct relationship between fluctuations in the price of the oil and gas used as raw materials, fuel and energy, on the one hand, and the production costs of basic chemicals, intermediate products and final items, on the other.

2.2.2. Impact of investment outlays on prices.

Within the production cost/price structure in the chemical sector, investment-related expenditure (depreciation, equipment maintenance and repair, property taxes, insurance, etc.) is second only to the raw material component. The chemical industry is one of the most capital-intensive branches of the economy. For example, the "cost" of a single working position at a petrochemical production facility ranges from $20,000 to $100,000, one of the highest figures in the industry. 7/

In the chemical industry's production cost structure the relative importance of depreciation is greatest in those areas that are most affected by technological advances. It is generally fair to say that depreciation allowance rates and their impact on production costs are considerably lower in the production of the basic inorganic chemical products than in the manufacture of organic chemicals, plastics, synthetic fibres and pharmaceuticals. Depreciation allowances for selected products accounted for the following percentages at the beginning of the 1970's of total production costs:

6/ See Chapter IV.

7/ The Petrochemical Industry, 21 November 1973, p.3, see also this chapter.

Sulphuric acid - 5 per cent
Phosphoric acid - 10 per cent
Acetylene - 10 per cent
Calcium Carbide - 10 per cent
Yellow phosphorous, hydrogen - 15 per cent
Ammonia - 12-15 per cent
Nitrogenous fertilizers - 10 per cent
Superphosphate - 5 per cent
Butadiene, caprolactam - 15 per cent
Vinyl chloride - 15-20 per cent
Acrylonitrile - 25 per cent
Methyl alcohol - 30 per cent
Polyacrylonitrile fibre - 25-30 per cent
Isoprene - 30 per cent

The development of new technological processes and products results in rapid obsolescence of production facilities. At a time of particularly accelerated technological progress the major factor resposible for the cyclic renewal of capital is no longer physical wear and tear of the equipment, but its obsolescence. Technical factors (corrosion, high temperatures and pressure, the need for stricter observance of safety procedures etc.) also necessitate a higher rate of depreciation allowance.

The price rises that have taken place for raw materials and fuel are having an increasing impact on the prices of chemical equipment and the cost of industrial construction in the branch. During the period from 1970 to 1977 the prices of chemical equipment, in the United States, for example, more than doubled. It is estimated that in the 1980's they will grow by 10 per cent a year.

At the present time, in addition to increases in the price of chemical equipment, another category of chemical production costs that is steadily gaining in importance is concerned with the avoidance of environmental pollution and the elimination of the contamination that has already been allowed to occur. More stringent environmental standards for the protection of the biosphere are making necessary additional outlays for pollution control systems and their maintenance. In turn, this is leading to an increase in the proportion of fixed assets that do not contribute to increasing production output. The result is a rise, within the chemical product cost structure, in the relative importance of investment-related expenditure such as depreciation allowances, routine repair and maintenance, and the like.

Capital costs for environmental protection are becoming an important price-setting factor affecting not only the structure of the products manufactured and the relative costs of production, but also the ability of individual countries to compete in the international market.

In estimating the changes likely to occur in the relative importance of depreciation as a factor in overall chemical production costs, it is useful to work on the realization that depreciation expenses depend on chemical equipment prices and/or on the cost of building new chemical production facilities.

2.2.3. Impact of technological development on prices

Scientific and technological advances in the chemical industries of the developed countries, accompanied as they have been by extensive process mechanization and automation and increasing labour productivity, have brought about a substantial reduction in labour costs per unit of production. In the United States, for example, during the period 1947-1968, wages and salaries as percentage of the sector's total sales, i.e. in prices, decreased from 21.2 to 15.9 per cent.

The chemical industry, and especially the petrochemical industry, is a typical example of a capital-intensive branch. In as much as labour costs per unit of production are low, the effect of rising wages and salaries on costs and prices is far less pronounced than in other industries. This is confirmed by the general trend in the movement of chemical prices in the post-war period. Money wage rates in the chemical industry have risen rapidly, but prices have fallen.

On the basis of the principal price-setting factors considered in this study it is possible to conclude that chemical production costs will continue to rise and that, by and large, prices will continue their upward tend.

At the same time, when predicting the movement of chemical prices for the period ahead, consideration must also be given to those factors which have a lowering effect on prices. One of the basic factors acting in this direction during the entire post-war period has been the industry's more than usually rapid scientific and technological advances. In the opinion of the leading chemical firms, a substantial modernization of technology or the development of radically new low-cost production methods is unlikely in the immediate future. In their view, during the next ten years the effect of significant increases in the cost of chemical equipment and the building of new industrial facilities in this industry will be that new plants will lack any appreciable advantages over old ones; the much heavier investment costs required for the erection of new plants of comparable capacity would mean that the chemicals produced would have to be sold at higher prices. Moreover, the development of low-cost raw materials and fuels for the chemical industry, through the possible industrial-scale exploitation of alternative energy sources - primarily the gasification of coal - will be feasible only if there is a radical improvement in the technology. The technological processes currently available for the gasification of coal afford no economic advantages over the use of oil and gas, despite the major increases that have occurred in the prices of these products. What is more, even if a new, highly efficient process is developed, within a few years, for the production of one or another chemical products, this would have no particular effect on the market for some years thereafter because of the impossibility of rapidly replacing the existing equipment and converting the branches of industry affected.

2.3 Irreversible trends of price increases

The conclusion suggested by this comprehensive evaluation of the effect of the principal factors tending both to raise and to lower prices is that chemical production costs will continue to increase during the decade ahead and that, on the whole, price trends in international chemical trading will continue upward. Within this pattern, it is the predicted further increases in the cost of oil and other energy sources that will most affect the level and movement of prices.

The result of rising prices for oil and gas in 1970's has been a substantial increase in production cost of basic petrochemicals in developed countries. Under these circumstances there is ground to expect that in 1980's international trade in these commodities will increase. This suggestion is supported by the fact, that in the developed countries there is a tendency to close unprofitable plants, substantial decrease of export and increase in import. This tendency will go on further as prices for oil and natural gas go up.

While trying to secure long-term needs in raw materials the developed countries are interested in constructing plants near the sources of hydrocarbons. The lower production cost of basic petrochemicals in the developing countries will stimulate production growth, considerable part of which will be exported.

In estimating the repercussions which the establishment of chemical and petrochemical industries in developing countries may have on the world market, it should be noted that these countries are concentrating on the production and export primarily of unsophisticated, relatively low-cost petrochemical products (basic, intermediate and commodity plastics). These countries are for the most part building plants to turn out the primary products of basic organic synthesis, but have virtually at the present time little plans to establish vertically integrated enterprises to produce a full range of petrochemical products.

Meanwhile, the developed countries are emphasizing specialization in the production of complex capital- and science-intensive chemical products embodying a high degree of processing. The expected large-scale production of basic and intermediate petrochemicals in the developing countries, coupled with their limited capabilities to undertake any appreciable processing of finished products (particularly speciality products) in a new kind of division of labour between developed and developing countries only on a higher level of specialization (degree of processing), replacing the traditional raw material/manufacturing relationship; in fact the pattern that is already emerging suggests that the developing countries will remain as a supplier of basic and intermediate products for the major chemical companies in much the same way that they formerly performed this function for the industrially developed countries in the area of fuels, various metals and other kinds of raw materials.

However, such a situation could not assume a permanent character and is expected to change in the future with increasing capabilities of the developing countries in terms of maturing the operations of petrochemical technologies and the marketing experience they will acquire. Co-operation between developing countries will further enhance their situation in the petrochemical industry and establish a new level (higher)

of division of labour. This dynamic process will continue: the greater the role of developing countries in the production mastery of basic, intermediate and general purpose petrochemical products, the further the degree of specialization of the developed countries in high-technology speciality petrochemical products.

2.4 Changing cost structure

World economic trends affect the cost structure and the economics of petrochemical production in different ways according to the type of product and its place of production. The purpose of this section is to analyse how these changes bear on developing countries in particular and their ability to enter world markets with competetive export products. The cost data developed in this context are used together with transport costs and tariff rates to assess the competitivity of new plants built in developing countries vis-a-vis their counterparts in traditional centres of petrochemical activity.

The general trend is for an increase in capital and feedstock cost at the expense of other factor inputs. The analysis therefore begins with a discussion of investment costs in the different regions for the main basic and end products in petrochemicals. This is followed by a study of production costs as a whole, their changing structure and the impact of changes in the different elements—feedstocks, fuel and energy, by-products, other operating costs and capital charges.

Investment and production cost are analysed in terms of a number of plants assumed to be operating at two points in time—1980 and 1985. The competitive situation is developed for three developed (the U.S. Gulf Coast, the Federal Republic of Germany and Japan) and three representative developing country locations (Indonesia, Mexico and Qatar). **The results are presented in annex G (1980) and annex H (1985). Each product is assumed to build a 5000,000 t/a ethylene cracker whose output is fed to downstream plants shown in fig.**

In the developing countries two feedstocks are considered - ethane and a 50:50 ethane-propane mixture. The latter provides by-product propylene for a downstream polypropylene plant as a section option.

Alongside these olefin complexes, additional plants to make methanol, ammonia (and thence urea) from methane and DMT, TPA and polyester terephthalate (for fibre production) are also included.

In many cases, especially in the oil exporting countries, the final product capacities shown in Fig. 2.A would be far too large for home demand. What starts therefore as a techno-economic problem of exploiting a local resource such as associated gas or utilizing by-product streams of local refineries quickly evolves into a problem of international marketing. The implications of this for the developed world and the need to find mutually beneficial solutions are discussed in Chapter VI.

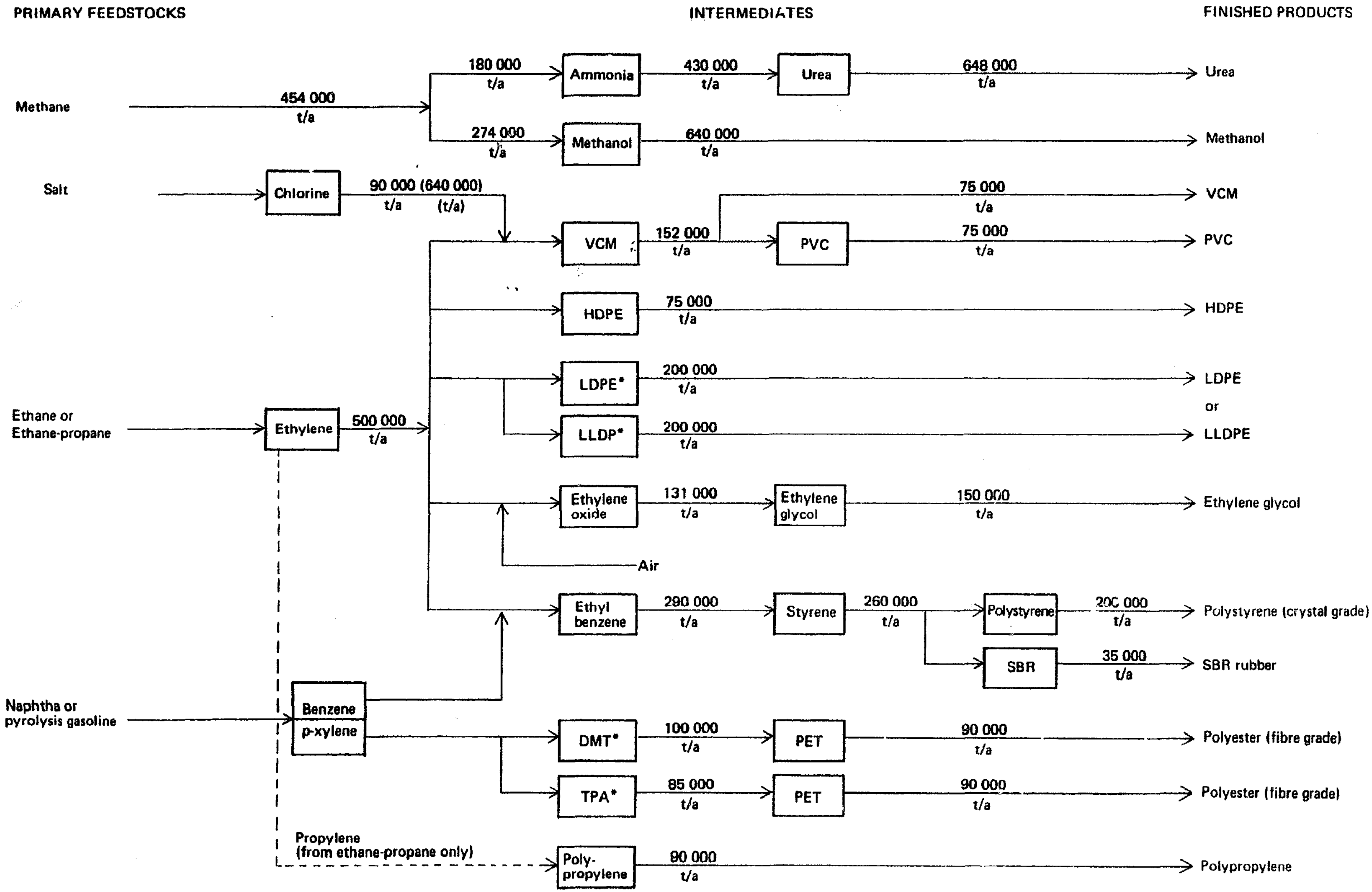
2.4.1. Factors leading to increases in investment costs

The cost of building a petrochemical plant depends on time, size and geography; all three work against the fledgling petrochemical industry in the developing countries.

Against the time factor, there is little to be done—plant costs have gone up all over the world at a rate outpacing general inflation and will continue to do so. As latecomers, developing countries recognize they are entering an industry with new and, albeit modern, plant, but they have to compete with traditional plant whose unit investment costs may be half of theirs or less.

The traditional way to compete with older units is to build large plants in order to gain the benefits of scale economies. Developing countries, however, often lack the experience either to operate the very largest units and/or to take responsibility for marketing the resulting product.

Fig. 2 A
MATERIAL FLOWS FOR SELECTED PROCESSES



Note: Asterisk (*) denotes alternatives.

Geography too is a fact of life. There are objective differences in the design-, procurement-, shipping-, erection- and start-up costs for a plant built in most developing countries vs. the industrialized countries. It is arguable, however, that the location factors used to summarize this difference by comparing overnight plant costs for equal size units are often exaggerated and/or out of date.

These three factors, analysed separately below, form the basis for the investment cost outlook in the different regions.

2.4.1.1 Impact of inflation

According to one survey in the decade 1970-79, the cost of building chemical plants in the United States rose 119 per cent, which is an annual rate of 8.5 per cent. Opinions differ as to the precise rate of increase, but there is general agreement that in this period chemical plant building costs rose substantially faster than the consumer price index, which averaged 7.2 per cent annually. Moreover, increased in the past year have, if anything, been even greater. Looking ahead, United States chemical companies expect cost increases for the next few years to range from 8 to 10 per cent annually. Engineering contractors, however, expect 10 to 20 per cent per year - all in current dollar terms. These higher figures from contractors reflect their view that there will be a repeat of the 1974 inflation burst in construction costs if demand picks up simultaneously in several sectors.

This 1973/74 rise is evident in the various construction cost indexes available for documenting long-term trends. The index established by Stanford Research Institute,[8/] for example, stood at 360 in mid-1980 for the United States. This compared to 100 in 1958:

8/ PEP Yearbook 1980, Stanford Research Institute, Zurich.

Construction cost indexes

Year (mid-year)	Index
1958	100
1960	106.4
1965	115.0
1970	143.1
1971	153.8
1972	158.1
1973	173.2
1974	208.2
1975	241.7
1976	251.3
1977	266.8
1978	282.4
1979	314.8
1980	357.3
1981	...
1982	...
1983	...

Source: SRI International, Zurich

During the next few years, SRI expects its PEP cost index for the United States to rise by 2 per cent per year in constant dollars. This assumes — conservatively compared to the engineering contractors — the cost of chemical plant construction in current dollars will rise at the same rate as the consumer price index, i.e. 10.5 per cent annually. By 1983, the midpoint in period 1982-84 when most of the construction costs will be incurred for any plant due on stream in 1985, this will mean a further 35 per cent rise, bringing the index in current dollars to 485.

To convert current dollars to constant dollars a deflator is applied based on the expectation that the value of current dollars will fall inversely with the rise in the United States GNP. This is estimated at 8.5 per cent for the next five years, effectively reducing the rise in the construction cost index to 2 per cent per year. On this basis the index would reach 382 in 1983.

2.4.1.2 Impact of plant size

Economies of scale in petrochemical plant mean that doubling the capacity costs less than double the investment. The precise relationship is given by a formula of the type:

$$I_A / I_B = (C_A / C_B)^n$$

where

I_A and I_B are the investment costs for two plants A and B, and C_A and C_B are their respective capacities.

The exponent n changes according to plant size but for most petrochemical units ranges between 0.6 and 0.8. In practical terms for 1980 this gives the ranges of capacities and the unit investment costs shown in table 2.5 for three developed and three developing countries.[9/] (The difference between the two groups reflects the location factors discussed in the next section.)

This table affords a quick estimate of total investment required to reach each stage in the production chain. Total unit investment cost at a given stage, e.g. ethylene glycol, are computed by adding the respective unit investment costs multiplied by unit feedstock consumption for all the plants, e.g.

$$T_{EG} = I_E \cdot Y_{EO} + I_{EO} \cdot Y_{EG} + I_{EG}$$

where

T_{EG} is total unit investment to make ethylene glycol; I_E, I_{EO} and I_{EG} are the unit investment costs associated with ethylene, ethylene oxide and ethylene glycol units respectively; Y_{EO}, Y_{EG} are unit feedstock consumptions for the ethylene oxide and ethylene glycol plants.

9/ See First World-Wide Study of the Petrochemical Industry, table 16, page 45 for similar information for 1978. Comparing the two sets of data indicates an across-the-board increase of 25 per cent in specific investment costs.

Table 2.5 Installed cost for petrochemical plants in 1980

($/ton/year at 100 per cent load factor)

Location (Location factor)		U.S. Gulf Coast (1.00)	Federal Republic of Germany (1.15)	Japan (0.90)	Indonesia (2.1)	Mexico (1.25)	Qatar (1.5)
Product	Capacity range 1000 ton/year	Installed cost range $/ton/year	Installed cost range $/ton/year	Installed cost range $/ton/year	Installed cost range $/ton/year	Installed cost range $/ton/year	Installed cost range $/ton/year
Ammonia							
from methane	300 - 590	277 - 313	318 - 360	249 - 282	581 - 657	346 - 391	415 - 469
from naphtha	300 - 590	317 - 356	364 - 409	285 - 320	665 - 747	396 - 444	475 - 533
DMT	75 - 300	883 - 1 181	1 015 - 1 358	795 - 1 063	1 854 - 2 480	1 104 - 1 477	1 324 - 1 772
Ethyl benzene	250 - 780	77 - 112	88 - 129	69 - 101	161 - 235	96 - 140	115 - 168
Ethylene-propylene a/	225 - 680	611 - 802	703 - 922	550 - 722	1 284 - 1 684	764 - 1 002	917 - 1 202
Ethylene-propylene-butadiene-benzene b/	225 - 680	787 - 1 025	905 - 1 179	708 - 923	1 653 - 2 153	984 - 1 282	1 181 - 1 538
Ethylene glycol	90 - 360	153 - 234	176 - 270	137 - 211	321 - 492	191 - 293	229 - 352
Ethylene oxide	67 - 270	701 - 1 006	806 - 1 157	137 - 905	1 472 - 2 112	876 - 1 257	1 052 - 1 509
HDPE	50 - 200	478 - 640	550 - 736	431 - 576	1 004 - 1 344	598 - 800	718 - 960
LDPE	50 - 200	692 - 1 000	796 - 1 150	623 - 900	1 453 - 2 100	865 - 1 250	1 038 - 1 500
LLDPE	50 - 200	461 - 634	530 - 729	415 - 571	968 - 1 331	576 - 792	691 - 951
Methanol							
from methane	160 - 640	206 - 287	237 - 330	185 - 258	432 - 602	257 - 358	304 - 430
from naphtha	160 - 640	225 - 325	258 - 373	202 - 292	472 - 682	281 - 406	337 - 487
Polyethylene terephthalate (PET)							
from DMT	22 - 90	828 - 1 178	952 - 1 354	745 - 1 060	1 738 - 2 473	1 034 - 1 472	1 242 - 1 767
from TPA	25 - 100	694 - 1 116	798 - 1 283	625 - 1 004	1 457 - 2 344	867 - 1 395	1 041 - 1 674
Polypropylene	45 - 180	799 - 1 013	919 - 1 165	719 - 912	1 679 - 2 128	999 - 1 267	1 199 - 1 520
Polystyrene	45 - 180	352 - 486	404 - 560	316 - 438	738 - 1 022	439 - 608	527 - 730
PVC	150 - 500	645 - 998	741 - 1 148	580 - 898	1 354 - 2 096	806 - 1 247	967 - 1 497
SBR	35 - 140	856 - 1 331	949 - 1 531	771 - 1 198	1 798 - 2 796	1 070 - 1 664	1 285 - 1 997
Styrene	225 - 680	215 - 282	247 - 324	193 - 254	451 - 593	268 - 353	322 - 423
Terephthalic acid (TPA)	75 - 300	863 - 1 1117	993 - 1 285	777 - 1 005	1 813 - 2 346	1 079 - 1 397	1 295 - 1 676
Urea	245 - 860	91 - 136	104 - 156	82 - 122	190 - 285	113 - 170	136 - 204
VCM	180 - 730	311 - 414	357 - 476	280 - 372	653 - 869	388 - 517	466 - 621

a/ cost per ton ethylene from ethane-propane feedstock

b/ cost per ton ethylene from naphtha feedstock

Table 2.6

Total unit investment costs for selected petrochemicals and intermediates in the United States

Intermediate/product	Small Plants Individual plant	Small Plants Total investment[a]	Large Plants Individual plant	Large Plants Total investment[a]
	$/ton/year	$/ton/year	$/ton/year	$/ton/year
Ethylene	802[b]	-	611[a]	-
HDPE	636	1450	448	1094
LDPE	1000	1850	692	1340
LLDPE	634	1377	461	1027
Ethylene oxide	1005	1773	701	1286
Ethylene glycol	234	1556	153	1112
Ethyl benzene	112	328[b]	77	242[b]
Styrene	282	658	215	493
Polystyrene	487	1158	352	855
SBR	1331	1478	856	966
DMT	1181[b]	-	883[b]	-
PET	1178	2919	828	2150
TPA	1117[b]	-	865[b]	-
PET	1116	2632	694	1835
Chlorine	661	-	451	-
VCM	414	1195	312	875
PVC	998	2000	645	1514

a/ Including upstream investment

b/ Excludes investment for feedstock extraction plant

The results for selected end products made in both the largest and smallest plants considered are shown in table 2.6. Excluding investment in feedstock extraction units, this shows the specific investment cost for producing final petrochemical products ranges between $855 per ton/year for polystyrene to $2,150 for fibre-grade polyethylene terephthalate (PET) when made in large units throughout. Corresponding figures for small production units are $1,158 and $2,915 per ton/year respectively. The table also demonstrates the relative capital intensity of PVC compared to other polyolebines, and the potential advantages offered by linear low-density polyethylene over conventional LDPE.

The impact of plant size on production costs is seen in table 2.7 showing transfer prices associated with 18 petrochemicals made in the United States.[10/] Large plants are assumed to be four times, and medium plants twice the size of small units. The differential actually depends on where on the scale economies curve the three units lie, but those in table 2.7 are considered typical of industrialized country conditions. On this basis, the difference between the small and large units ranges from $24/ton for ethylbenzene—a relatively simple plant, not amenable to large-scale economies—to $455/ton where high labour costs can be distributed over large throughputs from the large units. This is shown graphically in Fig. 2.B which relates transfer prices of the large units to those on the smallest. From this, petrochemicals can be seen to fall into four groups:

	Products	Large versus small plants % difference
Group I	ethylbenzene, styrene	Less than 4%
Group II	PVC, VCM, PS, LLDPE, HDPE	7-10%
Group III	methanol, PP, ethylene, LDPE, ethylene oxide	13-16%
Group IV	SBR	19%

10/ Transfer prices include all production costs plus an allowance of 25 per cent return on investment assuming an 85 per cent load factor (see Annex I for further details).

Table 2.7

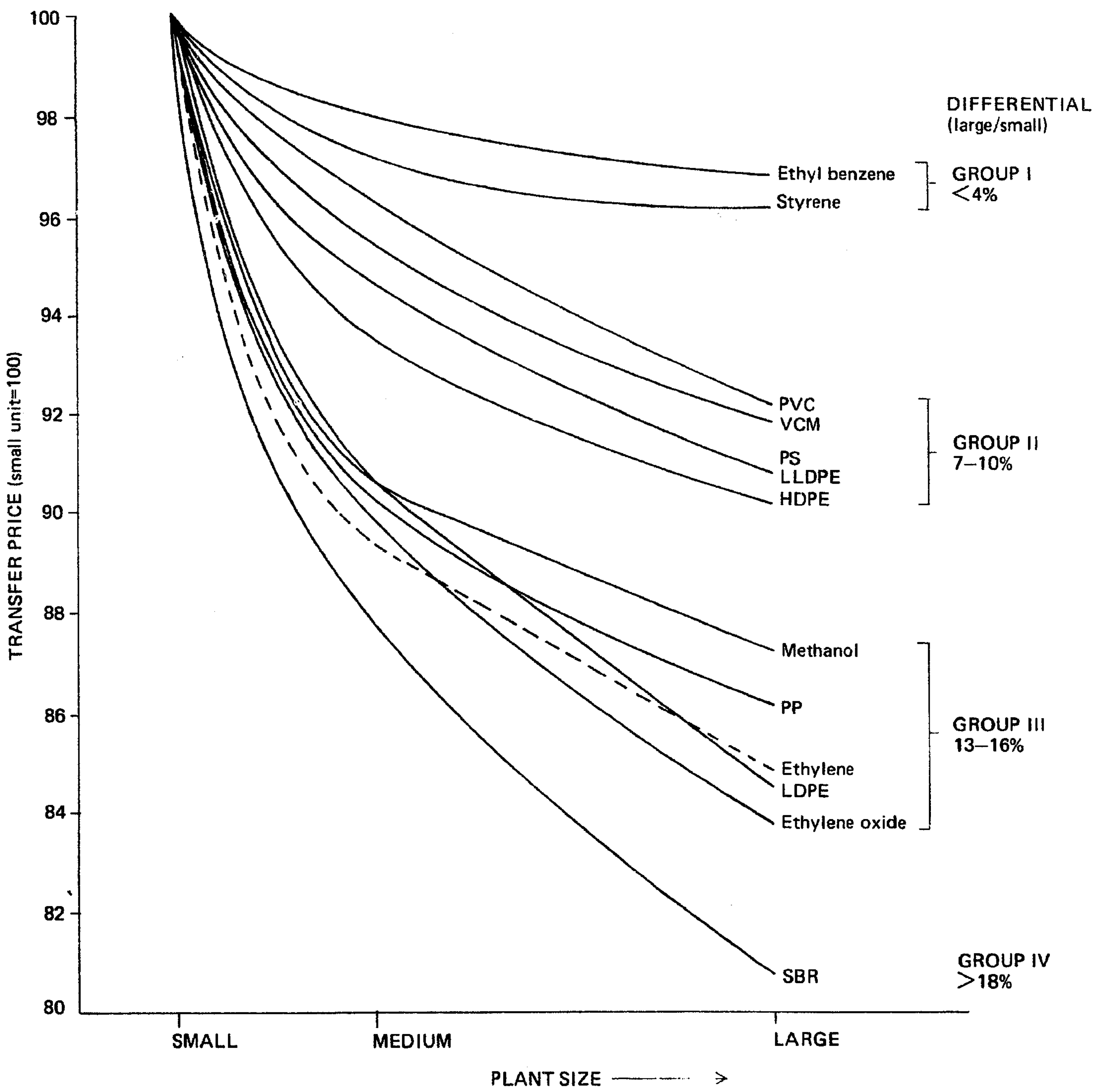
Impact of plant size on transfer prices
(United States Gulf Coast)

Product	Small plant (100) $/ton	Medium plant (200) $/ton	Large plant (400) $/ton
DMT	1392	1265	1195
Ethyl benzene	799	788	775
Ethylene-propylene[a/]	685	613	582
Ethylene-propylene, butadiene-benzene[b/]	862	772	732
Ethylene glycol	768	740	720
Ethylene oxide	1075	965	902
HDPE	1135	1061	1025
LDPE	1079	979	913
LLDPE	1006	951	915
Methanol	314	288	274
Polyethylene terephthalate (PET)	1924	1741	1620
Polypropylene	1067	986	938
Polystyrene	1146	1068	1043
PVC	1130	1090	1043
Styrene	920	893	885
SBR	2368	2079	1913
Terephthalic acid (TPA)	1294	1207	1145
VCM	836	798	769

a/ Ethylene price using ethane-propane feedstock

b/ Ethylene price using naphtha feedstock

Fig. 2 B
ECONOMIES OF SCALE FOR SELECTED PETROCHEMICALS



In passing it may be noted that the relatively new technology to make linear low density polyethylene (LLDPE) is less affected by scale economies than LDPE. The explanation lies in the low pressure operating conditions for LLDPE, but it means that there is less need to invest in large-scale plants in order to complete economically with LDPE units.

The significance of table 2.7 is that most of these differentials are large compared to, say, the cost of shipping petrochemicals from a developing location to the nearest industrialized country market. The average differential in production costs is $134/ton; this dwarfs, for example, shipping charges for bringing ethylene glycol to Europe at $16/ton.[11/]

2.4.1.3 Location factors[12/]

Location factors were introduced into plant capital cost estimating because of the different problems that arise in designing and building plants at different locations. Because the differences are greater, their main application has been in supplying capital goods to developing countries. The petrochemical industry, along with the fertilizer sector, is one of the main users of this concept.

In practice several definitions are current.[13/] The one used here is the simple ratio of fixed investment at a given location (I_{DC}) to that of the same production unit at a reference location, in this case the United States (I_{US}). Thus,

$$L_{DC} = I/_{DC} \Big/ I_{US}$$

This means that if the location factor for a given area is known, plant costs can be estimated from those published for the United States. As shown later, it is important, however, for the load factor to represent accurately the difference in supply, procurement and construction conditions for the developing country petrochemical plant.

11/ See table 2.20

12/ This section is based on the ideas submitted by SRI International, Zurich, to the Gulf Organization for Industrial Consultancy (GOIC). See Proceedings, "Construction, Production and Distribution of Petrochemical Products", GOIC, Doha, Qatar, October 1979.

13/ Location factors can compare total overnight construction costs, total fixed investment, inside battery limits or outside battery limits investment costs. Some sources also use location factors as a multiplier to go directly from ISBL costs in the United States to total fixed investment at another location.

The ratio is influenced by a large number of factors, of which the major ones are outlined in annex II.F. Two methods are offered for determining load factors--the points system and the detailed analysis method.

In the points system--considered accurate enough for preliminary estimates--a number of points (table 2.8) are given to each of 14 cost components in relation to the whole. The effect is to weight each component according to its importance in relation to the whole--in this case, the total of 100 being taken as the overnight construction cost in the United States. Points are assigned (a) to the United States equivalent plant and (b) to the second country unit--the second country being evaluated each time on a favourable-, medium-, and least-favourable case basis. Both costs are added up and the ratio of the two totals computed to give the load factor. An example based on a study for a large petrochemical plant in the Middle East is given in annex II.E.

The detailed analytical approach is used for all studies where the points system is generally regarded as not accurate enough, e.g. full feasibility studies. For example, whereas the points approach shown in annex IV gives a location factor of 1.61 for the Middle East, a more detailed analysis for another petrochemical plant showed a value of 1.577. If accepted by the buyer, this difference is equivalent to increasing his capital costs by 5.5 per cent, which on an ethylene plant would raise transfer prices by $15 to $25/ton--around half the cost of shipping ethylene to the nearest industrialized country market.[14] Variations in location factors of this amount can easily occur in a matter of two years or so. Buyers should therefore ensure that accurate, up-to-date information is being used in contractors' computation of location factors.

The basis of the analytical approach is that the overall location factor is built up from a number of subsidiary location factors for each cost component. At a Middle East location, for example, these component location factors range from 1.16 to 2.0 for the important components and 1.0 to 4.5 for the less important. On this basis (see table 2.9) the over-all load factor for total fixed investment ranges between 1.18 and 2.1.

The success of the analytical approach depends on the accuracy with which these component location factors are determined. They are used in stage 5 of the following 10-step procedure for estimating overall fixed investment cost:

14/ Estimated shipping charges for moving ethylend from Qatar to Genoa (Southern Europe) and Rotterdam (Northern Europe) are $36 and $48/ton respectively. See table II.5.1.

Procedure for estimating investment costs
(detailed analytical approach)

1. Define project - product, process, site, plant capacity and load factor.

2. Determine production capacity of equivalent plant in the United States.

3. Adjust United States' overall construction costs using load factor differential to give required output and location conditions.

4. Break down adjusted United States construction costs into 14 component parts (as per table 2.9).

5. Determine component location factors.

6. Use location factors to convert United States costs to location costs item by item. Consolidate the results to give construction cost location factor.

7. Determine impact of plant efficiency on construction costs.

8. Calculate plant cost location factor (construction cost load factor x plant efficiency load factor).

9. Add other capitalized costs.

10. Calculate fixed investment location factor.

Source: GOIC

An example of the analytical method applied to a 320,000 t/a methanol project in the Middle East is given in annex II.E.

Table 2.8 **Points assigned to 14 cost components of fixed investment in the points weighting system for estimating location factors for petrochemical plants**

Cost item	United States average weighting (total: 128.4)	Developing country conditions: most favoured (total: 173.5)		Developing country conditions: medium (total: 274.0)		Developing country conditions: least favoured (total: 420.5)	
		Points	Notes	Points	Notes	Points	Notes
Prefeasibility study	0	0.5	simple	1	several alternatives	1.5	several alternatives and locations
Feasibility study	0.5	1	simple	2	several markets	3	complex project, many markets
Site development	0	0	none	10	some infrastructure	30	much infrastructure
Machinery and equipment (incl. spare parts) delivered plant site	52	72	good access by sea, site near harbour	78	some transportation problems (inland)	82	transportation difficulties
Sales taxes, duties, fees	2	2	import duty	6	import duty	10	import duty
Installation a/	20	22	no restrictions on contractors	30	subcontractors mixed, local/foreign	38	specialized labour imported
Buildings a/, structural support	18	20	no restrictions on contractors	27	mixed local/foreign material, contractors	34	imposed use of local material and contractor little competition
Miscellaneous b/	2	4	low risk	17	medium risk	30	high risk
Engineering	6	9	well defined project, few special requirements	18	changes in design	27	project management difficulties, project ill-defined
Type of contract with engineering contractor	0	0	cost plus	2	lump sum engineering; procurement and construction on cost plus basis	10	lump sum
Streamfactor compared to United States	0	0	ratio to United States = 1	11	ratio to United States = 0.9	33	ratio to United States = 0.8
Cost escalation during construction c/	10	15	construction time as United States	26	construction time as United States + 1 year	45	construction time as United States + 2 years
Cost of construction financing	10	13	construction time as United States	26	construction time as United States + 1 year	47	construction time as United States + 2 years
Start-up cost incl. special training	8	15	trained staff available	20	lower staff new	30	all staff new
Total	128.5	173.5		274.0		420.5	
Location factor	1.00	1.36		2.13		3.27	

a/ as subcontract
b/ including commissions and goodwill
c/ United States = 2 years
Source: GOIC

Table 2.9

Location factors for cost components in the Arabian Gulf (1978)

Cost component	Location factor U.S. = 1.00	Weighting (Total = 120)
Machinery and equipment at site	1.3 - 1.5	52
Installation a/	1.0 - 1.9	20
Buildings, structural support a/	1.0 - 1.5	18
Miscellaneous b/	1.5 - 7.0	4
Engineering	1.5 - 4.0	6
Overnight construction costs	1.21 - 1.80	100
Provisions for cost escalation	1.21 - 4.5	10
Construction financing c/	0.6 - 3.5	9
Plant cost	1.1 - 2.0	119
Prefeasibility study		0
Feasibility study		0.5
Site development		0.5
Total costs	1.5 - 3.0	120

Source: GOIC

a/ As subcontract.

b/ Includes commissions and goodwill.

c/ Depends on length of construction time and financing conditions.

2.5 Production costs

The 1970s witnessed major changes in the structure of petrochemical production costs. Costs rose overall at rates exceeding the rate of inflation, and their structure was radically altered by differing the price patterns in the industry's two main cost elements—raw materials (feedstock and energy) and capital charges (depreciation and return on investment).

Throughout the decade developed countries' primary raw materials (gas and naphtha) typically accounted for 40 to 60 per cent of primary petrochemicals and 20 to 30 per cent for derivatives; capital charges are 25 to 35 per cent and 40 to 50 per cent, respectively. In developing countries with low primary feedstock prices, the cost distribution was more heavily weighted towards capital charges.15/

The critical change is the relative growth in feedstock costs16/ at the expense of all other input factors (see table below). This is reflected in the petrochemical industry's overwhelming preoccupation with feedstock availability and pricing; it is also the main reason why some industrialized country producers are turning to co-operation as a key element in their development strategy.

These relative movements in raw materials and capital charges, their relation to overall production costs, product prices at global inflation rate are illustrated by developments in naphtha-based ethylene in Europe:

Changing cost structure for ethylene (1972=100)

	1972	1977	1980
ethylene price a/	100	350	837
consumer price b/	100	...	...
production cost a/	100	404	861
Feedstock cost a/	100	610	1465
Depreciation b/	100	177	215

a/ See table 2.19
b/ At 10%/a.

15/ First World-Wide Study on Petrochemical Industry, 1975-2000, tables 17, 19.

16/ In practice, naphtha cracker operators work with net feedstock costs, but the trend is the same; see table

The outlook for the 1980s is that both raw materials and capital charges will continue to outpace inflation; primary feedstock cost will reflect annual rises in oil prices of 4.5 per cent in real terms; capital costs will similarly increase 2 per cent annually. This means that in general conditions petrochemical producers with direct access to low cost raw materials, e.g. natural gas, will be favoured. In the case of developing countries such a trend will partially offset higher capital charges derived from investment costs ranging from 25 to 110 per cent above those in North America.17/

This difference in the relative endowment of some developing countries (those with access to primary feedstocks) and developed countries (i.e. those with ample capital but facing a deficiency in raw materials and energy supplies) constitutes a prima facie case for North-South co-operation. The pros and cons of industrial co-operation in petrochemicals are discussed in chapter VI. This section attempts to quantify the position regarding production costs in the different regions. The information also updates corresponding data in the First World-Wide Study.18/

Because major new petrochemical production capacities will come on stream in the mid-1980s, especially in developing countries, production costs are worked out for three industrialized and three developing country locations. The data are developed for 1980 and 1985 to show the viability of developing country production in those years.

17/ For discussion of location factors applied to developing countries, see p. 00.

18/ First World-Wide Study on the Petrochemical Industry, op.cit., pp. 42-59

On this basis, the following pages show that, given favourable assumptions, a petrochemical industry was both viable and internationally competitive in selected developing country locations even in 1980. Trends in world feedstocks prices, rising world market prices and a relative fall in their capital outlays for petrochemical plant will put them in a more favourable position in 1985.

In order to understand the position of new developing country producers, production costs are broken down into the following key components: feedstock, energy, by-product credit, other direct costs (utilities, maintenance materials, operating supplies, operating labour, maintenance labour and control laboratory), depreciation, other fixed charges (plant overhead, taxes and insurance, interest on working capital), and general overhead (general and administrative charges, sales and R and D). The assumptions and values for each component are discussed in the next section; related definitions and the basic methodology are set out in (annex II.F). The production cost breakdowns for 18 petrochemical products[19/] are reproduced in (annexes II.G) (for 1980) (and II.H) (for 1985).

Although 18 petrochemicals have been considered, the analysis is mainly confined to two of the industry's basic building blocks for the present and future - ethylene and methanol.[20/] Petrochemical producers, especially newcomers in developing countries, must be competitive at this stage if they are to make serious inroads in international markets with downstream products.

Their advantage in low primary feedstock prices is evident from the impact of rising crude oil prices on the naphtha-based petrochemical industry in developed countries. When crude prices double, the price of naphtha in Europe, for example, rises 68 per cent. The effect of this on downstream petrochemicals is broadly as follows.[21/]

19/ For listing of the 18 products, see Tables.

20/ The future for methanol as a chemical feedstock, as opposed to its fuel and transport uses, is not yet clear. For discussion see Section p.00.

21/ For a similar set of relationships, see First World-wide Study on the Petrochemical Industry 1975-2000 UNIDO/ICIS.83, 1978, p.52.

The effect of doubling crude oil prices on West European petrochemical costs

Product	Feedstocks	Increase in Product cost %
Naphtha	crude oil	68.0
Ethylene and co-products	naphtha	37.5
Ethylene and co-products	gas oil	35.8
Ethylene and co-products	ethane-propane (LPG)	36.9
Polyethylene	naphtha-based ethylene	16.8
Polypropylene	naphtha-based ethylene	16.2
DMT	naphtha-based p-xylene	43.2
Polyester fibre	naphtha-based p-xylene	24.1

Although the above table suggests that the advantages to developing country producers with access to low cost liquid and gas feedstocks would be greatest at the upstream level, any decision on how far to go down the petrochemical chain is more complex. On one hand, shipping charges are often higher for primary derivatives such as ethylene and ammonia than for solid finished products like urea, polyethylene and fibres. Against this, selling costs and technical service requirements for finished products such as polyethylene impose a severe barrier for new producers. On the other, petrochemicals may be considered a vehicle for industrialization, for which finished products become the starting point of local manufacturing operations such as plastics processing.

These questions are taken up in a broad discussion of competitivity at the end of this chapter. At this point the aim is to compare relative production costs in selected developing and developed countries, and to isolate the factors that could change the relative advantages of the two regions.

2.5.1 Key factors determining production cost trends

The long-term trend in the relative cost of producing any particular petrochemical at different locations is influenced mainly by five factors:

- capital cost and related location factor
- working capital requirement
- plant size and choice of process
- feedstock prices
- by-product credits

The impact of changes in these factors on the competitive position of petrochemical producers in developing and industrialized countries for both 1980 and - in terms of a projection - for 1985, is discussed below. The overall impact of several changes in these factors occurring simultaneously is analysed at the end of the section.

2.5.1.1 Capital cost and location factor

The investment required for 22 products and processes in the petrochemical industry at two locations in 1980 is shown in Table 2.10. Plant sizes are in the range likely to be considered for export-oriented projects in developing countries. In all cases, minimum offsites (outside battery limits - OSBL) add considerably to the cost of the basic unit (inside battery limits - ISBL) - for example, for polypropylene they account for 46 per cent of total fixed cost.

For comparison purposes, investment costs for 1985 are computed assuming a real rise in both battery limits, investment cost and total fixed capital investment of 2 per cent[22/] annually for the next five years. Similar costs in other industrialized countries will rise at rates reflecting local inflation and exchange rates vis-a-vis the U.S. dollar[23/]

22/ This is based on an assumed annual rise of plant construction costs equal to the consumer price increase, i.e. 10.5 per cent annually. The value of the current dollar is expected to fall inversely with the rise in GNP, i.e. at 8.5 per cent. The difference, 2 per cent p.a., is the increase in the cost index at constant 1980 dollars.

23/ Exchange rates reflect market conditions, trade balances and political conditions such as investment credit and confidence of world investment in that particular currency.

BREAKDOWN OF 1980 INVESTMENT COSTS FOR PETROCHEMICAL PROCESSES AT TWO LOCATIONS

	U.S. GULF COAST						QATAR					
	Capacity 1000 t/a	ISBL $ million	OSBL $ million	Total fixed cost $ million	Working Capital $ million	Working Capital % fixed cost	Capacity 1000 t/a	ISBL $ million	OSBL $ million	Total fixed cost $ million	Working Capital $ million	Working Capital % fixed cost
Ammonia	430	90.2	35.5	125.7	12.4	9.9	430					
DMT	100	80.1	30.1	110.2	10.4	9.4	100	120.2	45.2	165.4	11.5	6.9
Ethyl benzene	290	18.7	11.9	30.6	23.1	75.5	290	28.0	17.8	45.8	23.8	51.9
Ethylene from ethane	500	215.3	100.0	315.3	46.6	14.8	500	323.0	150.0	473.0	18.6	3.9
Ethylene from ethane/propane	500	236.9	90.2	327.1	43.1	13.2	500	355.3	135.3	490.6	35.0	7.1
Ethylene from naphtha	500	285.7	135.5	421.2	130.6	31.0	-	---	---	---	---	---
Ethylene from gas oil	500	314.9	148.7	463.6	153.2	33.0	-	---	---	---	---	---
Ethylene glycol	150	18.2	11.1	29.2	13.0	44.5	150	27.2	16.6	43.9	16.4	37.3
Ethylene oxide	131	81.8	26.2	108.0	11.3	10.5	131	122.6	39.4	162.0	11.4	7.0
HDPE	75	23.2	19.0	42.2	7.9	18.7	75	34.8	28.4	63.2	7.0	11.1
LDPE	200	99.0	39.4	138.4	20.2	14.6	200	148.5	59.1	207.6	16.3	7.8
LLDPE	200	59.8	32.9	92.7	18.5	19.9	200	88.9	49.3	138.3	18.4	13.3
Methanol	640	86.5	45.3	131.8	19.4	14.7	640	129.7	67.9	197.7	8.8	4.4
Polyethylene terephthalate (PET)	90	41.0	33.5	74.5	14.6	19.60	90	61.5	50.2	111.7	25.9	23.3
PP	90	45.2	34.7	79.9	8.2	10.26	90	67.8	52.0	119.8	11.1	9.3
PS	200	40.2	28.9	69.1	24.4	35.3	200	60.3	43.4	103.7	26.8	25.8
PVC	75	43.9	21.9	65.9	8.0	12.13	75	66.9	32.8	99.8	13.1	13.1
SBR (rubber)	35	28.1	18.5	46.6	6.2	13.30	35	42.1	27.7	69.9	7.8	11.1
Styrene	260	41.2	29.1	70.3	30.4	43.24	260	61.7	43.6	105.4	31.5	29.9
Terephthalic acid (TPA)	85	68.2	24.3	92.5	9.1	9.84	85	102.3	36.4	138.7	10.9	7.8
Urea	680	35.6	28.0	63.6	12.4	19.50	680	53.4	42.0	95.4	11.3	11.8
VCM	152	37.1	28.3	65.4	10.6	16.21	152	55.7	42.4	98.1	12.3	12.5

Capital charges represent the cost allocations for depreciation and the expected rate of return on investment. In this study, a plant is assumed to be written off in ten years[24/] and the internal rate of return is either 25 per cent - the normal pre-tax expectation in industrialized countries - or 5 per cent. As shown below, some developing country producers often need this second option to remain viable under present-day conditions.

As emphasized in the first part of this chapter, the biggest disadvantage suffered by developing countries wanting to compete in petrochemicals internationally is the high cost of their production plant. Often imported or, as in India, equally expensive when made locally, due to protective tariffs on competing equipment that is imported, petrochemical plants erected and brought on stream in developing countries may cost more than double plants of the same size at the U.S. Gulf Coast.

These differences are exemplified by the breakdown of investment costs in table 2.10. These data for two locations - the U.S. Gulf Coast and Qatar - indicate an average ratio between the two of 1.5, i.e. any of these plants will cost 50 per cent more to build in Qatar than in the United States. In practice, a grass roots project in many developing country locations could cost a great deal more, since, for the purpose of this comparison, associated infrastructure developments - access roads, railways, port facilities, etc. - are assumed borne independently by the State and are therefore excluded.

The importance of this ratio, also known as the location factor, as a determinent of developing country competitivity, cannot be overemphasized. A 50 per cent penalty on investment costs means not only 50 per cent higher depreciation charges, but also that much higher a principal on which to calculate the internal rate of return for the production plant. As the following example shows, in an extreme case of a location factor of, say, 2.1, this can totally offset the advantage of low feedstock prices:

High location factor offsets low feedstock cost in ethane-based production

	Location factor	Ethylene production cost, $/ton product				
		Feedstock	Depreciation	25% ROI	Other	TOTAL
U.S. Gulf Coast	1.0	264.4	63.1	185.1	117.3	629.9
Far East	2.1	30.7	132.4	373.8	103.3	640.3

Source: Annex II.E

24/ A more liberal depreciation policy allowed in some developing countries' accounting systems permits a depreciation rate of 7.5 per cent annually. The difference for an ethylene producer could be a saving of up to 6 per cent on production cost, see table 2.15.

In this case, not even when ethane is priced as low as $25 per ton (compared to $215 per ton in the United States) can the producer compete if the expected internal rate of return is 25 per cent. Faced with such high capital charges, the producer must drop his expectations for return on investment - not only to compete in the world ethylene market, but also to produce ethylene for downstream units at a price permitting them to compete internationally as well.

Another demonstration of the importance of location factor is a sensitivity test in which capital costs are increased 10, 20 and 30 per cent respectively. The effect of a 20 per cent increase (the equivalent of raising Indonesia's load factor to 2.5 instead of 2.1, Qatar's to 1.87 instead of 1.5 and Mexico's to 1.5 instead of 1.25) is to raise the cost of ethylene in developing countries by between $60 and $100 per ton, i.e. 13 to 16 per cent. This underlines the importance of ensuring that consultants and engineering contractors use up-to-date information for computing location factors. A location factor error leading to an increase in investment cost of 30 per cent increases the cost of ethylene by less than 10 per cent in the United States and 12 per cent in Japan. In Mexico and Indonesia, the equivalent cost increase is 21 and 24 per cent respectively:

Impact of variations in fixed cost on ethylene production cost (1980)

	U.S.Gulf Coast	Japan	Indonesia	Mexico
Location factor	1.00	0.90	2.10	1.25
	$/t	$/t	$/t	$/t
Ethylene production cost:				
Base case	630	746	640	440
At 10% higher fixed cost	...	776	691	470
At 20% " " "	...	806	742	500
At 30% " " "	...	837	793	531

Source: Table 2.15

These figures also underline the need for certain developing countries to give high priority to infrastructural and other changes that will bring down unnecessarily high location factors.

Not all developing countries are penalized by high location factors, and some of those that are high at present could be brought down. Infrastructure improvements, better labour skills and increased mechanical engineering capacity in South Korea, for example, have, as in Japan, brought location factors down below those in the United States. In this analysis, it is assumed that progress will be made across the board in other countries[25/] and this is reflected in a 25 per cent reduction in the load factor for the calculations carried out for 1985 conditions (see annex III):

Country	Location factor 1980	1985
U. S. Gulf Coast	1.00	1.00
F.R.G.	1.15	1.10
Japan	0.90	0.95
Algeria	1.50	1.37
Indonesia	2.10	1.82
Mexico	1.25	1.18
Qatar	1.50	1.37

In practical terms the new location factors would give the countries with relatively low location factors, e.g. Mexico with 1.25, broadly the same capital costs in 1985 as in 1980. Countries with high location factors making a 25 per cent improvement could actually pay less in real terms in 1985.

2.5.1.2 Working capital

Working capital requirements, shown in table 2.10 vary considerably in their relationship to fixed capital. The practice of some engineering contractors, who apply a fixed percentage of fixed costs for all locations and processes, e.g. 20 per cent, should therefore be questioned. Developing countries are particularly handicapped, firstly because their fixed costs are already high due to the location factor, and secondly because many developing countries will evolve their petrochemical industries on the basis of gas rather than liquid feedstocks, for which working capital requirements are inherently higher:

25/ In Indonesia, for example, the fertilizer sector, in contrast to petrochemicals, already enjoys a location factor of 1.5.

Working capital requirements[a] for ethane- versus naphtha-based ethylene (1980)

(capacity 500,000 t/a)

	Feedstock	
	Ethane[b]	Naphtha[c]
	$ million	$ million
Stores	4.73	2.11
Cash	2.36	2.11
Raw material inventory	2.04	6.79
Finished product inventory	5.29	68.87
Accounts receivable	7.05	91.83
Accounts payable	-2.91	-41.06
TOTAL	18.56	130.65

Source: annex II.F

a/ For assumptions behind working capital, see annex I

b/ Qatar conditions

c/ F.R.G. conditions

d/ In some cost accounting systems, raw material inventory is considered as zero where gas is supplied by pipeline; see text below.

For most other products, a ratio of working to fixed capital is below 20 per cent for all countries. The exceptions are units in which processing is simple, i.e. plant costs are low in relation to high product values.

In most cases, working capital requirements for developing countries are slightly below those for developed country locations. Exceptions occur where local market prices for raw materials and products mean high inventory values for the developing country situation, e.g. for VCM and polyethylene terephthalate in the Middle East.

It can also be argued in contrast to the assumptions made for this study that with gaseous primary feedstocks and in integrated plants, there would be no need for raw material inventory. Whether this accounting approach is more typical of a developing than a developed country situation could not be ascertained. However, as far as the impact on total production costs is concerned, the difference is slight. Whether interest on working capital—the actual charge to the product—is taken as 10 per cent or zero, as favoured in some developing countries, the difference in ethylene production cost, for example, is around 1 per cent for developing countries and 1.6 per cent for the United States.

2.5.1.3 Plant size and choice of process

Products were selected for study on the basis of their suitability in terms of raw materials abailable to developing countries in particular. The emphasis is thus on olefins and other petrochemicals that can be derived from natural gas. Three products with an aromatic base are also investigated: polystyrene and intermediates, polyethylene terephthalate (PET) and intermediates, and styrene-butadiene rubber (SBR).

The influence of plant size on the competitivity of developing country production is apparent from the earlier discussion of installed costs at different locations (tables 2.5 and 2.6). Developing countries can only compete internationally when they build their main upstream plants, e.g. ethylene crackers, at something approaching world-scale. World-scale, however, reflects the evaluation of demand in developing countries rather than the combination of local demand and likely exports in the first few years after plant start-up in a developing country.

The difficulty of competing with small-scale units is illustrated by the position of such plants in Europe, built in 1980:

Construction for naphtha-based ethylene plants in Europe (1980)

	Plant size		
	50,000 t/a	300,000 t/a	500,000 t/a
Fixed cost, $ million	89.8	329.2	379.1
Unit cost, $/t/a	1796	1097	758
Total prodution cost a/ at 100% load factor, $/t	718.9	621.9	457.4

Source: Tables 2.18 and 2.19 and Annex II.G

a/ Excludes internal rate of return, general overhead and interest on working capital.

Because of the size of the above cost differentials, it has been assumed from the outset in this study that export-oriented petrochemical production in developing countries would have to start with world-scale ethylene crackers, i.e. with a capacity of 500,000 t/a. Mexico and Saudi Arabia are two of several developing countries with such plants under construction.

With this starting point, a wide variety of products and downstream capacities could be selected. Those for this study are shown in Fig. 2.B.

The processes chosen are generally proven technology for which there are already a number of licensees. An exception is made for linear low-density polyethylene (LLDPE) which is considered to have good prospects in both developed and developing countries within the time period considered in this study. No attempt has been made to assess the optimum or more probable processes for a given location. However, table 2.11 indicates the likely spread of production costs for other technologies or other feedstocks at an industrialized country location.

2.5.1.4. Feedstock costs

The importance of feedstock costs for selected petrochemicals is evident from table 2.12. In some cases, especially ethylene processes, co-production of by-products reduces the effective cost. This relationship is discussed in the next section.

Subject to local and seasonal variations, the feedstock prices listed in annex II.F (table II.F.2) are considered typical of mid-1980 conditions for the industrialized countries. Since they are the largest element in the production cost breakdown, an accurate knowledge of feedstock prices is vital for assessing the relative competitivity of production at two locations. Again using ethylene as an example, errors of ± 10 to 30 per cent can lead to major cost differences:

The effect of price variations in ethylene feedstocks on production costs (1980)

(500,000 t/a)

	U.S. Gulf Coast		Japan		Indonesia		Mexico	
	$/t	% dif.	$/t	% dif.	$/t	% dif.	$/t	% dif.
Base case	769	0	746	0	640	0	440	0
Feedstock at:								
+ 10 per cent	...		629	± 15.7	636	± 0.6	433	± 1.6
- 10 per cent			864		644		447	
+ 20 per cent	...		512	± 31.4	634	± 1.1	425	± 3.3
- 20 per cent			981		647		454	
+ 30 per cent	...		394	± 47.2	631	± 1.5	418	± 5.0
- 30 per cent			1098		650		462	

Source: table 2.13

Table 2.11 Selected processes and variations in transfer processes with alternative technologies

Product	Process Selected	Variation in 1980 transfer price using alternative technology or feedstock
Chlorine	electrolysis of sodium chloride in diaphragm cells	...
DMT	successive oxidation and esterification of p-xylene	...
Ethyl benzene	homogenous liquid phase of benzene	-0.5% (vapour phase process)
Ethylene	from ethane-propane by steam cracking	+26% (gas oil feedstock) to 28% (naphtha feedstock)
Ethylene glycol	carbonation of ethylene oxide	+10% (hydration process)
Ethylene oxide	air oxidation of ethylene	-11% (oxygen oxidation process)
HDPE	liquid phase solution process	-8.7% to +7.8% (gasphase vs. liquid phase slurry process)
LDPE	high pressure, autoclave reactor	-1.5% (tubular reactor)
LLDPE	low pressure gas phase process, pelletized product	-8% (granular product) +4% (low pressure slurry process) +6% (solution process) -0.5% (medium pressure solution process)
Methanol	copper-based catalyst process, methane feedstock	+18% (high pressure process using methane) +29% (naphtha feedstock, low pressure process)
Polyethylene terephthalate (PET)	from DMT and ethylene glycol	
Polyethylene terephthalate (PET)	from terephthalic acid (TPA) and ethylene glycol	
Polypropylene	homopolymer via vapour phase	+23% (liquid phase slurry process) +14% (homo- and copolymer by slurry process)
Polystyrene	bulk polymerization to crystal	+30% (expandable beads by suspension polymerization) +23% (suspension polymerization for high impact pellets)
PVC	suspension polymerization	-4.5% (bulk polymerization) +8% (emulsion polymerization)
Styrene	dehydrogenation of ethyl benzene	-0.5% (hydroperoxide process)
SBR	emulsion polymerization	+8% (solution polymerization)
TPA	bromine-promoted air oxidation	-10% (modified process for medium purity TPA)
VCM	balanced oxychlorination of ethylene	

Table 2.12 Feedstock prices, by-product credit, net feedstock cost and capital charges in relation to total production costs (1980)

	Developed country (U.S. Gulf Coast)				Developing country (Indonesia)			
	Feedstock cost % of total c/	By-product value % of total c/	Net feed-stock cost a/ % of total c/	Capital charge b/ % of total c/	Feedstock cost % of total c/	By-product value % of total c/	Net feed-stock cost a/ % of total c/	Capital charge b/ % of total c/
Ethylene from:								
ethane	41.9	- 9.8	32.1	39.4	4.8	- 2.1	2.7	72.4
ethane-propane	50.4	-15.6	34.8	42.4	21.0	-13.7	7.3	68.1
naphtha	114.8	-74.9	39.9	43.0	-	-	-	-
gas oil	126.0	-95.5	30.5	48.6	-	-	-	-
HDPE	51.4	-	51.4	27.5	46.3	-	46.3	37.9
LDPE	57.3	- 1.4	55.9	29.3	47.0	-	47.0	39.9
LLDPE	51.7	-	51.7	28.7	45.7	-	45.7	37.1
ethyl benezene	46.8	- 1.9	44.9	28.1	42.0	- 0.2	41.8	33.4
styrene	74.5	- 3.9	70.4	13.6	78.4	- 3.3	75.1	17.7
polystyrene	75.3	-	75.3	13.7	77.8	-	77.8	15.7
VCM	31.5	-	31.5	18.9	16.4	-	16.4	29.1
PVC	45.6	-	45.6	28.2	53.7	-	53.7	31.2
ethylene oxide	52.4	-	52.4	35.4	40.4	-	40.4	45.5
ethylene glycol	75.7	- 0.5	75.2	12.5	81.0	- 0.2	80.8	12.5
DMT	38.9	-	38.9	35.7	45.9	-	45.9	32.4
terephthalic acid(TPA)	32.6	- 1.1	31.5	43.8	23.1	-	23.1	58.3
polyethylene terephthalate	37.4	-	37.4	40.8	25.5	- 0.9	24.6	57.5
polypropylene	43.3	-	43.3	37.2	33.3	-	33.3	49.5
SBR	24.7	-	24.7	43.7	16.1	-	16.1	59.4
methanol	52.3	-	52.3	29.3	7.5	-	7.5	74.9
ammonia	47.7	-	47.7	36.8	5.3	-	5.3	74.7
urea	57.8	-	57.8	22.9	64.7	-	64.7	27.0

a/ Feedstock less by-product credit; Feedstock at market price for US Gulf Coast, at 5 per cent ROI price for Indonesia
b/ Depreciation at 10 per cent plus ROI at 25 per cent
c/ Including 25 per cent ROI, 85 per cent load factor; the minus (-) sign indicates a credit
d/ DMT feedstock
e/ Methane feedstock

For ethylene the variations in the industrialized countries are greater than are likely in practice because they would be partially compensated by the value of by-products (see next section). At the same time, those for the developing countries are small by comparison because of the relatively low contribution of primary feedstock costs (ethane at $25/ton for example) to total production costs.

For downstream products, the feedstock advantage for developing countries is not so great. The above data for Japanese ethylene production suggest this could be compensated in an integrated complex in which feedstock is provided at a 30 per cent discount. At that rate a downstream products plant could increase its relative productivity by up to 40 to 50 per cent. Such discount pricing is a key feature in Mexico's development plan for petrochemicals, for example. It is necessary because, as is shown later (table 2.16), the market price of many intermediates in industrialized countries is also well under the calculated cost of production assuming a 25 per cent return on investment. This fact would be a major stumbling block for developing countries trying to penetrate industrialized country markets unless they too have access to low cost intermediates. In this respect using transfer prices calculated to include a 5 per cent (instead of 25 per cent) return on investment—the assumption made in this study—is an alternative to discount pricing.

Many of the above differences are ironed out in the feedstock prices predicted for 1985. For this it is assumed that basic petrochemical raw material prices will escalate at varying rates (table II.F.2 in Annex II.F) consistent with a real annual rise in crude oil prices of 4.5 per cent. On average, the impact on petrochemical-based raw materials is a real rise of four per cent annually in the industrialized countries. This judgement is supported by information from public and private sources.[26/] In developing countries costs are assumed to rise by similar amounts unless, as with ethane from associated gas, the material is expected to remain in large surplus. Ethane and methane could however command a better price in 1985 and for this reason are costed in at $100 per ton.

26/ "Estimates of Petrochemical Costs in 1985", op.cit., p.4.

2.5.1.5 By-products: availability and pricing

Closely related to feedstock pricing is the value of by-products in the local market. By-products play a critical role in petrochemical competitivity and they vary considerably in price and availability from location to location. The existence of strong refinery sectors in the industrialized countries, for example, allows an interchange of by-products with the petrochemical industry— refinery gases (ethane-propane), naphtha, gas oil, benzene, p-xlene, as petrochemical feedstock; residual gas, propylene, C-4 stream, pyroylsis gasoline fuel oil, benzene and toluene for the refineries. Conversely where there is no local market, the case still for many developing countries, some petrochemical feedstocks would have to be imported at high prices while petrochemical by-products may have to be sold or consumed locally at their fuel value. This illustrates the importance of industrial strategies in oil exporting developing countries that are now developing a refining industry.

In the case of ethylene, a good market for by-products permits a broader choice of feedstocks with the addition of naphtha and gas oil. All available ethylene feedstocks produce by-products but their importance increases (see table 2.4.13) with feedstock molecular weight. In this context ethane has several advantages as an ethylene feedstock for developing countries without a well-developed refinery industry. The by-product disposal problem is at a minimum (0.1 ton per ton compared with 1.57 tons when using naphtha). In addition ethane, as assumed throughout this study, can often be recovered from associated gas at very low cost. If such low cost ethane is available, a developing country using any other feedstock would be incurring a deliberate penalty - justified perhaps by local demand for more of the by-products, e.g. propylene as the basis for polypropylene and motor fuel additives.

The ability to absorb or dispose of by-products apart, the optimum feedstock at a particular location depends on the relationship between feedstock and by-product prices. In 1980 in the United States for example the cheapest ethylene was made from ethane/propane, followed by ethane; gas oil and naphtha. In Europe and Japan where the availability of ethane propane is limited, gas oil would also have given cheaper ethylene than naphtha. By 1985 the pattern will change slightly with ethane giving the cheapest ethylene in the United States and naphtha the cheapest in Japan:

Ethylene cost in industrialized countries using different feedstocks

($/ton, 1980 dollars)

	U.S. Gulf Coast		Federal Republic of Germany		Japan	
	1980	1985	1980	1985	1980	1985
Ethane	630	721	-	-	-	-
Ethane-propane	613	927	-	-	-	-
Naphtha	773	1075	948	1103	746	828
Gas oil	739	939	918	929	680	873

For ethylene producers, especially those in industrialized countries, the role of by-products is such that not feedstock price but net feedstock cost (feedstock less by-product credit) is the principal concern. As table 2.12 illustrates, ethylene is exceptional in the olefin chain in that net feedstock costs are actually less important than capital costs. Seen another way, a drop of 25 per cent in the value of by-products for a naphtha cracker in Japan would have increased ethylene costs by 27 per cent in 1980 (see table 2.13). In developing countries, by-product credits generally contribute less than ten per cent to total ethylene production costs and are correspondingly less important. Thus, a similar 25 per cent drop in by-product credits for an ethylene cracker in Indonesia would have raised ethylene costs in 1980 by only two per cent.

One nonorganic-chemical for which by-products assume a major role is the chlorine needed for VCM and PVC plants. Chlorine production is not only size-sensitive but also greatly influenced by local prices for caustic soda:

Chlorine and caustic soda values in chlor-alkali units

Location	U.S. Gulf Coast	Japan	Indonesia		Mexico		
Plant size t/a	92,000	92,000	92,000	640,000	92,000	640,000	640,000
Product:	$/t	$/t	$/t	$/t	$/t	$/t	$/t
Caustic soda	165	309	220	220	115	120	381
Chlorine	408	573	670	351	487	276	66

With chlorine accounting for 19 to 26 per cent of VCM transfer prices, the very broad spectrum of chlorine values in, for example, Mexico, illustrates the importance of the caustic soda market for the petrochemical industry. The main large user is the pulp and paper sector. Its demand for caustic soda in some developing countries means that caustic becomes the main product, leaving chlorine as a low-price by-product. Conversely, where there is little or no demand for caustic soda, the resulting high price for chlorine may make production of VCM and PVC completely uneconomic as an export product.

2.5.1.6 Impact of fuel and energy

Fuel and electrical energy consumptions for different petrochemicals are shown along with other utilities in annex II.F.3. They constitute a significant portion of total production costs only for the following:

	Product	Percentage of production cost		
		Fuel	Power	Total
Developed country a/	ammonia from methane	17.7	neg.	17.7
	ammonia from naphtha	15.4	neg.	15.4
	chlorine c/	—	20.0	20.0
	ethylene from ethane	14.4	neg.	14.4
	methanol from ethane	18.5	neg.	18.5
	methanol from naphtha	18.7	neg.	18.7
	PVC	neg.	1.2	7.4
Developing country b/	ammonia from methane	2.0	neg.	2.0
	chlorine	—	13.9	13.9
	ethylene from ethane	1.5	neg.	13.9
	methanol from methane	2.7	neg.	2.7
	PVC	neg.	0.5	0.5

a/ U.S. Gulf Coast

b/ Indonesia

c/ Small unit, capacity 92,000 t/a

In these products, energy saving process technology is already being developed to minimize production costs in an area of generally rising energy charges. Whether developing countries should also demand this latest technology however bears some discussion. The designs involve further increases in capital costs, which, as noted, is often the developing country producer's weak point. The plants are also often more difficult to run and require highly trained personnel.

In all other products, the impact of fuel and energy on total production costs is less than five per cent.

2.5.1.7 Impact of other operating costs

Other operating costs; i.e. maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory, general overhead, plant overhead, taxes and insurance, general administration charges, R + D - are often individually small but as a group they add up to significant shares of total production cost. On a medium-size naphtha-based ethylene cracker in Europe the three largest-labour, plant overhead for joint services, taxes and insurance and interest on working capital-each account for around three per cent of total production cost.

Insofar as developing country operating costs are estimated by reference to ISBL capital costs, some charges in this category may be exaggerated. However, plants in industrialized countries often operate with lower maintenance labour and materials charges than those assumed in this study. These differences partly compensate one another in competitivity comparisons.

2.6 Sensitivity to factor inputs

To determine the relative importance of factor inputs, the ethylene cost sensitivity tests already mentioned were applied to nine variables: fixed capital, interest on working capital, depreciation, ROI, load factor, feedstock, energy and by-product credit. The results are tabulated in table 2.13 for four countries - the United States, Japan, Indonesia and Mexico. The United States and Mexico, because of their raw material position and long experience in petrochemicals can be considered among the best placed industrialized and developing country producers respectively. Japan because of its poor raw material position and Indonesia because of its high location factor disadvantage represent the opposite extreme. Transfer prices at each location are compared with a base case with 85 per cent load factor and 25 per cent ROI.

Table 2.13 Sensitivity of transfer price to variations in factor inputs ethylene production at four locations, 1980, in US dollars per ton

COUNTRY / Feedstock		U.S. GULF COAST Ethane		JAPAN Naphtha		INDONESIA Ethane		MEXICO Ethane	
Factor	**Variation in per cent**	Cost in US dollars per ton	difference in per cent	Cost in US dollars per ton	difference in per cent	Cost in US dollars per ton	difference in per cent	Cost in US dollars per ton	difference in per cent
Base case at 25% ROI and 85% load factor	-	630	---	746	---	640	---	440	---
Fixed capital	+ 10	655	+3.9	776	+4.0	691	+7.9	470	+6.8
	+ 20	680	+7.9	806	+8.2	742	+15.9	500	+13.6
	+ 30	705	+11.9	837	+12.2	793	+23.9	531	+20.7
Interest on working capital	+0	620	-1.6	705	-5.5	635	-0.8	435	-1.1
Depreciation	+7.5	610	-3.2	723	-3.1	600	-6.2	---	----
ROI	+0 a/	445	-29.4	518	-30.5	266	-58.5	216	-50.9
	+5 b/	504	-20.0	596	-20.1	375	-41.4	282	-35.9
Depreciation and ROI	+0 c/	382	-39.4	442	-40.7	134	-79.1	137	-68.9
Load factor	+100 d/	602	-4.5	708	-5.1	597	-6.6	413	-6.1
	+65 e/	684	+8.5	822	+10.2	726	+13.4	492	+11.8
Feedstock	- 30	544	-13.6	394	-47.2	631	-1.5	418	-5.0
	- 20	573	-9.1	512	-31.4	634	-1.1	425	-3.3
	- 10	601	-4.5	629	-15.7	636	-0.6	433	-1.6
	+ 10	658	+4.5	864	+15.7	644	+0.6	447	+1.6
	+ 20	687	+9.1	981	+31.4	647	+1.1	454	+3.3
	+ 30	715	+13.6	1098	+47.2	650	+1.5	462	+5.0
Energy	- 20	611	-3.1	746	---	638	-0.4	438	-0.4
	+ 20	649	+3.0	746	---	642	+0.4	442	+0.4
By-product credit	- 25	646	+2.5	950	+27.3	644	+2.1	442	+0.4
	+ 25	614	-2.5	542	-27.3	637	-2.1	437	-0.7

a/ Net cost of production at 100% load factor

b/ Net cost of production at 85% load factor

c/ Cash cost of production

d/ Net cost of production, 25% ROI, 100% load factor

e/ Net cost of production, 25% ROI, 65% load factor

Arbitrarily defining ± 10 per cent as an important difference at the point of production, capital and capital-related charges are seen to be significant at nearly all locations. Dropping ROI expectations from 25 per cent,the norm in industrialized countries,to zero or five per cent (acceptable in some developing countries is seen to cut ethylene costs by between 35 per cent and 60 per cent in developing countries.) The impact is less in an industrialized country like the United States because capital costs are less important in the total picture. Japan lies between the two because capital costs of naphtha crackers are higher than for ethane crackers.

In addition to location factors for developing countries and by-products for liquid based crackers in industrialized countries, table 2.13 the importance of quickly reaching high load factors in petrochemical production. Continuous production at 65 per cent of capacity increases production costs by ten per cent to fourteen per cent in Indonesia, Japan and Mexico.

Of generally less significance in determining international competitivity are variations in fixed capital requirements in industrialized countries, and-in all countries-operation at 100 per cent (versus 85 per cent) load factor, interest on working capital, energy costs in the range ± 20 per cent and a policy decision to drop depreciation rates from 10 to 7.5 per cent.

In reality, of course, competitivity would be subject to variations in several input factors simultaneously. A special case is where, for sales reasons, producers set prices for small lots at their cash cost of production with both depreciation and ROI set at zero. Because of their low feedstock costs, developing country producers are in a better position in this regard than industrialized country competitors. According to table 2.13, Indonesia, for example, could sell ethylene in small quantities at a price of $134/t, an effective discount of 80 per cent. On the same basis the United States producers can come down only to a cash cost of $519, a discount of 32 per cent.

Many input factors are not, however, under the producers' direct control. The combined detrimental effect of four variables—increased feedstock and energy prices, by-product credit values and operation at 65 per cent load factor could severely influence the production costs for a badly-positioned naphtha-based producer in Europe vis-a-vis a competing producer in the Middle East.

2.7 Production costs: competitivity

2.7.1 Competitivity in 1980

From the foregoing it is clear that the ability of developing country producers to manufacture petrochemicals more cheaply than their industrialized country competitors depends on the particular set of local operating conditions. In the following analysis the following basic assumptions are made:

Developing country producers:

- Have access to low cost primary raw materials - methane and ethane at $25/ton;
- Buy and sell intermediates and finished products at transfer prices calculated to include 5 per cent ROI, (i.e. in integrated plants);
- Buy other materials either at notional market prices calculated at 1.25 x United States prices (for imported materials) or at the nearest industrial market price less shipping costs and less a further 25 per cent.

Industrialized country producers:

- Buy all raw materials and intermediates at prevailing market prices;
- Sell finished products at transfer prices calculated with 25 per cent ROI.

On this - admittedly favourable basis for developing countries - developing country producers are seen to be potentially competitive with lower production costs than those in the nearest industrialized country market in nearly every product (table 2.14). Exceptions are ethylene glycol and fibre grade PET in Indonesia and PVC and fibre grade PET in Qatar. As already noted, the economics of PVC production are determined mainly by plant size and the local price for byproduct caustic soda in the associated chlor-alkali unit. In Qatar, calculated chlorine transfer prices range from $184 to $487/ton. Transfer prices for VCM and PVC were calculated using chlorine at $275/ton made on a 92,000 T/A chlor-alkali unit with a byproduct credit of $185/T for caustic soda.

Table 2.14 Calculated production cost[a] for selected petrochemicals
($/t - 1980)

	U.S. Gulf Coast	FRG	Japan	Indonesia	Mexico	Qatar
Feedstock price calculated to include:	25% RO1	25% RO1	25% RO1	5% RO1	5% RO1 g/	5% RO1
	$/t	$/t	$/t	$/t	$/t	$/t
Ammonia[b]	317[g]	345[g]	375[g]	195	126	151
DMT	1265	1417	1574	1178	842	928
Ethyl benzene	782	978	1168	680	556	618
Ethylene[c]	630	-	-	375	282	290
Ethylene - propylene[d]	613	-	-	437	315	360
Ethylene - propylene - butadiene - benzine e/	773	948	746	-		
Ethylene glycol	739	919	1053	1107	708	846
Ethylene oxide	965	1282	1287	905	581	695
HDPE	1061	1380	1479	886	625	737
LDPE	979	1295	1367	849	540	658
LLDPE	951	1243	1311	848	606	710
Methanol	288	313	352	136	93	111
PET[f]	1773	1808	2157	2592	1759	2235
PP	986	1129	1283	1112	727	944
PS	1068	1262	1474	1185	774	1051
PVC	1090	1311	1473	1699	796	1343
SBR	2079	2286	2335	1856	1255	1671
Styrene	893	1069	1231	938	604	831
TPA	1207	1381	1389	1201	876	972
Urea	169	197	349	168	109	134
VCM	798	996	1048	902	647	639

a/ At 85% load feedstock.

b/ Methane feedstock at current market price.

c/ Ethylene production cost with ethane feedstock at current market price.

d/ Ethylene production cost with ethane-propane feedstock at current market price.

e/ Ethylene production cost with naphtha feedstock at current market price.

f/ DMT feedstock.

g/ Based on ethylene at current market price: $230/t.

The number of products developing countries could sell in industrialized country markets in 1980 at prices that included a return of 25 per cent on their investment was far smaller than indicated in table 2.15. Indonesia's high capital charges only permitted this high rate of return on exports to Japan in the case of amonia, ethylene, HDPE, LLDPE, methanol and urea. Quatar to Europe would add DMT, ethylbenzene, ethylene oxide, LDPE, TPA and VCM; Mexico to the United States would increase this list with PP, PS, styrene and TPA. None of the developing countries could sell either ethylene glycol or PET or SBR so profitably.

The above conclusions are summarized in table 2.15. While it may be concluded that for the three developing countries studied, their profitable sales in 19 out of 57 possible combinations of products and markets at 25 per cent ROI transfer prices, and 40 out of 57 with 5 per cent ROI or more transfer prices indicate grounds for optimism, the reality facing these would-be exporters to industrialized markets is otherwise. The range of market prices below which they must land their export products - taking into consideration transport, tariffs, local expenses and other costs derived from other obstacles to entering the market - is in many cases far lower than their local competitors calculated transfer price assuming 25 per cent ROI (see table 2.16). In other words in 1980 the petrochemical industry in industrialized country markets was vastly underpriced. Only for five products in the United States, three in Europe and seven in Japan did calculated production costs indicate a better than 25 per cent return on investment. Even more important for the future health of the industry in these countries is the long list of petrochemicals in each market that were apparently sold at a negative return on investment:

Petrochemicals being sold at low profitability in industrialized country markets a/, in 1980

Market	Low profitability products
United States	ammonia, DMT, ethylbenzene, ethylene, methanol, PET, PVC, SPR, styrene, TPA, VCM.
Federal Republic of Germany	ammonia, DMT, ethylene glycol, ethylene oxide, methanol, PVC, SPR, styrene, TPA, VCM.
Japan	DMT, ethylene glycol, PET, PVC, SPR, TPA, VCM.

a/ With less than zero apparent return on investment.

Table 2.15 COMPETITIVITY OF DEVELOPING COUNTRY PETROCHEMICAL PRODUCERS IN NEAREST INDUSTRIALIZED COUNTRY EXPORT MARKETS - 1980
(production cost compared to market prices)

Supplier (market)	Indonesia (to Japan)						Mexico (to United States)						Qatar (to Europe)					
Feedstock	at special or market price		at price including 25% ROI		at price including 5% ROI		at special or market price		at price including 25% ROI		at price including 5% ROI		at special or market price		at price including 25% ROI		at price including 5% ROI	
Export price:	F.O.B. export prices potentially competitive at: 25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	F.O.B. export prices potentially competitive at: 25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	F.O.B. export prices potentially competitive at: 25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI
Ammonia	yes	yes	-	-	-	-	no	yes	-	-	-	-	no	yes	-	-	-	-
DMT	-	-	no	no	no	no	-	-	no	no	no	no	-	-	no	no	no	no
Ethyle benzene	...	...	...	...	...	...	-	-	yes	yes	yes	yes	-	-	no	yes	yes	yes
Ethylene	yes	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
Ethylene glycol	-	-	no	no	no	no	-	-	no	no	no	yes	-	-	no	no	no	no
Ethylene oxide	-	-	no	no	no	yes	-	-	no	yes	yes	yes	-	-	no	yes	no	yes
HDPE	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	no	yes	yes	yes
LDPE	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
LLDPE	-	-	-	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Methanol	yes	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
Polyethylene terephthalate	-	-	no	no	no	no	-	-	no	no	no	no	-	-	no	no	no	no
Polypropylene	no	yes	-	-	-	-	yes	yes	-	-	-	-	no	yes	-	-	-	-
Polystyrene	-	-	no	no	yes	yes	-	-	yes	yes	yes	yes	-	-	no	yes	yes	yes
PVC	-	-	no	no	no	no	-	-	no	no	no	no	-	-	no	no	no	no
SBR	-	-	no	no	no	no	-	-	no	no	no	yes	-	-	yes	yes	yes	yes
Styrene	-	-	no	yes	yes	yes	-	-	no	no	yes	yes	-	-	no	no	yes	yes
Terephthalic acid	-	-	...	...	...	...	-	-	no	no	no	no	-	-	no	no	no	no
Urea	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	no	yes	yes	yes
VCM	-	-	no	no	no	yes	-	-	no	yes	yes	yes	-	-	no	no	no	no

Although these negative rates of return suggests an apparent loss, in reality what industrialized country producers are experiencing is a period of low profitability, for which there are two causes. Firstly, prices are too low in the sense they do not justify new investment. Private industry only invests when there is at least an expectation of higher prices to justify operating plants with the latest, i.e. high capital charges. Such expectations are hard to find in industrialized country markets at present and, as the next chapter shows, there is a consequent dearth of investment.

At the same time, prices for most petrochemicals in all three industrialized countries reflect the oligopolistic nature of those markets. Prices are not based on the free interplay of supply and demand because in most products there are too few independent producers. This is evident from the following table:

Petrochemical producers in developed countries

	Olefins	Benzene	Xylenes
Western Europe	26	21	10
Japan	11	20	3
United States	47	37	15

In addition there are often very strong ties between these petrochemical producers and the local oil refining industry. In Europe 47 per cent of the top 34 petrochemical firms are back-integrated into oil refining. Back integration is less of a feature in Japan, but the number of producers is relatively smaller. In the United States the number of producers is larger and the degree of back integration is lower. Nevertheless in the olefins group, there are only 25 ethylene producers, 17 propylene manufacturers (mostly oil companies), and five butadiene suppliers.

Price setting in oligopolistic markets is exemplified by the approach of United States ethylene producers. As in this study, they calculate both their own and all their competitor's transfer prices by combining present day feedstock and other direct costs with capital charges based on overnight construction costs. This results in high transfer prices because - in a period of rising capital cost - capital charges that would not apply for two or three years (until a plant ordered today was built and running) are added to current raw materials and other charges. In a sellers market the contract prices actually negotiated are broadly at a level of the second or third most expensive producer. However even that producer operates at a lower real cost of production since his plant incurs historic capital charges - not overnight ones. Hence all producers in an oligopolistic market should make some profit. Conversely in a buyer's market - the case for practically all petrochemicals at present - prices drop to lower levels leaving marginal producers without profit and all producers with no immediate incentive to increase capacity. A buyer's market can occur, it should be noted, because of a fall in demand or because of an increase in supply - for example as imports. Low ammonia prices in the United States reflect low cost imports from the USSR, Trinidad and Mexico, for example. In these circumstances, as noted above, producers only re-invest when they believe immediate real price rises will justify it.27/

The implications for prospective petrochemical producers in developing countries is that they, like the local producers in each industrialized country market, face a prolonged period of low intermediate prices. However prices will probably rise in real terms in the next five years; developing country producers can therefore expect gradually rising returns from their exports to these markets.

The second broad conclusion evident from this analysis of manufacturing costs is that at current feedstock prices certain processes are clearly more economical than others:

- Ammonia from methane is 17 to 20 per cent cheaper than from naphtha in industrialized countries; similar savings accrue with methane versus naphtha based methanol.

- Ethylene from ethane-propane is 2 to 3 per cent cheaper than from ethane in the United States; in developing countries where propane has a high opportunity cost as exported LPG, ethane-base ethylene is 8 to 14 per cent cheaper than from ethane propane.

- Liquid feedstocks (gas oil and naphtha) for ethylene are around 20 per cent more expensive than ethane propane in the United States.28/

27/ These calculations are necessarily simplified. In reality companies use accounting techniques such as DCF to determine medium-term profitability and return on investment over the life of prospective new plants.

28/ Similar savings should be available to European producers with access to ethane or ethane propane from the proposed North Sea gas gathering pipeline.

Table 2.16 Calculated production costs [a/] compared to local market prices for petrochemicals - summary results ($/ton - 1980)

	U.S. GULF COAST		FEDERAL REPUBLIC OF GERMANY		JAPAN		MEXICO	
	Production cost	Market price	Production cost	Market price	Production cost	Market price	Production cost	Market price
Ammonia [b/]	317	172	345	201	375	591	199	66
DMT	1265	705	1417	675	1574	1020	1171	-
Ethyl benzene	782	661	978	754	1168	...	589	-
Ethylene [c/]	630	529	-	754	-	864	490	254
Ethylene-propylene [d/]	613	529	-	754	-	864	479	254
Ethylene-propylene-butadiene-benzene [e/]	773	529	948	754	746	864	-	254
Ethylene glycol	739	750	919	743	1053	908	919	
Ethylene oxide	965	860	1222	948	1287	1140	997	
HDPE	1061	918	1380	1180	1479	1480	988	
LDPE	979	1030	1295	1190	1357	1290	958	
LLDPE	951	1030	1243	1190	1311	1290	925	
Methanol	288	238	313	223	352	492	145	161
Polyethylene terephthalate (PET) [f/]	1773	1260	1808	1830	2157	1960	2262	
PP	986	1040	1129	1010	1283	1410	733	
PS	1068	1010	1262	1350	1474	1430	911	
PVC	1090	761	1311	873	1473	928	1497	
SBR (rubber)	2079	1260	2286	1200	2335	1570	1598	
Styrene	893	787	1069	937	1231	1200	861	
Terephthalic acid (TPA)	1207	772	1381	902	1389	1960	1158	
Urea	169	176	197	216	349	397	98	
VCM	798	485	996	611	1048	908	858	411

a/ Based on 85 per cent load factor, 25 per cent ROI
b/ Methane feedstock
c/ Ethylene cost using ethane feedstock
d/ Ethylene production cost with ethane-propane feedstock at current market price
e/ Ethylene production cost with naphtha feedstock at current market price
f/ DMT feedstock at current market price

- Low pressure technology for making LLDPE is seen to be some 3 per cent cheaper per tonne of polymer across the board compared to LDPE.
- Polyethylene terephthalate (PET) is 11 to 12 per cent cheaper using terephthalic acid (TPD) in developing countries and 3 to 6 per cent cheaper in Japan and the United States compared to the DMT route. Low DMT prices in the Federal Republic of Germany give a 5 to 6 per cent saving the other way in Europe.

2.7.2. Competitivity in 1985

One possible scenario for 1985 is represented by table 2.17. The assumption is that between now and 1985 market prices in industrialized country markets will rise to give producers there something approaching their desired 25 per cent ROI. Along with other assumptions concerning the relative rise of feedstock and capital charges discussed earlier in this chapter and this shows an across-the-board improvement in thecompetitive position of all developing country producers compared to 1980 (table 2.15. Both Qatar and Mexico would be able to profitably market the complete range of petrochemicals with both selling and transfer prices based on a 25 per cent ROI. This is despite a four-fold increase in the price of ethane and methane (arbitrarily assumed to reach $100/tons by 1985 for local industry). Indonesia, still suffering from high, although reduced, location factors would be profitable at export prices based on a 5 per cent ROI in the case of ethylene oxide, LDPE, LLDPE, PET, PVC and TPA. Ethylene glycol would be exported only on the basis of an ethylene transfer price with a 5 per cent ROI.

This means that if world market prices rise to a point where new investment is justified in the industrialized country markets, developing countries could compete in their nearest industrialized country with 48 out of 57 product-market combinations with a 25 per cent ROI throughout and 57 out of 57 with export prices offering producers a 5 per cent return. At the higher ROI price level this represents a 150 per cent improvement of their position in 1980.

It can of course be argued that the construction of additional capacity by the developing countries and its use to supply the three industrialized country markets will prevent prices rising to levels permitting new investment in those markets. In practice, as chapter I makes clear, developing country production capacity in relation to world capacity will still be small in most petrochemical products. Their impact on world trade would be equally slight. Only in two product areas will developing country producers capture substantial portions of world output - ammonia and methanol. In both cases the advantages of low cost feedstock are so overwhelming, developing countries can produce and ship economically at far lower prices than the industrialized country market is ever likely to reach.

Table 2.17 **COMPETITIVITY OF DEVELOPING COUNTRY PETROCHEMICAL PRODUCERS IN INDUSTRIALIZED COUNTRY EXPORT MARKETS - 1985**

Supplier (market)	Indonesia (to Japan)						Mexico (to United States)						Qatar (to Europe)					
Feedstock:	at special or market price		at price including 25% ROI		at price including 5% ROI		at special or market price		at price including 25% ROI		at price including 5% ROI		at special or market price		at price including 25% ROI		at price including 5% ROI	
	F.O.B. exports potentially competitive at:						F.O.B. exports potentially competitive at:						F.O.B. exports potentially competitive at:					
	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI	25% ROI	5% ROI
Ammonia	yes	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
DMT	-	-	no	yes	-	-	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Ethyl benzene	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Ethylene	yes	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
Ethylene glycol	-	-	no	no	...	...	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Ethylene oxide	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
HDPE	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
LDPE	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
LLDPE	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Methanol	yes	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
Polyethylene terephthalate	-	-	no	no	...	...	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Polypropylene	no	yes	-	-	-	-	yes	yes	-	-	-	-	yes	yes	-	-	-	-
Polystyrene	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
PVC	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
SBR	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Styrene	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Terephthalic acid	-	-	no	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
Urea	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes
VCM	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes	-	-	yes	yes	yes	yes

2.8 Changing structure of production costs

The main change in the structure of petrochemical production costs anticipated for the 1980s is a further increase in the importance of feedstocks at the expense of capital charges. This general trend will be enhanced by technology improvements that increase product yields and allow milder, and therefore lower cost, processing conditions (see below). On average petrochemical raw materials--ethane, naphtha etc.--are expteced to rise in price at a rate of around four per cent[29/] compared to two per cent for investment costs. This differential is of course diluted with each step down the petrochemical chain, but it essentially works in favour of developing countries, for nearly all of whom high capital costs are a major hurdle in their attempts to enter world markets.

The extent of the change depends not only on the product and processes used but also on the age and size structure of plant in a particular industry. In the case of a small (50.000 t/a) naphtha cracker for ethylene in Europe (see table 2.18), a plant built in 1972 would have had a cost structure in which 80 per cent of production costs were accounted for by depreciation charges. Because by-product credit exceeded the cost of naphtha, net feedstock cost at start up was -8.6 per cent. The feedstock/capital charge retio already reversed in 1977 and the importance of capital charges continued to decline over the life of such a plant, finally vanishing altogether when it was fully amortized after ten years. An identical trend is seen for a large (300,000 t/a) unit except that capital charges are relatively lower due to scale economies (table 2.19)[30/] For both units, the proportion of total production costs (excluding ROI, interest on working capital and general overheads) allocated to capital and net feedstocks is summarized as follows:

29/ See chapter IV.

30/ Tables 2.18 and 2.19 imply that, because of their lower depreciation charges, older units are always more economic. However, this analysis takes no account of technology improvements that--plant size apart--could be included in new units, but may be difficult to apply to existing plants without extensive reinvestment. Production costs on new units could therefore be lower due to improved yields, lower utilities and catalyst consumption, reduced manning and less maintenance.

Table 2.18 Cost of naphtha-based ethylene in Europe
(Capacity: 50 000 t/a current $)

	1972	1977		1980			1985			
		1972 unit	new unit	1972 unit	1977 unit	new unit	1972 unit	1977 unit	1980 unit	new unit
Fixed capital cost, $ million	43.7	43.7	77.5	43.7	77.5	89.8	43.7	77.5	89.8	137.09
Manufacturing cost, $/ton:										
raw materials	70.5	430.0	430.0	1033.4	1033.4	1033.4	2121.1	2121.1	2121.1	2121.1
bi-product	-79.9	-283.0	-283.0	-625.7	-625.7	-625.7	-1299.7	-1299.7	-1299.7	-299.7
utilities	3.6	7.3	7.3	6.8	6.8	6.8	10.9	10.9	10.9	10.9
Catalyst and chemicals	2.1	3.3.	3.3	1.7	1.7	1.7	3.2	3.2	3.2	3.2
Manpower	2.3	3.7	3.7	23.0	23.0	23.0	86.0	86.0	86.0	86.0
Other charges	22.5	40.0	40.0	100.0	100.0	100.0	205.7	205.7	205.7	205.7
Depreciation	87.4	87.4	155.0	87.4	155.0	179.7	-	155.0	179.7	274.2
Total production cost	108.9	288.7	356.3	626.6	694.2	718.9	1127.2	1282.2	1306.9	1401.4
Product prices and values:										
ethylene	90	315	315	754	754	754	1623.9	1623.9	1623.9	1623.9
propylene	55	220	220	441	441	441	828.5	828.5	828.5	828.5
C-4 fraction	...	...	...	...	...	456	...	...	1048.0	1048.0
butadiene	150	370	370	661	661	...	1494.6	1494.6	...	...
propane	32	130	130			...	432.8	432.8	...	
butane	32	168	168	309	309	...	559.3	559.3	...	...
pyrolysis gardine	...	...	...	...	...	359	...	...	789.4	789.4
....	...	...	...	...	...	210	...	...	442.1	442.1

Table 2.19 Cost of naphtha-based ethylene in Europe
(Capacity: 300 000 t/a, current $)

	1972	1977		1980			1985			
		1972 unit	new unit	1972 unit	1977 unit	new unit	1972 unit	1977 unit	1980 unit	new unit
Fixed capital cost, $ million	153.3	153.3	271.6	153.3	271.6	329.2	153.3	271.6	329.2	502.4
Manufacturing cost, $/ton:										
raw materials	70.5	430.0	430.0	1033.4	1033.4	1033.4	2121.1	2121.1	2121.1	2121.1
bi-product	-79.9	-283.0	-283.0	-625.7	-625.7	-625.7	-1299.7	-1299.7	-1299.7	-1299.7
utilities	3.6	7.3	7.3	6.8	6.8	6.8	10.9	10.9	10.9	10.9
Catalyst and chemicals	2.1	3.3	3.3	1.7	1.7	1.7	3.2	3.2	3.2	3.2
Manpower	2.3	3.7	3.7	23.0	23.0	23.0	42.3	42.3	42.3	42.3
Other charges[a/]	22.5	40.0	40.0	75.5	75.5	75.5	112.4	112.4	112.4	112.4
Depreciation	51.0	51.0	90.5	51.0	90.5	109.7	-	90.5	109.7	167.5
Total production cost	72.2	252.3	291.8	563.7	603.2	621.9	990.2	1080.7	1099.9	1157.7
Product prices and values:										
ethylene	90	315	315	754	754	754	1623.9	1623.9	1623.9	1623.9
propylene	55	220	220	441	441	441				
C-4 fraction	...	...	...	...	...	456				
butadiene	150	370	370	661	661	...				
propane	32	130	130			...				
butane	32	168	168	309	309					
pyrolysis gardine	...	...	...	...	...	559				
....	...	...	...	...	...	210				

a/ Includes only maintenance materials, operating supplies, control laboratory, plant overhead, taxes and insurance, i.e. excludes interest on working capital, general overhead and ROI.

Capital and feedstock charges for small and large ethylene units as a percentage of total production cost

	1972	1977		1980			1985			
		1972 unit	new unit	1972 unit	1977 unit	new unit	1972 unit	1977 unit	1980 unit	new unit
				Small plant (50,000 t/a)						
	%	%	%	%	%	%	%	%	%	%
Capital charges	80.2	30.3	43.5	7.2	22.3	25.0	-	12.1	13.7	19.6
Net feed-stock cost	- 8.6	50.0	41.0	65.1	58.7	56.7	72.8	64.1	62.8	58.6
				Large plant (300,000 t/a)						
Capital charges	70.6	20.2	31.0	9.0	15.0	17.6	-	8.4	9.9	14.5
Net feed-stock cost	-13.0	58.3	54.0	72.3	72.3	65.5	82.9	76.0	74.7	70.9

One non-quantifiable factor that could substantially change feedstock/capital ratios is significantly lower investment costs from improved process technology. As an example, new catalysts are being developed to give 50 to 100 per cent improvements in yields for some processes. With a similar aim, other catalysts reduce the severity of processing changing operating conditions from high pressure-high temperature to low temperature-medium temperature conditions. On new plants this automatically cuts investment and utility requirements for a given throughput.

Whether these new low investment technologies will be freely available to developing countries is not clear. Their sources, petrochemical producers in the developed countries, are becoming more cautious in their licensing strategies than in the past. This underlines the need on the part of developing countries to bring down the investment costs for petrochemical plants in their home markets based on generally accessible, more convential, technology. At the same time engineering contractors must prepare bids on the basis of realistic location factors that truly reflect the difficulties in erecting plants at one location versus another. In this context, assessing location factors in developing countries and persuading engineering contractors to adopt the lower values in their calculations is an area where UNIDO could provide worthwhile assistance.

2.9 Transportation of petrochemicals

Given a favourable production cost profile at one location, two further factors are important in determining the competitivity of petrochemicals at a second location. Market access factors - tariffs and the cost of overcoming non-tariff barriers - were discussed in chapter II: this section focuses on the cost of transporting petrochemical products to international markets. Freight costs are assessed at two points in time, 1980 and 1985, for four basic product types [31/] being exported from three developing countries to each of three developed country markets:

These petrochemical products:	Exported from these developing countries:	To each of these industrialized country markets:
LPG (similar to ammonia, ethylene and propylene)	Indonesia, Mexico, Qatar	United States Northern Europe, Southern Europe, Japan
Methanol (similar to ethylene glycol and other chemicals not requiring refrigeration or pressurization)		
Urea in bulk and bags		
PVC powder in bulk and bags (similar to low- and high-density polyethylene)		

In each case it is assumed that product is shipped by sea to a port in the industrialized country market from which local distribution costs would be equal to those of a local competing producer, and for the purposes of this comparison can therefore be ignored. The resulting matrix of transportation costs (table 2.20) is built up from a consideration of the following factors: cargo characteristics, type of carrier required (e.g. pressurization, refrigerization or both), carrier newbuilding prices, carrier operating costs (manning, repairs and maintenance, insurance, etc.), voyage costs (fuel, port charges, canal dues), and vessel size (varying vessel size versus standard unit size).

31/ Shipping data for LNG were also studied; see "Study of Transport Costs for Shipping Petrochemical" H.P. Drewry Ltd., London, February 1981.

To forecast shipping charges for 1985, it was assumed - in line with forecasts for production plant earlier in this chapter - that ships would be ordered in 1983 and operational by 1985. Operating costs are expected to increase at 10 per cent per year in current dollars, their historical rate—port costs are assumed to pace inflation at 8.5 per cent per year and canal dues for the Suez routes are fixed in SDR units. Bunker prices were calculated assuming crude oil prices would rise either $40 or $80/barrel in 1985. In this section a median value has been taken, relating approximately to $60/barrel, i.e. $40 in 1980 dollars.

Table 2.20 shows the freight costs involved in shipping product from developing countries to developed country markets in 1980. In this connection several points are clear. Firstly shipping charges are an important factor compared to production costs in determining competitivity. Taking exports from Qatar as an example (Table 2.21), they exceed 10 per cent of production costs for ammonia, ethylene, polyethylene (high-, low- and linear-low density), methanol and urea going to all three industrialized markets. In the case of ammonia, ethylene and urea, freight charges account for 20 to 40 per cent of production costs.

The importance of shipping costs changes with the producer's position in the petrochemical chain. They are at their highest with methane (LNG) and ethane, pass through a minimum with methanol as a representative non-refrigerated, non-pressurized liquid product, finally rising again for the solid products such as polyethylene. In each case the cost is strongly influenced by the use of varying or standard vessel sizes:

- ethylene glycol could be shipped at up to 70 per cent of methanol transportation charges due to specific gravity differences. This differential would be reduced by higher capital charges for more expensive tanks, however;
- although neither glycol nor methanol are required—under IMCO regulations—to be shipped in chemical carriers, future revision could classify them as type III cargoes (least hazardous of the dangerous chemicals), effectively doubling transportation costs;
- the impact of bagging (versus bulk shipment) is to increase transportation costs for urea, for example, by 66 per cent. This mainly reflects a difference in stowage factor of 1.4 cu.m./ton for bulk and 1.52 cu.m./ton for bagged products;
- other solid products would cost more or less according to their stowage factors: bulk PVC powder, 1.98; bagged PVC powder, 2.2; LDPE bulk, 2.35; bagged LDPE, 2.63; bulk HDPE, 2.265 and bagged HDPE, 2.60 cu.m./ton;
- all transportation costs are calculated assuming return journeys being made in ballast, a backhaul cargo could thus reduce costs considerably.

2.10 Competitivity in major markets

The main precondition for export success is a landed price that is lower than prevailing market prices. The purpose of this section is to demonstrate to what extent this condition is met for petrochemicals being shipped from developing to developed country markets in 1980 and how the situation could change by 1985. Landed prices are computed by adding transfer prices at the production plant (discussed earlier in this chapter) to freight costs (presented in the previous section) and applying ad valorem or equivalent tariff rates (Table 3.5, chapter III). The complete results for 18 products are presented in tables 2.22, 2.23 and 2.24.

Table 2.20 Freight costs for shipping petrochemicals to industrialized country markets in 1980
(1980 dollars)

Destination market		Japan	Northern Europe	Southern Europe	United States
Producer (exporter)	Product	$/ton	$/ton	$/ton	$/ton
Qatar	LPG	41.1	45.5	34.4	59.0
	Ammonia	35.4	39.1	29.6	50.1
	Ethylene	43.2	47.8	36.1	61.2
	Propylene	40.3	44.6	48.2	78.4
	Methanol	19.2	21.8	16.6	29.0
	Urea (bulk)	39.2	41.6	33.1	54.2
	Urea (bagged)	67.0	69.2	58.4	84.6
	PVC (bagged)	85.1	88.2	72.5	110.7
	LDPE (bagged)	92.3	95.7	78.7	120.0
Mexico	LPG	59.1	33.3	56.1	9.0
	Ammonia	50.8	28.6	48.2	7.7
	Ethylene	62.1	35.0	58.9	9.4
	Propylene	67.4	38.0	63.9	10.3
	Methanol	27.9	15.6	16.6	4.0
	Urea (bulk)	54.1	31.9	34.8	11.5
	Urea (bagged)	85.1	58.0	66.1	31.7
	PVC (bagged)	109.9	72.0	83.7	34.4
	LDPE (bagged)	119.3	78.1	90.8	37.3
Indonesia	LPG	24.3	53.1	42.3	68.8
	Ammonia	20.9	45.7	36.4	59.1
	Ethylene	25.5	55.7	44.4	72.2
	Propylene	27.7	60.5	48.2	78.4
	Methanol	11.4	25.2	20.2	35.5
	Urea (bulk)	24.9	48.1	39.6	61.1
	Urea (bagged)	49.2	77.2	66.6	93.2
	PVC (bagged)	59.4	99.8	84.4	123.0
	LDPE (bagged)	64.4	108.2	91.6	133.5

Table 2.21 Cost of shipping petrochemicals from Qatar to industrialized country markets (1980)

Product	Production Cost[a/] $/ton	Freight cost to:							
		Japan		North Europe		Southern Europe		United States	
		$/ton	% production cost	$/ton	% production cost	$/ton	% production cost	$/ton	% production cost
Ammonia[b/]	151	35.4	23.5	39.1	25.9	29.6	19.6	50.1	33.2
DMT	928	19.2	2.1	21.8	2.3	16.6	1.8	29.0	3.1
Ethyl benzene	618	19.2	3.1	21.8	3.5	16.6	2.7	29.0	4.7
Ethylene[c/]	290	43.2	14.9	47.8	16.5	36.1	12.5	61.2	21.1
Ethylene glycol	845	19.2	2.3	21.8	2.6	16.6	1.9	29.0	3.4
Ethylene oxide	695	19.2	2.7	21.8	3.1	16.6	2.4	29.0	2.4
HDPE	737	92.3	12.5	95.7	13.0	78.7	10.7	120.0	16.3
LDPE	638	92.3	14.5	95.7	15.0	78.7	12.3	120.0	18.8
LLDPE	710	92.3	13.0	95.7	13.5	78.7	11.1	120.0	16.9
Methanol[b/]	110	19.2	17.3	21.8	19.7	16.6	15.0	29.0	26.2
PET[d/]	1874	92.3	9.9	95.7	5.7	78.7	4.2	120.0	6.4
PP	944	92.3	9.8	95.7	10.1	78.7	8.3	120.0	12.7
PS	1051	92.3	8.7	95.7	9.1	78.7	7.5	120.0	11.4
PVC	1344	85.1	6.3	88.2	6.5	72.5	5.4	110.7	8.2
SBR	1671	92.3	5.5	95.7	5.7	78.7	4.7	120.0	7.2
Styrene	831	19.2	2.3	21.8	2.6	16.6	2.0	29.0	3.5
TPA	972	19.2	1.2	21.8	2.2	16.6	1.7	29.0	3.0
Urea (bulk)		39.2	29.2	41.6	31.0	33.1	24.7	54.2	40.4
VCM		43.2	6.7	47.8	7.5	36.1	5.6	61.2	9.6

Typical shipping costs for petrochemicals:
Qatar to Northern Europe, 1980

(Dollars per ton)

Product	Vessel type	Transportation costs	
		Variable vessel size	Standard vessel size
Methane (as LMG)	Refrigerated	-	70.34 a/
LPG	Pressurized and semi- or fully-refrigerated	50.22	45.5o b/
Ethylene	Fully refrigerated	52.73	57.77 b/
Methanol	Products carrier	26.39	21.76 c/
	Chemical tanker type III	-	42.08
Urea (bulk)	Bulk carrier	41.63	-
Urea (bagged)	Bulk carrier	69.23	-
PVC (bagged)	Bulk carrier	88.23	-
LBPE (bagged)	Bulk carrier	95.75	-

a/ 125-130,000 cu.m.

b/ 75,000 cu.m.

c/ 55,000 DWT.

In connection with the above table it may be noted that:

- using standard vessel sizes dedicated to particular materials can reduce shipping costs by 10 to 25 per cent;
- in the LPG group, the lower specific gravity of anhydrous ammonia reduces transportation costs to 86 to 87 per cent of those for LPG;
- conversely, ethylene will cost more to ship than LPG due to lower refrigeration temperature: a 5 per cent premium is assumed;
- propylene's lower specific gravity would increase shipping costs by 14 per cent compared to LPG;

Table 2.22 Production cost, shipping charges and tariffs influencing competitivity of petrochemicals from Indonesia exported to industrialized country markets landed vs. local costs (1980) (US dollars/ton)

Product	Production Cost at 5%	Export Market															
		Japan				Northern Europe				Southern Europe							
		Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25 %
Ammonia	195		23	239	375	46	27	268	345	36	25	256	345	59	6	260	317
DMT	1178		—	—	—		—	—	—		—	—	—		—	—	—
Ethyl benzene	680		—	—	—		—	—	—		—	—	—		—	—	—
Ethylene	375	25	24	424	746	55	27	458	918	44	26	445	918	72	80	497	
Ethylene glycol	1107		—	—	—		—	—	—		—	—	—		—	—	—
Ethylene acid	905		—	—	—		—	—	—		—	—	—		—	—	—
HDPE	886	963	104	1053	1479	107	124	1117	1379	91	122	1099	1379	131	110	1127	
LDPE	849		100	1023	1367	108	120	1076	1295	90	118	1059	1295	133	106	1088	
LLDPE	848		100		1144	108	119	1075	1243	92	117	1057	1243	133	106	108	
Methanol	137	11	7	155	352	25	21	183	313	20	20	177	313	32	25	194	
PET	2336		—	—	—		—	—	—		—	—	—		—	—	—
Polypropylene	1112	64	258		1283	108	152	1372	1129	92	150	1354	1129	133	139	1384	
Polystyrene	1185	64	175		1474	108	161	1455	1262	92	160	1437	1262	133		1519	
PVC	1699	59	105	1863	1473	100	225	2024	1310	84	223	2006	1310	123	172		
SBR	1856	64	0	1920	2334	108	59	2023	2286	92	58	2006	2286	133		1989	
Styrene	939		—	—	—		—	—	—		—	—	—		—	—	—
TPA	1201		—	—	—		—	—	—		—	—	—		—	—	—
Urea	168	39	—	—	—	48	—	—	—	39	—	—	—	61	—	—	—
VCM	902		—	—	—												

Table 2.23 Production cost, shipping charges and tariffs influencing competitivity of petrochemicals from Qatar exported to industrialized country markets landed vs. local costs (1980) (US dollars/ton)

Product	Production Cost at 5%	Export Market															
		Japan				Northern Europe				Southern Europe							
		Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25 %
Ammonia	151		7	193	375	39	21	211	345	30	11	192	345	51	5	207	317
DMT	928		—														
Ethyl benzene	618		—														
Ethylene	290	43	20	353	746	48	21	359	918	36	20	346	918	62	0	352	612
Ethylene glycol	845		—														
Ethylene acid	695		—														
HDPE	737	91	91	919	1479	95	104	936	1379	78	102	917	1379	119	92	948	1061
LDPE	638	92	80	810	1367	96	92	826	1295	79	90	807	1295	120	80	838	979
LLDPE	710	92	88	890	1144	96	100	902	1243	79	99	888	1243	120	89	919	751
Methanol	111	19	6	136	352	22	17	150	313	17	17	145	313	29	20	160	281
PET	1875		—	—	—		—	—	—		—	—	—		—	—	—
Polypropylene	—	92			1283	96			1129	79			1129	120	181		986
Polystyrene	1051	92	160	1303	1474	96	143	1290	1262	79	141	1271	1262				
PVC	1343	85	86	1514	1473	88	179	1610	1810	73	177	1593	1310	120	131	1302	1068
SBR	1671	92	0	1763	2334	96	53	1820	2286	79	52	1802	2286	111	136	1590	1090
Styrene	831		—											120	0	1791	2079
TPA	972																
Urea	134	39	—	—	—	41	—	—	—	33	—	—	—	54	—	—	—
VCM	639		—	—	—		—	—	—		—	—	—		—	—	

Table 2.24 Production cost, shipping charges and tariffs influencing competitivity of petrochemicals from Mexico exported to industrialized country markets landed vs. local costs (1980) (US dollars/ton)

Product	Production Cost at 5%	Export Market															
		Japan				Northern Europe				Southern Europe							
		Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25%	Shipping Cost	Tariff	Total Cost	Local Cost at 25 %
Ammonia	126	51	7	184	375	29	17	172	345	48	19	193	345	8	4	138	317
DMT			—	—	—		—	—	—		—	—	—		—	—	—
Ethyl benzene	431		—	—	—		—	—	—		—	—	—		—	—	—
Ethylene	282	62	21	365	746	35	20	337	9.8	59	21	362	918	9	0	291	612
Ethylene glycol	707		—	—	—		—	—	—		—	—	—		—	—	—
Ethylene acid	581		—	—	—		—	—	—		—	—	—		—	—	—
HDPE	625	118	82	825	1479	77	88	790	1379	90	89	804	1379	36	75	736	1061
LDPE	539	119	72	730	1367	78	77	693	1295	91	79	709	1295	37	67	643	979
LLDPE	606	119	80	805	1144	78	85	770	1243	91	87	784	1243	37	75	719	751
Methanol	93	28	6	127	352	16	14	123	313	17	14	124	313	4	16	114	188
PET	1615	—	—	—	—		—	—	—		—	—	—		—	—	—
Polypropylene	519	119	140	778	1283	78	75	672	1129	91	76	686	1129	37	65	621	986
Polystyrene	774	119	125	1018	1474	78	106	958	1262	91	108	973	958	37	132	942	1068
PVC	796	110	54	960	1473	72	108	976	1310	84	110	990	1310	34	80	910	1090
SBR	1255	119	0	1374	2334	78	40	1373	2286	91	40	1386	2286	37	0	1292	2079
Styrene	603		—	—	—		—	—	—		—	—	—		—	—	—
TPA	876		—	—	—		—	—	—		—	—	—		—	—	—
Urea	109	54	—	—	—	32	—	—	—	35	—	—	—	12	—	—	—
VCM	646		—	—	—		—	—	—		—	—	—		—	—	—

Tables 2.22, 2.23 and 2.24 permit two general conclusions concerning competitivity of developing countries petrochemicals in 1980. Firstly, geographically well placed countries such as Mexico and those in the Middle East can land olefins and olefin derivatives at lower prices than those expected from similar new plants built in the industrialized countries. The main qualification is that the developing country producers may have to accept a relatively low rate of return on investment, e.g. five per cent, while competing industrialized country producers can price at levels that yield a 25 per cent return before tax.

The exceptions in the Middle East are petrochemicals with an aromatic base and those involving chlorine made on a dedicated chlor-alkali unit. As noted earlier in this chapter, aromatics prices are likely to be high in countries where the refining sector is under-developed, but this position could change radically in the oil exporting developing countries within a few years. Similarly, chlorine could drop dramatically in price as soon as markets are obtained for by-product caustic soda and where large chlor-alkali plants can be constructed.

In contrast, some developing countries are either not well placed geographically or suffer heavy disadvantages due to high capital costs. Indonesia, for example, could compete in intermediates and polyolefins in Japan and Europe but would find it difficult to export finished polymer to the United States.

The second conclusion is an issue directly for government negotiations: while tariffs on intermediates such as ethylene are modest, on finished products they account for a significant portion of landed price - often equalling or exceeding costs of shipment. High tariff rates are not consistent with the recommendation of the First Consultation on the Petrochemical Industry 32/ that future plants for basic and intermediate products should be constructed preferably in developing countries with oil and gas resources. On the basis of the 1980 figures the commercial wisdom of high tariffs can also be questioned. Among the polyolefins, tariffs are not high enough to offer serious protection to inefficient industrialized country producers. Their impact therefore is simply to raise prices to consumer industries in the industrialized country markets or to depress profitability of production in developing countries.

32/ Report of the First Consultation, ID/227, paras 2 (i) and 2 (o)

2.11 Summary and conclusions

The petrochemical industry has enjoyed a unique position among all industries in that the prices of all its products have been declining throughout the post-war period due mainly to the then prevailing low costs of raw material and energy, the tremendous technological progress that took place during the period and the increases in plant capacities and their subsequent effect on the cost of unit produced. However, due to the highly centralized nature of the industry and the effective possibility of price control the price/cost relationship for petrochemical products were still considered high compared to other industrial products thus offering higher rates of profits while at the same time maintaining a high demand to push the industry forward.

The price increases in crude oil and energy since 1973 have, however, changed the situation and upset all the previously established balances. Prices became erratic and a new price/cost relationship has been introduced where the ratios of product prices to feedstock prices have been greatly reduced, reflecting the increasing impact of feedstock on cost and final prices. In the context of declining demand due to the general economic recession and the excess capacity resulting from previous anticipation of continuous high growth of demand, prices fell at times short of production costs. Due to the expected cost increase of raw material and energy as well as the increase in investment outlays, it is believed that the future tendency of the prices of petrochemicals will be characterized by a continuous increase closely related to the growth in feedstocks and energy prices.

The close analysis of the cost structures of 18 petrochemical products has further revealed that the most important factors affecting investment costs were inflation and plant size. For developing countries extra investment outlays connected to their locations is by far the most influential factor on investment as well as production cost. What is known as location factors for developing countries varies between 1.25 and 2.1 compared to a factor of 1.0 at a US Gulf location for the same plant. The main elements of production costs, i.e. capital costs (depreciation, rate of return on investment, etc.), working capital, feedstock, fuel and energy costs, credits for by-products, plant loading factors, plant size and process used, were all analysed in detail for all eighteen products at six different locations in developed and in developing countries.

The impact of each of these factors was subjected to sensitivity analysis in order to ascertain the range of its influence on net production cost. The objective of these in-depth analyses was to come out with a picture, as clear as possible, of the viability of establishing a competitive petrochemical industry in some developing countries and to accurately assess the degree of this competivity with similar products produced in the developed countries. Because the prices of petrochemical products in 1980 were not in many ways representative of a normal situation (i.e. in many cases they were below costs or with marginal profits), an additional future year was considered, 1985, in which transfer prices were used in order to have a better view of competivity. This projection of competivity into the future greatly improved the competitive position of the selected developing countries vis-a-vis the developed countries.

Since the techno-economic characteristics of the industry impose the establishment of production capacities far in excess of the internal demand for their products in most of the countries examined here, the competivity analysis has to be taken a step further to the markets of the major consumer/producer developed regions, i.e. Japan, the USA and Western Europe. For this purpose transportation costs for the various products and in the various regions were analysed. To the transportation costs were then added the expected tariff charges to arrive at the final cost/price of the products in the markets of the developed retions. Through this elaborate exercise it was established that the selected developing countries could be competitive in the markets of developed regions in a number of petrochemical products and their position would further improve if they were ready to foresake some of the stringent postulates usually adopted by market economy developed countries such as 25 per cent ROI, 10 per cent per annum depreciation, interest on working capital, etc.

Furthermore, tariff and non-tariff restrictions imposed by the developed countries have to be eased in order to facilitate the flow of these products. It should also be recognized that such action would have to be taken within the general framework of a global agreement based on macroeconomic relationships between the developed and developing countries.

III INTERNATIONAL TRADE IN PETROCHEMICALS : THE NEED FOR RESTRUCTURING

3.1 Structure of international trade in petrochemicals

3.1.1. Chemicals

The chemical industry is among the most dynamic sectors in any industrial economy. With its extensive range of listed products, the chemical market includes approximately 40 different sub-branches, which together manufacture many thousands of products. During the entire post-war period this market has been characterized by high rates of growth, major changes in its branch structure and intensive exploitation of breakthroughs in science and technology.

In the period of 1950-1970 world chemical production increased fivefold, and average annual growth rate was 8.4 per cent as compared with 5.7 per cent for total industrial production. In spite of the slower growth rate since 1973, it still remained higher than that of total industrial production. As a result the share of the chemicals in industrial production of major developed countries increased from 5-7 per cent in 1950 to 10-14 per cent in the 1970s. By production value, it ranks as a rule the third among different industrial branches.

The industry is heavily concentrated in developed countries in terms of production and consumption.

Chemicals are one of the fastest growing groups in international trade. During 1950-1970 their export increased more than ten times compared with total export increase of five times - annual growth in chemicals was 12.4 per cent, whilst total export growth was 8.3 per cent.

The pattern of industrial localization applies to the trade flows of chemicals and petrochemicals in general, and up to now it has been dominated by the activities of the developed market economies (Table 3.1). During the 1970s the whole chemical sector accounted for 7 per cent of the total world trade, with the developed market economies leading the rest of the world in the volume of trade. The share in world chemical trade of the centrally planned economies, on the other hand, has been

Table 3.1

World trade in chemicals

(in million US dollars f.o.b.)

Exports to / Exports from	Year	World	Market Economies: Developed	Market Economies: Total Developing	Market Economies: OPEC	Centrally Planned Economies
World	1974	64424	42789	15873	2977	5463
	1975	60898	37942	16441	3770	6374
	1976	68385	45324	16114	3558	6178
	1977	78146	51300	18987	4495	7120
	1978	95927	62565	24048	5517	8410
Developed Market Economies	1974	56559	39189	13633	2582	3492
	1975	53205	35256	13962	3251	3888
	1976	60346	42348	13726	3179	3581
	1977	68561	47486	16089	3966	4239
	1978	85312	58869	20390	4889	5184
Developing Market Economies	1974	4012	2181	1650	276	174
	1975	3273	1378	1691	325	181
	1976	3597	1716	1697	230	188
	1977	4611	2358	2029	352	236
	1978	4851	2055	2547	416	222
OPEC	1974	550	278	243	43	29
	1975	569	241	311	102	17
	1976	649	367	247	36	33
	1977	633	365	204	38	52
	1978	537	158	338	52	39
Centrally Planned Economies	1974	3854	1419	589	119	1797
	1975	4420	1308	789	194	2305
	1976	4442	1260	691	148	2410
	1977	4975	1456	869	177	2645
	1978	5764	1642	1112	212	3004

Source: Monthly Bulletin of Statistics, United Nations, July 1980
Note: (SITC, Revised, 5)

Table 3.2

STRUCTURE OF WORLD TRADE - Share by Regions for Chemicals (Percentage)

Export to / Export from	Year	Share of Trade in Chemicals: Origin of Export: Total	Share of Trade in Chemicals: Origin of Export: Chemicals	Share of Trade in Chemicals: Destination of Export: Total	Share of Trade in Chemicals: Destination of Export: Chemicals	Share of World Trade by Regions: Origin of Export: Total	Share of World Trade by Regions: Origin of Export: Chemicals	Share of World Trade by Regions: Destination of Export: Total	Share of World Trade by Regions: Destination of Export: Chemicals
1. World	1970	100	7.0	100	7.0	100	100	100	100
	1975	100	7.0	100	7.0	100	100	100	100
	1977	100	6.9	100	6.9	100	100	100	100
	1978	100	7.4	100	7.3	100	100	100	100
2. Developed Market Economies	1970	100	8.7	100	6.5	71.8	88.6	70.1	66.2
	1975	100	9.2	100	6.7	66.1	86.7	65.7	62.5
	1977	100	9.4	100	6.8	64.8	88.0	67.0	65.9
	1978	100	9.8	100	7.2	67.2	88.5	67.0	65.8
EEC	1970	100	10.1	100	7.1	35.9	51.5	35.1	35.6
	1975	100	10.9	100	7.6	33.9	52.7	32.6	35.3
	1977	100	11.3	100	7.8	33.7	54.9	32.9	37.2
	1978	100	11.5	100	8.5	35.3	54.9	33.6	38.8
USA	1970	100	9.0	100	3.2	13.6	17.5	12.5	5.7
	1975	100	8.4	100	3.9	12.2	14.2	10.7	6.0
	1977	100	9.2	100	3.7	10.5	13.9	12.8	6.9
	1978	100	9.7	100	3.7	10.8	14.1	13.0	6.5
Japan	1970	100	6.4	100	5.2	6.2	5.6	5.0	3.7
	1975	100	7.0	100	3.5	6.4	6.3	5.8	2.9
	1977	100	5.3	100	4.1	7.2	5.5	5.6	3.3
	1978	100	7.4	100	4.3	5.1	5.2	5.3	3.2
3. Developing Market Economies	1970	100	1.7	100	9.1	17.6	4.3	18.6	24.3
	1975	100	1.8	100	8.2	24.2	6.	23.3	27.0
	1977	100	1.5	100	7.3	25.7	5.5	23.5	24.8
	1978	100	1.6	100	6.1	23.2	5.6	23.5	25.3
OPEC	1970	100	0.4	100	8.4	5.8	0.3	3.1	3.7
	1975	100	0.5	100	6.6	12.9	0.9	6.6	6.2
	1977	100	0.2	100	5.5	13.4	0.4	7.3	5.8
	1978	100	0.3	100	5.6	11.2	0.5	7.5	5.8
4. Centrally Planned Economies	1970	100	4.7	100	6.5	10.5	7.1	10.4	9.5
	1975	100	5.2	100	7.0	9.7	7.2	10.6	10.5
	1977	100	4.7	100	6.8	9.5	6.5	9.5	9.3
	1978	100	4.6	100	6.8	9.6	5.9	9.5	8.9

Source: Based on monthly Bulletin of Statistics, UN July 1980.

Table 3.3 Structure of the international market of chemicals by area of origin and destination in 1978

(billion US dollars)

EXPORTS from / EXPORTS to:	World	Developed Countries	Developing Countries	Centrally Planned Economies
World	95.9 (100.0%)	62.6 (65.2%)	24.0 (25.1%)	8.4 (8.8%)
Developed Countries	85.3 (100%)	58.9 (69.1%)	20.4 (23.9%)	5.2 (6.1%)
Developing Countries	4.9 (100.0%)	2.1 (45.0%)	2.5 (52.0%)	0.22 (4.4%)
Of which: OPEC Countries	0.5	0.16	0.34	0.4
Centrally Planned	5.8 (100.0%)	1.6 (28.5%)	1.1 (19.3%)	3.0 (52.1%)

Source: Based on Monthly Bulletin of Statistics, U.N. July 1980 rather low, followed only by the share of the developing countries regions as far as export is concerned (Table 3.2).

As a group, the developing countries are second only to EEC in the import of chemicals. Chemical exports to the developing countries originate mainly in developed countries, although an increase in chemical inter-trade among developing countries, and a small but rising growth of chemical export to developed countries from developing countries has been noticed (Table 3.1). The bulk of chemical export originated in developing countries includes fertilizers and some finished products.

3.1.2 Petrochemicals

In the period of the 1950s and 1960s the application of new technologies led to the use of oil and gas refinery products, such as feedstocks for chemical production. The economic advantages were responsible for a steady increase in the share of oil and gas in the sector's over-all raw material balance and a rise in the proportion of petrochemicals in the industry's output, reaching 50-70 per cent in the developed countries in the 1970s. The petrochemical sector made remarkably rapid headway. While total industrial production in OECD members rose during the period 1960-1973 by 5.6 per cent annually and chemical production by about 8-9 per cent, petrochemicals showed a rate of growth between 10 and 17 per cent for important products (butadiene - 10 per cent, benzene - 13 per cent, propylene - 16.5 per cent, ethylene - 17 per cent). In volume terms, between 1960 and 1973 production went up (in million tons) for ethylene from 3 to 24 (30 in 1980); for propylene - from 1.6 to 12.4 (16 in 1980); for butadiene - from 1.1 to 3.7 (4.5 in 1980); for benzene - from 2 to 11 (14 in 1980).

During the period 1950-1970 world consumption of synthetic fibres (in volume terms) increased by 68 times, plastics - 18 times and synthetic rubbers - 9 times. In the same period while total value of chemical export rose by 10.3 times, export of organic chemicals - by 24 times and that of plastics - by 32 times. Meanwhile, export grew considerably more (in volume): plastics - 76 times, synthetic fibres - 55 times, synthetic rubbers - 28 times. The increasing share in total chemical export of organic chemicals and plastics (15 per cent in 1950 and 40 per cent in 1970) as well as synthetic fibres and rubbers reflects the main changes in the structure of world chemical trade in favour of petrochemicals.

Under the prolonged economic recession and deepening of the energy crisis since 1973, the rates of growth of petrochemical production, consumption and international trade slowed but still remained higher than for the chemical industry as a whole.

The pattern of trade flows for chemicals also applies to petrochemicals. However, a distinction has to be made in respect to the group of products involved. The largest international trade flows for bulk petrochemicals are concentrated in developed market economies and in particular, in those of inter-trade in Europe. By comparison, inter-continental trade in bulk petrochemicals is still at relatively modest rate (Annex III.A)

The share of the developing countries in world trade of petrochemical has been low and only in recent years some exports; mainly fertilizers and natural gas derivatives (methanol to EEC, Japan and United States and ammonia to developed market economies, except Japan) grew at a significant rate.

3.2 Organization of petrochemical markets and distribution systems

In the developed countries many large chemical companies have been steadily moving towards closer integration of their downstream operations. The bulk of oil based feedstock for olefins and aromatics production are supplied by pipelines from nearby refineries or gas liquids fractionation plants. Apart from feedstocks transportation savings the co-products or by-products from ethylene cracking can be easily transferred back to the refinery. Since cracking economics dictate high levels of plant loading, companies try to raise the volume of captive consuming business which they control. Consequently, the merchant olefins sellers have seen their business reduced. However, in N.W. Europe and US Gulf Coast the pipeline system gives possibility to maintain some level of merchant market and producers/buyers located on these grids have not had the worries as olefins producers in isolated locations.

The primary chemical products, where downstream integration has been sought are as follows:

Ethylene	HDPE, LDPE ehtylene oxide, ethylene glycol, styrene, ethylene dichloride (EDC), VCM,
Propylene	Polypropylene, cumene, acrylonitrile,

Butadiene	SBR,
Benzene	Styrene, cumene,
Paraxylene	DMT/TPA,
Orthoxylene	Phtalic anhydride.

Of the three main industrial areas, i.e. Western Europe, United States of America and Japan, integration levels between building block chemicals and downstream derivatives, are at their highest in Western Europe, owing to the intense competition. In the production of LDPE/HDPE, ethylene oxide/ethylene glycol, styrene, cumene , acrilonitrile, SBR, the level of integration and captive supplies is extremely high. However, the degree of integration in production of EDC/VCM, para-xylene, orthoxylene is much lower. In the United States there is a high level of integration but the sheer size of the market has enabled a much larger number of non-integrated or partly integrated downstream producers to stay in business. The level of integration and consequently the captive supplies are considerably less in Japan.

The merchant markets are made up of both buyers and sellers, who are wholly non-integrated or are only partially integrated. The merchant business can be broken down into contract sales and spot sales. There are merchant markets, which are concentrated and comparatively price stable and other markets, which are fragmented and price unstable. This market characteristics reflect the types of companies involved in a particular business sector. Ethylene, propylene, butadiene, benzene and para-sylene are products traded mostly between relatively few producers/sellers. Nearly all transactions are between relatively large companies under contracts (3-5 years). For new suppliers this is a good type of markets, since both buyer and seller need each other over a long period. On the other hand, styrene and orthoxylene generally move to a smaller type of chemical companies, the market is more fragmented and the attitude is that the cheapest price takesthe business when the demand is weak. In these markets large intra-company transactions and long standing relations in general are not a rule. Besides, the loaders and brokers are much more heavily involved than they are in olefins and this may be a contributing factor. Spot sales include both regular business of a speculative nature and non-recurring business. Even a large buyer of a given commodity will cover no more than, say, 80 per cent of his requirements by contracts. The rest will be acquired on the spot market in the hope that by means of agile purchasing the weighted average cost of the commodity can be somewhat reduced, without incurring too much outside risks. The spot market is handled mainly by brokers and traders.

During late 1960s and early 1970s the number of chemical trading companies grew to more than 100 companies. But growing popularity of long-term direct relations between producers and consumers is one of the reasons for the shrinking role of trading companies.

A characteristic feature of the chemical products market at the present is the stability of the relationships both between producers and consumers in national markets, and between exporters and importers in international trading. This is reflected in the increasing practice of concluding long-term contracts for the sale of chemicals in recognition of the advantages offered by stable supply relationships as opposed to short-term operations. By ensuring guaranteed markets and supply sources for raw and other materials, long-term contracts help to keep production facilities operating at higher capacity, contribute to lower production costs, and enhance the opportunities for production planning. In addition, because of the reliable quality characteristics of the raw materials used and the goods produced, the possibility of employing stable technological processes is afforded. This is particularly important at a time when the scale of production is being significantly increased, thereby complicating the restructuring of production processes and the transition to new product lines.

Lowering the utilization of capacity at a production facility causes a substantial increase in production costs. For example, in the case of a 400,000 ton/year ethylene production plant operating at 75 and 50 per cent of its optimal capacity, ethylene production costs increase by 15 and 45 per cent, respectively[33/].

In international trading, long-term contracts have become most common in the case of those kinds of chemical products for which stable quality is a major factor. This is true of the majority of basic petrochemicals.

33/ The Petrochemical Industry. United Nations, New York, 1973, p.3.

The greater volume of trade being conducted on the basis of long-term contracts is having a marked effect on chemical prices. The history of international trading on this basis indicates that, during the post-war period, the most common approach in such contracts has been the method of fixed prices set for a definite period, after which they are subject to review in the light of changes in the basis production and overhead cost components having the greatest effect on prices. Under long-term contracts, changes in the manufacturer's production costs are generally compensated not in full, but within certain limits, agreed by the parties, within which prices may deviate during the subsequent period with respect to the original (base) period. Thus, in the case of ethylene, a standard reservation on the review of the fixed base price has included a cost variation index for labour, materials, and the basic raw material - naphtha. Accordingly, the base price level may be changed by as much as 70 per cent [34].

Other methods of adjustment, which take into account changes in the producer's costs, the foreign-trade prices charged by other countries, etc. are also in use. As a rule, the intention of the parties concluding a long-term contract is that the prices under the contract should not differ substantially from current market prices, i.e. the so-called "open market" prices, as this has an adverse effect on the interests of both buyer and seller. While by and large reacting to the movement of open market prices, the prices charged under long-term contractual agreements remain stable over specified periods and do not reflect current fluctuations in market conditions. The disparity in the prices charged under long-term contracts and those charged for one-time (spot) deals is a reflection of the ratio of the advantages to the partners as a result of the establishment of long-term commercial contracts and the consequent reduction in production and overhead costs. However, despite the relatively minor share of short-term commercial operations, the open market price functions as a price "leader" for long-term contracts as well. As spot prices rise, companies that normally sell on a long-term basis endeavor to dispose of as much of what they produce as possible on the open market, while conversely buyers try to curtail their open-market purchases. As the process also

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34/ European Chemical News, 22 No 563, 18 (1972).

works in the opposite direction, the result is an equalization of long-term and spot prices.

The events of 1973-1974 showed that for many chemicals the price level increased by a factor of 3 to 6 over the 1972 level. At the same time the accompanying shortages gave rise to a proliferation of prices for one and the same kinds of products. The peak prices, however, not only reflected the real extent of chemical shortages and the rise in production costs, but were also very largely speculative in nature. Taking advantage of the higher prices, even major producers substantially expanded their sales on the spot market. The most severe losses during this period were sustained by those raw-material-consuming companies whose purchases were not ensured by long-term contracts, under which the price level was considerably lower than on the spot market. At the beginning of 1974, for example, the prices for styrene charged by the large Western European exporters were U$S 600-900 per ton, while the spot prices were as high as U$S 1,200-1,700 per ton.

The substantial increase in prices for petrochemical raw materials in the 1970s and the sharp fluctuations in prices during certain periods were responsible for a shortening of the specified period of fixed prices guaranteed under long-term contracts. Adaptation to new market conditions resulted in a greater degree of mobility in the prices charged under these contracts and their convergence with the prices prevailing on the "open" market.

At the present, very few products are the subject of traders' attention. Their involvement with benzene, paraxylene, ammonia and ethylene glycol is low in comparison with the volume moving from company to company; it is specialized traders who own facilities, i.e. Transammonia owns ships. On the other hand, styrene, orthoxylene, phthalic anhydride and methanol have always had a high level of traders' involvement, although the actual volumes handled by traders probably do not account for more than 15 per cent of the total market. The traders have no essential place in the basic chemical business and for overseas suppliers it is better to establish direct relations with end-users. But in some cases and for particular types of companies or commodities, trading companies with experience, know-how and contacts can serve several useful functions.

In the chemical business, distributors are service-oriented companies that are selling and delivering the products of large chemical companies to small consumers as well as the products of companies that cannot afford the cost of their own sales network. Most distributors own warehousing facilities and a fleet of delivery trucks. Their flexibility enables them to service large numbers of small customers. The chemical companies use distributors when they are unable or unwilling to set up similar organizations of their own. The distributors rarely handle building-block chemicals, but are widely involved in markets such as phthalic anhydride and polymers, where the end-user pattern is highly fragmented.

In attempting to enter markets in the developed countries, new suppliers' strategies must be product-based because the type of product will determine the strategy used. In general for petrochemicals, which have a restricted number of buyers - for example, ethylene, it is desirable to sell directly to end-users. However, once a move downstream into products is contemplated, which are performance-oriented, and the end-users' pattern is fragmented, such as styrene monomer and plastics, the problems of marketing, technical support and distribution arise.

3.2.1 Basic petrochemicals

In the United States there are significant merchant markets in all the major petrochemical products, but particularly in butadiene, benzene, styrene, VCM and orthoxylene. There is less of a merchant market in propylene, cumene, paraxylene, DMT-TPA and acrylonitrile. Although in Western Europe there are relatively few totally non-integrated companies, the merchant market still tends to be quite large because of imbalances within companies, particularly in ethylene, propylene and butadiene. Benzene is also a moderately open market, as is orthoxylene; paraxylene, on the other hand, is mostly a restructed market. Amene is now closely integrated. The merchant styrene market is comparatively large, but recently it has shrunk. In Japan, a significant market appears to exist for most products.

In comparison with other basic petrochemicals, including derivatives and major intermediates (polymeres), ethylene world trade has been very small, except for EEC inter-trade. The high degree of concentration of ethylene processing and trade can be explained by the fact that the bulk of ethylene is consumed in downstream plants owned by the very same companies that control the upstream activity and/or the major international producers, and consumers have established ethylene grids in the main two developed regions, namely, Western Europe and the United States, in order to facilitate easy supply and a captive market for their ethylene.

Nearly all ships supplying ethylene are refrigerated, whereas the pipelines are pressurized. The problem of unloading ethylene from ships and into pressurized storage in order to connect with pipelines is a major one. Direct transfer from a ship into the grid is not yet possible.

Excluding inter-trade in EEC, ethylene export to developed regions originated mainly in non-European DMEC. However, 22 per cent of the total export to the developed regions seems to have originated in developing countries, mainly Algeria, Mexico and the Republic of Korea.

The situation is quite different for other olefines. Both EEC and the United States import appreciable quantities of propylene from other DMECs, mainly non-European. In the case of butadiene, the United States is a major importer - 290,000-330,000 tons per year - and the facilities exist along the coastline to handle this product. EEC exports significant quantities to the United States, and other DMECs are involved in the trading of small quantities of butadiene with major developed regions. Of the developing countries, only Mexico and Venezuela exported butadiene to the developed countries.

World trade in aromatics seems to involve all producing regions, particularly in the case of xylenes. These products can be shipped in uncoated steel tanks and stored under similar conditions. Considerable tankage in public terminals is available for importers, exporters and traders. The flow of trade in aromatics is somewhat different from that of olefines. While major exporters to EEC were other European DMEC countries, the United States was the main exporter of olefines and the CPE was the main exporter of aromatics. In general Western Europe might be considered a net exporter of olefines, but a net importer of aromatics.

The situation is different in the United States, which is a net exporter of xylenes and propylene but a net importer of butadiene.

In the meantime, the United States relies on the imports of some quantities of aromatics, mainly benzene, from other developed regions, e.g. Canada. Because of the gasoline situation in the United States - higher consumption of unleaded high octane gasoline that creates a tight situation for aromatics - exports to Western Europe may decrease.

Developing regions involved in the exporting of limited quantities of aromatics to the three major DMECs include a long list of countries that usually serves one or more areas (Argentina, Colombia, the Dominican Republic, the Republic of Korea, Netherlands Antilles, Trinidad and Tobago, United States Virgin Islands, Yugoslavia, etc.). Other DMECs particularly non-European countries, also export small quantities of aromatics to other developed regions.

The flow of gas-derivatives in world trade has been mainly from CPE and developing countries to developed countries. Major developing countries involved in the export of methanol include Algeria, the Republic of Korea, the Libyan Arab Jamahiriya, Mexico and the People's Republic of China. Those who exported ammonia in appreciable quantities in 1979 were Mexico, Colombia, Iran, the Libyan Arab Jamahiriya, Trinidad and Tobago and Venezuela. Some DMECs exported small quantities of methanol, which originated mainly in non-European areas that, as a group, were net exporters of methanol, and ammonia to other developed regions.

The international ammonia trade has been undergoing fundamental changes in recent years and the level of imports has increased dramatically. In 1973 the United States exported three times as much ammonia as it imported. During the first half of 1980, three times more ammonia was imported to the United States than was exported. Occidental petroleum compensation trade agreements with the USSR will allow them to import 2.8 million tons of ammonia in 1981. In the first half of 1980, Canada, Mexico and Trinidad have also increased their exports to the United States to a level of 1,090,000 tons. As a result of this changing pattern, some 28 ammonia plants in the United States have closed down since 1976. In Western Europe many companies have now moved to use imported ammonia. Japan has been conducting an industry rationalization programme since 1970, which has reduced ammonia production capacity by some 750,000 tons per year, in order to allow for ammonia imports.

In 1980 there was a continuation of the decline in the export of methanol from such countries as the United States (by 50 per cent to 81,000 tons), the Federal Republic of Germany (by 15 per cent to 23,000 tons) and Japan (to 3,000 tons as opposed to 24,000 tons in 1979). At the same time, imports to Japan reached 275,000 tons, to the Federal Republic of Germany, 492,000 tons and to Great Britain , 22,000 tons.

In the case of basic petrochemicals, the three major DMEC regions exported only a small portion of their 1979 production, ecxept for butadiene from Western Europe (and to a limited extent methanol and xylene from countries other than the EEC), xylene from the United States and ethylene from Japan. It is obvious that the bulk of their basic petrochemical production is directed toward local downstream processing that is highly integrated.

In general, the biggest exporters of petrochemicals have been the EEC and Japan. But Japan has been, and may continue to be, a good market for imported methanol and, to a certain extent, xylene and ammonia. Should Western Europe choose to rely on heavy feedstocks at the expense of heavy fuel requirements, which will be compensated for by North Sea gas and gas imported from the USSR and nuclear energy, and if it decides to increase the use of unleaded gasoline, the situation for aromatics may improve, thus lifting the pressure of the tight United States situation of aromatics. Such a situation may alter the trade flow of aromatics and open the door for new suppliers.

3.2.2 Intermediates

World trade in intermediates has not been very significant and it is concentrated heavily within developed regions. Inter-trade of intermediates among countries of the same developed regions was more pronounced in the case of the EEC. Exports of intermediates to developed regions have been very minimal, but are expected to increase, at least in the case of monomers, once polymer processing capacities increase in developing countries.

The styrene monomer is probably the product most widely traded and stored. European imports from the United States have been running at 150,000-200,000 tons per year during the 1970s. Compared with this volume, ethylene glycol and ethylene dichloride movements have been miniscule. Movements of acrilonitrile are primarily within the fibre industry. In general, storage facilities for imports are readily available for styrene and ethylene dichloride (EDC). Fibre grade ethylene glycol storage will be harder to find.

3.2.3 Polymers

The bulk of the trade in developing countries has been in end products, i.e. plastic resins, synthetic fibres and synthetic rubber. The major partner of the developing countries in this activity has been the developed regions, where most exports are generated, rather than other developing countries that usually export semi-finished and finished products instead of polymers and resins. However, the developing regions have exported small quantities of polymers, mainly PVC, to developed-market economies. Among the major developing countries that exported some quantities of end-product groups plastic resins and SBR were South-East Asian and pacific countries and Brazil.

The share of DMECs, other than the three major developed regions in the export of end products has not been high except for polyethylene and SBR. In the case of SBR, non-European countries had a better share than the rest of other DMECs.

Centrally planned economies trade with developed market economies involves basic aromatics, plastic polymers and synthetic fibres. But the export of polymers, mainly polyethylene and PVC, and polyester fibres have been, relatively speaking, in small quantities destined for the EEC. In the meantime, most of the trade in olefines between CPEs and DMECs was noted between the EEC and CMEA.

Balance of end-products traded quantities in 1979 indicate that the United States was a net exporter in most polymers, except PVC, and synthetic fibres, but not SBR, whose imports came usually from developed countries. Its export of end-products has been directed mainly toward Western Europe, particularly in the case of polyester fibres.

In 1979 the three major consuming regions- Western Europe, Japan and the United States - had an overall trade flow which indicated them as net exporters of polymers (Annex III.B) and in general that the export share of their production has changed considerably for each of the main polymers from that of 1978 (see Table 3.4).

Polyethylene, the largest plastic consumed, represents over 50 per cent of the net trade in all polymers of the three major consumption centers, with LDPE accounting for the highest trade volume among the rest. However, the highest plastic polymers in terms of trade growth during the period 1976-1979 have been polypropylene (17 per cent per year) and HDPE (13 per cent per year), while polystyrene represents the lowest growth rate (3 per cent per year).

In 1979 Western Europe seems to have dominated plastic polymers trade except for ABS, with their aggressive pursuance of certain traditional markets, namely the Middle East, North Africa, South East Asia, South America and Eastern Europe. For specific products, namely polypropylene, Western Europe had good access to other markets in Canada and Latin America. In the meantime, the bulk of Japan polymers export has been to South East Asia, which in effect represents the largest import-consuming centre of polymers among all developing regions. The United States also has access to South East Asian markets, but Japan is the dominant trade partner; its share is nearly 50 per cent in that region in comparison with the United States and Western Europe. It is to be noticed that Eastern South Asia is the largest market for polystyrene among all others for the major exporting regions.[35] Other markets for United States polymers include Canada and Latin America; for certain products, such as polystyrene, Mexico has been the major market.

The Federal Republic of Germany has been holding the highest trading position in polymers among all countries, with 30-40 per cent of its production going into export. Japan, on the other hand, has been among the major exporters, but started to loose considerable volume of its exports in the past few years in its own market, i.e. Eastern South Asia[36].

In the late 1980s, overall self-sufficiency may be reached in the developing countries. Depending on the product, exports will become important, for example PVC to particular countries, both to other developing countries and to major consuming regions. Thus a shift in historical trade patterns can be expected, with reduced plastics export opportunities from Western Europe, the United States and Japan.

3.3 Factors affecting trends of future trade in petrochemicals

Future trend in petrochemical trade patterns will depend on many factors, but the cost factor will be the dominant one. During the last decade world trade was developing under the circumstances of slower rates of growth and inflation. Since 1973 a preocupation with secure feedstocks has dominated both the investment plans and strategic planning of the petrochemical industry. Feedstock uncertainties now tend to delay investment

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[35] R.G. Dodge, International Plastics Markets and Trends

[36] Ibid.

Table 3.4 **Plastic trade of the three major consuming areas**

	Trade a)				Share of export to production (Percentage)					
	(Thousands of tons)			1979/1976 Growth rate	USA		Western Europe		Japan	
	1976	1978	1979	(%)	1978	1979	1978	1979	1978	1979
LDPE	880	1065	1080	7	10	13	12	NA	12	18
HDPE	500	685	715	13	10		18		21	
PP	420	600	680	17	12	42	10	19	8	10
PVC	535	500	620	5	4	8	20	14	21	6
PS	290	320	315	3	4	3	10	17	12	11

a) Trade volume for Western Europe include intra-trade.

Source: 1978 figures obtained from Dodge paper (International Plastics Markets and Trends) and 1979 figures obtained from data provided by UNCTAD (K.T. Murray).

iecisions and add to installed plant cost. Rising feedstock and energy costs also lower profitability, since producers often find it difficult to pass these higher costs on to their customers as rapidly as they incur.

At the present time the Western European chemical industry is dominated by about 34 large companies, but of these top companies only 16 have some equity participation in a refinery. The United States chemical industry is dominated by 27 companies and only 5 are oil companies, who have moved into petrochemicals. The Japanese market in building block petrochemicals exhibits a moderate degree of vertical integration between oil refining, olefins and aromatics - of 25 top companies in chemical industry only 3 are directly involved in oil refining and 6 are involved in olefines manufacture. Meantime high cash flow and control of raw materials will facilitate the major oil companies' penetration into many of intermediate petrochemicals. This will tend to make production of such petrochemicals considerable less attractive to traditional chemical companies.

Ascending crude oil prices and relevant energy policies are likely to prevail in the 1980s and will have a direct impact on the competitive position of traditional suppliers, affecting most of all the level of utilization of their plant capacities. Furthermore, it is likely that new investment if undertaken may not be compensated by maintenance of profit margin. Accordingly some adjustment to the overall chemical trade structure can be expected.

Because of its feedstock position, the United States with its high product/feedstock advantage may continue to enjoy in spite of decrease a trade surplus in chemicals and its petrochemical industry may have a higher growth rate than Western Europe, its major chemical trade partner.

Total value of the United States chemical export during 1979 and 1980 jumped 37 per cent and 20 per cent respectively. In 1980 conspicuous gainers in export were organic intermediates, up 13 per cent over 1979 level for a total value of US$ 5,7 billion, synthetic resins and plastic materials, up to 20 per cent (U$S 3,9 billion), synthetic rubbers, up 20 per cent (U$S 695 million). In 1980 the value of its petrochemical exports (organic intermediates, fertilizers, plastic resins, man-made fibres and synthetic rubber) constituted 59 per cent of total chemical export and 6,5 per cent of its total export (except fuels) with fertilizers showing the highest growth (57 per cent per year over 1979)[37]. In 1980 the volume of petrochemical export from the United States was twice larger than in 1977 and exceeded U$S 14 billion in value. At the same time the share of its petrochemical imports (the above mentioned 5 groups) of products constituted 50 per cent of chemical import and only 2 per cent of the total import (except fuels). However, the United States import of petrochemicals has been rising, with organic intermediates and fertilizers showing the highest growth (17.4 and 17.6 per cent during 1979/1980 period).

There are reasons to believe that the United States chemical trade surplus has reached its zenith in 1980 and is likely to shrink during the next few years. Under the circumstances of coming decontrol of oil and gas prices, the United States chemical producers will loose an advantage of their feedstock and energy costs, and conversely, foreign producers' goods will be more competitively prices in their home market and in the United States. The outlook is that there will be a decrease in the growth rate of the United States chemical export, and an increase of import, particularly of benzenoid chemicals and some organic intermediates.

With the expected expiration of gas price controls the United States may need to import petrochemicals, and this may force the United States to negotiate relaxed trade agreements with new suppliers (specially where hydrocarbon resources are abundant) for importing certain petrochemicals that seem to be critical as far as cost is concerned. Costly environmental regulations and marketing strategies made few United States petrochemical producers seek alliances with producers in developing regions. Already some agreements have been concluded with countries like Saudi Arabia to that effect.

The US petrochemical industry may be in a better position to withstand the competition of oil-based developing countries than other developed regions. But it is envisaged that some of its traditional markets (namely Canada, Mexico and some Latin American countries) may not only reach a point of self-sufficiency but could become competitors, particularly Canada which enjoys some trade concessions in the United States markets.

37/ Chemical Week, March 4 1981.

The weaker growth in demand may force European petrochemical producers to seek bigger export markets to load their plants operating at marginal basis, with the hope of maintaining good price levels at home. Western European producers that already feel the United States threat, particularly in speciality porducts including synthetic fibres but not intermediates[38/], will face more competition from Eastern Europe that may reach parity in production with Western Europe by 1985, and from developing countries that are destined to bring even larger volumes of petrochemicals by 1990s to world market[39/].

West European traditional suppliers may also look into the possibility of participating in developing countries capacities. But because they are in a somewhat better position than Japan as far as feedstock position is concerned, and because they intend to invest at home with exports in mind, their participation in outside capacity will be limited to projects located in highly populated developing region markets rather than in larger export orientated projects.

Japan, realizing the changing situation in feedstock, has been inclined to participate in new petrochemical projects in developing countries. New investments are being channeled in part toward joint-venture in oil exporting countries to ensure the economic supply of basic petrochemicals for polymerization and down-stream processing at home, and also to have an assured market in those countries for its end products as well. Its ventures in Iran and Saudi Arabia are two good examples.

It is quite possible that other DMEC, particularly those facing critical balance of payments situation, might seek bilateral agreements with oil exporting countries whereby they can reduce the financial burden of raw material and energy while at the same time expanding the exports of their engineering industries embodied in new petrochemical capacities at minimum risks. In this context, co-operation between producers and governments will be imperative.

To manage a solution for the energy problem in general, major companies may seek further co-operation with governments. Such co-operation might involve arrangements for the construction of synfuel plants, subsidies

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38/ Chemical Age, 30 November 1979.

39/ Chemical Week, 24 January 1979.

on buy-back arrangements for the product through long-term government contracts, etc. Such a process will allow the improvement of feedstocks situation for petrochemicals and hence affect the trade flow.

Giant petrochemical companies, particularly those in the United States, have already been pursuing backward integration of their down-stream processing activities. This has also lead to close co-operation between chemical producers and oil companies, who have become more involved in petrochemicals than before, particularly in Western Europe. For all these companies, it was important that their prior objective should be to pursue a policy of feedstock flexibility to hedge against shifts in prices and availability. Toward that end, some companies have started already to invest in relevant infrastructure expansions (terminals and distribution systems of different feedstocks from different sources).

Traditional producers, also under the pressure of rising raw materials and capital costs, as well as environmental considerations, are indicating more interest in bein selective in their projects.

Quite few are planning to move further down-stream to speciality areas, thus slowly relinquishing part of their control over commodity petrochemicals. This might open bright prospect for developing countries to enter into world trade.

Developing countries may continue having significant imports of plastic materials and synthetic fibres in the 1980s but most likely it will be at lower rate. Up to now the import of polymers in general comprised mostly low cost products or polymers of low sophistication level and of limited variation in grade properties in comparison with developed regions. This may have been due to foreign exchange problems in some countries and/or due to the limited technological capacity in the case of others. Their plastic exports on the other hand, have been mainly semi-finished and consumer goods, and this may continue to be the case for some time.

With ambitious plans to build up their production capacities, some developing regions may reach an overall self-sufficiency in certain categories of products. OPEC countries are already in the process of building their commodity petrochemical capacities. Irrespective of some shortfalls associated with excess of capital cost and technology handicap, these capacities will bring about occasional disruption of the market in the 1980s. Up to now the developing regions have been a merchant market for end products. Increased local intermediate petrochemical capacities will result in the captivity of their markets for certain products.

Geographic redeployment of the industry will also be influenced by other factors; the rapid development of the economies of such major petrochemical contenders among the developing countries such as Brazil and the Republic of Korea, the major petrochemical expansion plans of the USSR, China as well as other Eastern European countries that enjoy raw material and manpower skill positions, and the efficient exploitation of oil resources by some major consuming areas, such as Canada and Mexico, to build solid position in petrochemical commodity products.

Prospects for more changes in the international trade structure may also be promoted by other factors:

- Mergers and consolidations toward fewer but bigger companies which can afford better investments in research and development and better leverage in trade strategies. This will be stimulated more in the United States to afford the cost of complying with government regulations.

- Formation of more trading blocks among geographic regions countries is likely to take place. An example is the proposed North American Common market that includes United States, Canada and Mexico.

- Low per capita utilization of petrochemical end products and foreign exchange situation may bring about higher inter-trade activities among CMEA members, a fact that may reduce export potentials from that area, but also ought to diminish import. However a too-tight hard currency situation may lead to some export, enough to tip the balance of trade at least in Western Europe.

3.4 The prospects of new producers in international trade in petrochemicals

The bulk of petrochemical production has been managed up to now by OECD multinationals. The management of the international trade and investment in this sector has led to the growing oligopolization of the market, and to the rapid increase of trade power which is concentrated in the hands of the multinationals leaving the developing countries with residual markets.

The dominance of the petrochemical market by the developed countries is quite evident as illustrated in Annex III.B. The Annex contains data for seven basic petrochemicals (ethylene, propylene, butadiene, benzene, xylene, methanol and ammonia) and five intermediates (polyethylene, polypropylene, polystyrene, PVC and SBR). For basic petrochemicals (ethylene, propylene and benzene) imports account for a minimal share of domestic consumption in the developed countries; butadiene (for the United States), xylene (for Western Europe) and methanol (for Japan and Western Europe) account for a moderate share. Imports account for a minor share of consumption for each of the intermediates.

On the average, imports of petrochemicals account for only 4 per cent of developed countries consumption, and the developing countries account for only 21 per cent of these imports, i.e. imports from the developing countries account for less than 1 per cent of total consumption. Moreover, two-thirds of this developing countries' trade involves a single product, namely methanol. Excluding methanol, total imports account for 3 per cent of consumption with the developing countries supplying 9 per cent of imports and less than 1/4 of 1 per cent of consumption.

The fact that developing countries account for a small share of current consumption in the developed countries does not mean that they will not do better in the future. However, a comparison of developed country productive capacity with total consumption shows that these countries currently have capacity that is roughly 25 per cent greater than current consumptions; and capacity utilization averages only 83 per cent even though the developed countries were net exporters of petrochemical products in the magnitude of over 4 million metric tons (in 1979). Such excess capacity might explain why the developed country producers express concern over the recent trends in world-wide capacity.

This relationship between capacity and consumption presents definite problems for the developing countries in their needs for dynamic export market. However, the result of rising prices for feedstock in the 1970s has led to substantial increase in production costs of basic, intermediates and final petrochemicals in developed countries. At the present time the costs of raw materials and energy as a percentage of the over-all production costs of Western Europe's petrochemical industry has risen to 83 per cent as opposed to 73 per cent in 1977 and 46 per cent in 1973. Under these circumstances there is ground to expect that in 1980s intercontinental trade in these commodities will increase particularly after 1985. This suggestion is supported by the fact that in the developed countries there is a tendency to close unprofitable enterprises, substantial decrease in export and increase in import of some basic petrochemicals and intermediates. This tendency will grow further as prices for oil and natural gas go up. While trying to secure long-term needs in feedstock, the developed countries are showing greater interest in constructing plants near the sources of hydrocarbons. The lower production costs of petrochemicals in the developing countries will stimulate production growth, the considerable part of which will go for export.

However, the entrance of developing countries petrochemical products in developed countries markets is expected to be met with great resistance including tariff and non-tariff barriers. Most important obstacles will be discussed hereunder.

3.4.1 Tariff barriers

A tariff is a tax on a product when it is imported into the customs territory of a country. Since the tax is not assessed on locally produced products, the immediate impact of a tariff is to place a wedge between the price which consumers (or users) in the importing country pay and that which the exporters receive. Thus, the foreign exporter would receive less for the same product than the local producer (by the amount of the tariff) in order to be competitive. In other words, the foreign exporter must be a more efficient producer than the local producer in the importing country. Or to put it in another way, the local producer can be less efficient and still remain competitive in his home market.

(A) Effective rate of protection

Table 3.5 presents the average tariff rates which the major developed countries assess on imports of selected petrochemical products. The products include seven basic petrochemicals, five intermediates and two fibres. In general, the tariff rates on basic petrochemicals, 56 are zero or less than 1 per cent; 8 are 5 per cent or less and 10 are between 6 per cent and 7 per cent; only 14 are higher than 7 per cent and half of these involve a single product - methanol - and five of them applied in a

Table 3.5

Post-MTN average tariff rates for selected petrochemical products: (ad valorum or ad valorum equivalent)

PRODUCT	EEC	Japan	USA	Austria	Australia	Canada	Finland	New Zealand	Norway	Sweden	Switzerland
Basic Feedstocks											
Ethylene	6.3	6	F	F	F	F	F	F	F	6.5	-
Propylene	6.3	6	F	F	F	F	F	F	F	6.5	-
Butadiene	6.3	6	F	F	F	F	F	F	F	6.5	-
Benzene	F	4	F	10	F	F	2.2	F	F	F	-
Xylene-para	F	2	F	10	F	F	F	F	F	F	-
-ortho	F	2	F	10	3	F	F	F	F	F	-
Ammonia	11	4	3	22	F	F	F	13	F	9	6
Methanol	13	5	18	15	19	10	F	F	7.7	9	-
Intermediates											
Polyethylene-LD	12.5	11	12.5	21	22.5	9.5	F	F	10	9	2
-HD	12.5	11	12.5	21	37.5	9.5	F	F	10	9	2
Polystyrene	12.5	14	17	21	22.5	9.5	F	F	20	9	2
Polypropylene	12.5	22	12.5	21	22.5	9.5	F	F	20	9	2
PVC	12.5	6	10.1	18	22.5	9.5	F	F	20	9	5
SBR	3	F	F	F	37.5	F	F	F	7.7	F	-
Fibres											
Polyester	7.5	10	9	F	F	8.5	F	F	2	3.2	6
Polyamide	7.5	10	5	F	7.5	8.5	F	F	2	3.2	6

Source: National tariff schedules and GATT, Geneva (1979) Protocol to the General Protocol to the General Agreement in Tariffs and Trade, 30 June 1979 and Protocol Supplementary to the Geneva (1979) Protocol to the General Agreement on Tariffs and Trade, 22 November 1979.

(F) duty-free
(-) less than 1 % ad valorum

Note: In some cases the product is subdivided for tariff purposes with different rates applying to the various subdivisions; in such cases a trade weighted tariff rate is given.

single country - Austria.

In contrast, the tariff rates which apply to the intermediate petrochemical products are significantly higher. Of the 66 possible rates only 19 are zero or less than 1 per cent and involve synthetic rubber (a holdover from World War II) or are applied by Finland or New Zealand. With the exception of synthetic rubber, the EEC, Japan, the United States, Austria, Australia, Canada, Norway and Sweden have uniformly high tariff rates ranging from 9 per cent up to 37,5 per cent. Moreover, there are considerable differences in the tariff rates relating to different groups of countries, particularly to CPE countries.

The tariff rates applicable to fibres vary by country more than by product type. Half of the possible tariff rates are less than 4 per cent. However, the three major markets (EEC, Japan and United States) tend to have the higher rates.

A casual examination of these tariffs would imply that developing country exporters have rather open access to the developed country markets for the basic feedstocks - with only a small efficiency advantage required by developing country exporters. Regarding intermediates, the required efficiency advantage is more substantial at 12,5 per cent for exports to the EEC, from 10 per cent - 17 per cent for the United States, 6 per cent - 22 per cent for Japan and so on (excepting SBR).

However, a more careful application of the theory of tariffs reveals that the protective effect of a tariff is often much higher than indicated by the nominal tariff rate. And, therefore, the foreign exporter must be much more efficient than the local producer. This so-called theory of effective protection is designed to quantify the competitive advantage which is provided to local producers by tariffs. To illustrate the relationships involved, consider the processing activity of converting ethylene into polyethylene (high density). Roughly 50 per cent of the cost of polyethylene is expended on ethylene as input; the other 50 per cent of the costs are local value-added , i.e. utilities, labour, capital (depreciation, maintenance, etc.) and so on.

If a developing country wishes to export ethylene to the United States, it faces no tariff related competitive disadvantage since ethylene is subject to duty-free treatment. However, if the country wishes to process the ethylene into polyethylene for exportation, the polyethylene will be subject to a 12,5 per cent tariff. Thus, if U$S 1.00 worth of ethylene is processed into U$S 2.00 worth of polyethylene, upon importation into the United States market it must pay a tariff of $ 0.25 (12,5 per cent of $ 2.00) which brings the total cost to $ 2.25. In contrast a United States producer would be able to process the ethylene into polyethylene for sale on the United States market for only $ 2.00, i.e. $ 1.00 worth of ethylne and $ 1.00 worth of local value-added. In order for the foreign producer to be competitive in the United States market he must be able to sell polyethylne, inclusive tariff, for $ 2.00. Thus, the foreign producer must be able to convert $ 1.00 worth of ethylene into polyethylne for only $ 0.75 in processing cost in order to have a total cost, inclusive of tariff, of $ 2.00 (i.e. $ 1.00 (ethylene) + $ 0.75 (processing) + $ 0.25 (tariff) = $ 2.00). In comparison with a United States producer, the foreign producer must be more efficient in processing (i.e. processing cost of $ 0.75 versus $ 1.00 for a United States processor) in order to be able to be competitive[40].

This efficiency differential is better explained by the so-called effective rate of protection (ERP), which can be calculated as:

$$ERP = \frac{T}{VA} \qquad (1)$$

where T is the tariff rate (in decimal form) and VA is the share of total costs accounted for by local processing costs (value-added). In the above example ERP = .125/.5 = .25 and denotes that the foreign processor must improve his local processing cost efficiency by 25 per cent in converting ethylene into polyethylene in relation to the United States processor to counteract the latter advantage accorded to him by the tariff.

An assumption underlying this example is that both the foreign and the United States processor can obtain the essential feed, ethylene, for the same cost. This would be essentially true in the case of the United States since the United States processors have duty-free access to world markets. In Germany however, processors must pay a 6.3 per

40/ The analysis is simplified in:
- assuming equal production components costs (feed and local value added) in both regions, or
- assuming custom valuation by the importer for protection purposes or as anti-price measure.

cent tariff on ethylene imports - which put them at a competitive disadvantage by increasing their costs of ethylene feed. This element can be incorporated into the formula for the effective rate of protections as

$$ERP = \frac{T - at}{VA} = \frac{T - at}{(1 - a)} \qquad (2)$$

where T and VA are as in equation (1), t is the tariff on the ethylene feed and "a" is the share of total costs which is accounted for by the ethylene feed (thus, 1 - a is the processing cost). In the case of Germany, ERP = (.125 - .5 X . 063) / (1 - .5) = .187 and thus the foreign processor must be 18.7 per cent more efficient in processing ethylene into polyethylene than the German processor. The difference between the United States ERP of 25 per cent and the German ERP of 18.7 per cent is due to the competitive disadvantage imposed on the German processor by the 6.3 per cent tariff on ethylene feed[41].

Effective rates of protection have been calculated for the five intermediates in the sample of petrochemical products ; these calculations are presented in Table 3.6. Two sets of calculations were made for each of three major markets: one using current input coefficients and market prices, the second using estimates of full costs of production (including a 25 per cent before-tax profit margin) at 100 per cent capacity utilization. With the exception of synthetic rubber (SBR) these calculations indicate that on the average, foreign exporters to these countries must improve local processing costs by 23 per cent in processing basic petrochemicals into intermediates in relation to local producers in order to be competitive in import-country market; the efficiency differential is 69 per cent higher on the average than the price wedge imposed by the tariff. In contrast, the structure of tariffs is quite insignificant in the case of SBR due to the very low duties on this product.

41/ The formula can be expanded to include several, say k, feedstocks as

$$ERP = \frac{T - \sum_{i=1}^{k} a_i t_i}{(1 - \sum_{i=1}^{k} a_i)}$$

where T, t and a are defined as above and i indicates the particular feedstock.

Table 3.6 Effective rates of protection (%)

Product	EEC			Japan			USA		
	Tariff Rate	ERP Actual	ERP at 100 % capacity	Tariff Rate	ERP Actual	ERP at 100 % capacity	Tariff Rate	ERP Actual	ERP at 100 % capacity
Polyethylene									
High Density	12.5	24	24	11	18	22	12.5	28	30
Low Density	12.5	25	23	11	23	21	12.5	27	29
Polystyrene	12.5	23	23	14	NA	29	17	35	35
Polypropylene	12.5	18	18	22	37	42	12.5	22	24
PVC	12.5	19	15	6	7	6	10.1	19	16
SBR	3	0.5	1.3	0	NA	- 4.7	0	0	0

Source: SRI International, PEP Yearbook 1980 and UNIDO secretariat calculations.

(In fact, for Japan the ERP is negative which implies that tariffs on basic petrochemicals put Japanese processors at an actual competitive disadvantage of almost 5 per cent).

There is a qualification to the above analysis and conclusion about the protective significance of tariffs, namely the preferential access of developing country exports to the developed country markets under the so-called Generalized System of (Tariff) Preferences (GSP).

Under the GSP, EEC, Japan and the United States imports of intermediates enjoy duty free treatment. Thus, whenever GSP duty-free treatment is applied, then developing country exports will not face any tariff imposed efficiency differential requirement. However, if any developing country becomes a major supplier of any of these petrochemical products it is likely to lose the benefits of duty-free treatment under the GSP, i.e. its exports (or increasing exports) will face normal tariffs and the efficiency differential requirements as calculated in Table 3.6. For example, in 1980 a customs duty in the amount of 14.4 per cent was imposed on methanol imports from Libya to Western Europe, whereas previously this product had been imported duty-free. Furthermore, the GSP is a non-reciprocal arrangement which contains numerous limitations including ceilings on the volume of duty-free trade, minimal processing requirements, special documentation to certify origin of products, and so on.

In this respect, the evolution of trade liberalization in the 1960s - 1970s and participation of the developing countries in the series of negotiations within GATT are of interest.

(B) Trade liberalization

Post-war tariff and trade negotiations resulted in some significant results by 1967 during the Kennedy Round within the framework of the General Agreement on Tariff and Trade (GATT). The chemical sector, and particularly petrochemicals, occupied a prominent position in the Customs Co-operation Council Nomenclature (CCCN) for partial harmonization of tariffs, as a step toward trade liberalization.

It has to be emphasized that the whole programme was promoted by the leading trading powers, notably the United States and the EEC. The main objective of the programme is to place all major producing companies on the same competitive level when there is no significant difference between properties of products produced in different countries. Worth noting in this respect is that the EEC pursued the negotiation more feverishly than the others for the following reasons[42]:

- The Common External Tariff (CET) of the EEC was generally lower than that of the United States, and thus special treatment for a long list of chemical items for which appreciable tariff disparities exist was very important.

- Under the American Selling Price System (ASP), which was introduced in 1922 for the protection of the dyestuff industry and been applied to certain organic chemicals derived from benzene, duties were assessed on the basis of the value of competitive United States products rather than on the value of the imported chemicals themselves, thus the elimination of the (ASP) and other valuation systems meritted consideration.

The final Kennedy Round agreement incorporated certain tariff reductions on dutiable petrochemical imports on individual basis by different countries who subscribed to the Round's concessions.

Some important concessions included in the Round were[43]:

- 50 per cent tariff reduction by the United States on most chemicals which had previously been subject to duties higher than 8 per cent and 20 per cent reduction on those previously subjected to 8 per cent or less, while keeping the ASP valuation method in effect.

- In general a 20 per cent tariff reduction by EEC on chemicals imported from the United States, with higher reductions on those subject to duties of 25 per cent ad valorem.

- 44 per cent tariff reduction (on a weighted average basis) by Japan on dutiable chemical imports from the United States.

There have been some exceptions invoked by different subscribers, in line with each country position in that particular product. Important tariff reductions in general were made for synthetic rubber and manufactured fertilizers. Low reduction concessions were made for artificial fibres and certain kind of synthetic man-made fibres were excluded by EEC for United States products because of the significant disparities.

In the Tokyo Round (MTN) of GATT negotiations, further concessions were negotiated to improve the prospects of trade, mainly among industrialized

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42/ UN-ECWA publication. E/ECWA/MTN/SEM.1/4. Petrochemicals in World Trade.
43/ idem.

countries. Among the main features of that round was the discontinuation of valuation practice, particularly the United States ASP system.

As a measure to apply the agreement on an even basis among various parties, some provisions were made in the event that countries adopt national policies which upset trade flow. The imposition of such measures might be seen in the case of rising imports from a producing country where price dumping or a price-war among local producers made the product very attractive to the importing area. A case in point is of a recent occurance when EEC introduced a dumping duty on imported United States polyester fibres (15.6 per cent for flat fibres, 9.7 per cent for textured yarn and 10.6 per cent for vinyl acetate, a fact that could force the United States to pursue an antidumping action.)

The underlying principles of the GATT are non-discrimination and mutual benefit (reciprocity). The international negotiations conducted under these principles have resulted in a general lowering of tariffs and the binding of negotiated rates. Binding essentially means that tariff rates will not be increased and, therefore, tariffs are gradually being eroded as a trade policy tool. Tariff negotiations of today concentrate on which products must be exempted from negotiated reductions in order to maintain effective protection. Four of the five intermediates contained in Table 3.5 have apparently been on the exception list, or at least singled out for less than average tariff reductions. In contrast, the dictates of World War II resulted in very low tariffs on synthetic rubber (SBR).

Few industrialized countries (Australia, Austria, Canada, EEC, Finland, Japan, New Zealand, Norway, Sweden, Switzerland and the United States) have introduced preferential tariff arrangements on imports of manufactured and semi-manufactured products originating in certain developing countries. The scheme, known as the Generalized System of Preference (GSP) does have some advantages to those granted the treatment, but it also incorporates a series of exceptions which might undermine its validity:

- Not all the countries can benefit from every developed market economy GSP. In other words, it could be discriminatory.

- Not all petrochemicals qualify for GSP tariff treatment. Some developed countries exclude paraffins and basic aromatics, others exclude man-made fibres or bulk polyethylene from their GSP lists.

- Major petrochemical producing regions (United States, EEC and Japan) place limits on the value of imports that can receive GSP tariff treatment.

- Some countries, i.e. EEC and Japan place ceiling limits on value of imports from all beneficiaries combined on certain product groups that receive preferential treatment. Ceiling limits imposed by EEC included chemical fertilizers, man-made fabrics and their yarns, and woven fabrics of synthetic fibres. Japan includes artificial resins and plastic materials in its ceiling limits list.

Imports in excess of the ceiling limits imposed by some of these countries could receive most-favoured-nation (MFN) duties. However, such concession sometimes would be ineffective if the import of a specified product from a single country is limited to a posted percentage of the total import ceiling.

There has been a tendency among the original sponsors of the GSP scheme to remove from the beneficiary list both the more advanced developing countries and the so-called sensitive products including final petrochemicals. The United States scheme has already incorporated a competitive need criteria under which a beneficiary country may no longer qualify for GSP tariff treatment, regarding a certain product whose export value to the United States has a high absolute value or its quantity would be over a certain percentage of United States total import of that product. In the meantime the EEC has been in the process of reviewing its scheme with the idea of easing the limits for single countries but only for specific products. But in 1980 there was a failure to adopt the measures to make it easier for the developing countries to gain access to the markets of EEC countries. The Commission's proposals called for a ~~reduction in the~~ number of products protected by import quotas or other trade barriers from 30 to 11 in 1981. Under pressure from Western European manufacturers 24 more chemicals were added to the list of protected products.

The preferential agreements embody certain reciprocal concessions, aiming at establishing a custom union or a trade area. This could in effect restrict the entry to the beneficiary of certain products originating outside the country or trading block granting the preferential treatment. A good example was the high duty applied by Greece on HDPE imported from non-EEC countries (36 per cent) when it was granted the EEC preferential treatment (before joining the EEC).

The chemical industry in the developed market economies considers tariff as the main issue for trade negotiation. Non-tariff barriers, i.e. subsidies, customs valuation, government procurements, standards, etc. are of little significance to their intra-trade prospects.

The participation of the developing countries in GATT has been minimal, and any benefit accruing to these countries resulted from negotiations on the basis of reciprocity. Furthermore, despite the Tokyo Round cuts, tariff charges on quite few sensitive petrochemicals, will still be relatively high enough to hamper new petrochemical producers entry to the international market in petrochemicals, though the range varies from one market to the other. This is more true in the case of intermediates and end-products, particularly synthetic fibres and plastics. It should be stated in this context that escalating tariff rates for certain products on a country level is quite possible. Therefore, unless some vigorous action is undertaken at the international level, under the auspices of multi-trade negotiations (MTN) new producers in developing countries may not be able to export substantial amounts of their surpluses.

The multi-trade negotiations(MTN) may offer a good opportunity for developing countries to negotiate improved and more secured terms of access to main petrochemical consuming centers. In contrast to the GSP which is a unilateral system taken on a non-reciprocal basis and without contractual status MTN concessions can be duty-free and of relative stability, and more related to the bargaining power of the countries involved. An advantage of MTN reduction is their multilateral nature when the obligation not to increase the rate is taken in respect to all petrochemical suppliers.

The developing countries who are in a position to offer competitive products ought to be in a position to participate in the trade liberalization process through the MTN system of negotiations. However, their status as late comers may turn down their negotiation strenght. Thus their trade advantage based on a comparatively cheap raw material should not preclude them from being granted preferential treatment and should not justify any safeguard measures or so-called anti-dumping procedures against their export. Furthermore, as it was noted by some participants to the Conference of the Society of Chemical Industry (The Hague, October 1979) that while trade should be free, preferential tariff treatment ought to be granted to developing countries as a part of a comprehensive policy of preferential treatment.

3.4.2 Non-tariff barriers

While the tariff rates were being lowered on a reciprocal basis, two other trends emerged. First, as tariffs became less a barrier to trade other governmental barriers to trade became visible - such as quotas, health, safety and environmental standards; import licensing schemes; governmental purchasing preferences in favour of domestic producers; customs valuation practices[44] and so forth. The second trend was the emergence of changing international comparative advantage and the pressures placed on governments to safeguard domestic firms that were unable to scope with such developments. Since governments could not increase tariffs they are increasingly resorting to non-tariff techniques such as "voluntary export restraint" agreements (now called "orderly marketing agreements").

Government non-tariff barriers may include a spectrum of mechanism each of which is an obstacle to import . The main barriers include:

- Arbitrary customs valuation based on different criteria in assigning a home market value for determining the tariff.
- Explicit import quotas on certain products from specific regions or in general.
- Imposing special import fees and/or border taxes.
- Discretionary import licensing programme, which affects most intermediate products.
- Administrative discouragement to local importers through the requirement of tedious licensing procedures and exchange control.
- Specification and standard requirements to qualify the imported products for utilization in home markets.
- Applying stringent rules of origin in qualifying the imported product for duty reduction on entry to the local market.
- Subsidies and other government aids to local manufactures, including the provision of credits and marketing infrastructure facility, conducting bilateral negotiations for qualifying local production for exports, etc.
- Government preference in selecting suppliers for its own and public welfare procurement.

[44] The most infamous of these techniques was the American Selling Price system for administering tariffs on benzoid chemicals. Under this system tariff rates were applied on the value of the product selling in the American market in comparison to the general practice of using the (significantly lower) price recieved by the exporter. This practice could easily double the tariff assessment. This practice was discontinued under the Trade Agreements Act of 1979 which implemented US concessions negotiated in the Tokyo Round (MTN) of GATT negotiations.

- Limited exemptions of companies from anti-trust law imposed by their governments.

- Antidumping procedures.

Regarding the petrochemical products mentioned earlier, the EEC imposes quotas on imports from Romania (on synthetic fibres (CCCN 56.04); Italy has a bilateral quota regarding Yugoslavia (on acyclic alcohols: CCCN 29.04) and Italy has certain restrictions regarding centrally planned economies countries (polymerization and copolymerization products: CCCN 39.02 and synthetic rubber: CCCN 40.02); Japan imposes industrial standards on the basic petrochemicals and intermediates; and the United States imposes quota on import from USSR (ammonia). As far as it can be determined at this time, non-tariff measures do not appear to be a serious obstacle to developing country exports to the EEC, Japan or the United States. But, of course, the reason for this is the very high protective effect of the existing tariff structures of these three major markets on one hand and the limited volume of import on the other. And there is a danger that under the circumstances of depressed growth rates in advanced economies the problems of adjustment in developed countries will be shifted to developing countries through import restrictions as their petrochemical export will go up. Export of some petrochemicals from developing countries at low prices, which reflect comparative costs advantages, could lead to a retaliation in the form of either tariffs or import quotas.

3.5 Obstacles facing developing countries in world trade of basic, intermediate and final petrochemicals

The examination of obstacles to trade imposed by governments of the developed countries indicates that emerging developing country exporters will face substantial tariff barriers. The calculations presented in Table 3.4 reveal for instance, that the effective rates of protection range for polyethylene from 18 per cent to 30 per cent, that is to say, developing country processors of ethylene must be 18 per cent to 30 per cent more efficient than those of the EEC, Japan and the United States to be competitive in exporting polyethylene to these three markets.

Such protection provided by the structure of tariffs in the developed countries is in effect to discourage the developing countries from processing their basic petrochemicals into more advanced products for exportation.

Instead, the developing countries are encouraged to export basic petrochemicals rather than processing them into commodity intermediates and final products, which have higher value added. This is now more sophisticated form of international division of labour which is not in the interest of developing countries. Moreover, other factors more important than tariffs put greater limits to the prospects of developing countries' exports of such building blocks as ethylene, other basic intermediates and final products.

3.5.1 The vertical integration of the petrochemical industry in major developed regions

Ethylene is mostly limited to companies that process ethylene into downstream products such as polyethylene, ethylene oxide, ethylene dichloride, ethylbenzene, etc. The first three intermediates account for roughly 75 per cent of the ethylene market with polyethylene being the largest (about 40 per cent). In the United States, the four major polyethylene producers (Union Carbide, Dow Chemical, Du Pont and Gulf Oil) account for just under one-half of the entire market - and each has ethylene capacity to satisfy its actual polyethylene requirements. That is to say, these four companies are not likely customers in short run for foreign producers of ethylene who wish to export to the United States, unless highly attractive economic factors compete these companies to close their ethylene capacities. Dr. Wohoff (of Azko N.V. Arnhem, the Netherlands) has estimated that 84 per cent of ethylene used to produce low density polyethylene in the United States provided within the company (the figure is 52 per cent for Europe[45/]). It is anticipated that a similar pattern prevails for high density polyethylene. Thus assuming no shut down in ethylene capacities only 16 per cent of the United States market and 48 per cent of the European market is even potentially available for foreign exporters to serve. Moreover, a significant share of this "open" market is, in practice, a "closed" market which is being served under long-term contracts or through traditional (historical) marketing/distribution channels. Considering no changes in the present

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45/ "Integrated and Non-integrated Petrochemical Companies: Why all the the Discussion" presented at the 13th Annual Meeting of the European Petrochemical Association, 30 September - 2 October 1979, Venicelido, Italy.

situation, only one-half of the "open", truly "open" market, since the other half is "closed" by such arrangements, would provide access for 8 per cent of the United States market (or 1 million metric tons in 1979) and 24 per cent of the European market (or 3 million metric tons in 1979).

3.5.2 Degree of concentration of the market

A second issue which might limit developing countries access to the developed country markets is the degree of concentration in these countries. If the market is essentially served by very few suppliers in the developed countries, it is possible that the major companies would jointly determine the allocation of suppliers in the market. A common measure of the degree of concentration in the market is the "concentration ratio", namely a measurement of the share of the market served by the largest (four and eight) suppliers. Table 3.7 presents the concentration ratios pertaining to ethylene for the United States, Japan and the larger EEC member States.

Table 3.7 Concentration ratios for ethylene supply in 1980
(percentage of total)

Market	Largest 4 suppliers	Largest 8 suppliers
United States	40	66
Japan	39	70
EEC		
France	82	100
Italy	93	100 (top 6)
Netherlands	100	100 (top 4)
United Kingdom	95	100 (top 5)
West Germany	60	89

Source: Based on information in Oil a. Gas Journal, Sept. 1, 1980.

The concentrations are quite high for Europe, and moderately high for the United States and Japan. Moreover, a closer examination of the company names producing ethylene reveals that the major suppliers in Europe are often foreign affiliates of the United States companies; similarly Shell Chemical is one of the top 4 companies in the United States. Thus, the world market is highly linked by cross-ownership of productive capacity by the large oil and chemical multinational corporations.

This indicates that developing countries which are moving into the petrochemical field must be aware of the dominance of Western markets by relatively small number of large companies. Whereas under the existing conditions it would be possible to carve out a small nitch in the large market, it would be very difficult to export products to these markets in large volume unless the developing country productive capacity is taken into consideration by the multinational corporation's network through long-term arrangements such as joint ventures, long-term contracts or other close commercial arrangements. Otherwise, the introduction of large capacities in the developing countries would create a new situation which sooner or later disrupt the existing market structure causing unforeseen losses to all concerned.

3.5.3 The oligopolistic structure of the market

The high competitive position of traditional suppliers in the world trade is linked to, and resulted in the continuing maintenance of good performance over a long period, which has been associated with availability of enormous capital to finance the needed investments for production and development, and the access to economic feedstock resources. The time-lead enjoyed by the multinationals made it possible for them to get a better leverage in various aspects of the industry. In the absence of long-term arrangements and mutual understanding between the traditional suppliers and the new ones the threat of new suppliers may cause traditional ones to respond to:

- patent monopolization
- price fixing practices;
- group "gentlemen" agreements on investment and territorial market allocations;
- cartel arrangements which propagate a posted price policy in equalizing the competitive position of all associates, and
- joint facility for rates (with profit-equalization plan) or for distribution of products (i.e. piping grid system and terminal facilities to be used by all partners) as well as for production.

However, comparative cost advantages would ultimately be the decisive factor in proving the effectiveness of such measures.

3.5.4 Competitive position of dynamic new suppliers

New suppliers from developing countries may face competition in the international market, not only from traditional suppliers, but also from other developing countries, particularly from those linked to traditional suppliers from developed regions through joint venture, buy-back contracts, territorial marketing arrangements, distribution facility arrangements, etc., although such linkage might have some negative aspects. Relocation of some phases of the industry by traditional suppliers nearer to oil resources is usually for the purpose of ensuring continuous access to raw material and to a growing market. But usually relevant joint ventures are directed toward the replacement of traditional products manufactured from alternative or natural origin resources, which are usually less competitive in developed regions. Imposed conditions on markets and on product mix and specification may hamper the development of the industry in those developing regions. The most damaging tactic to the developing countries in conjunction with joint ventures would be the delays in implementation of new productive capacities.

It needs no emphasis that mutual understanding between traditional and new suppliers as partners would offer an ideal situation for the transformation of this industry to a new structure of production and trade to the net benefit of all concerned.

3.5 Summary and conclusions

During the period 1950-1970 the value of international trade has grown 20- fold. Petrochemicals have had the best performance within the chemical sector in the same period.

It is noted, however, that the organization of the petrochemical markets is such that the major part of basic and intermediate products are captively used by the same producers or by virtue of the closely integrated production process or ownership control. Very little, between 16-50 per cent, of the production of the basic and intermediate products are transacted in the open merchant market. A major part of this is again organized on a long-term contract basis (3-5 years) on traditional supplier/consumer relationship.

The major part of the products are concentrated in three main regions of developed countries, i.e. United States, Western Europe and Japan. Therefore, the trade flow is essentially between or within (in the case of Western European developed countries) these regions. The share of the developing countries in petrochemical trade is minuscule.

Since the increase in oil price and the subsequent changes in the production cost structure of petrochemical products, i.e. increasing share of raw material and energy share, better prospects for some developing countries for the production and marketing of petrochemicals have emerged. This situation is expected to influence the restructuring of international trade in the future whereby the role of developing countries as exporters of basic and intermediate petrochemicals will greatly increase.

However, in view of the present situation of economic recession, overcapacities in developed countries, and the energy problems it is expected that the increase of exports from the developing countries to developed countries will meet greater resistance. The system of tariffs imposed by the developed countries is so organized, increasing ratio as the degree of processing go higher, as to discourage the developing countries from further processing their basic petrochemicals for export purposes. Thus the average effective rate of protection against exporters to developed market economy countries (DMECs) is 23 per cent for intermediate petrochemical products. Furthermore, a host of other non-tariffs barriers will confront the prospective exporter from developing countries.

Since the cost/price factor will in the end determine the development of trade in the international market mechanism, it is thought that if this is left to happen at will, then the structure of the market will be disrupted with unforeseen losses to all concerned. However, the best way to manage the situation without allowing such disruption would be to come to some sort of global understanding (see Chapter IV) between producers/consumers with the direct participation of governments of the developed and developing countries to resolve the problem in a permanent way to the mutual benefit of all concerned.

IV. PETROCHEMICALS FEEDSTOCK

4.1 Energy and raw materials

The petrochemical industry came into existence in association with the chemical industry in general and the crude oil refining and energy industry in particular. Therefore the study of the future development of the petrochemical industry should be considered within the context of the development of energy resources. If the feedstock demand of the industry has smoothly developed in the past decades, prior to the sharp increases in crude oil prices, due both to its limited share in total energy requirements and to the availability of cheap and excessive supply of hydrocarbon resources,the situation after 1973 is quite different. A possible fuel/feedstock conflict could jeopardize the future development of the petrochemical industry.

This chapter deals with the possible future development of traditional feedstock supply, mainly naphtha and LPG and the trends of development of alternative feedstocks to satisfy the expected development in demand and still maintain a viable petrochemical industry.

4.1.1 World energy balance in the next two decades

Projections made by different analysts for energy supply and demand for this decade and thereafter seem to vary considerably. Economic recession and the energy crisis, energy conservasion policies, improved utilization of energy resources, environmental protection measures and energy pricing policies underline the arguments of most authors. The arguments used in these projections seem to reflect the attitude of two different camps; i.e. major energy consumers and oil exporting developing countries. The oil exporting countries are adopting measures to maximize the life span of the their hydrocarbon resources through higher prices and production cuts whereas the oil consuming countries are restricting higher energy consumption and trying to develop alternative energy resources.

Efforts by major consumers (developed countrie for co-ordinating energy programmes are going just short of direct int rvention. Governments of few countries are being involved in developing alternative sources of energy while at the same time minimizing their oil imports and restricting the expansion in energy and fuel consumption by means of energy conservation measures and prices control.

In the meantime major oil exporters, responding to domestic (social and economic) needs are becoming more reluctant to allow higher export. With foreign exchange no more a constraint, and in view of the limited absorptive capacity for local investment, oil-rich developing countries see themselves in a position to dictate less production, better prices (specially for gas), and more involvement in petroleum downstream activity to valorize their oil resources before it is depleted.

While prices have a strong relationship to energy demand, it has only a minimum effect on demand for petrochemicals. Since high energy cost, while increasing feedstock cost, it will also increase indirectly the cost of natural products for which petrochemical end-products are substitutes.

A first approach to achieve higher energy efficiency is the modification of refineries to maximize the utilization of the oil barrel's energy content. Usually the output of any refinery depends not only on the characteristics of the crude feed but also on the severity of treatment as deemed essential by market demand quantitatively and qualitatively. With higher conversion processes, such as cracking, minimum losses (of too-heavy, undesired products) and more by-products will result. Some of these by-products are valuable as petrochemical feedstocks.

To design a refinery scheme, fuel consumption pattern need to be analyzed. This means the analysis of other energy sources available and the nature of the sectors they serve most. Thus, a regional analysis is required since each region differs from other in its consumption trends. For instance, while natural gas is a major fuel for the domestic and commercial as well as the industrial sectors in the US, fuel oil is the one that serve mainly these sectors in Western Europe and Japan. This fact together with the high fuel consumption of the transportation sector in the USA promoted the development of conversion refineries there at a much earlier stage to the point that the possibilities for higher conversion are almost exhausted (Table 4.1). Demand in the developed market economy countries on three groups of refined products is given in (Table 4.2).

Table 4.1 Developed countries refining capacity (MMB/day)

	USA[a/]	OECD Europe	Japan	Other OECD	Total
TOPPING	18.104	17.672	5.509	3.019	44.304
CAT. Cracking	5.869	0.908	0.341	0.815	7.933
Thermal Cracking	1.496	0.616	—	0.079	2.191
CAT Reforming	3.794	2.323	0.565	0.613	7.295

a/ USA and Canada capacity as of 1 January 1979, except for US topping which is, like the rest, as of 1 January 1980.

Source: OPEC, Proceedings of the "Workshop on Refining Operations in OPEC member countries", Djakarta, Indonesia, 11-14 February 1980.

Table 4.2. **Oil product demand in major consuming markets**

(MMB/D)

	Demand 1978	Per cent growth rate 1973-1978	Predicted Demand 1980	1985	1990
USA					
Gasoline	7.454	2.1	7.12	6.8	6.46
Middle distillates	4.619	1.1	4.80	5.32	5.87
Residue oils	2.881	0.2	2.90	2.96	2.96
OECD Europe					
Gasoline and naphtha	3.128	1.4	3.3	3.73	4.22
Middle distillates	5.080	0.06	5.29	5.84	6.45
Residue oils	3.955	-2.8	4.3	4.75	4.75
Japan					
Gasoline	0.572	4.1	0.63	0.80	0.98
Naphtha	0.652	-0.1	0.66	0.66	0.73
Middle distillates	1.265	4.3	1.25	1.52	1.76
Residue oils	1.867	-3.0	1.8	1.88	1.95

Source: OPEC, Proceedings of the "Workshop on refining operation in the OPEC member countries, Djakarta, 11-14 February 1980.

Most projections for energy balance are based on the author's interpretations pertaining to the traditional relationship between population, GDP and energy, taking into consideration energy savings or conservation policies and relevant technological developments. Since the energy crisis of the 1970s, energy supply/demand projections have become one of the most popular theme of our time. In one such study world demand was predicted to grown on the average by 3.7 per cent annually between 1973 and 1985, and by 3.2 per cent from 1985 to the year 2000, as against GDP growth rate of 4.2 per cent and 3.4 per cent and population growth rate of 2 per cent and 1.7 per cent for the same period, respectively.[46] Changes in income elasticity of net energy use for the periods under consideration, hence, were 0.9 and 0.95. Results of the study are presented in (Table 4.3).

Table 4.3 Production

	1973		1985		2000	
	MMB/D[a]	%	MMB/D[a]	%	MMB/D[a]	%
Coal	34.2	28.9	58.4	30.6	126.3	38.5
Oil, NGL	58.2	49.3	81.4	42.7	93.4	28.5
Gas	22.6	19.1	36.2	19.0	48.6	14.8
Hydro-power	2.2	1.9	3.9	2.1	7.6	2.3
Nuclear energy	1.0	0.8	10.9	5.	46.3	14.1
Other sources	-	-	-	-	5.8	1.8
Total	118.2	100%	190.9	100%	328.1	100%

a/ Equivalent to barrels of oil. For hydrogen at 3.6 MJ per Kwh, and for nuclear power at 10.29 MJ/Kwh corresponding with efficiency of power generation of 35 per cent.

46/ Van Mem and Associated Ltd, supply and demand analysis, 1973-2025, Canada, 1978.

Table 4.3 (continued)

World net energy demand

	1973		1985		2000	
	MMB/D	%	MMB/D	%	MMB/D	%
Coal	20.2	20.2	31.4	20.3	63.2	25.4
Oil, NGL	50.0	50.0	70.9	45.8	85.9	34.6
Gas	19.5	19.5	30.7	19.8	45.4	18.3
Electricity	10.3	10.3	21.9	14.1	52.0	20.9
Other sources					2.1	0.8
Total	100.0	100%	154.9	100%	248.7	100%

Other projections also stress the competition between coal and oil as a major source of energy in the next two decades. Coal is expected to generate more energy for the industrial markets, but not in the residential or commercial markets, since electricity which can be based on coal could be the major competitor to oil products (namely heavy fuel oil) with some dependence on oil products (light fuel oil, diesel fuel, natural gas) at least for peak load. Nuclear power might expand at higher rates. But oil products will continue to be uncontested energy source for transportation for a long time.

The latest projection on primary energy resources just published by IIASA indicate another interesting view on the future development of energy resources. (Table 4.4).

Table 4.4 **Primary energy sources, 1975, 2000, 2030**
(in Quads = 10^{15} BTU)

	1975 (base year)		2000		2030	
Primary source	Quads	%	Quads	%	Quads	%
Oil	115	46.5	177	35.0	205	19.2
Gas	45	18.2	93	18.5	179	16.8
Coal	68	27.5	148	29.3	359	33.7
Nuclear	4	1.6	52	10.3	242	22.7
Hydroelectricity	15	6.2	25	4.9	43	4.0
Solar	0	-	3	0.6	14	1.3
Others *	0	-	7	1.4	24	2.3
Total	247	100.0	505	100.0	1066	100.0

* Include biogas, geothermal, commercial wood use.

Source: IIASA as quoted in CW/March 18, 1981.

With all expected changes in energy consumption and production trends the highest portion of world energy will always be oil and their products. Energy major exporters in this context will no doubt be OPEC members (dominated by the Middle East and North African countries), and very few non-OPEC countries, i.e. USSR, Mexico. Whereas world trade in coal is expected to be dominated by USA and USSR.

4.1.2 Energy balance in selected developed regions

4.1.2.1 Energy situation in the USA

Growth in petroleum consumption in the US is forecast to average 2.3% per annum between 1977 - 1990[47/], a significant reduction from the 7.7% rate observed between 1960 - 1970. The ratio of energy consumption to GNP in the USA is expected to decline from 57.3 to 50.6 thousand BTUs per dollar (at 1972 prices) between 1977 - 1990. The main changes in consumption is expected to be in transportation (from 26% to 22%) with motor gasoline requirements projected to peak in the early 1980s, reflecting improvement in automotive fuel economy. OECD countries as a whole is expected to reduce the average annual growth of oil consumption by 1.3% over the same period, with an average growth rate of 1.7% in petroleum production. OPEC member states, on the other hand, are expected to lower their production growth rate to 1.1% annually, with their share in global supplies probably declining to 45% in 1990. But non-OPEC developing countries (Mexico etc.) may increase their global supply share to 12% by then, growing at a rate if 6.5% annually. In the meantime the centrally planned economies (mainly USSR and China) will remain a net exporter.

Share of oil and gas in total energy consumption may decline from about 75% (1977) to 62% (1990) while coal and nuclear power share should rise from 22% to 34% during the same period.

Local production of domestic fuel may stay at the same level, while that of gas should decline according to all studies on US energy projection. To compensate for that the country plan to rely on increasing imports of oil and gas, and on local coal production which is anticipated to increase 80% by 1990 over 1977 level.

On the average, there should be a moderate increase of light end products consumption as compared to that in the early 1970s.

4.1.2.2 Energy situation in Western Europe

Energy supply/demand situation in Western Europe is expected to change during the 1980s and thereafter not only as a result of energy

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47/ Refinery flexibility, an interim report of the National Petroleum Council, Dec. 1979.

conservation policies and new sources, but also to balance the specific need to be imposed on different resources. In mid seventies petroleum constituted 56% of all energy supply, followed by coal (21%), natural gas (13%), hydroelectric power (about 8%) and the rest was nuclear energy. During the 1980s the growth rate of supply is expected to be very high for nuclear energy, followed by natural gas; and by 1990, petroleum may account for 50% followed by coal (20%) natural gas (16%) and hydroelectric power (8%).

In balancing the supply/demand situation for different petroleum products, it is anticipated that transportation will be a big sector in promoting any adjustment. With high increase in motor gasoline and jet fuel requirements, naphtha will be in greater demand. To overcome the tight situation of naphtha supply which is also widely used as petrochemical feedstock, new refinery configuration will be needed, along the line which has long been taken by the refineries in the USA, to maximize the middle and light distillates, (catalytic cracking and visbreaking). This could add substantive quantities of synthetic naphtha to supplement the virging naphtha at the expense of the heavy fuel oil which might be replaced by natural gas, coal and nuclear energy in the utility and industrial sectors (for power generation). This also means better supply situation for gas oil which will be relieved as a substitute or supplement for residual oil market.

LPG (and some lower paraffins) from refining operations in Western Europe is normally used for fuel in residential or municipality applications. Only a small amount of either propane and butane is used as petrochemical feedstocks. Larger quantities should be available in conjunction with NGL indigenous resources. Speculations are that NGL surplus will be at hand in this decade. The argument should be valid if the price of imported NGL (mainly from the Middle East region) is right.

Western Europe suffered no lasting negative effect of petroleum supply disturbances that happened in the past, and it does not seem that they will, except for high prices associated with cost of developing new resources.

4.1.2.3 The energy situation in Japan

Japan's energy situation is characterized by its high dependence on foreign resources and high elasticity againts GNP. This elasticity is expected to drop from 1.1 to 0.7 by 1985 mainly due to the decreasing contribution of energy intensive industries. The increased utilization of nuclear energy for power generation and the intensive drive to use coal and diversify the energy supply resource should ultimately lower the degree of Japan's dependence on imported crude oil and natural gas from 74.5 per cent in 1975 to 50 per cent in 1990 (Table 4.5).

Table 4.5

Outlook for energy demand and supply for Japan

Demand	1975	1985	1990	
	4.12	6.62	7.22	oil equivalent 10^8KL
(after energy saving)		5.82	7.00	"
Oil imports (incl. LPG)	3.07	3.06	3.66	"
LPG imports	9.39	20	26	million tons
Energy dependence on imported oil	74.5%	62.9%	50%	

4.1.3 Energy balance in petrochemicals

There is a consensus that during this decade the main sources for feedstock and energy for the petrochemical industry still will be oil and natural gas. This conclusion eminates from the fact that:

(a) economic decision making has to take into account the high risks involved in high-cost investments in alternative feedstock or energy sources at this stage, and

(b) the time required to install immense capital investment needed to create significant alternative sources makes it unlikely that a large section of the industry would shift to other than petroleum based resources within relatively short period of one decade.

Quantity of energy used as raw material will remain almost proportional to production volume of respective petrochemicals. But for power generation the energy consumption will depend on the technological development in conjunction with fuel saving. In general, the chemical industry consumption of energy as power and as feedstock has been in the proportion of approximately 3:2. The bulk of the energy used is in the form of electric power, steam or other energy carrier media before entering the process.

Petrochemical products are heavy energy consumers with consumption varying according to the feedstock used and to the technology involved. The energy value (content of a product i.e. energy consumed in the form of raw material plus energy spent over the various transformation steps) are represented in (Table 4.6) for some petrochemical products.

Table 4.6 Energy requirements of petrochemical building blocks a/

	Energy requirement Thermies/ton (kgcal/kg)	Feedstock energy (equivalent ton of naphtha)	Process energy fuel equivalent ton of fuel
Ammonia	9900	0.535	0.429
Benzene	14150	1.750	- 0.423
Butadien	17870	1.226	0.500
Ethanol	10930	0.736	0.320
Ethylene	14070	1.226	0.120
Methanol	9450	0.550	0.367
Propylene	14070	1.226	0.120
Toluene	12160	1.400	0.254
O-xylene	19580	1.652	0.223
P-xylene	22350	1.652	0.500

a/ C. Rainsbault, and others, Evolutions of the Refining and Petrochemical Industry, Technip, Institute Francais du Petrole, Technip, 1979.

Based on certain assumptions pertaining to growth rate of chemicals production and improved fuel efficiencies, energy requirements of the chemical industry (including feedstock energy contents) were predicted to grow annually at 4.8% for the USA, accounting for 10.7% of the country's total energy consumption by 1990 (as compared to 7.3% in 1971, with 52% coming from oil as against 31% in 1971). The proportion of oil and natural gas to total energy earmarked for petrochemical consumption in centrally planned economies is expected to be 6% by 1990. For the world as a whole the share of energy used as raw material is expected to rise from 5-6 in mid-seventies to more than 12% in the year 2000[48].

4.2 Feedstocks for the petrochemical industry

4.2.1 Present situation

From the outset the petrochemical industry has been based on hydrocarbon resources whose primarily utilization was energy generation, starting with coal, then settling predominantly on petroleum-based resources including natural (dry) gas. Thus, discussing the feedstock situation, it is imperative that the trend in energy supply and consumption be viewed in terms of the interrelationship between energy and non-energy uses of hydrocarbon resources.

Petrochemical feedstocks in general can be categorized as gas-based geedstocks or liquid feedstock.

Gas-based feedstock include methane, ethane and propane, all of which make up the bulk of the constituents of natural gas (including associated gas) and refinery gases as well as synthesis gas.

Liquid feedstocks, on the other hand, are mainly crude oil refining cuts, NGL and condensates whose components include in addition to the above some olefins and aromatics. The most noted of these cuts are butane (in LPG), naphtha and gasoil. Synthesis fuel (namely from coal), coking liquids as well as biomass ethanol are also classified as liquid feedstocks.

Traditionally the location of petrochemical industry has been resource oriented. In Europe and Japan in the neighbourhood of oil

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[48] Energy economy and efficiency in the Chemical Industry: EEC publication

refineries, in the USA it is largely concentrated on the US Gulf Coast near the Texas and Louisiana gas fields. Products were disposed of via water transport to the East Coast and barge transport to the Midwest.

4.2.2 Main Feedstocks

The petrochemical industry relies essentially on ethylene and benzene derivatives. Other basic petrochemicals (except for ammonia and methanol) are usually produced concurrently with these two major building blocks and are difficult to adjust to he demand. Thus, feedstock selection will depend on the most appropriate source for ethylene and benzene in terms of their long-term supply reliability and prices, including by-product credits.

Natural and refinery gases as well as refinery liquids form the main sources of feedstock for all petrochemicals around the world. However, different feedstocks patterns prevail in different regions, pending economic availability and supply security. Gaseous feedstocks are the most desired for ethylene production, but its competitiveness is influenced by its marketing potential as a fuel.

Cost of gas cross oceanic transportation place a high burden on its import, because of high cost essential logistics required for terminal facilities and carriers whereas pipeline transport afford a much cheaper alternative when possible.

Refinery liquids as feedstocks could be very competitive because they render both ethylene and benzene. But their competitiveness will depend very much on the by-product credits associated with ethylene production, in spite of the fact that their ethylene/feedstock yield is much inferior to the gaseous feedstock (Table 4.7).

Table 4.7 Tons of feedstock per ton of product (ethylene)[a]

- steam cracking naphtha	3.57
- steam cracking gas oil	4.2
- steam cracking ethane	1.22
- steam cracking NGL	1.52
- steam cracking LPG	2.30

a/ SRI data for average Western European feedstocks

For other products, the following conversion factors represent an average: (Ton per ton)

2.08 tons of naphtha per ton of aromatics;

1.07 tons of naphtha per ton of ammonia;

0.53 tons of naphtha per ton of methanol.

Feedstock availability is governed primarily by price value in alternative uses (i.e. heating media, or for power generation, etc.) and by the supply and demand situation. In the case of heavy (liquid) feedstocks, i.e. naphtha and gas oil, prices are dependent on crude oil prices. Therefore, any approach in estimating feedstock prices has to take into consideration first the trend in crude oil prices.

Petrochemical producers are currently most concerned with the supply of feedstocks and the cost of energy. Major efforts are being made to reduce future risk and uncertainty by ensuring flexibility to use a range of oil or gas based feedstocks and subsequently by diversifying out of oil sources, for example by switching to coal, lignite, or electricity as an energy source. Feedstock uncertainties tend to delay investment decisions and add to installed plant cost, through provision of operating flexibility for alternate raw materials. Rising feedstock energy costs also lower profitability, since producers often find it difficult to pass these higher costs on to their customers as rapidly as they are incurred.

Competition from the fuels market is also now beginning to restrict the ability of petrochemical producers to satisfy their feedstock requirements at an acceptable cost. If, as expected, crude oil prices keep rising at a rate faster than inflation and supplies of petroleum products are frequently tight, the petrochemical manufacturers will need to develop effective strategies to lessen their dependence on those hydrocarbons that are particularly valuable in the fuels market, including naphtha, aromatics and natural gas.

4.2.3 Gas-based feedstocks

4.2.3.1 Natural gas

The major constitutes of natural gas are methane and ethane. Methane is the main feedstock for ammonia and methanol (so-called gas petrochemical derivatives). Ethane is an excellent feedstock for ethylene production both economically and technically; since it entails lower investment and simpler operation with minimum by-products volume (which could be all utilized within the plant as fuel) as compared with other ethylene feedstocks. There is no other competitive use for ethane, except as fuel. Natural gas containing more than 3 per cent ethane is likely to be considered for ethane recovery. Natural gas liquids and associated gas are two important sources for LPG, which upon recovery present an interesting feedstock for steam cracking.

4.2.3.2 Refinery gases

Gases from distillation, catalytic cracking, catalytic reforming, thermal cracking or vis-breaking contain appreciable quantities of ethane and propane as well as small quantities of low paraffins and olefins (butane, ethylene, etc.). Ethane-propane mixture, is a good cracking stock for ethylene production. Other low olefins can be produced from refinery gases, but they are most used as in-plant fuel.

Ethane as valuable feedstock has been widely used to produce ethylene in the USA but little elsewhere though it does seem to be an obvious feedstock for developing countries. Ethane high yield of ethylene (70-80 per cent conversion) and negligible yield of propylene or C_4's makes it unsuitable feedstock for other products which could be obtained from other sources (i.e. propylene from cracker gas, butadiene from butane).

A large part of the ethane in the USA is captively used and only a small part is marketed. The average price of ethane in the USA for the period 1970-1980 is shown in Table 4.8, as well as the projection of these prices

Table 4.8 Ethane average prices in the USA (U$S/ton)

1970	22	1977	119
1971	24	1978	112
1972	22	1979	143
1973	24	1980	191
1974	48	1985 a/	345
1975	75	1990 a/	660
1976	86		

a/ UNIDO estimates

The price of ethane is expected to increase faster than the price of crude oil, and in accordance with the price increases of natural gas (in terms of calorific value). In the seventies the price of gas was low compared with crude oil (on a calorific value basis) and a rapid price increase should be expected if natural gas is to reach parity with oil. This means that the advantage of producing ethylene from ethane may not be as great as might have been expected in areas where it has immediate alternative uses. Low cost methanol from natural gas and from petroleum residues is an energy-carrier and a major chemical intermediate, covering the entire range of naphtha supports. The production technology for methanol passed the prototype scale, and is available for commercial use (with units of 2500 tons per day).

Methanol and syngas could be used directly to produce some ethylene derivatives, thus if it becomes commercially viable, these routes may reduce ethylene consumption, and hence reduce the reliance on its conventional feedstocks.

4.2.4 Liquid feedstocks

The major petroleum based liquid feedstocks are naphtha, gas oil, NGL/LPG and condensates. The first two and LPG are available as oil refining products, while the rest (as well as LPG) are produced in conjunction with natural gas processing. Thus their availability and prices should be a function of crude oil prices and refining schemes which are in turn a function of energy supply and demand situation.

4.2.4.1 Naphtha

Naphtha is a mixture of many components whose properties being a function of crude oil properties and fractionation cut. It is usually produced as a straight distillation cut (virgin naphtha which is usually made available for transportation fuel and petrochemical's or specialty uses) or as the non-aromatic portion in catalytic reformate after solvent-extracting BTX. It is also a by-product associated with pyrolysis gasoline or produced in the cracking of various heavy feedstocks. In the latter cases it is usually referred to as synthetic naphtha (non virgin naphtha).

As an ethylene feedstock, its use depends on its availabilty and price which has been influenced by the growing need for catalytic reforming in modern refining schemes because of the increased demand for better gasoline. Its consumption as a petrochemical feedstock is less than its use for gasoline production. The preference for naphtha as a feedstock is usually eminent in areas where there exists high demand on its valuable by-products.

Since naphtha prices are closely related to crude oil prices, producers in their effort to secure long-term supply of naphtha, are usually integrated with refineries in order to avoid too much reliance on the spot market.

Historically the price of naphtha has been 1.3 to 1.4 times the price of the basic crude oil though it was lower in the early 1970s, when it was in very free supply. A probable naphtha/crude oil of 1.35 could possibly be held during the 1980s with a little higher ratio for Japan (may be 1.45). Another important factor that will effect the naphtha price is fuel oil prices. The price of fuel oil will broadly be in equilibrium with the cost of coal. At a time when fuel oil was at US$ 210 per ton, naphtha was US$ 310 per ton but this difference was not stable. It costs about US$ 40-50 per ton to convert one ton of fuel oil into lighter products by cracking so with the present price differential there is an incentive to instal more cracking capacity as there is a shortage in Western Europe. The differential between fuel oil and naphtha should settle down at US$ 50-60 per ton. Fuel oil has been near parity with crude oil but as the latter rises coal will depress the price of fuel oil, motor gasoline and possibly naphtha will bear the brunt of the increase. The cost of conversion in real terms will however increase perhaps to US$ 60 per ton in 1980. If therefore the price of crude oil reaches US$ 350 per ton, naphtha will presumeble be in the US$ 430-480 per ton range.

If crude oil prices are projected to increase in real terms at an average annual rate of 3-4.5 per cent for the period 1980-1985-1990, then naphtha prices, on the basis of 1.35 multiplier to crude prices, will be as indicated in (Table 4.9).

Table 4.9 Estimated average price of naphtha (US$/ton)[a]
(in 1980 US dollars)

Years	Western Europe at growth rate 3%	Western Europe at growth rate 4.5%	USA at growth rate 3%	USA at growth rate 4.5%	Japan at growth rate 3%	Japan at growth rate 4.5%
1980	344	344	368	368	350	350
1985	400	496	400	496	430	533
1990	462	534	462	534	497	573

a/ Crude at an average price of US$ 250 per ton.

Table 4.10 shows the relationship between crude oil and naphtha prices in Western Europe and USA for the period 1970-1980.

Table 4.10 Crude oil and naphtha prices in Western Europe and USA
1970-1980*(US dollars per ton)

	Western Europe			USA		
	Crude oil[a]	Naphtha[b]	Naphtha/crude oil	Crude oil[c]	Naphtha	Naphtha/crude oil
	(1)	(2)	3=2:1	(1)	(2)	3=2:1
1970	14.0	21.0	1.5	22.3	20.0	0.9
1971	21.2	21.0	0.99	23.8	21.0	0.9
1972	21.2	25.0	1.2	25.3	23.0	0.9
1973	28.9	69.0	2.4	26.7	25.0	0.9
1974	76.0	123.0	1.6	64.0	80.0	1.2
1975	95.5	110.0	1.1	73.6	130.0	1.8
1976	98.5	131.0	1.3	79.6	125.0	1.6
1977	103.2	125.0	1.2	87.8	130.0	1.5
1978	105.4	146.0	1.4	90.7	140.0	1.5
1979	189.4	312.0	1.6	133.1	179.0	1.3
1980	255.0	320.0	1.2	211.3	268.0	1.3

* Crude oil gravity assumed at API 38° (0.85 S.G).
a/ C.I.F. Rotterdam, Platt's Oilgram Press Service
b/ F.O.B. Rotterdam (barges), Platt's Oilgram Press Service
c/ Average price paid by Refiners in USA, taking into account the effect of control

N.B. The USA price takes into consideration the phasing out of controls by the end of 1981. In the case of Japan higher factor was used in view of the fact that the refiners there places higher burden on naphtha to compensate for lower-than usual kerosene prices to accomodate domestic consumers.

4.2.4.2 Gas oil

Atmospheric gas oil is a possible olefin feedstock, but its economics depend on its value as a fuel and as a feedstock for catalytic cracking and synthetized gas production. Should lighter crudes which give high yields of naphtha without cracking become dearer, gas oil could be a valuable alternative to naphtha.

However, a refinery production - demand balance should be achieved before large quantities of gas oil could be committed as feedstock, since a large demand for light distillate for the fuel market, including gas oil for the diesel engine does exist. Furthermore, certain refining conversion process rely on gas oil. It is to be noted that gas oil with maximum quantity of parafinic hydrocarbons is desired both as petrochemical feedstock and as diesel oil (with higher cetane value and lower sulfur content).

Quite few steam crackers have been designed for naphtha-gas oil flexibility. In order to be competitive, it was ascertained that the gas oil price must not exceed 85 per cent of the naphtha price, due to the lower yield expected from gas oil and the higher investment involved. Such case may not materialize because of the expected increase in demand for middle distillates in the regions where naphtha might be available. Thus, it is not likely that gas oil will be an important feedstock in the near future except in special circumstances when it is in surplus.

Historical prices of gas oil in Western Europe in the seventies indicate that their ratio to crude oil prices (except for 1973) fluctuated between a maximum of 1.85 in 1970 to a minimum of 1.04 in 1975 but settled at around 1.2 in the late seventies (except for 1979 that it climbed to 1.6 per cent). A rough indicator of the future prices of gas oil would be arrived at by multiplying crude oil prices by a factor of 1.2.

Because VGO's have significantly lower price than both naphtha and gas oil, pretreatment may afford to render improved steam cracker feedstock along with other products (i.e. cracked fuel oil, diesel oil, etc.). The viability of its use in this route will depend on its availability and pretreatment cost involved as well as market realization of the co-products and degree of utilization of the cracked fuel oil in the production of carbon black for instance.

4.2.4.3 Liquified petroleum gas (LPG)

L.P.G. generally speaking is a mixture of butane, isobutane and propane with possibly some propylene and butylenes. It is usually obtained from L.N.G. or associated gas or, depending on the pressure under which the oil well is operated, it may be the first fraction when crude oil is distilled. It may also be the first liquefiable fraction from cracking a high boiling petroleum fraction but in this case it will contain substantial amount of olefins i.e. propylene and butylene.

Its traditional use has been as a heating media. The butanes fraction used for domestic heating can be stored at relatively low pressures, with some propane required in the liquid gas to give the necessary volatility in cold climates. For industrial purposes propane under a relatively high pressure is generally preferred.

L.P.G. can be used as petrochemical feedstock but till now little elsewhere. The good yield of both ethylene and propylene makes it very attractive and ought to boost its price which is usually low as a fuel. In practice it is very difficult to find representative prices for L.P.G. as a whole. In the U.S. it is usually separated into its three major constituents which have different values. There is little difference between them on a weight basis as a fuel, but isobutane has a definite value as a chemical raw material. It reacts with olefins, (usually butylenes) to give 'alkylate', a hydrocarbon with a high anti-knock rating and a valuable blending agent in gasoline. With the phasing out of lead this product may become even more valuable. A process has just been announced by which isobutane can be dehydrogenated to isobutylene which react with methyl alcohol to give methyl tertiary butyl ether (M.T.B.E.), a recently developed super blending agent for gasoline.

In a rather different field isobutane can form with oxygen under suitable conditions a peroxide which will then react with propylene to form propylene oxide and tertiary butyl alcohol.

n-Butane has also been used on a very large scale for the production of butadiene by dehydrogenation. This has been widely used in the U.S. where ethane and propane have been for many years the preferred cracking stock but the gradual shift to naphtha has enabled butadiene to be extracted from the C_4 stream of naphtha steam cracking. Thus the demand for butane for dehydrogenation, which has been always small in West Europe, is steadily falling of in the U.S.A.

In steam cracking of L.P.G., isobutane is poor cracking stock and gives little ethylene. Table 4.11 shows the product from cracking 1000 tons of L.P.G. of different composition under comparative conditions.

Table 4.11 Product from cracking 1000 tons of L.P.G.s 1/

	Propane	n-Butane (less than 5% iso)	70% n-Butane 2/ 30% Isobutane
Gases (largely methane and hydrogen)	262	225	229
Ethylene	440	410	330
Propylene	150	170	185
C_4s	35	110	115

1/ The figures represent the arithmetic mean of those of Stone and Webster and Chem. Syst.

2/ Isobutane fraction in total butane from different crudes ranges between 20% and 50% iso and the 70% - 30% represents a fair average.

Isobutane is undesirable as a cracking stock. In only very few cases it has been possible to obtain prices for unseparated L.P.G.'s. Average prices for the three components of L.P.G. in the U.S.A. are shown in Table 4.12.

Table 4.12 Average U.S. prices for propane, n-butane and isobutane (in $ ton)

	Propane	n-Butane	Isobutane
1970	25-43	22	24
1971	25-44	24	33
1972	24-44	22	32
1973	45-52	31	40
1974	80-84	128	70
1975	82-100	86	114
1976	92-112	145	145
1977	118-128	117	141
1978	116-128	112	142
1979	contract 140, spot 200	250	350
1980	" 230, " 270	330	400

Propane prices vary according to location, the highest prices are f.o.b. New York harbour. Normal butane and isobutane prices between 1970 and 1978 are tariff commission unit values representing an overall average.

The price from 1978 onward became very erratic. Butane which had been at about U.S. $ 120 per ton in the latter half of 1977 fell during 1978 to about $ 80 per ton. During early 1979, the Iranian situation caused an increase in butane demand for blending with naphtha as cracking feedstock, for blending with gasoline and even for steam generation owing to the high price of intra-state natural gas. Spot market prices rose fourfolds to U.S. $ 320 per ton or even higher. However they fell again to U.S. $ 200-220 per ton towards the end of 1979. Usually little butanes or propane is sold on the spot market and the actual contract price may be steadier than it has appeared.

Propane in the U.S.A. is used mainly as a fuel for heating and is subject to price control so the price has shown far less fluctuations than butane. Imports from Canada via the pipe-line, were priced at about $ 120 per ton and averaged $ 160 per ton for those delivered from the Middle East. A further complication is that whereas propane is always controlled, as mentioned above, butane and isobutane are not controlled except when used for domestic purposes.

In Japan the prices for butane between 1974 and 1976 inclusive remained remarkably constant, falling slightly from U.S. $ 143-140 per ton, which is not very different from the price of L.P.G. in Europe. There has, however, been steep rise just recently and a price of more than U.S. $ 300 per ton has been reached. The price of propan as domestic fuel is more under control in Japan, although it is higher than those of other regions.

In trying to estimate the future prices for L.P.G. a number of factors must be borne in mind. When its sole use is for fuel, an average price will be used in which case the user will be paying a premium for the isobutane which has no great calorific value.

The use of butanes to make butadiene is likely to decrease. N-butane is a useful additive to gasoline, helping to quick starting of motors. Separation of the two isomers is not absolutely essential but is advantageous as any appreciable amount of isobutane would give vapour lock.

A recently developed process to produce maleic anhydride direct from butane should be in competition with benzene and n-butylene, and add to its value.

There is much competition for L.P.G. use as a cracking feedstock. Chem Systems have forecast, however that the use of L.P.G. will increase as steam cracker feed from 7.2% (mainly in U.S.A.) to 13.1 % by 1990. Existing naphtha crackers may allow 10-15% of butane in a naphtha feed blend. Simple modification would be needed to operate on butane alone. New crackers design is essential in order to have a larger flexibility of propane, however it could be handled in association with ethane better.

In view of its high yield of ethylene a higher price for L.P.G., particularly n-butane, would be justified in a steam cracker. If it is assumed that n-butane will be worth 10% more than naphtha and isobutane at least 10% more than that, while propane would remain about 10% below fuel parity with n-butane. A future price indication for these products on the basis of the above assumption is shown below for Wester Europe.

Table 4.13 Future prices of propane and butanes in US $/ton (1980 dollar)

	Propane	n-Butane	Isobutane
1980	359	378	416
1985	419	441	485
1990	485	511	562

For the U.S.A. the figures for 1985 onwards would be similar. In Japan the prices are expected to be slightly lower, owing to the drive for keeping L.P.G. prices down for the sake of the domestic uses, making the use of L.P.G. for steam cracking more attractive.

4.2.5 Logistics for oil-based or liquid feedstocks (naphtha, gas oil, NGL/LPG condensates)

The bulk of oil based feedstocks for olefins and aromatics production are supplied "over-the-fence" by short pipelines from nearby refineries or gas liquids fractionation plants. Occasionally, somewhat longer pipelines might be used, as occurs in naphtha movements from Flushing to Terneuzen for Dow Chemical or, as is now proposed, a gas liquids pipeline from Scotland to Teesside, linking existing ethylene plants at Wilton and Grangemouth with the new Exxon cracker at Mossmorran in Fifeshire.

Apart from feedstocks transportation savings it is the fact that the coproducts or byproducts from ethylene cracking - pyrolysis gasoline, raffinate (minus aromatics) or C_4 streams can be easily transferred back to the refinery, for the gasoline pool, which makes an over-the-fence logistic system the prime favourite.

However, the West Europeans and the Japanese in particular, plus isolated U.S. companies, such as Union Carbide and Corco in Puerto Rico, have regularly imported large volumes of naphtha and condensates and in the future sill import large quantities of L.P.G. chiefly from the Middle East, North Africa and the North Sea. The main sources of export naphtha for Western Europe, Japan and the U.S.A. are shown in Table 4.14.

Table 4.14 Main export naphtha suppliers
(main countries excluding Iran)

Country		Approximate aanual naphtha metric tonnage for sale
USSR		3 000 000
Bahamas		2 500 000
Kuwait		2 000 000
Egypt		900 000
Algeria		400 000
Bangladesh		300 000
Pakistan		300 000
Cuba		300 000
Romania		200 000
Libya		300 000
Yugoslavia		200 000
Tunisia		150 000
Sri Lanka		100 000
PDRY		100 000
Singapore		1 500 000
	TOTAL	12 250 000

The largest naphtha buyers in Europe of these exports are Dow, ICI, DSM, CdF Chimie and BASF. These companies usually take delivery of 20 000 metric ton cargoes, either directly into their own storage (ICI and Dow) or via the extensive public terminals in the Rotterdam-Antwerp area, such as those of Paktank, Van Ommeren or Pakhoed.

Condensates move in the same way, in handy size 20-25.000 metric ton oil tankers and again Dow, CdF Chimie and BASF are major buyers, with Sonatrach in Algeria the largest seller. Some of this condensate also moves as far as Puerto Rico for use by Corco and Union Carbide, because it was treated as a chemical feedstock, under the US Government entitlement system.

L.P.G., which is a feedstock only now gaining popularity for ethylene production is facing ligistics problems because of the lack of either directly owned or public terminalling facilities. Dow Chemical has built its own storage facilities at Terneuzen and Van Ommeren/Thyssen Bornemizva are constructing a major public terminal (Eurogas) in Flushing. DSM are discussing underground clay cavern storage in Antwerp and Shell/BP are constructing a large terminal at Maasvlakte on the edge of Rotterdam's Europoort, to be opened in 1984. However, there is no doubt that the build-up of imported L.P.G. usage by the Europan chemical industry, to a level of say 7 to 10 million metric tons per year, will take time, because of the slow pace of import terminal building. There is no doubt that L.P.G. export availability and much of the sepcialised shipping are already in existence. Possible export availabilities from North Africa and the Middle East is expected to amount to 33.0 mt/y and 33.4 mt/y in 1985 and 1990.

Table 4.15 LPG export forecast for Middle East and for Africa to 1990 (millions of metric tons)

Area/Country	1978	1980	1985	1990
Saudi Arabia	4.9	6.7	12.8	12.9
Other Middle East	2.5	5.7	14.2	13.6
Algeria	0.2	2.0	5.6	6.1
Other Africa	0.2	0.3	0.4	0.8
	7.8	14.7	33.0	33.4

Source: Chem Systems.

Japan and the U.S.A. are believed to be in a better position than Western Europe as regards L.P.G. terminals because of the higher levels of historical L.P.G. fuel usage in Japan and in the U.S.A., as well as the existence of specialist L.P.G. companies, such as Neches Butane, who produce butadiene from butane. In addition, the USA has been for a long time a major user of L.P.G. feedstocks for ethylene production.

The very large volumes of chemical feedstocks required, (40 million metric tons of naphtha in Western Europe per annum, for example), have led companies to install pipelines and storage facilities to handle the products and they are ready to invest further sums if a feedstock price/supply advantage can be obtaines such as with L.P.G. Imports of naphtha/condensates have been in the 3 to 5 million metric ton range in the U.S.A., about 5 to 7 millions for Western Europe and somewhat less for Japan.

The effect of feedstock on production cost varies according to the properties of feedstock and changes in by-products credits. By-products credit depends on the availability of a market for its utilization, mainly for further processing or as end-product, but not as fuel. A 1980 costing relationship of different feedstock was made for a developed region (USA) where a market for the by-products do exist, expressed as a percentage of ethylene cost. The percentages indicated express the relationship between the cost of ethylene produced and the net cost of the feedstock used, i.e. the cost of naphtha less the value of the propylene, butadiene, etc. co-produced (table 4.16).

Table 4.16 Raw material (feedstock) costs and by-product credits expressed as a percentage of ethylene cost

	50/50 per cent ethane - propane	Gas oil	Naphtha	70/30 per cent N and ISO - butane
Gross feedstock cost	53.3	119.5	111.2	109.7
By-product credit	14.0	82.4	63.8	65.5
Net feedstock cost	39.3	37.1	47.3	44.2

It is to be ascertained that co-products such as popylene and butadiene might be considered as by-products since their production do not always respond to a demand situation. Thus their prices are usually influenced by their over-supply via many processes when they are by-produced in conjunction with products (other than ethylene) i.e., cat. cracking since there is a certain degree of control on their quantities as co-products to ethylene and where some balance can be achieved.

Accordingly the cost of ethylene is linked to the value of all co-products. Ethylene prices, however, assume a wide spectrum in each region even as contract prices, with occasional spot prices falling in between the spectrum limits which interlinks themselves when contracts are negotiated at different periods. The magnitude of the variation in prices of ethylene as a commodity product is usually influenced by the feedstock prices and the degree of control over their movement. The effect of this can easily be noticed in table 4.17, in which United States' ethylene price range seems to be lower than that of Japan and Western Europe, indicating better cost range (with ethane as a major feedstock where higher yeild, less low priced by-products and gas price control).

Prediction of future prices of petrochemicals on the basis of products sources (crude and gas) cost is rather hard, particularly for those in a further down stream activity. This is quite obvious from Table 2.2 and Annex II.A which presents a historic trend of prices of feedstocks and different products.

Table 4.17 Ethylene ontract rice 1970-1980
(in dollars per ton)

	Wester Europe	U.S.A.	Japan
1970	80	68	n.a.
1971	80	77	n.a.
1972	83 - 90	66	n.a.
1973	88 - 142	73	n.a.
1974	242 - 350	77 - 176	200 - 251
1975	280 - 333	176 - 259	282 - 297
1976	298 - 350	242 - 270	312 - 332
1977	311 - 338	259 - 286	332 - 365
1978	339 - 373	242 - 330	331 - 488
1979	460 - 679	292 - 397	394 - 528
1980	723 - 805	441 - 550	756 - 770

4.2.6 Ethylene pipeline grid systems

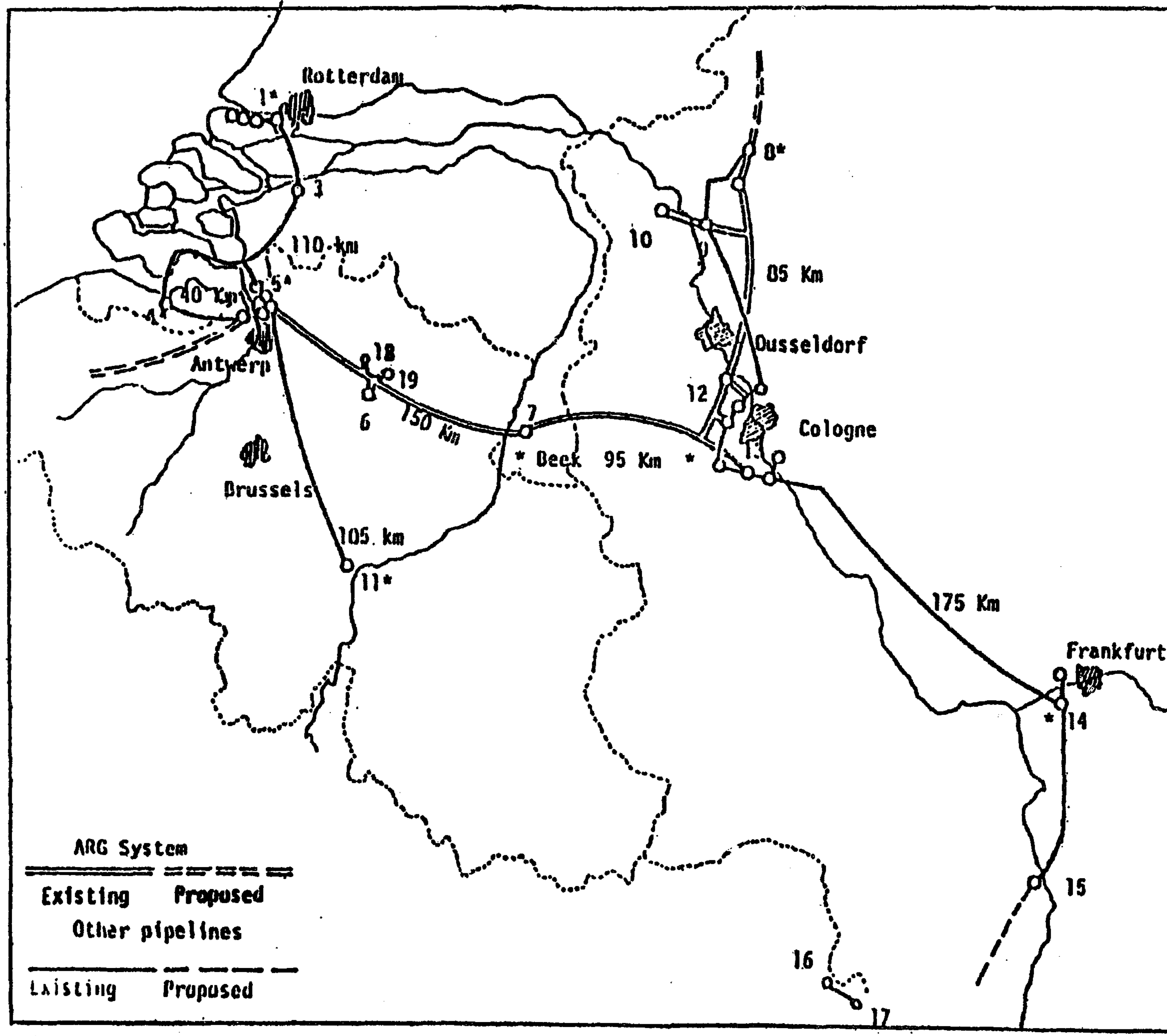
It is appropriate to discuss the inter-producer/consumer pipeline grid systems which exist in Europe and the US Gulf. They are very extensive and complex. This type of system is confined to ethylene and, apart from some short pipelines between producer/consumers, similar systems are not used for propylene. There is no ethylene grid in Japan.

There is at present, certainly in Western Europe, no possibility for an overseas producer to supply ethylene into these grids without the co-operation of one of the participants with a sea pipeline linkage - such as Dow Chemical at Terneuzen. Nearly all ethylene ships are refrigerated, whereas the pipelines are of course pressurised. The problem of unloading ethylene from ships and into pressuresed storage, for connection into the pipelines, is a major one. Direct transfer from a ship into the grid is not possible.

These pipelines systems are the best example of the sophisticated logistics systems developed by the European and US chemical industries. The ARG system grid began in the 1950' and 1960', when a number of local ethylene pipelines were constructed between suppliers and customers in the Rhine-Ruhr area of West Germany. In mid 1968 Hoechst, Frankfurt, were connected to UKBK, Wesseling, a distance of 156 km. Also in 1968 a new company, the Aethylen Rohrleintungs Gesellschaft (ARG), was founded to safeguard supplies in the face of increasing demand, especially during upsets and shut-downs. The ARG was founded by six equal share partners amongst the suppliers and consumers in the Rhine-Ruhr area. They rapidly developed a 100 bar pressure grid which by the end of 1970 connected DSM, Beek, with Erdoel, Dormagen and hence to Veba, Scholven, together with a spur to ROW, Wesseling. At the same time, an ethylene pipeline system had developed in the Antwerp, Terneuzen, Rotterdam area, also capable of operation at 100 bar, and by 1971 ARG had constructed a line extending from DSM, Beek to Bayerm Antwerp.

By 1971 therefore, there was a grid extending between Rotterdam and Terneuzen on the Netherlands North Sea coast, via Antwerp and Cologne, to both the Ruhr and Frankfurt areas of West Germany. Since tat time, many small additions have been carried our to the overall grid, the largest of which was to extend the line south from Hoechst, Frankfurt to BASF, Ludwigshafen in 1978. The overall scheme is complex and is shown schematically in detail in Figure 4.4. Total length of the system is now about 1.100 km, of which about 450 km comprises the central ARG grid.

Fig. 4.A North-West European ethylene grid (geographical)



1. Gulf
   ICI
   AKZO
   Esso
2.)
3.) Shell
4. Dow
5. Bayer
   BP (UCC)
   BASF
   Petrochim
   Polysar
   Esso
   Solvay
   Polyolefins
6. LVM
7. DSM
8. C W Huels
   Veba
9. Ruhrchemie
10.)
11.) Solvay
12. Erdoelchemie
    Wackerchemie
    Esso
    Bayer
13. Dynamit Nobel
    Knapsack
    ROW
    URBK
14. Hoechst
    Caltex
15. BASF
16. CdF Chemie
17. Solvay
18. Esso
19. Dow

The ARG system is centrally controlled from a site in DSM at Beek. Because the line is pressurised, extraction of ethylene by the customer takes place at the same time as the supplier pumps ethylene into the line. ARG charges fees according to distance and authorises pumping. The ethylene itself changes hand at free market controlled prices between buyers and sellers. There is no such thing as an ARG price.

Other shorter pipeline systems are found in the UK, France, Italy, Germany and Spain and are shown in Table 4.18.

So far, nearly all the ethylene trade in Europe has been between European locations. Thus, Dow Chemical has regularly moved ethylene from Terneuzen to Tarragona and ICI has shipped regularly from Teesside to Rozenburg.

However, in 1979 Algerias Sonatrach began to export ethylene to Southern Europe.

Table 4.18 Other West European áthylene pipeline systems 1980

Country	Line route	Companies involved
United Kingdom	Grangemouth-Wilton-Runcorn-Carrington-Sanlow	BP/ICI/Shell
France	Fos/Lavera-Lyon-Tavaux	ICI/Naphthachimie/Shell/Rhone Poulenc/Assoc. Feyzin/ATO. Solvay/PCUK
France	Carling-Sarralbe	Cdf Chimie/Solvay
France	Port Jerome Line	Esso/ATO and 6 consumers in the area
Italy	Mantova-Ferrara-Porto Maghera	Montedison
Italy (Sicily)	Gela-Ragusa-Priolo	Montedison/ANIC
Spain	Tarragona-Martorell	Enpetrol/ERT-IQA/Dow/Aiscondel/Viniclor
Germany	Muenchmunster-Burghausen-Gendorf	Veba/Marathon/Wacker Hoechst

USA

In the USA, ethylene movements have been almost exclusively internal. There are currently only two liquid ethylene terminals in the US and neither are being used. Conoco installed a 90 ton/hr import terminal during the

1973/74 ethylene shortage and imported 3-4 loads in late 1974 time period. Conoco's terminal was mothballed shortly thereafter. Conoco has evaluated adding liquification capability, but elected to forego the opportunity.

Puerto Rico olefins (PRO) a joint venture of Corco and PPG, has been active in exporting liquid ethylene, especially to Venezuela. However, this plant was shut down indefinitely in November 1978, due to a feedstock pricing dispute between Corco and PPG and the consequent Chapter 11 bankrupcy of Corco. The 6,800 tons of storage at Penuelas represented total plant storage capability for all purposes, including customer inventories. Thus, they only had space for 2-3 thousand tons which could be devoted to the export market.

Georgia Pacific is currently planning a salt dome type of import terminal at Plaquimine, La, to be on-stream in 1982. These three terminals should be compared to the 21 in/out terminals which exist in Wester Europe and are capable of receiving and delivering liquid ethylene to and from a ship. On the other hand internal ethylene movement by pipeline in the USA is very extensive. Figure IV.B is a pull out of the Texas Louisiana ethylene pipeline system, broken down into 21 geographic areas.

Summary

Logistic systems for chemical gases have generally only been built to meet a specific trade. Eurogas in Flushing is the only example of speculative investment. Ammonia and VCM facilities are mainly specific; butadiene facilities are primarily orientated to the Europe/USA trade, and ethylene/propylene terminals only exist at company locations.

4.3 Feedstock outlook

In developed regions, the feedstock situation is expected to be different from the previous trends due to many reasons:

1. Declining share in total world production capacity, with a lower growth rate in building blocks (ethylene and aromatics) capacities. This may also stem from the developed countries' growing interest in speciality products. On the other hand, a growing share of developing regions in world petrochemical production, particularly those with abundant feedstock resources, is expected to materialize during the later part of the 1980s.

2. Technological development that allow new routes for the production of certain intermediates directly from unconventional sources, such as syngases and methanol.

3. The negative impact of the energy situation, inflation and environmental protection on investment in the developed regions, in which case traditional producers become very selective when considering new investment opportunities.

The important issue in selecting the feedstock for future investment and/or for buying existing plants would be the availability and prices of reliable feedstocks. This issue compresses the degree of dependency on energy sources for fuel and the degree of backward integration of the processing to those sources. To dwell on this point further, the feedstock situation in major production centres needs to be discussed.

4.3.1 Feedstock situation in the United States of America

4.3.1.1 Trends in feedstock utilization

In the United States of America, traditional feedstocks for ethylene production consisted mainly of ethane and propane. Trends in recent years have been toward increasing the use of naphthas and middle distillates. If present rate of increase of prices persists and if the pattern of energy usage of petroleum products changes as mentioned earlier, future olefins plants in the United States will increasingly use heavier feedstocks. This will be a more realistic trend should the cry for fuel conservation and the substitution of coal for petroleum products in electrical power generation continue. This could lead toward more naphtha based olefins plants should available gas, which is depleting at a modest rate, is channelled toward power generation and municipality usage at a higher rate. But future supplies of naphtha in the United States at attractive prices are not certain either.

Increased utilization of naphtha (and middle distillates) for the production of petrochemicals in the USA will result in a significant shift of petrochemicals spectrum. This by itself will have an impact not only on international trends in petrochemicals, but also on the structure of the industry in the USA itself. The latter point can be explained better by considering the higher shift toward naphtha production of certain important by-products (butadiene) in naphtha based olefins plants which will lead to shutdowns of dehydrogenation facilities (for the butadiene). The same can apply to present refining facilities producing aromatics, although, the effect is not as clear due to the possible increasing need of such facilities for more aromatics in conjunction with higher need of improved motor fuel.

Although heavy feedstocks will be available at attractive prices, pretreatment to enhance their value as petrochemical feedstocks will add to production cost of final products.

For heavy petroleum residues no economically attractive technology has yet been commercialized, although on-going pilot activities indicate that products yield of vaccum gas oil is quite comparable to that of naphtha. Thus, more work is needed to help in increasing the range of feedstock flexibility.

The trend in the United States of olefins feedstock (for ethylene) has been projected 49/ in the following manner, expressed in percentages of ethylene produced.

Table 4.19 Feedstocks in the United States for ethylene production (per cent of ethylene produced)

	1965	1970	1975	1980	1985
Ethane and refining gas	51	52	46	40	29
Propane	32	33	25	10	8
Butane		2	2	2	9
Naphtha and middle distillates	17	13	27	48	54

Yield of different feedstocks depends not only on the feedstock properties (constituents and component characteristics) but also on the process conditions and technology involved. However, the variation in the yield of the same range of one type of feedstock can be very minimal, and an average yield can be drawn for the sake of comparison. A comparative analysis of an average yield of different ethylene feedstock in the United States 50/ is given in table 4.20.

The feedstock situation in the USA is expected to change such that the combined effect of heavier feedstocks usages would lead to an appreciable increase in by-products quantities associated with ethylene production, i.e., between 1975 and 1985, the yield trend would give an increase of 56-58 per cent for propylene and butadiene, 100 per dent for benzene and 75 per cent for Xylene.

49/ Hydrocarbon processing, Nov. 1974, CEP Sept. and Oct. 1976.

50/ Oil and gas Journal, August 1977.

Furthermore, the supply of butadiene and benzene from olefins plants would increase from 30 per cent to 96 per cent and from 11 per cent to 27 per cent of the total demand between 1975 and 1985 respectively.

Naphtha and gas oil are expected to dominate the US feedstocks well past the end of the century. But coal-based synthesis gas is not expected to be of significance before the 1990s.

Table 4.20 Average yield of ethylene feedstock in the United States

Feedstock	Ethane-Propane 50 per cent mix	Full range naphtha	Syn. Gas Gas oil
Feed rate	1.77	2.97	3.86
Products			
Ethylene	1.00	1.00	1.00
Off-gas	0.38	0.49	0.47
Propylene	0.15	0.47	0.62
Butadiene	0.05	0.15	0.18
Butene - Butane	0.10	0.13	0.19
Benzene	0.03	0.18	0.23
Toluene	0.01	0.14	0.11
Xylene	-	0.07	0.08
Others	0.03	0.22	0.28
Pyrolisis fuel oil	0.02	0.12	0.7

4.3.1.2 Feedstocks sources and future prospects

Because of the abundant domestic supply of natural gas liquids (NGL's) for ethylene production in the U.S., there is currently a much lower level of chemical company integration with refinin sector than in Western Europe. Even though many of the top companies own refineries, they have primarily integrated these with aromatics production (via reformate) and not used them to supply naphtha feedstock. However, this situation is changing since the demand for naphtha and gas oil feedstocks for steam crackers is expected to nearly double from the 1979 level by 1985. This new demand is the result of an almost complete shift to heavy liquids cracking for plants built or planned since the mid 1970's, which is in turn due to the poor outlook for increasing the supply of NGL's. The diminishing supply of natural gas and the high cost of extracting NGL's in new gas plant facilities are expected to limit the availability of ethane for steam cracking. Government regulations establishing propane allocation and use patterns have curtailed any steam cracking expansion based on this feed. However, the legislated expiration of controls on propane in 1981 could cause its possible use as a steam cracker feedstock to be reconsidered. As long as normal butane is primarily prices relative to the gasoline market, it will not seriously contend as an olefins plant feedstock. However, with diminishing gasoline demand in the USA, any surplus n-butane will probably be sent for steam cracking, when the price drops to a level competitive with other olefins feedstocks.

a) Olefins production

Of the 25 ethylene producers in the USA only 13 own refineries and only 10 of those own more than one refinery. In general those large oil companies with several refineries also have significant ethylene capacity, between 1 and 4 billion pounds per year, except for two, i.e., Mobil and Conoco. There are only two large ethylene producers who are not heavily involved in refining, Union Carbide (the 'largest' ethylene producer in the USA) and Dow Chemical.

In 1979 the practice of substituting NGL's for heavy liquids in steam crackers became more widespread as operators strove to make up for shortfalls of naphtha and gas oil supply after the (Iranian cutback) and in some cases to improve economics with lower cost feeds. Such substitutions can be expected to continue in varying degrees, depending on the economics of the feed choices in each case.

Based on committed new plants scheduled to come on stream through 1985, the NGL-related ethylene capacity is expected to decrease from nearly 65 per cent of total operating nameplate capacity in 1979, to about 53 per cent in 1985.

Installed ethylene nameplate capacities in billion pounds per year 51/ for 1979 and 1985 are broken down according to feedstock type as follows:

51/ 50 states plus Puerto Rico.

Additions

	At end of 1979	1980–1985	Net at end of 1985[1]
NGL[2]	21.1	0.2	21.4
Heavy liquids[3]	14.3	4.6	18.7
Total	35.4	4.8	40.1

1/ Total includes estimated shutdown of old plants and restart of former Arco-Polymer E/P cracker by USS Chemicals.

2/ Ethane, propane and n-butane.

3/ Naphtha, condensate and gas oil.

N.B.: Note the difference from that indicated in table 4.19, which were based on projections made in 1974, 1976. However, the two figures were maintained in order to show that the projected trend was foreseen at the beginning of the energy crisis.

b) Other olefins

1. Propylene

Unlike Europe and Japan, where almost all propylene and butadiene is derived from olefins production, the United States, because ethylene capacity has been natural-gas based, produces propylene primarily from refineries. However, this balance is slowly changing, as shown in Table 4.21.

Table 4.21 US Propylene supply 1980–1985 (billions of pounds)

Source	1980	1985	Percentage split 1985
Steam crackers			
NGL feed	2.0	2.2	
Naphtha/gas oil feed	5.4	9.1	
Subtotal	7.4	11.4	35
Refineries	20.7	20.7	65
Total	28.1	32.0	100

2. Butadiene

There has been a significant shortfall in US butadiene needs for several years which has been eliminated by the imports of European olefin derived butadiene, at the rate of about 250 thousand metric tons per year. This shortfall (and the European surplus) is directly attributable to the production of ethylene from non-naphtha feedstocks in the USA. One third of US butadiene is currently made by butene hydrogenation or butane dehydrogenation although this percentage is declining, as more heavy liquids crackers come on stream, as shown in Table 4.22.

Table 4.22 US Butadiene supply 1980-1985 (million pounds)

Source	1980	1985	Percentage from each source 1985
Steam cracker by-product	2,100	3,200	81%
Dehydrogenation	1,360	760	19%
Total	3,460	3,960	100%

Unlike Western Europe or Japan, there are in the USA a number of specialised companies who produce the butadiene from non-olefin sources, such as Neches Butane which is a joint venture of Texaco, Uniroyal and BF Goodrich.

c) Aromatics

1. Benzene

In the United States as in Western Europe and Japan, benzene is produced by three routes, refinery catalytic reforming, olefins production and coal tar processing. Additional supplies are imported, while high cost intentionally produced benzene, made via hydrodealkylation and disproportionation, bridges the gap between supply and demand. A summary of current and future benzene supply by source is given in Table 4.23.

Table 4.23 US Benzene supply (million gallons)

Source	1979	1980	1985	% in 1985
Catalytic reformate	718	709	820	39.2
Olefin plants	310	310	525	25.1
Coal tar processing	120	120	120	5.7
Imports	81	70	90	4.3
Inventory change	(48)	(35)	-	
Subtotal	1,181	1,174	1,555	74.4
Hydrodealkylation and disproportionation (by difference)	582	506	535	25.6
Total benzene supply	1,763	1,680	2,090	100,0

2. Xylenes

A mixture of the xylene isomers (ortho, meta and para) plus ethylbenzene is commonly called mixed xylenes. This mixture is produced during catalytic reforming and steam cracking. Mixed xylenes are frequently used as gasoline blending stock, normally without extraction from the reformate stream. However, a major portion of extracted mixed xylenes is employed as feedstock for the production of the separated paraxylene and orthoxylene. Extracted mixed xylenes also find use in solvent applications and some extracted material is blended back into gasoline.

The only chemical use for paraxylene is in the manufacture of dimethyl terephthlate (DMT) and terephthalic acid (TPA).

All paraxylene and orthoxylene producers in the USA except Hercofina are benzene producers, but 10 out of the 25 ethylene prodrcers do not make any aromatics.

4.3.2 Feedstock situation in Western Europe

4.3.2.1 Trend in feedstock utilization

Western European petrochemical industry has been primarily naphtha based[52/]. Competing for naphtha are petrochemicals and gasoline, with the demand, by both, increasing at a higher rate than the demand for other energy products during the past few years. The situation in the future may be slightly different due to possible declining growth rate in ethylene and aromatic production, and changing pattern in energy consumption.

It is estimated that by the year 2000, 99.5 million tons of feedstock will be required by W. Europe, a quantity representing about 13 per cent of the total petroleum demand in that region. The estimates of feedstock requirements which were based on projected petrochemical production (using an average annual growth rate of 3.6 per cent for ethylene and 3.9 per cent for aromatics) and gross feedstock conversion factors (SRI data) are summarized in table 4.24.

Feedstocks requirements for petrochemical production in Western Europe

Feedstock	Thousand of metric tons				Average annual growth rate (%)
	1977	1980	1985	1990	
Naphtha	39,500	41,500	47,700	54,300	2.7
Gas oil	4,000	7,600	12,500	15,200	7.7
NGL	200	900	1,100	3,200	15.3

The above estimate represents an overall annual growth rate in feedstock demand for motor gasoline in the last few years, low naphtha surplus (which was used as boiler fuel) went down. Since higher gasoline demand is expected, naphtha supply will be tight to a point that it becomes essential that other types of feedstock such as gas oil, exclusively or in conjunction with naphtha, be used.

52/ R.G. Muller (SRI) reported that petrochemical industry in Europe was based on: 94 per cent naphtha, 5 per cent gas oil and 1 per cent NGL. "Outlook for Traditional Feedstocks in Western Europe", symposium of chemical engineers and The Society of Chemical Industry Process Engineering Group, London, 24 April 1980.

In a more specific way, besides naphtha, gas condensates (NGL) from the North Sea Oil fields have been in use mainly in Norway as olefin feedstock. As these fields continue to develop, it is expected that more ethylene plants, particularly in North-West Europe, will be built. But one has to consider the magnitude of investment required not only in developing these fields, but also for facility to transfer feedstock from remote sources such as those, and the effect of that on feedstock prices.

The lighter feedstock supply to Western Europe may come from the USSR and OPEC countries, particularly from the Middle East and North Africa. The latter may enhance the feedstock situation in South Western Europe.

For aromatics, Europe rely on reformates for about 2/3 of its production. The rest is based on pyrolysis gasoline and to a much less degree on coal gas and coke production. The latter source which used to be the main traditional source in Europe still occupies a 7.5 per cent share in total capacity and may be relied upon for sometime to come.

For the so-called gas derivatives (ammonia, methanol, acetic acid, etc.) naphtha and heavier petroleum cuts are being used (at a rate of about 5 million tons a year). Their low economics may not allow their use further, at least in the case of heavy petroleum cuts.

In the mid 1970's, 26 per cent of the total European naphtha was used as petrochemical feedstock as against 71 per cent for gasoline. The same ratio is expected to prevail for a while. By 1990, total naphtha supply is expected to be about 217 mt with synthetic naphtha contributing about 26 per cent of the total supply as compared to about 10 per cent in 1977 (when total naphtha demand was about 150 million tons).

Technological development for alternative sources of energy and feedstock will be directed in Western Europe towards lesser dependence on petroleum derived feedstock. Coal liquification and gasification will be a major area of extensive research. But it is unlikely that commercialization of technology to affect the realization of important projects will start before the 1990's.

4.3.2.2 Degree of integration of petrochemical industry and future prospects

47 per cent of the top 34 companies involved in olefins production in Western Europe are back-integrated into refining.

Very few large olefins companies now find themselves entirely non-integrated into refining, i.e. Dow Chemicals and DSM.

Benzene is produced by three routes by 36 companies operating as follows:

- Pyrolysis gasoline route - 18 companies;
- Reformate route - 19 companies;
- Coal route - 7 company groupings.

Of the seven coal-based producers/marketers (who produce 10 per cent of the benzene in Europe), only one top chemical company is involved in the production of benzene, CdF Chimie (in France). The 18 benzene producers from pyrolysis gasoline are all back integrated into refineries, either directly or via a joint venture, except one (DSM).

However, some of the reformate based benzene producers are not involved in olefins. Mobil is the leading example with its aromatics plant adjacent to the Naples refinery. Petrogal in Portugal is another example, plus CEPSA and UERT in Spain and CONOCO in the United Kingdom. All of these companies except CONOCO have made attempts to move into olefins production within the last 10 years; Mobil at Wilhelmshaven and CEPSA/UERT with Dow at Huelva in Spain. Portugal is a special case since the Portuguese government has now olefins production at Sines, under CNP banner. All major chemical production in Portugal is state-owned.

All producers of paraxylene/orthoxylene produce both products except for ICI and Texaco who produce one product each. All producers are back-integrated into refining. Producers except Mobil and CEPSA are involved directly or indirectly with olefins production.

The above presentation illustrates the total integration level between refiners, olefins producers, benzene and xylenes producers. The highest integration level is between refining and olefins production with benzene not far behind. The key to this close structure is the very high naphtha requirement of the petrochemical industry in relation to gasoline. In 1979, about 100 million metric tons of gasoline and

Table 4.24 West European links between olefins producers, oil refiners and aromatics producers 1980

Company/Grouping	Refining	Olefins	Benzene	PX	OX
ANIC/ENI	X	X	X	X	X
BASF/ROW/Wintershall	X	X	X	-	-
BP/Erdoelchemie/ Naphthachinie	X	X	X	X	X
British Celanese	-	X	-	-	-
CdF Chimie	X	X	X	-	-
Caltex/Texaco	X	X	X	-	X
CNP/Petrogal	X	X	X	X	X
Dow Chemical	X	X	X	-	-
DSM	-	X	X	-	-
Elf/ATO/CFP	X	X	X	X	X
Enpetrol	X	X	X	-	-
Exxon	X	X	X	-	-
Gulf	X	X	XX	-	-
ICI/Phillips	X	X	X	X	-
IQA	X	X	-	-	-
Marathon	X	X	X	-	-
Montedison	X	X	X	X	X
Neste Oy	X	X	X	-	-
Noretyl	X	X	-	-	-
OMV	X	X	-	-	-
Petrochim (Phillips/Fina)	X	X	X	-	-
SIR/Runianca	X	X	X	-	-
Shell	X	X	X	X	X
Solvay	X	X	-	-	-
Veba-Huels	X	X	X	X	X
URBK	X	X	X	X	X

Source: Chem-System

40 million metric tons of naphtha were consumed for petrochemicals in Western Europe, thus petrochemicals having become a highly significant market for refinery production.

The major advantage of integrated companies is their ability to switch feedstocks within a few days from naphtha to gas oil to LPG, according to the dictates of the market, provided that olefins crackers are modified suitably. Table 4.24 gives a clear picture of the degree of integration between olefins producers, oil refiners and aromatics producers in Western Europe in 1980.

In future, North Sea hydrocarbons and imported LPG will influence this close refinery-olefins relationship. The major impact expected from the increasing availability of North Sea hydrocarbons on the European chemical industry will be that of natural gas liquids in the sector of olefins. Crackers will be built or converted to consume essentially all ethane plus some propane/butane, generally in the areas where these materials are separated. Capacities will be related to feedstock availabilities rather than to local market requirements and net shipments of both the excess olefins and derivatives will be made from Northern United Kingdom/Norway to Continental Europe.

The increase in the quantities of LPG coming onto the international market (Middle East and African sources) in the early 1980s will provide opportunities for European olefins producers to further diversify their feedstock base. Italian companies are well placed geographically to take advantage of this situation. Partial modification of existing plants and the provision for LPG cracking in new plants will be justified in many cases. LPG is expected to be a more interesting alternative to naphtha than gas oil.

The greatly reduced growth rate of fuel products and the availability of good technology from engineering companies will lead hydrocarbons producers to take over, to an ever increasing degree, the manufacture of olefins, aromatics and their first stage derivatives. In future, oil companies - both private and government owned - will produce an increasing share of intermediate chemicals. High cash flow and control of raw materials will facilitate the oil companies' penetration into many of these markets and will tend to make production of such petrochemicals considerably less attractive to traditional chemical companies. The oil companies will also continue their pattern of acquiring existing plants from chemical producers who plan to specialize in other areas. The independent chemical companies will, conversely, find it increasingly difficult to generate the cash necessary to remain competitive in the area of primary petrochemicals. This will lead to a number of possible solutions, including withdrawal to downstream products, as recently happened with Rhône-Poulenc. (See Chapter VI.)

4.3.3 Feedstock situation in Japan

All Japanese olefins production of ethylene, propylene and butadiene is based on naphtha feedstocks. Most of this naphtha is supplied from Japanese refineries under arm's length contracts. A controlled quantity of naphtha is also imported and for this purpose there is a special association of importers known as PFIC (Petrochemical Feedstock Importing Company) jointly operated by Sumitomo, Mitsubishi Petrochemical, Mitsui Petrochemical, Showa Petrochemical, Osaka Petrochemical and Mitsubishi Chemical, who handle the purchases collectively.

In Japan as in Western Europe, benzene is produced by three routes - pyrolysis gasoline, reformate, and coal. The largest number of producers (55 per cent) tend to use the olefins route, using pyrolysis gasoline as feedstock. There is however a high degree of flexibility to use alternative feedstocks. Table 4.25 shows the benzene capacity in Japan in 1979 and the sources of feedstock.

Paraxylene producers in Japan tend to be neither olefins nor benzene producers but rather DMT producers, back integrated. Thus, a low level of integration between the aromatics producers and the paraxylene/orthoxylene producers doeswexist in Japan. Only a moderate degree of vertical integration exists in Japan between oil refining, olefins and aromatics. The only two fully integrated groups are Mitsubishi and Toa Nenryo/Tonen Petrochemical/Tonen Sekiyu Kagaku, the joint ventures between Mobil, Exxon and Japanese interests (see Table 4.26).

Out of the 25 major chemical companies in Japan, 3 are directly involved in refining and only six are involved in olefin manufacturing. However, there is a strong relationship between oil refiners and olefin producers. The major significance of this relationship is their co-operation in making available feedstocks from overseas for refining operations managed or owned jointly by Japanese companies.

Table 4.25 Japanese benzene capacity 1979
(thousand metric tons per year)

Company	Location	Capacity	Source
Asia Oil	Sakaide	100	Reformate
General Petrochemical	Sakai	30	Reformate
Idemitsu	Tokuyama	175	Pygas/reformate/HDA
	Chiba	155	Reformate
Kawatetsu	Mizushima	36	Coal Tar
Maruzen Oil	Matsuyama	8	Reformate
Maruzen Petrochemical	Chiba	159	Pygas
Mitsubishi Chemical	Mizushima	150	Pygas
Mitsubishi Oil	Mizushima	134	Reformate/pygas
Mitsubishi P/chemical	Yokkaichi	356	Pygas
Mitsui Petrochemical	Chiba	76	Pygas
	Iwakuni	96	Pygas
Nippon Petrochemical	Kawasaki	70	Pygas
	Ukishima	73	Reformate
Osaka Gas	Torishima	90	Coal Tar
Osaka Petrochemical	Senpoku	100	Pygas
Sanyo Petrochemical	Mizushima	230	Pygas/reformate/coal/HDA
Shin Daikyowa	Yokkaichi	70	Pygas
Shin Nippon Steel	Muororam/hirohita	64	Coal Tar
Shin Nippon Steel Chemical	Tobata	72	Coal tar/pygas
	Ohita	80	Coal tar/pygas
		127	Pygas
Sumitomo Chemical	Chiba	90	Pygas
	Nijhama	65	Pygas
Toa Oil	Nagoya	112	Reformate
Tonen	Wakayama	40	Reformate
Toray	Kawasaki	90	Disproportionation/HDA
Total Japan		2,857	

Source: Chem-Systems

Table 4.26 Japanese links between oil refiners and aromatics producers 1980

Company/Grouping	Refining	Olefins	Benzene	PX	OX
Asia Oil	X	-	X	-	-
Idemitsu	X	X	X	-	-
Kawatetsu	-	-	X	-	-
Kuraray	-	-	-	X	-
Maruzen	X	-	X	-	X
Matsuyama	-	-	-	X	-
Mitsubishi Group	X	X	X	X	X
Mitsui Group	-	X	X	-	-
Nippon Petrochemical	-	X	X	-	-
Osaka Petrochemical	X	X	X	-	-
Sanyo Petrochemical	X	X	X	-	-
Shin Daikyowa	X	X	X	-	-
Sumitomo Group	X	X	X	-	-
Toa Oil	X	-	X	-	-
Tonen Petrochemical	X	X	X	X	X
Toray	-	-	X	X	X

Source: Chem-Systems

4.3.4 Feedstock situation in the developing countries

It is more difficult to estimate the feedstock situation in the developing countries according to its sources, partly because of the limited quantities of petrochemicals produced there and partly because of the limited statistical data available. However, taking into consideration the pattern of petrochemical production, mainly basic olefins, and the pattern of demand on petrochemical products arising mainly from predominantly primary economies requiring little sophisticated products, as well as the low level of fuel consumption, it can be said that at present and during the 1980s the problems confronting the developed countries are not likely to confront the majority of the developing countries, i.e. fuel/feedstock conflict.

However, such a generalized statement would not be true when applied to the developing countries as a whole but rather to specific groups of countries within the developing countries. Oil producing developing countries will have an obviously excessive supply of feedstocks, even after taking into consideration all the planned utilization of their hydrocarbon resources to the end of the century. Flared gases alone in oil producing countries have reached a level of 2.7 mbl/d (oil equivalent) in 1978 which was equivalent to 46 per cent of their total production of these gases, and 8.4 per cent of their total crude oil output.[53/] With the anticipated increase in their refining capacities for export purposes, this group of countries would have large amounts of feedstocks for the production of aromatics in the future not only to satisfy their own production plans of petrochemicals but also would be available for exports to developed and developing countries.

Newly industrialized developing countries with no hydrocarbon resources which have achieved a relatively high level of petrochemical production to satisfy their internal demand and achieve a certain position in the international market, will be in a situation of dependence on imports not much different from developed regions. The future of their petrochemicals in this context will depend on the availability of supply and prices of crude oil (for refining) and imports of supplementary feedstocks and basic and intermediate petrochemicals from the rest of the world, especially oil producing developing countries.

53/ See The Industrial Uses of Associated Gas, UNIDO, A third group of developing countries with large vegetation or large coal supply would be in a favourable position in the future to utilize these resources for the production of syngas and methanol (see Table 4.27).

The majority of the other developing countries will have to depend for their energy and feedstock supply on imports from the oil exporting countries. With anticipated increase in oil prices, it is doubtful if these countries could maintain a viable petrochemical industry without entering into special long-term arrangements with oil producing developing countries and/or with other developing countries, either on multilateral or bilateral basis.

4.4 Alternative sources of feedstocks

The major hydrocarbon resources that have been utilized as a common source for energy and feedstocks for the petrochemical industry have been petroleum and natural gas. Non-petroleum sources, including coal, biomass, shale oil and tar sands, have their own economic or technological limitations at least for the time being.

4.4.1 Coal

In the case of coal, the cost of mining, transportation and environmental investments are still high enough to block its uses for the industry on a competitive basis against even the expensive new oil discoveries.

Furthermore, under present economic conditions, synthesis gas (carbon monoxide and hydrogen which has been utilized for the production of a number of petrochemicals, i.e. acetaldehyde, acetic acid, vinyl acetate, ethylene glycol, etc.) is not so economical if it is coal-based when compared with petroleum-based hydrocarbons. Thus the trend in coal usage for the industry will be toward large energy plants co-generating electricity and low-pressure steam, probably in conjunction with the production of synthesis gas. However, efforts of many companies and governments of few developed countries are underway to develop a better system for coal gasification and liquification, but active investments are still confined to regions that have already been in this activity for a long time, such as South Africa.

In the United States, plants of 1,000-1,500 tons of coal per day capacity are being considered for the provision of synthesis gas as feedstocks for the petrochemical industry and as fuel for power generation. The gas can be used for the synthesis of ammonia, methanol, hydrocarbons and substitute natural gas as well as for the production of hydrogen.

Economics of such plants varies. At a United States location in mid-1977, the investment for a 4 million cubic meter/day plant was estimated at $120 million. For a low-cost coal feed, the synthesis gas cost would amount to $2.5 per million BTU, but for deep-mined coal (as in Europe) the cost could be as high as $3.5 per million BTU.[54/]

Underground gasification experiments have been initiated in different parts of the world to optimize the yield of coal mines in response to energy crises. Marginal coal gasification experiments in places like Wyoming in the United States gave some indications of successful results in comparison with underground liquification.[55/]

Synthetic fuel technology is still under improvement and it was predicted that several decades may elapse before there is any commercial production of coal-derived fuels.[56/]

There is a large number of processes for obtaining oil from coal and many of these include the production of naphtha and similar feedstocks for petrochemicals.

Omitting processes based on coal carbonization, which have been in use for a very long time and produce mainly aromatic hydrocarbons but only as by-products, the following are the main existing processes producing ethylene precursors.

4.4.1.1 The Bergius process

This process is basically the hydrogenation of powdered coal under very high pressure. A modification was used by ICI before the war. National security was then of more importance than economics with gasoline as the main products, although it could yield steam-cracking stock. There was, and had been, considerable use of the process in Germany but most of their plants were destroyed during the war. The

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54/ Chemical Age, 26 October 1979
55/ Chemical Engineer, 3 December 1979
56/ Chemical Week, 6 December 1978

only one that remained operating into the fifties was that at Leuna (GDR). ICI have soon found that the process was uneconomical, and its plant was converted to other uses. Later developments for this process have taken place mainly in the United States.

4.4.1.2 The COED process (EMC Corporation). In this process, coal is converted to char (60%) and"synthetic crude oil"(Syncrude) (10-20%).

4.4.1.3 Flash pyrolysis (Occidental Research Corporation). This is a rapid pyrolysis at low pressure and rapid quench. The tar is hydrotreated to form a "syncrude".

4.4.1.4 Hydrogen donor solvent process (Exxon). Coal is heated with a hydroaromatic solvent to give naphta-blending stock with 30-40% recovery on coal.

4.4.1.5 H-coal process (Hydrocarbon Research Inc.). In this process, pulverised coal slurried with coal-derived recycled oil is mixed with hydrogen and fed into amebullated bed in the presence of a cobalt-molybdenum catalyst. It yields a low-sulphur fuel oil, with 30-40% recovery on the coal. This fuel can be used as cracking stock.

4.4.1.6 Fischer-Tropsch process. This was operated in the F.R.G. during the war and now operates on a large scale in South Africa, where complete gasification of coal is followed by hydrogenation over cobalt catalyst. It is mainly designed for gasoline (excellent cracking stock), but it also yields large quantities of paraffin wax.

4.4.1.7 Mobil process. Coal is completely gasified and converted either via methanol or directly over a Zeolite catalyst to yield liquid hydrocarbons. Ninety per cent yield is claimed. This is possibly one of the most promising of the processes.

4.4.1.8 Solvent extraction (National Coal Board). In this process, coal is extracted with super-critical gas, e.g. toluene vapour. Fifty per cent of the coal can be extracted, to be converted to chemical feedstocks or liquid fuel.

Except for the Bergius process, which is considered unviable, and the Fischer-Tropsch process, all other processes are at various stages of development mostly at pilot plant stage. The Mobil process is understood to be going ahead, but from methanol produced from oil in the first instance. Many of the others are excellent for producing high-boiling aromatics, but these do not produce good cracking stock.

Calculations have been made by the National Coal Board indicating that with crude oil at $ 30 per barrel a range of oil products including naphta could be produced at competitive prices now that the price of coal is $ 35-40 per ton. So that from the NBC calculations, a viable process from coal could be developed now that the price of crude is being allowed to reach world prices.

It must however be reemphasized that none of the processes, except the Fischer Tropsch, give much better yields than the old Bergius process. SASOL in South Africa are not very forthcoming about costs, but their balance sheets do show that they are making a profit.

The price of coal is inevitably linked with the price of fuel oil and it is possible that coal might hold the price of fuel oil down, in which case the lighter products might have to carry more of the refining cost. If the coal is required on a large scale for petrochemical production its price may be increased, and once again it becomes uncompetitive.

4.4.2 Biomass

The world production of photosynthesis biomass was estimated at 150 billion tons/year, and probably no more than 5% of this quantity will be necessary to meet the present demand for oil and gas[57/]. This portion appears to be too small to really affect other utilization of biomass i.e. food for human, animal feed, restitution to the soil of organic matter in order to maintain fertility.

The major problem associated with utilization of this source of energy and feedstocks for the chemical industry is the difficulty to collect the appropriate quantities. To overcome such a situation special economic and efficient production scheme known as energy farming has been proposed. For certain countries this may not be feasible because of soil and climatic limitations. For others, large quantities of agriculture wastes are being transfered to useful by-products and/or for energy purposes.

57/ Workshop on Fermentation Alcohol for Use as Fuel and Chemical Feedstock in Developing Countries (ID/WG.293/41, P. Duyuy: Products of Photosynthesis as Raw Material for Chemical Industry)

The most important routes for the utilization of biomass for the petrochemical industry are the ethanol and methanol routes. Several companies are investigating different aspects of relevant economic processes to justify this application not only in oil-deficient countries, but to improve their competitive status in areas with other hydrocarbon resources.

Most of the attention in this area has been focussed on motor fuel production, notably ethanol for gasohol. The conclusion has generally been that biomass is not an economical energy source without some form of government subsidy. However, many governments are prepared to provide this subsidy in one form or another, so it is to be expected that such energy projects will proceed in some developing countries that are rich in agriculture and short of hydrocarbon resources. Such countries include those listed in table 4.27. Having said that, the French Government has recently, to confound everyone, begun investigations into gasohol with potential imports from Brazil.

Since chemicals are generally highly-valued products than fuel, it has been suggested that biomass might be able to replace significant amounts of petroleum derived chemical feedstocks over the next 20 years. Many small volume, specially chemicals and pharmaceuticals, produced via fermentation enzymes and other biotechnologies, are already important and will expand dramatically during this century but will have little effect upon demand for petroleum derived feedstocks. Biomass feedstocks must be competitive for the production of large volume commodity chemicals such as ethylene if they are to have any significant effect on the petrochemical industry.

The only biomass derivatives for which the technology for conversion to usable chemical intermediates exists are ethanol via fermentation (with or without hydrolysis), synthesis gas via partial oxidation, and pyrolysis liquids via thermal pyrolysis.

The economic analysis can be simplified by examining the economics of the primary conversion processes. The products of these processes which include synthesis gas, pyrolysed liquids, and ethanol are not in themselves generally considered commodity petrochemicals; they are instead intermediates to major petrochemicals. Thus further conversion

Table 4.27

COUNTRIES WITH FAVORABLE FACTORS FOR BIOMASS UTILISATION

	Oil Balance MM metric tons	Oil Reserves MM bbl	1975 Trade Balance, MM $	1975 International Reserves, $ Billion	Forested Land, MM hectares	Arable Land, MM hectares	Economically Active Population, % of total population	IDA Commitments, MM$
Ivory Coast	-1.5	-	141	0.1			-	
Kenya	-2.6	-	-227	0.2	2.3	1.7	-	188.3
Brazil	-38.1	800	-6 745	4.0	517.9	30.1	31.7	-
Colombia	-0.9	960	-226	0.5	69.4	5.1	29.4	19.5
Peru	-2.1	730	-1 613	0.1	87.0	2.7	28.6	-
Burma	0	55	-96	0.1	45.3	16.4	-	158.5
India	-14.1	3 000	-	0.6	60.5	163.6	32.9	4 606.7
Philippines	-9.6	100	-1 241	1.4	14.6	8.5	31.0	32.2
Thailand	-7.4	0	-687	1.8	27.2	-	49.0	32.0

Source: Chem-Systems

to commodity chemicals such as ethylene must also be examined, in order to evaluate the economic competitiveness of biomass versus petroleum derived feedstocks.

According to Stone and Webster ethyl alcohol could be obtained from the fermentation of corn in a temperate climate, using the straw as a source of energy in the distillation process at about $ 780 per ton, wholesale price without tax. Corn is costed into the plant at $ 230 per ton and straw at $ 35 per ton, both prices on a tax-free basis. This is of little use at present as to be in equilibrium with gasoline on an energy basis it would have be down to about $ 310 per ton again without tax.

Davy McGee's costing for ethylene from ethyl alcohol for a 60,000 tons p.a. plant was as follows:

1 ton of ethylene requires	1.7 tons of ethyl alcohol	$	1326
	1.1 tons steam	$	22
	475 KwH electricity	$	47.5
	0.625 K cals fuel	$	11.8
	depreciation	$	15
	labour	$	1
	20% on capital	$	30
	Total	$	1453.3

i.e. ethylene produced from ethyl alcohol from corn would have to be priced at not less than $ 1450 per ton so that it could only be competitive with ethylene from naphta in an industrial country if the price of crude oil increased much faster than the price of corn.

In a country like Brazil using sugar cane in very large quantities the position is much more promising. Crude oil has to be imported over relatively long distances and shortage of foreign exchange has resulted in the Government encouraging chemicals from fermentation in various ways. Cane sugar is particularly valuable as it provides its own energy. Badger reckon that ethyl alcohol can be produced for about $ 500 per ton at 1980 prices which would make ethylene cost about $ 980 per ton. This is still considerably higher than present prices. But according to Badger much more weight is being placed on the production of other organic materials such as ecetaldehyde, acetic acid, 2-ethyl hexanol and butadiene. In 1979 the cost of producing the first three from fermentation alcohol was only slightly above that from naphta and it would only take a very small shift in the cane sugar/crude oil price ratio to make the fermentation route the cheaper for these particular chemicals. This of course only applies to Brazilian conditions. Badger's actual figures are shown in table 4.2.8.

Table 4.28 Prices of chemicals obtained from fermentation alcohol and from naphta in $ ton, 1979 figures

	From alcohol	From naphta
Ethylene	702	393
Acetaldehyde	495	484
Acetic acid	575	563
2-Ethyl hexanol	1445	1204
Butadiene	1181	563

4.4.3 Others

For shale oil and tar sand, recovery technology has been developed and quite few projects based on these two resources have already been undertaken. But due to the volume of investment and time needed, it is not certain that these sources will have a significant impact on the feedstocks trends in the near future. Furthermore, these two sources of energy would involve tremendous environmental and water problems which may not be solved within the present decade or even after.

The utilization of biomass or photovoltaic energy in the chemical industry has not yet gained much attention except in certain areas or countries in a very specialized use of by-products from forestry and food industries where small petrochemical processing plants are installed to cater for small local markets. Brazil is a good example, success is being attained in this direction. In regions where major traditional hydrocarbon resources are available, such as the USA, no evidence supports that biomass will be of importance to the industry. Furthermore, there is a controversy regarding the effect of its utilization on food production.

4.5 Summary and conclusions

The petrochemical industry relies predominantly on crude oil and natural gas resources for its main raw materials and energy supply. In the era of cheap energy supply the industry developed rapidly on the assurances of the continuity of such supplies. Analysis of the three major producing/consuming areas, i.e. Western Europe, the USA and Japan, shows a very high degree of integration between refiners and petrochemical producers for the majority of the products.

The increase in oil prices since 1973 and the economic recession of the 1970s have disturbed the balance of feedstocks supply to the industry and have created a host of complications which have hastened the process of restructuring the industry with regard to specialization, refinery configuration, the search for new sources of feedstocks supply and a general reexamination of the industry's future.

The increasing demand of the fuel sector on naphta and the middle distillates have initiated a potential motor fuel/feedstocks conflict that is threatening the future of the petrochemical industry in Western Europe and Japan. Coupled with this, the depleting natural gas resources in the USA have brought home to the USA the same type of situation. Furthermore, the worry about security of supply and prices of crude oil, the main source of naphta production, have initiated and accelerated measures and actions in the direction of reduced energy and fuel consumption in general and the search for alternative sources of energy and feedstocks as a consequence. It is not expected, however, that these changes will have a substantive effect on the feedstock structure of the industry in the timespan of one decade. As energy sources, coal, natural gas and nuclear energy will make some advances and thus release part of the pressure on crude oil products which then will be available in greater quantities for the fuel sector and for the petrochemical industry.

To alleviate the problems of feedstock supply security the general trend of the industry is feedstock-flexibility which will give producers better maneuverability with regard to type and price of feedstock. It is understood that the greater the degree of severity of cracking, the higher is the level of utilization of the oil barrel, but of course at higher cost. It is clear that the adjustments which are being made to cope with the feedstocks problem will succeed in maintaining the viability of the industry but at higher cost. A more logical solution seems to be the restructuring of the industry towards the sources of energy supply, particularly in areas where associated gas are being flared, long-term arrangements between hydrocarbon producers and consuming nations for secutity of supply and greater attention towards the development of alternative resources particularly from biomass, which present a promising solution to many developing countries.

V. PETROCHEMICAL TECHNOLOGY: STRUCTURE AND PROSPECTS

5.1 The structure of the petrochemical industry

Since two of the basic issues of the present study relate to the modalities of transfer of industrial capacity and the direct transfer of technology to developing countries, neither of which is moving at the pace demanded or needed by the developing countries, it becomes important to analyze those factors which have inhibited such industrial transfers. A study of the structure of the industry is therefore necessary.

The technological structure of the industry is analyzed hereafter in basically two time periods, i.e. the period prior to 1973 and the succeeding period. Although desirable, it has not been found feasible to characterize each period with all data pertinent to that period. As a result some of the information presented here overlaps and part of the information is qualitative in nature.

5.5.1 The period 1950-1973

In the years 1950-1973, the petrochemical industry was superimposed on an organic chemical industry which was largely based on by-products of the coking industry and on acetylene manufactured from calcium carbide. The pattern of the industry's development has varied according to the geographic regions of the United States, Western Europe and Japan as a result of different raw materials' becoming available to them, particularly from the petroleum-refining industry, which is the main impetus to the boom in petrochemical investment.

Low-cost crude enabled the United States to support an energy-intensive high-octane gasoline market, resulting in the co-production of large volumes of butane and propylene - chemical feedstocks - in association with high-octane gasoline blending stocks in fluid catalytic crackers (FCC). In a contemporary development in the United States, natural gas liquids (NGL) and condensates, but more importantly their ethane component, became a surplus commodity as a result of energy industries exploiting low-priced associated and natural gas from rich fields in the southeastern part of the United States. Thus, a major feedstock for ethylene, again a by-product of an unassociated industry, became available to the chemical industry.

In Europe and Japan, the chemical industry has developed based on circumstances, but is still an off-shoot of the petroleum refining industry. In both regions, refinery configuration in the early post-war years was oriented to the production of heating oils with better access to low-cost light crudes from the Middle East. Such a configuration yields large quantities of the co-product naphtha for which there was then inadequate demand as gasoline. Thus with alternate use only as boiler fuel, European industries in particular developed the naphtha-cracker, the predominant world-wide source of chemical feedstocks today and especially that of ethylene. One of the important results of the naphtha-cracker concept has been the concurrent availability of three important chemical raw materials, propylene, butadiene and pyrolysis gasoline. Market prices for the latter products (by-products credit) in effect lead to a lower ethylene price than would be feasible in gas-cracking of ethane.

While the technological development of the naphtha-cracker to the giant plants that are presently in operation is significantly the contribution of the United States engineering companies as a result of their association in the design and construction of large and complex petroleum refineries in the United States, technological innovation in downstream products, particularly in petrochemical intermediates, is the joint contribution of the United States and Europe. Thus major European technologies such as high-density polyethylene (Hoechst), acetaldehyde from ethylene (Hoechst), vinyl acetate monomer (Wacker), suspension grade of PVC (Wacker), polypropylene (Montecatini), polyesters (ICI), and in a slightly different context low-density polyethylene (ICI), either led to the discovery, or played a large role in the development, of each of the big five thermo-plastics - LDPE, HDPE, PP, PVC and PS - as well as other petrochemical products, i.e. high-density polyethylene (Hoechst), acetaldehyde from ethylene (Hoechst), vinyl chloride monomer (Hoechst), vinyl acetate monomer (Wacker), suspension grade of PVC (Wacker), polypropylene (Montecatini), polyesters (ICI), methanol (ICI), ammonia (ICI) and in a slightly different context low-density polethylene (ICI), synthesis gas (BASF), aromatics (BASF), ethylene oxide (Shell), ethanol (Shell), acetic acid (BP), cumene/phenol (BP). While these product technologies are of essentially European origin, those related to acrylonitrile (Sohio), nylon (Dupont), ethylene glycol (Dupont), propylene oxide, styrene-butadiene rubber, etc., enamate from the United States.

Essentially, of course, such technological development was the result of market forces at work. On the demand side, chemical products presented a viable means for substituting, on a cost-performance basis, traditional materials as metals, glass, ceramics, natural fibres, natural rubber, etc. On the supply side were located the factors of low-cost and free availability of co- and by-products of the petroleum-refining and energy industries.

In the case of advanced countries, however, technology did not and could not remain at the level of inventor companies. In products such as ethylene, propylene and butadiene, technology was basically concentrated in the hands of engineering companies which were eager to multiply the number of production units. In the area of most petrochemical intermediates (with exceptions such as acrylonitrile), effective patent protection was not feasible because specific utility (as with pesticides or pharmaceuticals) could not be claimed or because a variety of dissimilar production routes could be developed. At the same time, priviledged production through patent protection was not available for products such as polyethylene, styrene or polyvinyl chloride because their development had been government-funded or because they constituted public disclosures following the end of the Second World War.

Similarly, because of the anticipated costs of patent infringement suits, many companies continued imitating or copying technologies which were otherwise under the protection of viable patents (polypropylene). In addition, to avoid competitive development of technology, a divisioning of markets was attempted by methods such as cross-licensing of patents (ICI and Dupont) or competition avoiding licensing agreements, which in their provisions fell just short of penalties and restrictions imposable under the Treaty of Rome (EEC countries) or the provisions of the United

States Anti-Trust Acts. In fact, it would not be incorrect to say that technological diffusion occurred to the extent that it was not prohibitable under the aegis of free enterprise economies within the developed market economy countries. Although technology was diffused, and perhaps each major country of Europe as well as the United States and Japan had the proprietory and competitive sources of technology covering most petrochemical intermediates (and potentially available for licensing outside these regions), it was limited in number and controlled in most parts by a small number of multinational organizations.

Thus, whereas upstream technologies such as those pertaining to naphtha-cracking are available from engineering companies because the latter do not have a competitive interest in production, and technologies for intermediates become potentially licensable because of technology diffusion, an entirely different situation prevails for products far downstream such as speciality plastics (e.g. engineering plastics), pesticides, pharmaceuticals, etc. In these areas, the inventor companies have extremely strong proprietory positions in patent and trademarks; hence the technologies are the most difficult element to obtain, even in the advanced countries. In such products, the inventor companies have geographic presence wherever markets are large and prefer not to license technologies to firms in which they do not have controlling interests. The possession of such technologies thus becomes the source of differential (monopoly) profits to these companies. The Governments of the countries of the market economy developed countries (Europe, the United States and Japan) have also supported the concentration of productive capacity within their regions and overseas near large markets (mostly markets in the market economy developed countries) through incentive taxation. Substantial tax credits for overaseas locations, large depreciation allowances for home industries and research and development write-offs have provided companies with funds which have enabled them to integrate substantially downstream, which in essence is the establishment of the strong propriety positions in products far downstream, as discussed above.

Another important facet of the petrochemical industry is its geographic concentration in areas of largest immediate markets (developed market economy countries' markets) almost to the exclusion of considering low-cost production centres in developing countries or production siting near sources of primary raw materials, such as those of the oil-producing developing countries. Yet when one examines the location of the United States and European industry today, one finds them situated near sources of percursor feedstocks (United States Gulf Coast, Rotterdam, near the ARG pipeline, or in the case of Italy near its largest refineries). The concentration of production facilities in developed areas seems to result from strategic (political) reasons rather than economic ones. Among the petrochemical producers until 1973 a fairly sharp line could be drawn between the market interests of oil majors and the chemical majors, even though some oil majors (such as Exxon and Shell) were very active in the chemical industries of Europe and the United States. Particularly in Europe, firms such as Hoechst, Bayer, ICI and Solvay were confident enough to avoid upstream integration, both with respect to refinery products and naphtha cracking. In the United States, too, firms such as Union Carbide, Dupont and Monsanto were prepared to depend on long-term supply contracts of ethane, propane and naphtha but, compared to Europe, had integrated to the extent of having self-sufficient facilities for propylene and ethylene (i.e. ownership of gas and naphtha crackers; see Chapter IV and Annex).

Over the period 1950-1973, rapid growth of home markets was the primary impetus for production expansion, and virtually all such productive capacity remained in the neighbourhood of the markets. Engineering companies in Europe, the United States and Japan focussed almost entirely on developing advanced country clientele. The size of physical facilities grew at a rapid pace as each size increment reduced capital charges which until 1973 had dominated or had been a major constituent in production cost. While the number of production sites also grew, many units at such sites were feeder units to companies of the same group. There was little dispersion in the ownership of capital.

While all the advanced countries and their corporations were conscious of the rising dependence on imported energy, there was actually no fuel feedstock conflict. The enormous industrial output of the countries made feasible by low-cost energy and supported by large value-adding exports led to trade surplus sufficient to meet the rise in volume imports of energy. This facet, combined with growing productivity in industry, also enabled the countries to maintain stable currency values. Stable currency, in turn, further gave confidence to corporations to undertake large expansion projects and to renovate or dispense with older plants.

In the United States, the United Kingdom, the Federal Republic of Germany and The Netherlands, most of the major chemical corporations were privately-owned or were public stock companies, without Government capital, control or direction. Once again, most existed without collaboration with the oil majors. In France and Italy, however, some companies had investments from oil firms, the latter mostly government-financed. Despite such an ownership pattern, the companies nonetheless operated independently as public stock companies in a laissez-faire environment within the market mechanism of market economy developed countries.

5.1.2 The post-1973 period

Although one notes quite significant changes and shifts in the structure of the petrochemical industry in the advanced countries in the years following the increase in oil prices, the viability of the industry itself appears to be unaffected, i e. increased prices of downstream products, resulting from price increases in upstream feedstocks, have not been sharp enough to cause a displacement of the industry's products by substitution materials, to alter ratios in the usage of the industry's major products or to shift principal directions of trade. It is also felt that the governments of the advanced countries have consciously intervened in the market mechanism to maintain the viability of the industry by ensuring that otherwise competitive energy markets did not pre-empt the industry of its basic feedstocks. As a result, supply abberations that disrupted gasoline and heating oil markets in the years 1973-1975 had a minimal effect on the industry's level of raw material requirements provision. The overall effect of the economic and energy crisis of the 1970s on the products of the industry was mainly reflected in the slowdown in consumption growth rates from 5 to 7 per cent, ahead of the GDP growth rate of individual countries to about 2 per cent.

Despite the short-term measures adopted by governments of advanced countries to maintain the working of the petrochemical industry, the governments (with perhaps the exception of that of Japan, which basically intervenes in all industry) show stronger intervention attitudes in the energy industry, particularly with respect to electrical power generation, heating fuels and motor gasoline, than in the petrochemical industry. However, there are significant differences in approaches among the countries, In the United Kingdom where there is little public opposition towards the use of nuclear energy, the nuclear route is seen as a major source of electrical power. However, with its North Sea finds, the United Kingdom, among the major advanced countries, is the least threatened with respect to energy or feedstock materials.

The situation in Italy is different because of public opposition to the establishment of nuclear plants and declining domestic natural gas reserves, which currently furnish about 40 per cent of Italy's energy requirements. However, measured according to its proximity to the Middle East refining capacities, its extensive arrangements with the USSR for part of its natural gas requirement, and now the completion of a submarine gas pipeline connecting Italy to Algeria, Italy's problems are not so much those of the economics of access (such as is the case with Japan), but rather those of ability to finance its imports. Thus, unless the petrochemical industry is able to obtain a better valorization in its use of feedstocks, the energy-feedstock competition in Italy promises to be the sharpest in Europe.

The United States have substantial coal, crude oil and natural gas reserves; however, due to its enormous consumption of gasoline, it is dependent to some 50 per cent on imports for its crude requirements. Despite Government intervention to raise domestic gasoline prices and to curb gasoline consumption, which is no longer rising, and support for constructing the Alaskan crude oil pipeline, the United States show little sign of being able to reduce the volume of imports. Since the economic growth of the country is limited to higher availability of energy, stress is being placed by the Government, through Government-assisted projects, on exploiting the country's large coal reserves, the vigorous use of which, however, is partially limited by ecological and environmental considerations. For similar reasons the United States has not been able to expand its nuclear capacity rapidly. While this situation potentially heightens a fuel-feedstock conflict, its solution appears to depend upon the extent to which ownership in the chemical industry differs, or will differ, from that of oil.

Japan's situation in terms of energy or feedstock dependency is radically different from the positions of those countries discussed above, basically because at present over 97 per cent of Japan's energy (essentially partly as a result of the domestic political situations and partly stemming from the nature of their resource endowments. Such intervention lessens the energy-feedstock conflict and indirectly favours the position of the chemical industry.

In France, the major thrust is to replace fuel oil and natural gas with nuclear energy for electrical power generation so that it can constitute the base-load in power distribution, with fuel oil and coal, ultimately used only as peak-shaving fuels. In addition, by 1990 France plans to draw 10 per cent of its gasoline from non-petroleum sources, particularly from methanol and its derivatives. The Government is in a position to implement these changes because of its predominant ownership position and thus control in power generation and petroleum refining.

In the Federal Republic of Germany (FRG), the Government is committed to the maximum use of domestic lignite and hard coal, the sources of which it controls, and of natural gas from the Dutch Croningen fields and the USSR, for the generation of electrical power, as is shown in Table V.1 below:

Table 5.1 Means of electrical power generation in the Federal Republic of Germany

Means of electrical power production	1977-1980 (average in percentage)
Fuel oil	8
Natural gas	20
Hard coal	27
Lignite coal	30
Nuclear energy	10
Other	5

As far as the FRG is concerned, the principal source of demand for liquid fuel products will essentially come from the transportation and chemical products sectors and less for users in "static" forms, i.e. electrical power generation and domestic/institutional heating.

as petroleum fuels) is imported. In addition, it is also necessary to recognize the vulnerability of the country to transportation economies since the basic configuration of its refineries is oriented towards Middle Eastern distillates. These facts have made it traditionally necessary that the Government intervene in aspects such as industrial planning, energy allocations between consuming sectors and pricing energy. However, in Japan there has always been an effective dialogue between industry and Government which, nevertheless, permits a substantial degree of competition between industries and between firms of the same industry.

5.2 The role of governments and private sector corporations in the petrochemical industry

5.2.1 Government role in the petrochemical industry

In almost all of the developed market economy countries, chemical firms have traditionally operated as autonomous organizations, even though there is government investment in the capital structure of some of them. The independence of the firms is greatest in the United States, FRG, the United Kingdom and The Netherlands. Examples of firms which are wholly without government investment are Dupont, Union Carbide, Dow Chemicals and Monsanto in the United States, Hoechst, Bayer and BASF in the FRG, ICI Exxon and Shell in the United Kingdom, and Shell N.V and AKZO in The Netherlands.

While the same can be said of the Japanese companies Mitsubishi, Mitsui and Sumitomo, for example, these are not public stock companies of the type found in the United States of the FRG, for substantial holdings of these companies lie in the banking companies of the complexly organized Zaibatsus.

In France and Italy, however, and particularly in recent years, Government intervention can be seen in major corporations usually by way of investments made in these companies by Government-controlled petroleum companies. Thus, in France public sector oil companies such as Elf-Aquitaine and Total have investments in ATO Chimie. A similar situation appears in the newly-formed organization CHLOE (Rhone Polenc, Total/El-Aquitaine), which is essentially a regrouping resulting from the virtual disinvestment by Rhone Poulenc. Likewise, CDF Chimie is a subsidiary of Charbonnages de France (once a Government organization wholly involved in coal products) which is now basically a Government oil company. However, private-sector organizations do exist in France such as Produits Chimiques Ugine Kuhlman (PCUK), one of France's largest companies, and Naphtha Chimie (50 per cent BP, 50 per cent CHLOE), although their presence is diminishing.

The scene in Italy today is somewhat confusing since the Government is managing all the major Italian companies - Montedison, SIR, Rumiancea, Liqui-chinica and ANIC - due to the serious financial problems of the first four of these. In reorganizing of the Italian petrochemical industry the state-owned ENI has further entered into joint ventures with Montedison and Exxon. Under the auspices of ENI a new division of responsibilities within the industry is taking place whereby the role of wholly private companies is diminishing. The penetration of public ownership into the petrochemical industry in Western Europe as indicated above and the consequent effort to reorganize the various activities within this industry on the basis of national division of responsibilities has the following objectives:

- the improvement of the competitive position of the industry through greater public financial support;
- backward and forward integration;
- greater promotion of research and development for the development of new technologies.

This was also evident as part of the national effort to reduce dependence upon the major oil companies.

5.2.2 Increasing presence of the oil majors in the petrochemical industry

One of the significant developments in the period following the rise in oil prices since 1973 is a marked increase in the penetration by oil majors directly and indirectly into the petrochemicals industry, which is most evident in Western Europe and the United States. While Shell, BP and Exxon have traditionally been separately constituted chemical subsidiaries, in Europe they (the oil majors) have existed without linkages to the predominant chemical companies such as Hoechst, Bayer, BASF, ICI, Solvay, etc., and in direct competition with them.

Since 1973, however, the oil majors have had an opportunity to participate more effectively in the chemical markets by virtue of their control over the hydrocarbons supply and since some major chemical firms were seeking assurance of their feedstocks. One of the plausible reasons for chemicals firms' seeking this assurance appears to be their overestimation of the market growth for chemical products and the subsequent creation of large capacities for petrochemical intermediates. Without feedstock security, investments in new capacities would be seriously threatened; therefore the chemical majors are either disinvesting in basic and intermediate petrochemicals, which are taken up by the oil majors, or are entering into joint ventures with the oil majors to secure their feedstock supplies.

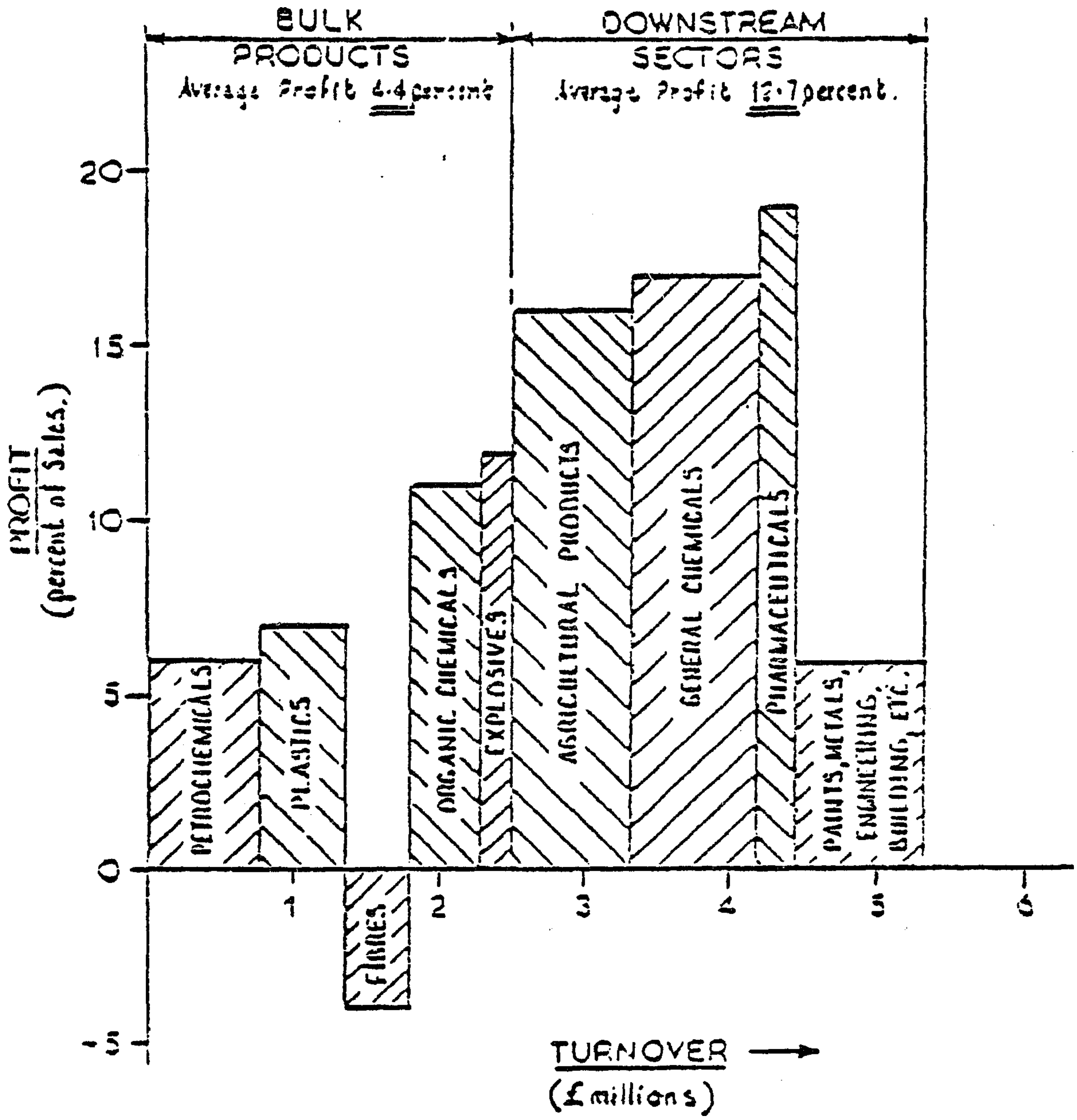
As discussed above, in France and Italy chemical firms have feedstock security to some extent by virtue of their linkage with Government-owned oil companies. However, it is characteristic of today's European chemical industry that most major chemical companies either have their own (or shared) refineries (ICI, Montedison, BASF, Solvay) with purchase routes to crude in the conventional oil market, or are in collaboration with oil majors for the production of first generation intermediates (Bayer, Solvay, PCUK, Rhone Poulenc, BASF) and the aromatics. Although Hoechst is the largest consumer of ethylene in Europe, it is virtually the only company which is only slightly back-integrated.

Although the oil majors in the United States have made significant penetration into the chemical industry's first generation products, the chemical firms (Shell, Amoco, Texaco and Gulf) have ethylene capacities as large, or larger than, those of the chemical majors. Among the major chemical companies, Monsanto, Union Carbide and Dupont own no refinery, whereas the biggest refiners, i.e. Shell, Exxon, Gulf, Arco, Amoco, Phillips, Texaco, Mobile and Conoco, have among them the largest ethylene capacities in the United States (20,555 billion pounds per year).

As mentioned above, in Japan the Government intervenes (through MITI) to allocate raw materials to industry; therefore, although firms such as the Mitsubishi group and Sumitomo have refineries, the pressure for feedstock security is abated.

The losses recorded by most chemical majors in 1980 demonstrate that their partial backward linkages (to feedstock) did not change the on-going

Figure 5.A Analysis of Divisional Profits of ICI - 1977



SOURCE - ICI ANNUAL REPORT, March 1978

trend of the encroachment of the chemical major, by virtue of their control over the hydrocarbon supply, on basic, intermediate and some commodity petrochemical products. The attention of the chemical majors has therefore more and more been drawn towards the downstream sector.

The move downstream will be gradual while the major chemical companies reduce their commitment to certain intermediates and commodity resins by spinning off those activities or gradually reducing their market share (see Figure 5.A). These sectors will be replaced by the increased production of speciality chemicals (e.g. pesticides, coatings), resins (e.g. engineering thermoplastics, adhesives) and performance chemicals (e.g. water treatment, oil field additives, lubricant additives and base stocks), supported by their traditional superiority in research and development and marketing.

In the meantime, the greatly reduced growth rates for fuel products and the ready availability of appropriate technology from engineering companies will lead the hydrocarbons producers to take over, to a substantial degree, the manufacture of olefins, aromatics, and their first stage derivatives. In the future, oil companies, both private and government-owned, will produce an increasing share of intermediate chemicals, including styrene, vinyl chloride, ethylene glycol and many grades of commodity thermoplastics (e.g. polyethylene and polypropylene). High cash flow and control of raw materials will facilitate the oil companies' penetration into many of these markets and will tend to make production of such petrochemicals even less attractive to the traditional chemical companies. The oil companies will also continue their pattern of acquiring existing plants from chemical producers that are planning to specialize in other areas. The moves in 1980 of Rhone Poulenc out of the petrochemical building blocks and by BP and Exxon to take over petrochemical assets of Rhone Poulenc, Union Carbide and USI in Western Europe are indications of this trend.

The resulting lack of raw materials control by the chemical companies will be judged less important than in the past with the world-wide availability of basic commodity petrochemicals from oil companies and the new producers. These rationalization trends will be inhibited to some degree in Europe and Japan, in comparison with the United States, by nationalism and growing government influence in the industry. In summary, the structural break-point between oil and chemicals will move downstream into chemical building blocks and primary intermediates.

5.3 Technology ownership and diffusion

The years 1950 to the late 1960s were perhaps the most fertile for technological innovations in the petrochemical industry, particularly in the development of processes for the production of the first-generation products, ethylene, propylene and the aromatics, chemical intermediates such as ethylene oxide, acrylonitrile, acetaldehyde, the fibre intermediates, and most important, polymer materials, high-density polyethylene, polypropylene, suspension PVC, the elastomers, etc. Technology innovation in this period of time was characterized in particular by the scaling up of plant sizes, simplification of processing steps, and greatly improved specification in the action of catalysts, their robustness and life.

After the late 1960s, despite sharp increases in production costs (as a result of increased crude prices in 1973), there were few dramatic changes in technology or in the invention of new major products; this was again especially the case with olefins, aromatics and the intermediates.

While the universities and scientific institutions made contributions to new technologies (for example, the stereo specific Zeigler-Natta catalysts which led to the commercialization of polypropylene and the cis-rubbers), by and large most of the new technology was developed by independent chemical corporations, occasionally in collaboration with engineering companies. As discussed above, the major contributions came from the United States and Western Europe.

With some exceptions, such as Sohio's acrylonitrile process, the direct role of the oil companies in petrochemical technology has been limited. At the same time it should be recognized that many oil-industry-developed technologies related basically to petroleum refining operations are crucial in the integration of a chemical processing plant. Thus technologies of the Universal Oil Products (UOP) and the Institut Français du Petrole (IPF) are of importance in the structure of chemical industry plants.

These preliminary facts are necessary in order to recognize a very important characteristic of the technological material. While some innovating firms have had patent protection with respect to technologies dealing essentially with processing and catalysts, today there is a plurality of technology sources in individual products. As a result, competitive technologies exist in HDPE (for example, Solvay, Hoechst, Union Carbide, Phillips, Mitsubishi), in LDPE (Union Carbide, ATO Chimie, CDF Chimie, ICI, etc.), in vinyl chloride and PVC (Solvay, B.F. Goodrich, Sumitomo, Wacker Chimie), etc. Basically these technologies are owned by producer companies and it is therefore competitive market presence (in products) that has been the principal driving force for diversity of technology ownership. Thus, diffusion of technology in the market-economy countries has mostly been through the imitative development (self-generation) rather than through licensing (Japan being an exception, at least in its early phase). This phenomenon is best exemplified in one of the latest developments, namely that of linear low-density polyethylene (LLDPE). Although it has been only four years since Union Carbide and Dow announced their technologies, development of similar technologies is well on its way at Phillips, Mitsui Petrochemicals, Amoco, CDF Chimie and Amoco. One of the significant results of these self-developed technologies, particularly in polymers, is product variation. Each technology yields a range of resins with some properties superior to its competitors which enables the companies to find (and hold) a new group of customers. This characteristic of the industry also leads to large markets for "narrow specification" products, which in turn makes it difficult for broad specification materials, such as those produced or those which would be produced in the developing countries, to break through in these established markets.

In addition, it should be noted that technical services provided by companies to their clients are more or less considered part of the technological development process. This aspect, together with product specialization (narrow specification materials) results in the phenomenon of clusters of clients grouped around particular companies, which to a greater extent provides the innovator companies with a method of market segmentation.

5.4 The transfer of technology processes in the petrochemical industry

The present large international dimension of the technology transfer process can be said to have its beginnings in the decartelization of industrial combines that existed both in Europe (particularly the chemical cartels) and in the United States (the oil cartels) in the pre-war period. While the situations and motives that brought them about are dramatically different, in essence decartelization introduced the important mechanism of technology transfer or licensing by which technological exchange could take place between former cartel members on an "arms-length" basis. The reconstruction of European and Japanese industries in the post-war period and their needs for technology further expanded the concept of technology transfer and gave it its international character. Today it is viewed (particularly by the developing countries) as a viable mechanism by which industrial capacity can be geographically distributed, near markets or raw material sites, as logistics permit.

Total world turnover in technology (direct payments consisting of royalties, term and fixed payments) for know-how, trademarks, patents, technical assistance and management contracts is estimated by UNIDO to have been of the order of $10-11 billion in 1975. For the same year, transfer of technology to developing countries has been estimated at $1.5 billion, and for 1980, at between $3-4 billion. Although sectoral breakdowns are not available, the highest flows are assumed for chemical technology.

As pointed out above, a characteristic feature of the petrochemical industry is the high degree of duplication of technology (in chemical intermediates, particularly) which results in a plurality of both processes and technology owner firms in each product area with only marginal differences in product properties or in process-economics conversion costs (if raw materials cost is not included). Such a situation should normally favour low costs in obtaining access to technology. However, it is one of the widely recognized features of the industry that its transfer to developing countries manifests itself in high fees for technology, inadequate transfers of technological skills, restraints on licensee organizations on the rights to markets and the introduction of inflexibilities with respect to expansion of plant capacities, their geographic distribution or product range diversification. Even where marketing rights are accorded -

or not debarred - oligopolistic attitudes are evident in tariff strategies that facilitate entry into advanced country markets of petrochemical raw materials, such as ethylene or methanol, but not their downstream integrated products, such as the plastic resins. Further, even where corporations of advanced countries have established productive facilities in developing countries as subsidiary companies or joint-ventures, the objective continues to be containment of markets, on the one hand, and avoidance of vertical integration or other forms of valorization, on the other. Some of the basic arguments that are put forth by licensor firms are scale factors relative to market size or privileged market rights, under patents and trademarks granted to others (in attractive markets).

In order to highlight the incongruity of the position of the advanced countries, and more directly that of the corporations, it is necessary to consider their own marketing environment. For example, in Europe most of the large chemical corporations are export-oriented, both at the intermediate level and at that of downstream integrated products, with exports (although much of it could be within the European region) constituting 50-60 per cent of turnover. In other words, they operate at scales of production that are well in excess of demand at the national level. Similarly as discussed above, these corporations are integrated, both upstream and downstream, although there are no economic limitations placed on them for purchasing raw materials or intermediates from other firms, or importing them. In this connexion it is instructive to note that in some of Europe's largest chemical corporations (Hoechst, Bayer, ICI, PCUK) non-commodity speciality products are about 60-70 per cent of sales turnover, which emphasizes that lower valorization would otherwise be obtained if the product-mix stopped at an intermediary level.

When one considers potentials for the transfer of capacity, i.e. relocation of existing capacity or the creation of new capacity in new market areas as those of the developing countries, it is found that the industry has developed a complexity which would seem to indicate that the resulting costs would be prohibitively expensive (to the corporations). Indeed the complexity arises substantially from the defensive mechanisms which have long been in operation and which are expanding steadily. The very features that otherwise would make transfer rational are defeated by the sophisticated infrastructure that surrounds the chemical industry. It is important to note

Europe's long drive to build up a self-sufficient refining capacity while historically refinery siting has been at sources of crude. The establishment of ethylene distribution grids is yet another example of resisting the siting of chemical plants at raw material sources (while incidentally creating production centres in national territories).

The defensive mechanism also works at other levels. One of the emerging trends in ownership of technology, or more importantly, in alternate sources of technology, is the potentially increasing capability of engineering firms to undertake the construction of chemical facilities which can be operated without a "producer-company" involvement. This is characterized by the fact that the engineering firm, not being a "producer", would not have product-conflict or market-conflict interests. This situation also arises, particularly in commodity chemicals, because of the expiration of related patents. Nevertheless, the transfer of technology from the engineering companies is a relatively minor activity, except in the field of olefins, where, of course, they have always been in the lead. It is believed that one of the reasons which prevent this type of development from taking place is the producer-engineering company linkage, illustrative of which are the so-called technology-engineering packages of favoured associations such as Hoechst, i.e. UTDE processes for acetaldehyde, the Solio-Badger process for acrylonitrite, the Cosden-UCC-Badger process for styrene and other associations such as ICI-Kellog, Esso-Foster Wheeler, etc.

Likewise, there are also favoured "producer-equipment-supplier" associations which, in the transfer of engineering services or capacity, increase cost. Such association also occurs at a national level. For example, a survey carried out by the "Chemical Age" showed that, whereas for plant orders in the United Kingdom placed for hardware on local suppliers were 40 per cent of total equipment cost, those placed on suppliers from the United Kingdom for overseas plants rose to 76 per cent.

5.5 Technological forecasting

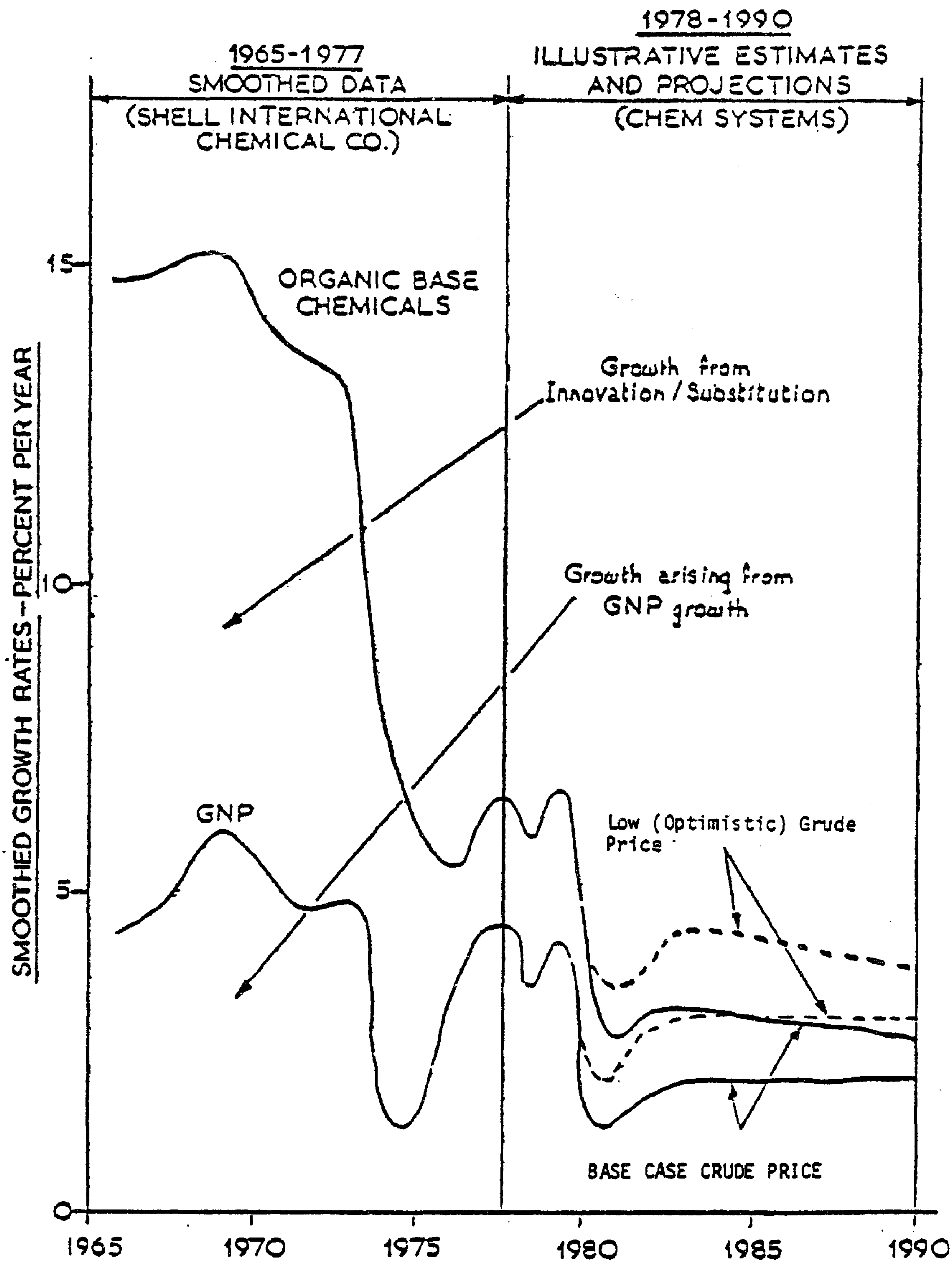
5.5.1 The uncertainties in forecasting

The stimulus for technological development comes from the commercial environment. Petrochemical products such as polyethylene have been demonstrated to have properties that make them ideal and cheaper substitutes for established materials. A demand is thus created and the technologists set out to improve (i.e. reduce the cost of) the product further so that it might gain even wider acceptance and at the same time improve the profitability of the firm that introduced the technological improvement. Nowadays almost all technological developments in the petrochemical industry are the result of planned research into known product/process areas and are guided by the commercial environment. Forecasting technological developments is therefore intimately connected with demand forecasting.

Forecasting the future has always been a hazardous exercise and estimating the future demand for chemicals is no exception. Undertaking this task at the present time (early 1981), during what appears to be a very significant recession, presents a number of particular problems. However, the following general considerations should be borne in mind in order to keep the forecasts in perspective:

- Forecasts should always, where possible, be related to past events. It is tempting to assume at almost any point in time that a unique situation exists, making reference to past history irrelevant; but with the passage of time, the situation can usually be seen as part of a continuing pattern. Moreover, from today's perspective, comparisons with 1975 are obvious;
- Generalizations applied, for example, to all organic base chemicals should not be allowed to obscure the broad differences which may exist between product groups. For example, several of the main aromatics derivatives find their way principally into synthetic fibres. The total potential for these, represented by the consumption of apparel-type fibres, has for many years been growing at a rate considerably lower than that of the economy, and the degree of penetration by synthetics is already high. The growth prospects must by now therefore be severely limited in the industrialized areas, quite apart from any special factors, such as textile imports from the Far East. Olefins, on the other hand, go mainly into plastics; but while quite

Figure 5.B ILLUSTRATION OF RELATIONSHIP BETWEEN BASE ORGANIC CHEMICALS GROWTH AND GNP GROWTH



deep penetration may have been achieved into particular applications, the theoretical opportunities for plastics in general are still very significant and the present degree of overall penetration incomplete. There is therefore no underlying technical limit to growth in this case and future prospects will depend more upon price and cost considerations and the innovative ability of the industry.

Nevertheless, it is clear that a number of petrochemical products and their derivatives are reaching a degree of maturity, so that growth rates in the future are likely to be well below historical levels. The problem now is to discern the new trends which will determine the future levels of consumption. A good deal of work has been done to identify the factors contributing to petrochemical growth. These have been described in terms of an industrial production related effect which has been linked to substitution/innovation. The situation is illustrated in Figure 5. 8. which can be regarded only as semi-quantitive, derived from an historical analysis by Shell Chemical.

While this concept is helpful, there still remains the problem of forecasting the future GNP situation and hence levels of industrial production as well as the rate and extent of decline in the substitution rate. The continuing changes in oil prices and subsequent fluctuations in feedstock prices are causing uncertainties in both aspects of growth. Thus, with respect to the future levels of GNP, two alternative scenarios based on those for future crude oil prices have been sketched. Substitution levels are also difficult to determine in view of the problem of assessing future competitive costs between synthetic and natural products, new and traditional materials. Furthermore, increased penetration, which may be occurring, is sometimes masked by reduced consumption brought about, for example, by the use of thinner plastic films and recycled material.

5.5.2 Technology trends

Figure 5.8 illustrates that the period of growth from innovation/ substitution has passed and that the industry has reached maturity. Throughout the earlier period of burgeoning demand growth, technological developments in production techniques occurred and the processes for the production of all the basic petrochemicals also reached maturity, so that the rate of change of technology has slowed down. In the main products, the change to ethylene, propylene, benzine and synthesis gas as the basic chemical building blocks is largely complete.

Over the medium term, the technology to produce most of these petrochemical building blocks is not expected to change either in feed-stock used, process technology or plant scale. Continuous gradual improvements will not rapidly outdate existing plants. Many of the processes to convert these building blocks to end products are also mature when judged according to these three aspects. For these processes, competitiveness may be more related to catalyst improvements, utility savings, integration and utilization rates, rather than to the latest plant design.

Few plants built in the last decade will be outdated in the next ten years. The 1980s will therefore be a period when producers with modern basic petrochemicals plants and technology will be relatively secure from competition based on new plant economics, but will need to maintain and optimize the operation of existing installations. They will also step up their research and development efforts to prepare for change in the 1990s, when escalating oil prices will lead both to the use of alternative feedstocks and processes, avoiding the current building blocks entirely.

It is not anticipated that any new basic polymers will be developed which could revolutionize the petrochemical industry as did polyethylene, polystyrene and polyesters in the 1950s and 1960s. However, some significant process changes are still occurring in a few bulk products such as popypropylene, ethylene glycol, propylene oxide and linear low-density polyethylene. Technology of a greatly improved (i.e. breakthrough) nature will be rare, but will continue to allow some producers to build new, highly profitable plants or increase their overall market share through improved economics. Some companies, in an attempt to achieve higher investment returns in this sector, are therefore emphasizing process research on selected commodity petrochemicals and polymers. As the emphasis on market development moves to increasing product performance, further opportunities are foreseen in research for processes to make advanced polymers and many speciality and performance chemicals.

Due to the commercial "push", process development work will be carefully planned and led by the traditional producers. Most of the advances in applied process technology will be made by the major oil and chemical companies rather than by universities or government researchers. Important opportunities are foreseen for those companies than can identify and utilize new technological approaches to cope with the changing manufacturing environment of the future.

Environmental considerations will also spur technical change. Greater government emphasis on addressing environmental and toxicological problems will continue to result in high research and development investment levels for compliance, resulting in lower relative investment in fewer facilities. Probably the greatest technological changes will occur during the last decade of this century and will be related to the cost and availability of energy and new raw materials for existing petrochemical products.

5.5.3 Energy and raw materials

Except in countries with ample hydrocarbon reserves, petrochemical producers will be greatly concerned with the supply of feedstocks and the high and unpredictable cost of energy. Feedstock uncertainties will tend to delay investment decisions and add to installed plant cost through provision of operating flexibility for alternate raw materials.

Competition from the fuels market will in the future hamper petrochemical producers from satisfying their feedstock requirements at an acceptable cost, whereas in the 1950s and 1960s they have had no difficulties in securing naphtha as a "surplus" product. They will therefore lessen their dependence on those hydrocarbons that are particularly valuable in the motor fuels market, especially naphtha and gas oil.

While some analysis is possible in respect of medium-term (1980-1990) changes in the use of petrochemical feedstocks in Europe and the United States, it is extremely difficult to guage the Japanese pattern because all of its crude requirements are imported from distant locations and two sharp increases in crude prices (since 1973) have begun to test the viability of the conventional petrochemical industry's continuing to remain home-based.

The attitudes of West European corporations are conditioned by three factors:

- access to feedstocks such as NGL, LPG and distillates from the North Sea fields;
- a sharp increase in the availability of LPG from the Middle East, the imports of which into Europe are expected to increase from 1.4 million tons in 1978 to 12.4 million tons by 1990;
- diminuation of the energy-feedstock conflict releasing feedstock, such as coal, lignite and natural gas (imported or domestic), together with nuclear energy, and energy conservation increases, reducing the needs of distillates for energy usage.

Thus, over the medium term, Europeans expect to build flexibility into their steam crackers so as to handle light feedstocks. It must be recognized in this connexion that investment requirements for such flexibility are substantially lower than for flexibility in heavy stocks, and that flexibility, in this case means the use of co-feeds, viz. naphtha and LPG, naphtha and NGL, etc., since otherwise co-products yields, which are important to steam-crackers, will seriously decline. Modification of existing plants is already proceeding in this direction and it is expected that provision for LPG cracking will be made in almost all new plants.

The following other factors also reduce the concern of European corporations with respect to feedstocks, particularly increasing requirements:

- substantial over-capacity in existing crackers as a result of investment decisions taken at a time of fast-rising demand for petrochemical products;
- new capacities created or being created in Norway, Spain, Portugal and Scotland (Exxon/Shell have indicated definite plans to build gas-based crackers using North Sea gas and liquids), all of which is expected to idle some of the presently operating crackers;
- greater stress in major European chemical corporations to pursue the development of speciality products which will have a low feedstock component in terms of product prices;

- the goal of some chemical corporations (such as Hoechst) to diversify into non-chemical businesses, and of others to disinvest (Naphthachimie, Rhone Poulenc); the last few years witnessed considerable disinvestment in synthetic fibres in the Europe-based investments of ICI and AKZO;
- from the viewpoint of chemical corporations, the expectation that, at least in the medium term, large new capacities, if any in Europe, would be created by the oil majors for whom diversion of distillates and the chemical industry would represent a small fraction of their business in oil.

In the United States, too, over the medium term, no basic alternatives in feedstocks are expected, particularly as far as the chemical firms are concerned. However, despite the expectation for Europe and the relatively quiet upstream investments, United States capacities in olefins are expanding. The Europeans, in fact, assess that in many product areas, for example HDPE and polypropylene film consumption, the United States trails Europe in per capita consumption and that growth in plastics will take place, although not at historical rates. In point of fact, European presence in the United States buttresses the aforesaid assessment. Thus, the list of European chemical firms in the United States is impressive (ICI America, American Hoechst, Moabay (a Monsanto-Bayer joint venture, now believed to be wholly Bayer); Soltex, a Solvay/Texaco joint venture; BASF-Wyandotte; Hercofina, a Hercules/Petrofina joint venture; American Petrofina, etc.). The firms operate in areas such as paraxylene (Hercofina); HDPE (Soltex and American Hoechst); ethylene oxide (BASF-Wyandotte and ICI American); propylene (BASF, America Petrofina); polypropylene (Soltex), etc.

While feedstock categories are not expected to change in the medium term, adjustments are none the less expected to occur in the relative proportions of feedstocks in use. This arises primarily from expected declines in NGL as natural gas reservoirs capacities decrease; and the retention of aromatics in motor fuel requirements at a no-lead level.

The decline in NGL is expected to be met by larger uses for naphtha (and gas oil), a situation which is encouraged by the fact that high-octane fuel production to a certain extent releases low-octane naphtha, which is usually excellent stock for ethylene production.

5.5.4 Alternate feedstocks

While the above trends are likely to hold in the medium term, there is world-wide recognition that towards the mid-1990s a major restructuring of the industry would become necessary. This is predicted on the basis that:

- unless the reserves/production ratio becomes favourable rather dramatically - an unlikely situation from the historical data - including new finds, natural gas production would decline, and along with it NGL and condensates;
- new oil discoveries, such as the North Sea fields and in China, etc., are oriented to heavy crudes which will not yield light distillates in the volumetric ratios that light crudes do; this ratio, of course, has afforded the chemical industry fairly easy access to light distillates;
- new oil discoveries are at remote locations, often in "hostile environments", which will increase extraction, processing and transportation costs which the chemical industry may not be able to bear.

Conscious of these trends the industry has in the last twenty years or so devoted increased attention to the development of new feedstocks. New directions of effort can be summarized as follows:

- technologies for utilizing the "heavy end of the oil barrel", such as hydrocracking, flexicoking, etc., end-products of which resemble essentially conventional feedstocks;
- methodologies for the production of synthesis gas from heavy oil fractions such as partial oxidation, with concurrent development of downstream technologies for the production of oxygenated hydrocarbons as well as the olefins; such efforts also comprise the utilization of tar sands and oil shale which are particularly abundant in the United States and Canada;
- the direct cracking of crude and heavy residues for the production of ethylene (UCC-Kureha-Chiyoda high temperature steam injection process, the Lurgi and BASF sand and coke based cracking processes);

- direct liquification of coal through a diversity of hydrogenation technologies (British Gas Corporation, Lurgi, Kelloggs, Institute of Chicago, etc.);
- indirect liquification of coal resulting in higher alcohols, methanol, etc., depending on the process route;
- biomass-based technologies for the production of oxygenated hydrocarbons, principally ethanol;
- biogenetic mechanism for the direct production of petrochemical intermediates, such as for example, ethylene and propylene oxides, ethylene glycol, etc. (Standard Oil, Monsanto, Dupont).

In practice all these technologies, with the exception of those the end-product orientation of which is methanol or the biomass/biogenetic processes, aim towards obtaining feedstocks, which are identical to, or resemble closely, those in current use and for which well-practiced technologies exist.

Another aspect of these technologies is that practically in all cases (except for the crude oil cracking technologies) the usage spectrum spans transportation fuels, energy fuels and chemical feedstocks.

The realization of these technologies is tied not so much to research and development tools or to the creation of research and development structures as it is connected with the level of investments required for scale-relevant production and sources of financing production plants. Investments in each of the facilities is expected to be of the order of $2-3 billion, which are beyond the capabilities of even the largest corporations. In addition, the engineering design loads are expected to be of the order of 6-7 million man hours per production facility, which again would strain even the largest engineering firms. Thus, the physical implementation of such projects would most likely be on a multi-agency basis with perhaps government participation. This type of situation leaves open questions as to ownership of technology and protection of technology through patents, which is usually the endeavour of private corporations. To some extent, such considerations indeed have delayed commercialization concepts even though most of the technologies have been adequately tested at the pilot scale.

Alongside these parameters there is wide recognition in the developed countries that any new development should be able to use existing in-place infrastructure - pipelines, terminals, tankers and marketing-distribution linkages - which has been built at a relatively low cost in a cheap-energy era. Thus this situation also requires that products of new technologies be equitable with the physical characteristics of present-day fuel, energy and chemical materials.

One of the bright new developments of considerable importance to both advanced and developing countries is the conversion of methanol into olefins, aromatics and gasoline. While the leadership in this field is with Mobil (the Mobil M process), other organizations have also developed competitive processes, especially IFP. The latter being oil-oriented firms, technological forms are on the development of a methanol-to-gasoline route because of the higher critical need for a transportation fuel substitute.

However, the technology permits olefins (and aromatics) to be obtained either as co-products with gasoline, or as a final product. This has induced many chemical companies, especially BASF and ICI, to give attention to this area, with pilot plants being run in collaboration with engineering firms.

A significant aspect of a chemical firm's interest in methanol-using technologies is that it permits them for the first time to gain a foothold in the petroleum industry. Thus, for example, Celanese and Dupont in the United States have committed plans to increase several-fold their involvement in methanol production; together they already produce approximately 50 per cent of the United States' requirements (1,100 billion US gallons). Celanese has forecast a 300-per-cent increase in United States methanol production between 1980 and 1990, with the world capacity increasing from 5,000 billion gallons to 11.3 billion by 1990. Even thereafter, a 14-per-cent growth rate has been forecast.

5.5.5 Process technology improvements

It has already been explained that the technology for the production of most of the petrochemical building blocks is unlikely to change greatly over the next decade. In addition to improvements in process technology over the last twenty years, there have been gradual improvements in the mechanical performance of equipment and materials, which have allowed both improvements in process performance and increases in the scale of plant. The overall result has been greatly improved production efficiency. Good examples of the marriage between mechanical performance and process technology include:

- in <u>olefins production</u>, improved tube metallurgy permitting the design of furnaces with vertical tubes which withstand very high heat flux; this, in turn, permits a much higher conversion of feedstock to ethylene, hence less feedstock to be processed, reduced size of downstream facilities and a more efficient and cheaper plant;
- in <u>ammonia production</u>, development of large centrifugal compressors which can discharge at high pressure for the ammonia conversion reaction. A single such compressor replaced batteries of older, reciprocating machines and allowed an increase in typical ammonia plant capacity to 1,000 tons per day and a quantum reduction in the production cost of ammonia. These large centrifugal compressor developments were subsequently applied to olefins production;
- in <u>aromatics production</u>, naphtha reforming using bi-metallic catalysts and moving bed, continuous catalyst regeneration, both of which reduce coke formation, increase yields and allow improvement in a number of other areas which results in greatly reduced production costs.

Examples of future technology developments which would count as "breakthroughs" are:

- <u>olefins</u>: catalytic conversion at high pressure would reduce the very expensive cracking/furnace area of a conventional olefin plant and, more importantly, greatly reduce or even eliminate compression of the cracked gas;
- <u>ammonia</u>: elimination of the carbon "carrier" in ammonia production.

It does not seem likely that either of these "breakthroughs" will be achieved in the foreseeable future, although the Mobil process for ethylene production (see above) goes some way, albeit indirectly, towards a breakthrough in olefins production.

Potential technological developments in the larger volume derivative products are summarized below under each of the major petrochemical building blocks.

Olefin derivatives

There are a great many minor process improvements occurring, but very few that can be considered to have much serious impact on the industry. The principal developments occurring at the moment are:

- Linear low-density polyethylene (LLDPE) has been promoted strongly by Union Carbide (Unipol process), but is now in an advanced stage of development by many companies. The majority of new LLDPE plants will be based on low pressure technology, while some existing high pressure capacity will be adapted for speciality grades. It is estimated that the potential for LLDPE in Western Europe and the United States is as follows:

Region	1985	1990
	(in million metric tons per annum)	
Western Europe	0.4	1.0
United States	1.2	2.4

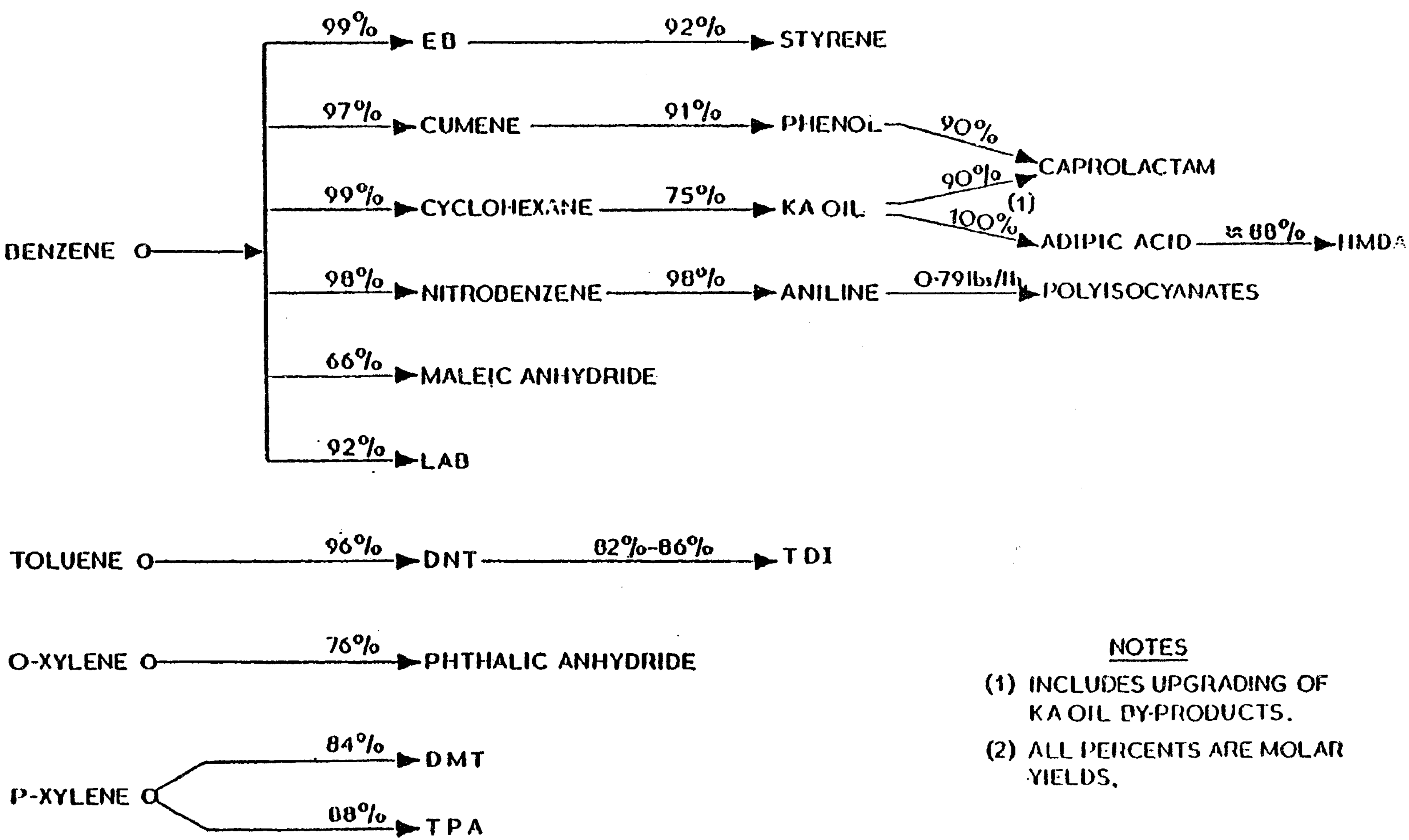
  The figures for 1990 represent 13 and 24 per cent of the overall polyethylene business in Western Europe and the United States, respectively.

- Propylene oxide: The historical chlorohydrine route has been largely superseded by direct oxidation (Oxirane) although Dow still operates the older route. It is expected that more direct oxidation routes will emerge over the next two decades.

Aromatics derivatives

There is little potential for developments which would have any significant impact on the petrochemical industry. All major aromatics derivatives are shown in Figure 5.C. Yields are already good and effort has therefore shifted to finding cheaper feedstocks to make the indicated products. The status of developments is shown in

Figure5 . C MAJOR AROMATICS DERIVATIVES



NOTES

(1) INCLUDES UPGRADING OF KA OIL BY-PRODUCTS.

(2) ALL PERCENTS ARE MOLAR YIELDS.

Table 5.2 DEVELOPMENTS IN AROMATICS DERIVATIVES TECHNOLOGY

Product	Development Cited	Remarks
Styrene	Toluene based routes show potential	Toluene and synthesis gas are the raw materials. Pre pilot stage.
Phenol/Caprolactam	Vapour phase benzoic oxidation	Doubtful economics
	Cyclohexylbenzene oxidation	Renewed activity. Implementation would reduce benzene consumed
Adipic Acid	Butadiene carbonylation	Economic trends favour this approach
HMDA (Hexamethylene Diamine)	None	All new capacity is already non aromatic
Aniline/Polyisocyanates	Nitrobenzene carbonylation	This route rquires 0 to +7.0% more benzene relative to present use
Maleic Anhydride	Butane/Butene oxidation	Economic and technical trends should be toward elimination of new benzene based units
Tolylene Di-Isocyanate	Dinitrotoluene carbonylation	No change in toluene usage
Phthalic Anhydride	Liquid phase oxidation	If implemented, it requires 15% less orthoxylene
Terephthalic Acid	Toluene carbonylation route	Substitutes toluene for paraxylene

5.6 Summary and conclusions

The petrochemical industry has developed as an off-shoot of an organic chemical industry based largely on coking by-products and acetylene. The development of the refining and energy industry during the 1950s and 1960s based on cheap hydrocarbon by-products imported at extremely low cost to the petrochemical industry, which developed at a rate of 5-7 per cent over and above the growth rate of GDP, providing the market with highly attractive substitutes - on cost performance basis - to traditional materials and products.

During this period outstanding development of products/processes was achieved. Most of these early technological developments orinated in Western Europe and the United States and were quickly diffused in the market economy developed countries. Basic petrochemicals, largely in the hands of engineering companies, and intermediate products quickly achieved a plurality, while only speciality products were effectively guarded by patent protection. Prior to the 1973 increase in oil prices major petrochemical production, marketing and research and development were concentrated in the hands of the major chemical companies in the United States, Western Europe and Japan.

The 1973 oil price increase brought about a market change within the structure of the petrochemical industry. The oil majors' taking advantage of their control over hydrocarbon resources and thus feedstock supplies, the increase in feedstock price and its supply uncertainty, abundant cash-flow availability and the diversity in investment strategy gradually encroached upon the position of the chemical majors particularly in basic and intermediate petrochemicals. As a defensive policy most of the chemical majors moved further downstream into speciality products and upstream to the hydrocarbon sources, alone or in joint ventures with the oil majors, to secure their feedstock supply. In several developed countries direct and indirect government intervention increased principally the form of creating integrated hydrocarbon-chemical independent national companies.

No new major breakthrough is expected either in products or processes related to the petrochemical industry in the medium term. The industry has achieved a high degree of maturity and any development will principally be directed towards improvement of processes and operation conditions to reduce costs, utilize less feedstock and less energy, and avoid environmental pollution. In the medium term, most of the development will be centred on the development of new feedstocks and feedstocks flexibility in existing and new plants. Most promising is the development expected in methanol as a feedstcok, which can be produced from a wide variety of sources. Particularly important for the non-oil-producing developing countries is its production from biomass.

The present structure and the expected development are expected to favour the development of basic, intermediate and commodity petrochemicals in those developing countries endowed with hydrocarbon resources or with large agricultural surpluses or vegetation. The development of speciality petrochemicals in the developing countries will be limited to a few newly-industrialized developing countries which have developed their economic and technological structures to a level compatible with the development and absorption of these products.

The developing countries will remain net importers of petrochemical technology from the developed countries. Co-operation with the developed countries and among themselves will be essential to increase their capabilities in the fields of selection, evaluation, and operation of imported technologies. Marketing, manpower development, research and development, and product transformation and servicing will remain the key issues for the development of their petrochemical industry.

Improved conditions for technology transfer from developed to developing countries will remain the subject of intensive negotiations between the two blocs of countries in order to allow the global development of this industry on a rational basis to their mutual benefit.

VI GLOBAL CO-OPERATION IN THE PETROCHEMICAL INDUSTRY: ANALYSIS OF THE PRESENT SITUATION AND FRAMEWORK FOR FUTURE CO-OPERATION

6.1 Introduction

The approach to co-operation in the restructuring process of the petrochemical industry could not and should not be considered as a mere demand on the part of the developing countries and a counter response from the developed countries. It is a much more complicated process in which the role of the different operators in the developed countries is of greater importance, at the present time, than that of the developing countries themselves. In order to have a clear understanding of this process and thereafter to determine the role of the developing countries which would be better served, analysis should be made of the structural changes that have been going on in this industry during the last decade, and particularly since the increases in oil prices that started in 1973.

There are numerous actors who exert real influence on the future development of the petrochemical industry and its restructuring, which could be conglomerated in five distinct groups, with several subgroupings. They are the Oil Majors (Mp), the Chemical Majors (Mc), the independents oil/chemical companies in the developed countries (Ipc), the states in the developed regions and the states of the developing regions. The role of each of these groups will be analysed in order to determine their place and influence in the future restructuring of the industry. Finally, a mechanism for co-operation will be examined which would facilitate the transformation of the industry, with minimum disruption, to a condition of global interdependence allowing its rationalization and serving the interests of all concerned.

6.2 Global evolution of the petrochemical industry between 1976 and 1983

In the developed countries, the dynamics of the operators in the petrochemical industry depends on their ability to ride through the "crisis" and at the same time to take upon themselves the process of restructuring that arises thereof. The petrochemical industry of the EEC and that of the USA present a specific case: they have emerged from companies starting:

- first and foremost, from the oil industry and from the chemical industry where some of these companies have grown to become Majors,
- second, from the coal industry, by decisions aiming at creating public enterprises,
- or/and finally from an exhaustive diversity of firms whose essential activity was centered in other fields[58].

The different economic powers dealing with such important questions as those connected with access to hydrocarbons, to investment capacities, to the internationalization of their presence compel us to distinguish between:

- the oil majors (Mp) such as SHELL, BP, CFP, EXXON, GULF, PHILLIPS, CHEVRON, MOBIL, TEXACO and ARCO;
- the chemical majors (Mc) such as ICI, BAYER, BASF, HOECHST, SOLVAY, AKZO, RHONE-POULENC, MONTEDISON, DOW, HERCULES, EASTMAN KODAK, MONSANTO, UNION CARBIDE and DU PONT;
- the less concentrated independents (Ipc), very dissimilar in the USA and in EEC for reasons dependent on the industrial background of these two separate economic groups.

When one comes to analyse the representivity of these groups of companies and therefore the relative rank they occupy with regard to possible approaches to long-term agreements, their investment decisions and financial control policies at different stages of petrochemical production are indicators of their power position. Thus, taking into consideration the projects which would start production within 1983, a look at the share of productive capacities in 1976, 1980 and 1983 will allow the synthesis of new facts which have emerged in the course of the economic and energy crisis of the 1970s and which are and remain essential to any type of restructuring. A systematic analysis, however, is not possible because of the difficulties encountered in

58/ The cases of U.S. Steel and PUK are typical example of these.

restructuring the history of the production structure prior to 1976.

Nevertheless, the information on EEC and the USA (Table 6.1) allows one to draw some (provisional) conclusions on this matter.

Table 6.1 Scope of the analysis on the share of financial control in 1976, 1980 and 1983 of nominal production capacities

	Financial controls in EEC	Financial controls in the USA
Basic products		
Ethylene	X	X
Butadiene	X	-
Benzine	X	-
Intermediate products		
Ethylene Oxyde	X	-
Styrene	X	-
Final products		
Low density polyethylene (LDPE)	X	X
High density polyethylene (HDPE)	X	X
Vinyl polychloride (PVC)	X	-
Polypropylene (PP)	X	X

6.2.1 The petrochemical operators in the EEC

A. The weight of the oil majors

a) Basic products

Oil majors (Mp) control from 43 to 62 per cent of the basic products (building blocks) through their interventions in 1973:

Ethylene	43.5%	(46.2% in 1976)
Butadiene	61.3%	(61.3% in 1976)
Benzene	43.0%	(44.5% in 1976)

These figures correspond to the units where they intervene, regardless of their financial control, i.e. the units where their partners, the major chemical companies, always have to co-operate/negotiate with the Mps. One can mention as examples:

- the ICI/BP unit (In Wilton, Great Britain),
- the BASF/SHELL unit (In Ludwigshafen, FRG),
- the BP/BAYER unit,
- the CFP/ELF unit (in Gonfreville, France).

In some, the Mp sell their production of building blocks:

- CALTEX and MARATHON (FRG): 310,000 ton/y of ethylene,
- EXXON: 60% of the 1,530 Mt/y of ethylene,
- GULF: half of its production.

b) Final products

The Mps spread their interventions systematically in the field of final products as shown below:

Product	1976	1983	Growth(%)
LDPE	30.1%	32.6%	+ 8.3%
HDPE	21.9%	25.1%	+ 14.5%
PVC	15.3%	21.3%	+ 40.0%
PP	22.3%	27.8%	+ 20.0%

NB: The repurchase of the PUK petrochemical interests by Occidental Petroleum should reinforce this tendency.

This is particularly the case of 3 Mps: EXXON, SHELL and BP, where their shares in final products have developed as indicated below:

	LDPE		HDPE		PVC	
	(1)	(2)	(1)	(2)	(1)	(2)
SHELL	480	+100	100	-	-	+120
EXXON	-	+480	-	-	-	-
BP	175	+230	210	+140	260	-
Total	655	+810	310	+140	260	+120

NB: (1) capacity at the end of 1977 in 1000 t/year.
(2) increase between beginning of 1978 and end of 1980 in 1000 t/year.

c) Intermediate products

The Mps are much less aggressive in the two major intermediate products (EO and styrene) as they are in plastics in spite of the repurchase by BP of the UNION CARBIDE ethylene oxide factory in Belgium (130,000 t/year) and the repurchase by BP of the share that RHONE-POULENC had in NAPHTACHEMIE (France) ethylene oxide and the investments of SHELL and BP (EXXON not being present) in the following capacities (1000 t/year) in styrene:

	End 1977	End 1982/83
SHELL	280	610
BP	220	520

The table below shows the evolution of the shares owned by the whole group of oil majors in the two intermediates:

	1975	1982/83	Growth(%)
Ethylene oxyde	20.8%	30.4%	+46.1
Styrene	32.4%	33.3%	+ 2.7

B. The weight of the chemical majors (Mcs)

The chemical majors (Mcs) have been adjusting their petrochemical policies to overcome the problems they encountered to secure feedstock and raw material supplies. This adjustment process is characterized by gradual withdrawal from exercising direct and independent control over basic and intermediate products. Some of the changes that have occurred since 1978 are indicated as follows:

- UNION CARBIDE has given up some activities in the EEC which BP took over (LDPE) and ethylene oxide);
- USI (a US company) has passed on to EXXON its unit of LDPE (240,000 t/year) operating in Belgium;
- finally RHONE-POULENC has left its polyolefins (HDPE and PP) to BP and its VCM/PVC to ELF and CFP.

Consequently, in 1980 only seven major chemical companies (Mcs) were left in the EEC petrochemical 2 US (DOW and HERCULES) and 5 EEC (BAYER, BASF, HOECHST, ICI, SOLVAY and MONTEDISON). (AKZO does not fare in the petrochemical products dealt with here).

In line with the recesses noted in the years 1978–1980,

- the Mcs' share in the basic products does not increase,
- their share in plastics goes down, and
- finally, their share in intermediate products also goes down in spite of important investments by some Mcs.

Table 6.2 Changing share of Mcs in petrochemical capacities, 1976–1982/83

	1976	1982/83	Growth (%)
Ethylene	33.5%	33.2%	0
Benzene	26.3%	27.4%	+ 4.1
LDPE	48.1%	34.5%	(-28.3)
HDPE	62.5%	50.9%	(-18.5)
PVC	62.8%	54.6%	(-11.1)
PP	71.5%	55.7%	(-22.1)
Styrene	51.1%	47.6%	(- 6.8)
Ethylene oxyde	67.2%	47.0%	(-30.1)

NB: The restructuring presently under way in Italy emphasizes this tendency with the partial withdrawal of MONTEDISON from basic petrochemicals.

But the significant facts concerning the Mc of the EEC chemical industry are to be found elsewhere:

a) Some Mcsare fighting to gain direct admission to hydrocarbons such as:

ICI: (i) participation in the NINIAN concession in the North Sea which has realized in 1979:
- a turnover of £ 519 million (8 per cent of total ICI turnover)
- a net profit of £ 79 million (12.5 per cent of ICI total profits).

(ii) six gas fields in the Gulf of Mexico where operations should start in 1980/81 .

BASF: (i) Development of the WINTERSHALL branch which conducts exploration, exploitation and oil refinery operations for BASF and for DEMINEX (BASF owns 18.5 per cent of the capital) in the Aegean Sea and in Qatar (natural gas); finally, development of its coal activities.

(ii) In total, these activities were most important in the BASF , turnover for 1978 (21.2 per cent) and 1979 (20.8 per cent).

b) All these chemicals majors, including those who withdrew from the EEC petrochemicals are trying to diversify themselves as much as possible in fine chemicals, i.e.

- agrochemistry (pesticides, herbicides), pharmaceuticals, film/reproduction, and to retain some petrochemical specialities, such as: polyurethane (BASF), acrylonitrile (MONSANTO), porpylene oxide (DOW), catalysts (MONTEDISON) and chlorinated solvents (ICI, RHONE-POULENC - before it withdrew from petrochemicals).

C. The less concentrated independents

Globally considered, these firms which have been formed with the assistance of state capital, have adopted as aggressive a policy as that of the Mpsin plastics and in intermediate products, while being relatively independent from the Mps in their access to naphta and gas supply.

In the pursuance of this aggressive development policy, the Ipcs:

a) rarely show a high cash-flow in their chemical activities; instead they depend on:

- the success of their interventions in hydrocarbons (DSM, ELF and ENI in particular)
- the help they get from the state (DSM, ENI/ANIC, CDF Chimie)
- agreements with groups outside the EEC (CDF Chimie and Qatar);

b) develop some technologies of their own with which they try to compete with Mpsand Mcs in the EEC as well as abroad. Examples of such particular technologies include: LDPE (ATO, CDF-Chimie, SNAM-Progetti); HDE (VEBA); PP (CDF Chimie); Ethylbenzene (SIR); VC/PVC (HUL-VEBA affiliate) and Cyclohexane (DSM by Stanicarbon).

Table 6.3 EEC: Share of Ipcs in selected petrochemicals 1976, 1983 (in per cent)

	1976	1983	Growth(%)
Ethylene[a/]	27.6	31.2	+ 13
Benzene[a/]	32.0	31.8	(- 0.7)
LDPE	27.7	30.1	+ 8.6
HDPE	15.6	24.0	+ 53.9
PVC	25.8	27.8	+ 7.8
PP	6.2	16.5	+ 116
Styrene	15.1	20.0	+ 32.4
Ethylene-Oxide	11.9	22.6	+ 89.9

NB: a/ Indirect control: total capacities in which they intervene. The transfer of some petrochemical activities by Montedison to ENI should reinforce the possible role to be played by the Ipcs of the EEC in possible approaches towards long-term agreement.

6.2.2 The operators of the petrochemical industry in the USA

A. The weight of the oil majors

a) Basic products

The major oil companies (Mp's) in the USA will directly control in 1983:

- 53.8% of the Ethylene capacities (42.5% in 1976)
- 45.4% of the Benzene capacities (46.6% in 1980),

and would have therefore greater determining role in the petrochemical industry than in the EEC. Moreover, unlike the West European industrial structure, if the common CONOCO and MONSANTO unit at Alvin (Texas) is excluded, there are no large steam crackers capacities in the USA in a joint venture between Mcs and Mps. Inversely, while in the EEC the production of non-captive ethylene is limited, in the USA numerous units are not or little integrated. The following not so fully

Table 6.4 Petrochemicals control in the EEC region (percentages)

		ETHYLENE c/		BUTADIENE c/		BENZENE c/		LDPE	HDPE	PVC	PP	OX. ETHYL	STYRENE
		I	II	I	II	I	II						
Mp CEE a/	76	34,8	25,9	52,1	39,6	24,2	22,7	30,1	18,4	13,6	22,3	20,8	25,8
	80	34,-	23,8	53,4	37,6	25,8	24,4	28,3	20,4	15,7	23,2	31	24,7
	83	32,3	24,5	52,8	38,4	25,8	24,4	28,-	22,2	18,7	22,8	30,4	26,7
Mc CEE b/	76	18,9	26,3	11,-	25,4	14,1	16,9	33,4	59,-	57,8	71,5	55,6	36,4
	80	16,9	26,5	10,-	26,1	14,-	16,4	30,3	53,5	54,4	54,8	53,5	27,2
	83	19,-	26,9	9,7	24,-	14,-	16,2	30,-	47,8	49,6	51,2	47,-	26,5
Mp US b/	76	11,4	11,4	9,2	9,2	20,3	20,3	-	3,5	1,7	-	-	8,-
	80	12,1	12,1	8,5	8,5	17,2	17,2	4,6	3,-	1,6	5,5	-	5,8
	83	11,2	11,2	8,5	8,5	17,2	17,2	4,6	2,9	2,6	5,-	-	5,7
Mc US	76	7,2	7,2	8,5	8,5	9,4	9,4	8,8	3,5	5	-	11,6	14,7
	80	6,8	6,8	7,5	7,5	11,2	11,2	7,4	3,2	4,8	5	-	21,7
	83	6,3	6,3	7,5	7,5	11,2	11.2	7,3	3,1	3	4,5	-	21,1
Ipc	76	27,6	29,2	19,2	17,3	32,-	30,7	27,7	15,6	22,-	6,2	11,9	15,1
	80	30,1	30,7	21,1	20,8	31,8	30,8	29,4	19,8	23,5	11,5	15,5	20,5
	83	31,2	31,1	22,4	21,6	31,8	30,8	30,1	24,-	24,1	16,5	22,6	20

a/ these are the percentages of the total EEC capacities controlled on a pro rata basis of their financial participations by each group.

b/ MpEEC: Oil majors of the EEC (BP, Shell, CFP); MpUS: Oil majors in the USA (Gulf, Exxon, etc.)

c/ For ethylene, butadiene, benzene, two figures are given: (I) share of the units where the oil majors are present regardless of their participation, Ex.: the ethylene unit BP-ICI is considered as directly controlled by BP.

(II) share according to the financial participation of each group. Ex.L the same BP-ICI unit is considered 50 per cent BP in the MpEEC group, 50 per cent for ICI in the McEEC group.

integrated ethylene capacities could be mentioned:

In 1981 EXXON sold 65% of its ethylene production to other parties; GULF 45%, MOBIL 65% and SHELL 50%. Together these represent a nominal capacity of 3 Mt/y available to ethylene transforming plants.

b) Final products

The Mps in the U.S. systematically spread their intervention and increased their share in final products as shown below:

	1976	1983	Growth in %
LDPE	22.5%	27.6%	+ 22.7%
HDPE	21.9%	32.6%	+ 48.9%
PP	47.4%	52.2%	+ 10.1%

This is particularly asserted for 4 major US oil companies (Mp):

	LDPE		HDPE		PP	
	(1)	(2)	(1)	(2)	(1)	(2)
SHELL	-	-	-	-	136	+136
EXXON	200	+236	-	-	190	+ 60
MOBIL	-	+136	-	-	-	-
GULF	260	+136	95	+105	-	+180
TOTAL	460	+508	95	+105	326	+376

(1) Capacity at the end of 1977 in thousand of tons per year.

(2) Increase between the beginning of 1978 and the end of 1983 in thousands of tons per year.

B. The weight of the chemical majors

In a parallel manner to their withdrawal from certain sectors in the synthetic fibres (withdrawals followed with similar purchases in the U.K. and in Spain, for instance Monsanto), the chemical Majors (Mcs) in the USA are modifying certain of their interventions in the U.S. petrochemical industry. Thus Montedison, Monsanto, Goodrich have taken action in this direction and are continuing to do so, e.g. Montedison has sold its interest in Novamont to U.S. Steel.

Despite the maintenance by certain firms of important investment programmes (Union Carbide, Dow, Solvay, ICI) the relative importance of the "Chemical Majors" in the US petrochemical industry tends to diminish as indicated below:

	1976	1983	Difference in %
Ethylene	40.0%	32.9%	- 17.7%
LDPE	40.4%	40.1%	- 0.7%
HDPE	44.4%	37.5%	- 15.5%
PP	38.4%	31.7%	- 17.5%

In this relative decline of the role of the (Mc)s, one should note that:

(i) the traditional leaders in plastics maintain their investments to keep their positions on the market taking advantage of their new technologies to reap differential profits (for instance the LLDPE at Union Carbide and Dow);

		1976 (Thousand tons capacity and rating)	1983
Dow	LDPE	445 2nd US producer	+120 2nd US producer
	HDPE	130 4th US producer	+130 3rd US producer
Union Carbide	LDPE	700 1st US producer	+227 1st US producer
Hercules	PP	500 1st US producer	+170 1st US producer

The above mentioned 3 Mc firms could be considered as having aggressive policies in plastics similar to those of the 4 Mps described earlier.

(ii) The diversification of the activities of the Mcs has become as a rule in: agrochemicals, pharmaceuticals (purchase of Richardson Merrel by Dow), electronics (development of Fisher by Monsanto), electro-metallurgy (Dow and DuPont in the titalium oxide sponge), etc. These are priorities for the Mcs similar to their efforts to have direct access to hydrocarbons.

(iii) The chemical industry of the EEC invests in North American petrochemicals: Corpus Christi steam cracker by ICI and Solvay plastics production extension by Solvay and Hoechst, specialties by Bayer (polyethers and MDI from its branch at Mobay), the intermediate products by BASF (ethylene, glycol and MDI at Wyandotte),...

C. <u>The role of other operators in the US petrochemical industry</u>

Although occupying an important place in the US petrochemical industry, the other operators in the US petrochemical industry are not fundamental elements for future approaches to long-term agreement: very little internationalized, very tied to a location (where they have the profit of the situation), these operators are centered on the North American market where they adapt to local evolution and patterns of development.

Table 6.5 sums up the control of petrochemical industry in the United States.

Table 6.5 - Control of the petrochemical industry in the U.S.
(percentages of production capacities)

		Ethylene	Benzene	HDPE	LDPE	PP
Mp - US	1976	32.6	na	21.9	22.5	38.1
	1980	42.1	38.1	37.1	28	42.6
	1983	40.1	37.9	32.6	27.6	41.7
Mp - CEE	1976	9.9	na	-	-	9.3
	1980	10.6	8.5	-	-	10.9
	1983	13.7	7.5	-	-	10.5
Mc - US	1976	38.2	na	32.3	44.4	38.4
	1980	30.7	9	26.7	37.2	25.6
	1983	30.4	12.5	22.4	40.1	28.2
Mc - CEE	1976	1.7	na	12.1	-	-
	1980	2.7	-	10.9	-	3.6
	1983	2.5	1.5	15.1	-	3.5
Others	1976	18.2	na	33.7	33.1	14.2
	1980	13.9	44.4	26.3	34.7	17.3
	1983	13.3	40.6	29.9	32.2	16.1

6.3 Internal changes indicative of the restructuring process

Since 1976 the decisions on new projects and the expansion of existing units have been taken on the basis of analysis taking into consideration an integrated approach to the crisis elements and the new world energy balance. Consequently, from now to 1983/1984 important changes will happen affecting the objective conditions inducive to international co-operation or long-term agreements between developed and developing countries. Most important among these changes are:

- the oil majors have taken advantage of the general economic and energy crisis to assert their presence in the petrochemical industry;
- the chemical majors have been re-directing their investments to reduce the effect of competition in "mature products"59/ and to ensure new bases for their cash flow;
- finally, within the EEC, the public petrochemical sector is expanding and is becoming a clear partner in international relations through states' interventions (financial contributions, creation of new industrial structures).

At stake at present is, therefore, restructuring. Such restructuring would direct the actions and attitudes of the operators of the petrochemical industry towards greater international economic relations and especially towards international industrial co-operation. This statement, confirmed through the previous thoughts on technological strategies contains various elements. They could be summarized in two propositions:

- The crisis in the petrochemical industry has differentiated, particularly with regard to the industrial means and policies, to the benefit of the majors;
- the economic and energy crises have jointly disrupted the dynamic balance achieved since 1960-1965 between petroleum and chemicals companies, on the one hand, and chemical companies and end users on the other.

59/ as opposed to "Engineering products" which they try to develop in order to renew their cash flow.

6.3.1 A restructuring process recuperated by the oil majors

The scope of the role of the oil majors in the petrochemical industry is not yet definitely finalized. It is possible, however, to evaluate its foundation from the information summarized in Table 6.6 and its analysis. Thus, within the group constituted by the United States, Canada and the EEC:

- the seven sisters[60] represent respectively 40% of the new steam crackers established between the beginning of 1977 and the end of 1983; and 83% of the expanded capacities of LDPE during the same period;
- Shell and Exxon concentrate alone nearly 30% of the additional ethylene capacities; and 60% of those of LDPE.

These figures stress the ability of the oil majors to take full advantage of the situation and the difficulties encountered by the chemical majors in order to enhance their investments in the basic petrochemical industry, a contradicting situation which led one of the Vice-Presidents of Union Carbide to state:[61]

> " One can anticipate that the rationalization process of a new investment in ethylene will include the re-examination of the dedication to the merchant market by those now supplying it. I also believe that some will conclude that investments downstream of ethylene are better options than continued expansion of ethylene capacity for their merchant customers."

There are several major factors responsible for the growing integration of the petrochemical industry within the activities of the oil majors. Three of these should be pointed out:

60/ B.P., Shell, Exxon, Gulf, Mobil, Texaco, Chevron.

61/ Loy Willeinson, "Resource issues affecting olefins business", CMRA, New York, May 1979.

Table 6.6 The dominant role of the oil majors in the process of restructuring the petrochemical industry
(in thousand tons per year)

	Ethylene capacities		LDPE capacities	
	a/	b/	a/	b/
1. Total EEC, United States and Canada	26,100	10,530	8,080	2,465
2. Total "seven sisters"	7,850	4,250	1,135	2,040
(2) ÷ (1)	30.0%	40.3%	14.0%	82.7%
3. Total Shell and Exxon	4,240	2,940	695	1,470
(3) ÷ (1)	16.2%	27.8%	8.6%	59.6%
(3) ÷ (2)	54.0%	69.0%	61.2%	72.0%

a/ end of 1976

b/ growth between the end of 1977 and the end of 1983.

i) that the joint effects of the evolution in the demand for refined petroleum products and of the utilization of heavier crudes (see chapter on feedstocks) explain the differential incomes from naphtha;[62/]

ii) that the need for higher price for ethylene to finance a profitable new steam-crackers of the chemical majors; "if you want to make 15% internal rate of return - and nobody gets fat on that - on a new plant today, you need either $80/ton more for your ethylene or to buy naphtha $ 45 per ton lower than contract prices";[63/]

iii) that the need for the chemical majors and the independents to benefit from the higher prices of ethylene used directly or indirectly for the production of LDPE, HDPE and PP and produced

62/ The cost of development of catalytic crackers (FCC); it is also appropriate to note that the oil majors benefit (differential income) from the spot prices of naphtha.

63/ R.W. Russel, "Light Olefins in Western Europe", ECMRA/CMRA Conference, Munich, November 1979.

in large quantities which, on the one hand, guarantee the full utilization of the steam-crackers' capacities, and on the other hand cover most of the fixed costs of the units.

As a result, the decisions of the oil majors contribute to the creation of large production surpluses, particularly in the EEC and the United States.

In the EEC: In 1978 it was already forecasted that there would be an overcapacity of production in the EEC for 1982/1984 in the order of 36 per cent for LDPE, 46 per cent for PP and 37 per cent for PVC. However, during this very same period, important investment decisions were taken by the oil majors, mainly in LDPE, namely:

- Exxon: buying the plant from USI and adding a new unit in Belgium;
- BP: buying a plant from Union Carbide.

The comparison of the arguments of a seller (Union Carbide) and a buyer (Exxon) demonstrates the ability of the oil industry to withstand the crises and at the same time to contribute to the restructuring of this industry.[64]

In Canada and the United States: The push of the oil majors in this production coincides with the massive utilization of the LLDPE production processes (plastics competing with HDPE and LDPE). In Canada, the capacities towards 1984/1985 will be close to 1.5 Mt/year for a market of the order of a maximum of 0.5 Mt/year.[65] In the United States, certain experts think that LLDPE plastics[66] will capture the whole growth demand in LDPE, which will result ultimately in the closure of numerous LDPE units.[67]

64/ Point of view of Union Carbide (Chimie Actualité, 6 April 1979): "...(for the 1980's)... we have not noticed for this period any recovery of the market growth for textile fibres and for polyethylene in Europe...and...(in Belgium)... our units should be substantially enlarged to become capable of ensuring a co-leader position in the industry...". Point of view of Exxon (Chimie Actualité, 15 June 1979): "...(considers)...the acquisition of USI as a logical extension of our plants in Europe...(after having underlined)... our forecasts coincide generally with those of CEFIC...".

65/ Shell project (in association with NOVA), 250,000 tons/year.

66/ Cf. the Exxon project (275,000 tons/year), Mobil (225,000 tons/year).

67/ Cf. Chemical Age, 30 Jan. 1981, which mentions the possible closure of a total capacity up to one Mt/year (p. 12).

Thus, the energy crisis and the problems connected with cash-flow/ profitability of invested capital in the petrochemical industry facing the chemical majors create new conditions for investments by the oil majors (Mps) which favour the diversification of their downstream investments in the refineries controlled by them. "Refinery/steam cracker/ final plastic products" constitute then an efficient line of differential profits for the oil majors.

6.3.2 Restructuring and interindustrial relations

A. Relations between oil and chemical industries

As early as 1975 it became clear that OPEC's decisions had led to the loss of economic balance of the chemical industry in its relations with the oil companies. Indeed, because of its price and its distribution among users, particularly in Western Europe and Japan, naphtha had become a new means of income for the "oil majors".

The negotiations of 1974/1975 allowed the chemical majors to re-evaluate the terms of their relations with their oil-producing partners; three representative opinions on this development are indicated below:

a) "Two distinct philosophies have emerged on the pricing of ethylene and propylene in Europe in the last quarter of this year. The philosophies reflect the widely differing positions of oil company-related olefins producers and non-captive olefins consumers. At the centre of the issue is the price of naphtha. Consumers say that the pressure for higher prices originates from the oil companies' inability to market their gas-oil and believe that naphtha prices should relate simply to naphtha costs and should not have to compensate refiners for losses in other areas..." (ECN, editorial No. 721, January 1976).

b) "... the independent petrochemical companies will find it harder to obtain domestic hydrocarbon supply... When the choice comes down to one between fuel use and raw material use, petrochemical producers will be in an increasingly vulnerable position... (Mr. B.H. Melton, W.R. Gracy Cy, CMRA Conference, New York, March 1975).

c) "..... In the supply and demand equilibrium the petrochemical and the larger gasoline market are competitors. For temporary imbalances this will be reflected in prices competition but in the longer term, the petrochemical industry has to be aware of the dependency of its supply situation on oil companies and government's decisions..." (Mr. A.H. Pecasse, DSM, idem).

The situation does not seem to have changed since then and price increases of naphtha in the years 1979/1980, which at times were more than proportionate to those of crude oil,[68/] have confirmed the convictions of the chemical companies.

Bearing the above in mind, the following points can be considered:

i) The "chemical majors" and the "independents" have included in their strategic analyses a long-term price increase for energy;

ii) The part to be played by the "oil majors" with regard to the price of naphtha and to its availability (same for the LPG) is the major concern of the "chemical majors" and the "independents" who are concerned with their own supplies. So much so that they try to act against the "spot-market" price of naphtha.[69/]

iii) Whether these actors will keep on playing this decisive role in petrochemicals depends partly on the solutions they find to diminish and/or modify their dependency on the "oil majors". Otherwise, their future is jeopardized as expressed in the declaration of R.W. Russel (op. cit.): "I believe that as the older capacities close down, replacement capacity will be owned by the oil companies";

iv) Dealing directly with the hydrocarbons-exporting countries and/or investing directly into the petroleum industry has

68/ Early in 1979, J. Gandois, President and General Director of Rhône-Poulenc declared to ECN "the price rise planned by the oil companies for the second quarter were speculative and dangerous... With the second quarter crude prices rising by 15-18 per cent, naphtha increases should be around 8-10 per cent. But the price ideas of the oil majors call for rises of 80-85% for naphtha and 100% on aromatics" (ECN,,9 April 1979).

69/ See the Declaration of Mr. R. Rose, Director of Petro-Chemicals at Rhône-Poulenc, to Chimie-Actualités (21 March 1980): "... There is no clear distinction between the ones who sell "on contract" and those who act on the "spot-market". The contracts had been set at $305/t for the fourth quarter of 1979, while the spot price in Rotterdam (which serves as reference point to establish contract prices) were rising from $335/t at the beginning of October to $395/t in December. The chemical companies tried in vain to sound the alarm the contract prices were nonetheless climbing to an average $367/t depending on the quotation published by the "five". Once the contracts had been signed, the spot prices would climb down to about $ 345/t and stabilize themselves at that level as though by magic." See the 1979 decision of ICI, DSM and Rhône-Poulenc to publish a medium-price of their quarterly contract in order to eliminate the use of spot prices as reference (Cf. ECN, 3 March 1980).

progressively appeared to be the only alternative to modify the relations of the chemical majors with the "oil majors".

Table 6.7 gives some indication of the new situation.

Table 6.7 - Attempts made by some "chemical majors" and "independents" to obtain autonomous crude supplies

Chemical Majors /Independents	Refinery	Contracts with hydro-carbon exporting countries	Exploration/ exploitation Oil/gas
BASF	X	Project	X
RHONE-POULENC		X	
ICI	X		X
MONSANTO			X
MITSUBISHI		X	
DSM		X	X
CdF-CHIMIE	X	X	
DIAMOND-SHAMROCK			X
DOW	X	X	X

B. Relations between the chemical industry and downstream industries

The relations between the "chemical majors" and "independents" and the downstream industries are not at present as clear as those with the "oil majors". After the synthetic fibre crisis (which has not come to an end) and its restructuring effects on the chemicals/petrochemicals of EEC and, to a lesser extent, the United States, the first signs of restructuring are appearing. Given impulse by the crisis encountered in the downstream petrochemical industries other than textiles, they should increase the already deeply devastating effects of the synthetic fibres industry.

Apparently, each major petrochemical producer sees a two-fold conflict facing its pricing and marketing situations:

- at the level of the petrochemicals producers themselves, mainly those of EEC facing the rest of the world, they have initiated anti-dumping complaints against imports from the United States, CMEA, and from developing countries to limit the entry of low-priced products. Some of these products are often needed by EEC petrochemicals' convertors to improve their competitive position. (e.g. ECN of 30 April 1979 also writes concerning synthetic rubber "The existence of considerable tonnages of SBR imports has, according to major European producers enabled a couple of manufacturers to regain some lost market share, albeit at "intolerable" price levels".)

- at the level of petrochemical producers and their end products users, the EEC is showing some typical cases of conflict: conflict on the price of butadiene between the International Synthetic Rubber Company (ISR) and its English suppliers[70]; and conflict on the price of polypropylene in spite of an obvious over-capacity.

Beyond "prices" and "share of the market", another subject of conflict and therefore of restructuring is taking shape, namely: the profitability of downstream industries is subjected to the contradictory effects of the increasing prices of petrochemical feedstocks and of international competition. Consequently, petrochemical producers in the market economy countries are confronted in the downstream industries with:

- the total transfer of payment of the revenues due to the oil majors (for feedstock supply);
- and being squeezed permanently to the extent that these industries will have no alternative except their redeployment to developing countries with less expensive factor inputs in order to improve their competitive position vis-a-vis other petrochemical producers in export markets.

70/ Conflict commented upon by ECN (28 January 1980): "It is also realistic to expect olefins producers to load as much value as possible onto products in which they have limited integration, in order to soften the blow to their ethylene and propylene consuming businesses". The new increase, requested by EXXON at the end of 1980 (+ 12 per cent), following the hard negotiations at the beginning of 1980, seems to force ISR to think over its own future regarding its squeeze by its principal suppliers and by the weakness of the demand on SBR (utilized capacity 30-35 per cent) cf. ECN (8 December 1980).

The whole of these internal mutations - and their end result, the restructuring of market economy petrochemicals industry - do not imply one single issue for the actors involved, for the economies and populations concerned by it, nor for the interventions of governments.

Put back into the context of the coming years and put into motion by the needs of the developing countries, this restructuring process can find in international co-operation modalities and contents which are compatible with both the respect and the broadening/expansion of mutual interests of developed and developing countries.

6.4 Petrochemical producers of the developing countries: their policies and significance in international petrochemical relationship

The identity of the petrochemicals producers of the developing countries is less complex than that of the operators of the EEC and the USA. The limited capacity of the private industrial capital to undertake large financial investments (more than 5-600 millions US$) in the highly capital intensive industry has led to a division of "responsibilities" along the following lines:

- the production of basic products is almost the exclusive responsibility of public companies, except perhaps the future complex of San Lorenzo (Argentina) which consists of private capital;
- other (downstream) products are divided between public and private sectors, the latter mainly acting in the newly industrialized countries.

This division of producers has sometimes been consolidated by legal action which tries to determine the field of interference of national and private foreign capital (cf. Algeria, Brazil, India, Mexico, ...). It should, however, be underlined that :

- . the definition of the sector destined to public funds varies from one country to another. For instance, LDPE has been designated to State companies in Mexico while it is not so in Brazil;
- . that the few private companies interfering downstream have, among others, the task to acquire foreign technology on an

ad-hoc basis in collaboration with the multinationals.

Consequently, the policy of each country should be considered as the frame of reference to know and understand the action of petrochemical operators of the developing countries. However, notwithstanding the diversity of the situations, the policies followed are relatively homogeneous within three groups of countries, namely: "newly industrialized countries"; "countries exporting hydrocarbons with small population" and the other developing countries.

6.4.1 Position of the newly industrialized countries (NIC_s)[71]

These countries have acquired the capacity to adjust the development of their internal demand to the benefit of their own industrialization. Likewise it is not surprising that their policy with regards to petrochemicals is comparable to that taken in numerous other sectors, mainly:

- to substitute their imports with national production and to instigate the development of their markets to suit the pattern of national production;
- to integrate basic products with downstream products, petrochemicals with capital goods, petrochemicals with engineering;
- to improve their basic technological capabilities by strengthening national integration, and reducing their dependency;
- to find new forms of financing to reduce the growth of their international debt and the charges occuring thereof.

The main common fields of interest in international negotiation for these countries are therefore:

a) to secure ways and means to develop their technological capabilities;

b) to secure good conditions for international credit;

c) to secure foreign funds and mutual guarantees in case of

71/ Under the term "Newly Industrialized Countries" the study includes countries such as Argentina, Brazil, India, Mexico, Republic of Korea, Turkey, Venezuela, Yugoslavia, Other Asia.

joint-ventures.

Some of these groups of countries are faced with other problems:

d) those deprived (or almost deprived) of hydrocarbons, want guarantees for their supplies and wish to develop direct relations with the OPEC countries: Brazil, India, Republic of Korea, Turkey and Yugoslavia;

e) those close to large consumers'zone do not wish to be limited in their exports a priori in order to make their units profitable.

The fields (a) and (d) mentioned above are the most peculiar to the petrochemicals industry and should be examined closely as follows:

A. Development of technological capabilities

The importance of this subject would be put in a better perspective when comparing the interests of the Newly Industrialized Countries with those of the industrialized countries:

a) The interests of the NICs

On the one hand it is a matter of lowering the cost of technology to be paid to foreign companies 72/ and, on the other hand, of limiting the restrictive practices in technology transfer, all in a perspective supporting the relative technological independence of these countries and improving their capability for the choice and evaluation of technology.

With such an objective, at international negotiations the NIC's would aim at:

72/ F. Manzilla (S[s]-Dr of Instituto Mexicano del Petróleo) evaluated at 9 per cent of Mexican petrochemical investments between 1976 and 1981, the payments for technology acquired from foreign companies being $ 276 million). cf. "Development and outlook of the petrochemical industry in Mexico", UNIDO, Doc. ID/WG.268/3, 2 February 1978.
Payment of"royalties" for petrochemical technologies raised to $ 76 million for the Republic of Korea between 1973 and 1978, being 32.7 per cent of the whole of royalties paid in those years by the Republic of Korea. cf. Young-Hun Kim: "The comparative studies of national experience in technologies policies: the case of the Republic of Korea" - UNIDO, Doc. ID/WG.325/1, 19 August 1980.

(i) products realization to enhance their grasp to master (more or less) the assembly of production units and their efficient operation;

(ii) sophisticated products ("specialities") to approach the highest limits designated by the technology (process and units operation) while at the same time lowering costs and constraints imposed by the "controlling" firms;

(iii) manufacturing of petrochemical equipment to increase their capacities for the design and manufacturing of petrochemical equipment, according to international standards.

b) The interest of industrialized countries

Because of the lack of active State interventions in market economy industrialized countries in the field of technology transfer concerning petrochemicals, the interest of these countries tempt to merge with those of oil and chemical majors in spite of the efforts of public petrochemical companies to offer other procedures for technology transfer[73/].

At the present time (see chapter on technology) the majors are concentrating on improving the qualities of marketed products in order toprotect their markets (experience drawn from the previous competition on fibres), and towards the improvement of their manufacturing processes through research[74/] in order to acquire monopolistic (or near monopolistic) revenues. If this policy of thé majors does not facilitate the efforts of the NICs, several factors lead one to think that

73/ cf. Technip (and KTI)/PETROBRAS agreement for ethylene and SIR/PETROBRAS for ethylbenzene and more recently the agreement ANIC (afiliated to ENI). The People's Republic of China regarding joint-research in the sectors of petrochemicals and synthesis polymeres.

74/ This research on monopoly revenues through new petrochemical technologies during the next years has been clearly referred to by Anthony Lowe (Shell Int'l Chemicals) quoted by Ann Taylor in Overseas Competition Dilema for European Chemicals, Chemical Age, 9 November 1979: "Success in discovering something in the high technology area could not always be translated into high profits. The key to successful exploitation of high technology probably lay in the ability to secure a degree of monopoly via patent" the majors can only delay or restrain a historical movement started for certain countries just after the Second World War as examplified by the constitution of PEMEX or PETROBRAS, and progressing with an acceleration since 1965. These factors are of two different natures:

Factor 1: The process of restructuring of the petrochemical industry is historical in nature: the agreements between majors for certain products and for marketing, linked with licencing monopolies are precarious; and the large chemical companies in the market economy countries[75/] seem to lose their efficiency due to the extreme competition among companies as dictated by the restructuring process.

Factor 2: The crisis imposes on the authorities of the industrialized countries the export of their capital goods in order to activate their engineering industries. The transfer of technology agreements facilitate these industrial agreements. If the major transnational companies are somewhat autonomous in their decisions, public Western European petrochemical companies can be efficient operators for technology transfers to the mutual interests of all the countries concerned.

B. To guarantee their hydrocarbons supplies

This global problem assumes particular importance when it interferes with the development of the petrochemical industry in the NICs:

- If they produce their naphtha,the conditions of the supply of crude oil affects the operational security of their installations (i.e. Republic of Korea) and their profitability;
- If they import their naphtha,they become completely dependent on the decisions of the oil majors

Consequently, the NICs seek:

- agreements on crude delivery with the OPEC countries and Mexico;

75/ cf. chapter III, "Comportements des grandes entreprises de l'industrie chimique" of the report published byUNCTAD: "La structure et le comportement des entreprises de l' industrie chimique: incidences sur le commerce et le développement des ces pays en développement" UNCTAD/ST/MD/23, 1 August 1979.

- agreements on crude refining with the same countries (as the example of Kuwait and the Republic of Korea);
- to develop their own hydrocarbon production, which concurs with the World Bank Fund for the development of energy in the developing countries;
- and finally, mainly in the case of Brazil and India, to develop alternative resources such as alcohol/methanol in Brazil and coal in India (as in the ammonia project).

6.4.2 The policy of hydrocarbons exporting countries with small population

Contrary to the countries mentioned above, certain Gulf States and Lybian Arab Jamahiriya have small internal demand, and the means to finance their own projects but do not have the industrial and technological basis to acquire, within a few years, a technological capacity to reduce appreciably this form of dependence. Consequently, considering their political will to valorize to the utmost their hydrocarbons these countries request: access to international marketing networks; cancellation of quotas restricting their exports to the markets of the market economy countries; and access to technical mastery (process and unit operation) of their installations.

Moreover, on the strength of their first industrial experiences, these countries refuse to pay an over-price to engineering companies and civil engineering firms by relying on international tenders to increase competition and ask for firm guarantees to operate their production units at maximum capacity.

This policy overs four production items[76]:

- the refining of crude oil
- production of methanol
- production of ammonia
- production of ethylene and its first derivates (LDPE, styrene, ethylene glycol, ethylene-dichloride)

76/ If Mexico has "petrochemical projects" as ambitious as those of the Gulf countries, they are not "export oriented" except for a part of its ammonia production.

If numerous units are under construction in these countries and if some of them are already producing, the main question posed to the developed countries, namely, the opening of their markets, has not yet received a clear answer, free access to their markets is not yet an acquired fact and remains the object of global negotiations. However, the current restructuring taking place in the industrialized countries drives the more aggressive firms to show an immediate interest in the projects of certain Gulf States and Lybian Arab Jamahiriya either through joint-venture agreements as in Qatar and Saudi-Arabia, or through long-term contracts as in Lybian Arab Jamahiriya.

Thus, generalizing the scope of the agreements between these firms and the countries mentioned, it could be considered that the questions related to the exports to the developed countries will be treated simultaneously by the State, in the developing countries and by companies having an immediate interest in accelerating the restructuring process in the field of petrochemicals.

Table 6.8 demonstrates that four out of five companies (SABIC's partners in the Saudi projects) are leaders in the world petrochemicals which, besides, have witnessed their largest expansions since 1976; the"crisis" has enabled them, therefore, to re-assert their role and in this capacity, their driving role in the restructuring process.

This convergence of interests is happening only with the"majors" who needed a clear-cut condition to associate themselves in joint-venture projects in the Gulf area. These conditions could, however, be revised when the second phase of petrochemical development in this area is reached.

a) The interest of the majors in ethylene or methanol projects is implemented through massive use of flared gas and not the use of naphtha produced by large refineries in the region. Naphtha would be undervalued (as compared with the international market price for crude) when used to provide a "relative advantage" in favour of petrochemical products, a situation, which finds little tolerance by the OPEC members.

   This establishes a future link between the "expansion of

Table 6.8

World position of M_{O}s and M_{Op}s partners in Saudi Arabia joint venture projects

PRODUCTS	Ethylene	LDPE	Methanol
MAJORS			
SHELL	1983, 4.6 Mt/y (3 Mt/y in 1976) world first producer. Long term projects in Scotland and Alaska	1983: 0.7 Mt/y(0,5 Mt/y in 1976. Long term project in Alaska	—
EXXON	1983, 3.2 Mt/y (1.6 Mt/y in 1976) world third producer. Long term projects in Scotlan, Alaska and Indonesia	1983: 1.05 mt/y (0.2 Mt/y in 1976) third world producer. Long-term projects Scotland, Alaska, Indonesia	—
MOBIL	Little development 500.000 t/y (from which 410.000 in the USA) in 1976 and 1983	1983: 0.36 mt/y (0 in 1976) long term projects in Canada	—
DOW	1983: 3.6 Mt/y (2.6 Mt/y in 1976) Second world producer.. Long term projects: Scotland, Alaska and Australia.	1983: 1,25 Mt/y (0,73 Mt/y in 1976). First world producer long term projects: Scotland, Alaska.	—
CELANESE			1983: 2.5 mt/y (1.1 Mt/y in 1976) first world producer. Long-term projects: methanol extraction from coal in the USA

refining" and "petrochemical expansion" in these countries.77/

b) The interest of the majors leads to the lessening of their financial commitments and to search for means to acquire part of the necessary capital accumulation needed for the implementation of their restructurating policy, to be taken care of by "external sources". It is not certain that the advantages granted by Saudi Arabia, in order to acquire a rapid mastery of technology (including construction) and in particular of international petrochemical trade, will be renewed in the future.78/

The long-term position of the petrochemical industries of these countries in the process of global restructuring cannot be considered as being final. Three factors will determine the future:

i) the possible consequences of the development of State to State79/ agreements (or regional economic organizations like EEC) on the delivery of crude and refined petroleum products, principally concerning the EEC countries and Japan;

ii) the progressively declining role of the oil majors as commercial and financial intermediaries between the Gulf States and the industrialized hydrocarbon importing countries;

iii) the development of exchanges and co-operation between the Gulf States and Lybia and other developing countries, particularly under the impulse of the energy problems.

6.4.3. The other developing countries

The main objective of a group of developing countries is to create the first elements of a petrochemical industry. The most advanced in this policy are:

- Some OPEC countries, such as Algeria, Indonesia, Iran, Iraq, Nigeria, which have larger population;

77/ It must be noted that the steam-cracker of Ras-Lanuf in the Lybian Arab J. will be supplied by the Ras-Lanuf refinery.

78/ The announcement made not to link any longer a privileged access to crude oil with the amount of investment in Saudi Arabia

79/ Between 1973-1979, the State to State world crude supply moved from 5% to 16.5% of the total world crude supply. Cf PIW, 25.2.1980.

- Some countries of South East Asia: Philippines, Singapore, Thailand;
- Finally, a few other countries: Chile, Colombia, Ecuador, Egypt, Pakistan.

All the problems pointed out earlier affect also these countries but with greater intensity: they have not reached the technical-industrial level of the NICs; they have no adequate surplus of petroleum revenues as enjoyed by certain Gulf States and the Lybian A.J. Only their hydrocarbons and their place in the context of international relations constitute implicit means of negotiations to facilitate the financing of projects in their territories and the external marketing of their production (if need be).

Until the present phase of development of their projects is achieved, which will last in certain countries until 1985-1987, the future of their petrochemical role could not be clearly defined at present.

As a matter of fact, their eventual new decisions to further develop this industry will be dependent on:

a) the future of the export-oriented petrochemical industry in the OPEC countries;
b) the co-operation in the fields of energy and industry between the same countries and other developing countries;
c) their external debts;
d) the existence, until then, of appropriate technologies conforming with their socio-economic conditions of development.

Moreover, the future of internal demand on petrochemical products in these countries, with a strong percentage of rural population and sometimes a low development level depends on the internationalization of their economies: only those having urban consumption models borrowed from industrialized countries, promotion of export-oriented industries and ambitious overall development programmes, relying on petrochemical products, are in a position to give an impulse to a significant rise in demand during the next ten years.

Taking into account the above-mentioned elements, the future of the petrochemical industry in the majority of the developing countries from now until 1990 seems to be insufficiently clear. A fundamental question arises: Could co-operation among developing countries in the petrochemical field substitute its own patterns for those of the present international division of labour (renewed by the current restructuring)? In the coming part of this chapter, attempts are made to present a framework which could present a solution to this fundamental question.

6.5. Conclusion

In concluding the presentation of the dynamics of the presently operating factors inasmuch as they affect international petrochemical relations and condition the field of every international co-operation, the analysed situations make difficult any firm statement for the future: however, there is room for alternative decisions.

On the one side, there cannot be any approach which considers the market economy industrialized countries and the developing countries as two homogenous groups: the oil majors and the state-owned companies of Western Europe are different realities in the restructuring process of the petrochemical industry and carry, therefore, different potentialities for international co-operation. Likewise, the objects of negotiations with the industrialized countries do not have the same priorities in the developing countries.

On the other hand, the place of the various partners in the 1990 image of the world petrochemical industry cannot be described today. Many structural questions remain unanswered because they imply choices and the means to make these choices, mainly by the major chemical companies, the State in developed countries (EEC, Japan), and the OPEC countries.

Faced with the economic recession and the energy crisis, the role of international co-operation, as an "extraordinary" medium of international relationship could present an important remedy. Furthermore, the period of observation of the partners (from the end of 1976 to the end of 1983) is a period of restructuring which will not end in 1984. It should be agreed, however, that the parties, at the present time, would be prepared to initiate negotiations under conditions very different from those which prevailed in 1974-76.

On the basis of ethylene production (Table 6.9), one may attempt to synthetize the characteristics of the restructuring process going on since 1976-77 and to recognize the dynamics pointed out previously.

The reinforcement of the position of some industries, the substantial recess of some others, the constitution of powerful national petrochemical industries and the definite engagement of the OPEC countries are indeed major facts which did not exist in 1975-76.

Partners in search for their place in a more and more interdependent world, in search for new inter-industrial connections, fixing long-term prices and profits are only some of the new realities in the petrochemical industry, indicating that new approaches are needed to be considered by all potential partners in international relations to safeguard the interests of each and every one but also to adapt them to the new international economic situation and to the evolution and the implications of the energy problems.

International co-operation appears then as a choice which, in the long run, minimizes the economic and social costs of this adjustment and maximizes mutual interests.

Table 6.9 Ethylene: Synthesis of the evolution of capacities controlled by each operator between the end of 1976 and 1983/84 (in thousands of tons per year)

	Situation at the end of 1976	Growth between 1977-1983/84	Shares in percent 1976	1983/84
Total USA + Canada + EEC	26,000	+ 10,530 (63.3%)	93.5	82.2
Oil majors	10,600	+ 5,870 (35.3%)	38.1	37.1
Chemical majors	9,420	+ 2,640 (15.9%)	33.9	27.1
Indep.(US + Canada)	2,460	+ 620 (3.7%)	8.9	6.9
Indep. (EEC)	3,520	+ 1,400 (8.4%)	12.7	11.1
Developing Countries (total)	1,790	+ 6,100 (36.7%)	6.5	17.8
NICs	1,680	+ 4,200 (25.3%)	6.1	13.2
OPEC (small popul.)	-	+ 1,100 (6.6%)	-	2.6
Others	110	+ 800 (4.8%)	0.4	2.0
World Total	27,790	+ 16,630 (100%)	100.0	100.0

6.6. Towards closer international co-operation in the petrochemical industry

6.6.1. The limited role of international co-operation in the past

The need to utilize specific ways and means of international co-operation is relatively recent in the international relations of the petrochemical industry. As a matter of fact, the search for solutions to soften the economic crisis of the industrialized countries during the 1970s has led to the development of two distinct major international negotiations concerning the petrochemical industry:

1) the compensation agreements with the CMEA countries, started in 1972 and based on the mobilization of international credit to finance the delivery of complete petrochemical plants to the USSR and Eastern European countries and to be repaid in kind either with products of the same plants or otherwise,

2) the international multi-fibre agreement between developed and developing countries enabling the developed countries to adapt their textile industry, through an agreement limiting the export growth of the developing countries.

Though moderate, the impact of both types of agreements on international co-operation in the petrochemical industry should be underlined:

a) they are innovations though imperfect, which can be evaluated[80/] as a contribution to international co-operation in the petrochemical industry because they have been put in practice;

b) they demonstrate by their relative successes and failures, that only an approach in terms of respect of mutual interests can open new prospects permitting an economic dialogue.

c) they have renewed the ways and means to deal with commercial matters.

The development of the petrochemical industry in the developing countries has not profited from these agreements or from any other form of international co-operation until the last few years.

The essential contribution of the industrialized countries to the developing countries prior to that was limited to:

80/ See contribution of the EEC (UN Geneva) "Counter-trade practices in the chemical industry; the experience of selected Western chemicals/ producers and plant contractors in East-West trade", document Trade R. 410, 30.9.1980.

- direct investments in a few countries and, recently, to certain joint-venture agreements (seldom requiring interventions by the Governments of the developed countries);
- transfer of technology according to traditional procedures; the protection of the licencer's interests being most frequently the main if not the only object of the discussions;
- "normal" credits for the export of capital granted in the framework of more or less active export promotion policies and allocated on a case-by-case basis.

The relative impact of these contributions could be illustrated by the information available on this subject in 1978 (Table 6.10) on the existing capacity to that date and on the projects being discussed and those under construction at that date (entering into function at the latest in 1984).

In 1978, only 5 of the newly industrialized countries were active in the three types of production lines (ethylene, intermediates/monomers for synthetic fibres and plastics). At that date, these countries were not beneficiaries of specific measures but only of some direct investments as Rhône-Poulenc in Brazil.

Between 1979 and 1984, some projects will benefit from new forms of micro-economic co-operation and only some operations will be based on co-operation policies (macro-economic co-operation) as discussed hereunder.

i) <u>Macro-economic co-operation</u>

Projects in Singapore, Iran, Qatar and a transfer of technology projects for COPESUL (Brasil)[81] are being constructed under the umbrella of macro-economic agreements involving governments of developing and developed countries.

ii) <u>Micro-economic co-operation</u>

This includes agreements between state or private enterprises in developing countries with petrochemical enterprises from developed countries and encompassing the financing/construction/marketing/managing,

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81/ India is interested in an enlarged petrochemical co-operation. Ecuador wants to benefit from its integrated project through a buy-back agreement; the projects will not be operational before 1985.

Table 6.10 Limits of development of the petrochemical industry in the developing countries from now to 1984

By type of production lines	Countries with petrochemical structure in 1978	New countries with available petrochemical structures between 1979 and 1984
Ethylene	7 countries (7 NICs)	10 countries
Intermediaries/monomers for synthetic fibres	7 countries (6 NICs + Indonesia)	5 countries
Plastics	8 countries (8 NICs)	9 countries
Synthesis	Number of countries intervening in all the above 3 production lines: 5 countries[a]	Number of completely new countries intervening in the above 3 production lines: 3 countries[b] Countries producing an additional product from now to 1984 2 countries[c]

a/ Brazil, India, Republic of Korea, Mexico, Other Asia.

b/ Lybia, Saudi Arabia, Singapore.

c/ Turkey, Yugoslavia.

etc. of the projects involved without affecting the overall economic or trade relation between the two countries. Such micro-economic co-operation involves projects in Saudi-Arabia, certain projects in Mexico (for instance intervention of STAMICARBON, a branch of DSM, in a caprolactum unit), projects in Indonesia, Portugal and Yugoslavia (for instance DOW and INA at Kirk).

Thus, since approximately fifteen years, the traditional instruments of micro-economic co-operation have found little use in the petrochemical industry. Macro-economic co-operation is too recent to be appraised and its application is still scarce. It should be noted that the developed countries have not granted a priority interest to macro-economic co-operation as a solution to the petrochemical crisis. Instead, they have preferred to rely on protectionist measures and internal restructuring operations (comprising petrochemical investments in the United States).

Moreover, micro-economic co-operation as well as the classical instruments available to firms and to developing countries have not permitted until 1978 a great expansion of the petrochemical industry in those countries and even in the newly industrialized countries.

The limitations of multilateral co-operation are also evident up to this moment. The only experiment along this line - the European-Arab dialogue - has encountered in 1977 many difficulties in bringing together the points of view concerning the refining of crude and the petrochemical industry. Thus two types of conclusions seem to assert themselves:

a) If the traditional forms of co-operation have not been efficient in the past years, how can they be better suited to respond to the evolution of an international petrochemical context during the coming decade? The analysis of present and future constraints, which is expected to reinforce interdependencies, should answer this question.

b) If international co-operation (micro and macro-economic) has played a very limited role, it might be worth considering that since 1973 the theoreticians and practicians on petrochemical development[82/] issued various doctrines responsible at present for the contradictory approach to this kind of co-operation by

82/ Cf. R. Stobugh: "Prospects of the petrochemical industry in the developing countries", Seminar on the utilization of petroleum resources in the Arab Countries, Tripoli, 20-23 April 1974. I. El-Zaim, "A reappraisal of the joint ventures and technology as a mean to petrochemical promotion". OPEC review,Vol.II, Nr.2,Vienna, April 1978.

the interested parties[83]. This certainly constitutes an essential contribution of the years 1973-1981.

6.7 Evaluation of future constraints reinforcing international interdependencies in the petrochemical industry

A set of constraints limiting the freedom of partners to approach each other exists and will continue to exist during the next decade. This is expected to lead to an increased interdependence of decisions making in the petrochemical industry. Consequently, a co-operative approach at different levels (global, regional, sub-sectoral) constitutes an alternative in the international relations in the petrochemical industry.

These "constraints/interdependencies" are the direct products of the various policies adopted by the developing countries to manage their hydrocarbons and to establish their petrochemical industry, and of the various strategies of the operators in the industrialized countries to adapt themselves to the present economic recession and to the energy problems.

6.7.1 The constraints/interdependencies originating from the policies of the developing countries

The policies of the developing countries affect the whole of the world's petrochemical industry, including the future of this industry in their own countries, mainly in three fields:

- the management (production, prices) of their hydrocarbons;
- the expansion of their crude refining capacities;
- the massive development of plastics production.

A. The effects of their hydrocarbon management

The legitimate policy of the OPEC countries to avoid the accelerated depletion of their oil reserves through too high production levels, and consequently to raise the price of crude oil in order to encourage the utilization of complementary sources of energy will affect mainly the

83/ OPEC, Seminar on "Downstream Operations" in OPEC member countries-Prospects and Problems, Vienna, October 9.11, 1978.

supply conditions of steam-crackers:

(a) unfavourable allotment to the petrochemical industry might happen when distribution of the various refined products among the various end users occurs. This will be the case if the forecasts of the OPEC experts is realized. These forecasts predict an appreciable decrease in the amount of crude exported by OPEC member countries in 1990 as compared with the 1979 level: 17 to 23 Mb/d against 28.3 Mb/d[84/];

(b) the export of heavier crudes requiring more capital intensive processes which will lead to a substantial increase in naphta price;

(c) a limitation on "flared-gas" utilized in the export-oriented petrochemical industry in favour of local consumption and reinjection in the oil wells;

(d) finally, a price level for crude oil, increasing in real terms by 3-4.5 per cent per year from now to 1990, but certainly by at least 10 per cent per year in current value, would reduce the possibility of long-term profits of numerous petrochemical industries.

B. The expansion of refining capacities in the hydrocarbon-producing countries

In the quest for a greater supply security (quantity and price), the large importers in the developed countries are bound to be confronted with a counter-proposal from the oil exporters: to lift the commercial barriers and to permit them to deliver increased quantities of refined products and basic petrochemical to their markets, partly substituting the export of crude oil.

Since 1978, when the main industrialized countries had minimised the importance of this question (European-Arab dialogue) the exporting countries have developed their refining capacities:

84/ v. the art. of Adnan A. Al-Janabi and Dr. F. Fesharaki in the OPEC Review, Vol. IV, 2, Summer 1980.

1977 - 1983 : + 100 MT/y
1984 - 1987 : + 140 MT/y (only on the basis of the advertised projects.)

This means a minimum total in the order of 610 MT/y by 1987[85/], permitting an export of at least 180 MT/y of refined products after domestic consumption is taken into consideration (7.4 Mb/d around 1987).

Negotiations in this field are expected to affect the whole petrochemical industry in the market economy developed countries:

- It would modify the role of the "oil majors" in the supply of steam-crackers[86/], curtailing in particular, the Rotterdam spot market;
- It would create dynamics in favour of a "global approach" integrating:
  - i) energy and petrochemical industry;
  - ii) production and marketing;
  - iii) developed countries and hydrocarbon exporting countries.
- It would further raise a fundamental question: the location of new steam-crackers, not in function of comparative advantages, but in function of economic policies and therefore mutual interests of North /South partners.

C. The development of their plastics production capacities

The development of intermediate petrochemical products implies an important diversification of industrial structures. Thus, it is expected by 1986/87 that twenty nine developing countries are expected to manufacture plastics, the most common polymer at the time will be PE: at least 24 countries will implement projects during the period 1980-1986/87, with a minimum total capacity of 2.6 MT/y, as follows: (see Table 1.4)

85/ Figures established by: W.G. Mathews "Analysis of world petroleum refining" prepared for UN Centre on Transnational Co-operation, November 1980; Oil and Gas, October 1980 and OPEC "Workshop on refining operations in OPEC member countries", Djakarta, February 1980.

86/ It should be pointed out that these majors are concentrating on their control over LPG port receiving installations in the EEC.

Latin America	+ 550,000 t/y
Mediterranean countries	+ 220,000 t/y
Gulf countries	+ 1.650,000 t/y
South East Asia and India and Pakistan	+ 815,000 t/y

The entrance of these new producers will increase the destabilization factors in this key production line affecting the profitability of steam-crackers; they will therefore contribute indirectly to re-direct the restructuring process to the benefit of the oil majors, and secondarily, some chemical majors as analysed in 6.3.1.

The simple export of 350,000 t/y of LDPE for instance, to the EEC countries (the nine) which is only 10 per cent of the additional capacities expected in the developing countries will speed up the destabilisation process. In addition to this, the EEC should also account for 600,000 t/y of more LDPE in Spain in 1984 and 280,000 t/y of LDPE in Sweden at the same time (owned by UNIFOS, joint venture between KEMA-NOBEL and Union Carbide).

Only an approach in international industrial co-operation which takes into account the interests of each party can provide an answer to this situation as an alternative to de-stabilisation. Such an approach has to be identified and agreed upon through the process of international negotiations.

6.7.2 The constraints/interdependencies resulting from the internal conditions for restructuring the petrochemical industry in the market economy developed countries

The factors mentioned previously indicate the main reasons for the adoption of a new approach in the world petrochemical industry, in order to establish a stable profile which could function best on the basis of international co-operations.

In a parallel direction, other constraints generated from ways and means available to the market economy countries; petrochemical industry to withstand the process of restructuring, will increase the interdependencies with the policies of developing countries, in particular the replacement of old steam-crackers within the EEC and USA; and the export of Western petrochemical engineering components.

A. The replacement of old steam-crackers

This problem will become acute throughout the market economy developed countries as of 1982 until 1987/90. It will be particularly worrisome for the industrialized vountries with no indigenous hydrocarbons production as the EEC and Japan. As a matter of fact its amplitude and the financing of the new projects expose these petrochemical industries directly to counter-proposals from hydrocarbon exporting countries. Regarding its amplitude:

a) In the EEC and Western Europe

According to R.W. Russel,in 1985:

- 33% of the capacities existing in 1979 will be more than 15 years old;
- 30% between 10-15 years (see figure 6.A)

b) In Japan

According to Mitsui experts[87/]:

35% of the Japanese steam-crackers capacities operating in 1979 will be 17 years old in 1985 (see figure 6.B)

All petrochemicals companies are concerned with the problem of financing new projects. However, the chemicals majors and petrochemical companies with public capital risk to be most affected in their decisions due to their foreseeable financing problems[88/].

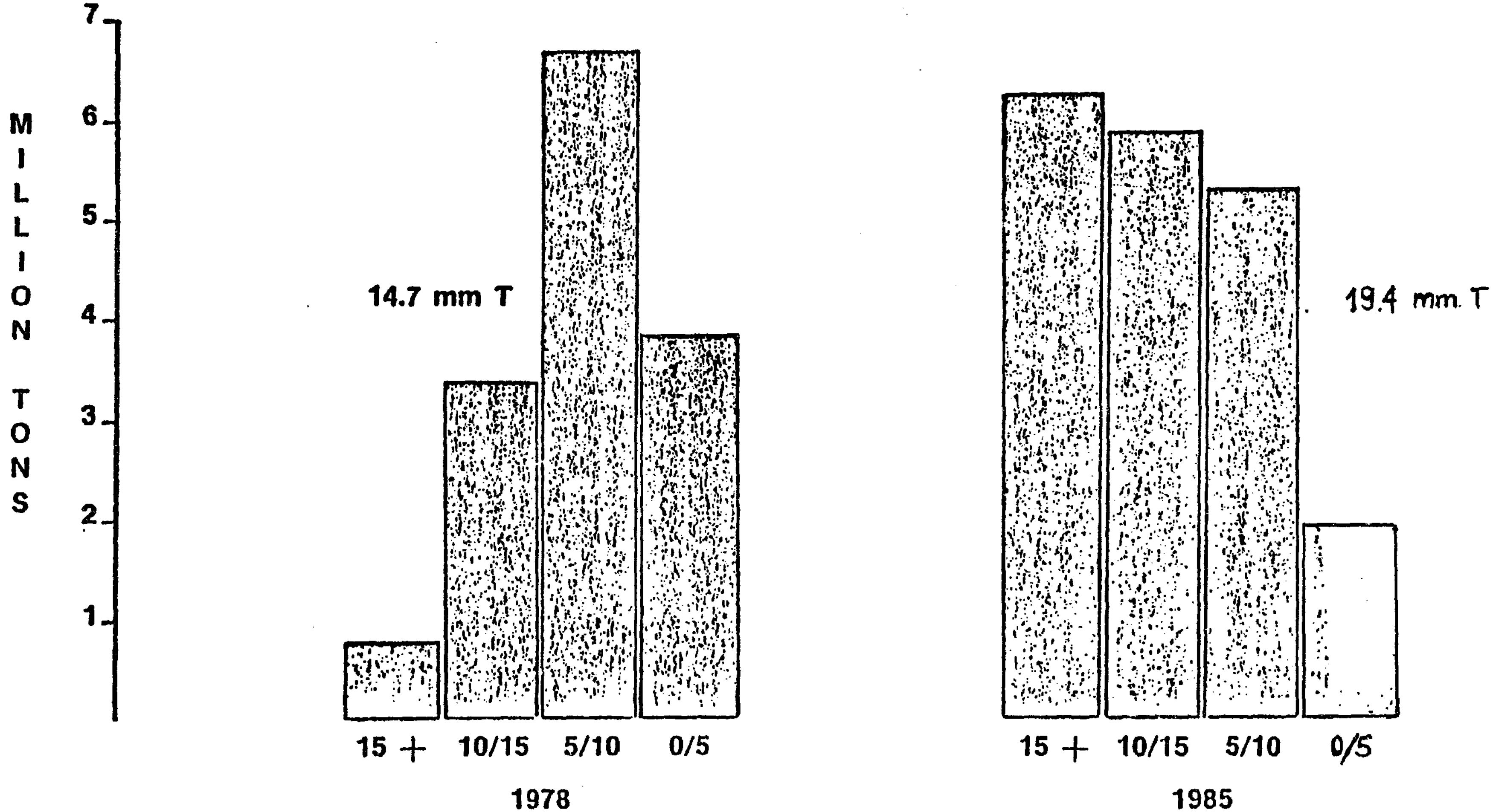
As a matter of fact, considering inflation in the OECD countries and the increasing complexity of equipments, the investment costs in the ethylene production lines (steam-cracker plus ethylene derivatives) is expected to increase as follows:

87/ M. Ischikawa and H. Koike (Mitsui and Co. "Japan's Petrochemical Industry". Chemical Engineering Progress, December 1980, Vol.76 No. 12.

88/ OECD, "L' industrie pétrochimique. Perspectives de la production et des investissements jusqu'en 1985", Paris, 1979.

FIGURE 6.A

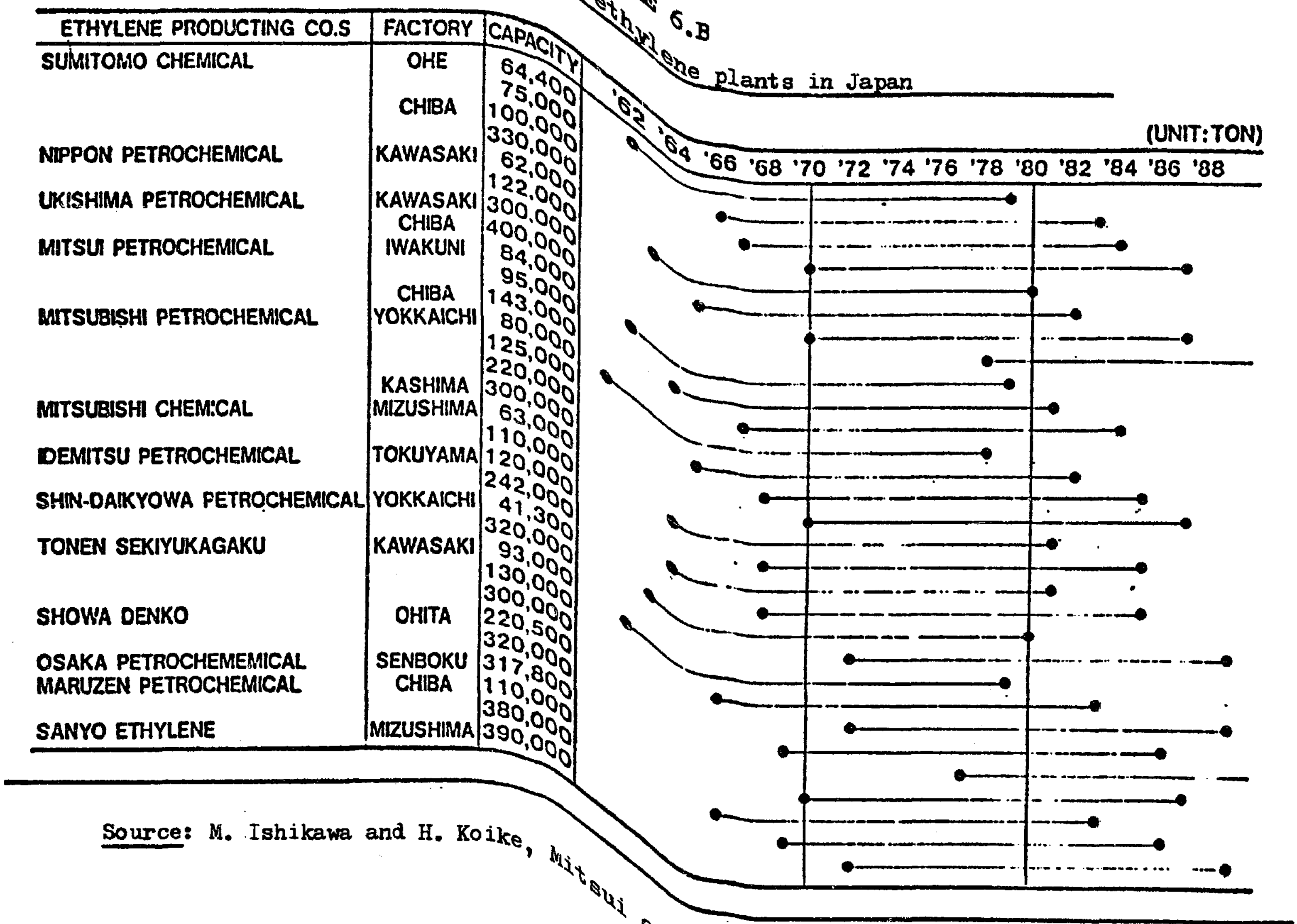
W. EUROPE ETHYLENE CRACKERS
AGE IN YEARS



Source: W.R. Russel, Light olefins in Western Europe, ECMRA/CMRA Conference, Munich, 1979

FIGURE 6.B

Durable period of ethylene plants in Japan



Source: M. Ishikawa and H. Koike, Mitsui Co., "Japan's Petrochemical Industry"

1976	$ 1000/Ton
1985	$ 2250/Ton
1990	$ 3000/Ton

This will require important reserves over and above the fiscally authorized amortization; at least $ 1,250/ton over the capacity existing in 1980[89].

However, the fight for the price of naphta as well as for that of the finished products (including the products imported from the CMEA countries, the USA and the developing countries) will restrict the cash flow resulting from the petrochemical industry producing final products and will force the chemicals majors and the national petroleum /coal companies operating in petrochemicals to an "essential" choice, "to be or not to be", namely:

a) Choice between investments in building blocks in the petrochemical industry (also possibly upstream, as refining, exploration/exploitation of hydrocarbons) and in investments in new zones of monopoly competition as biotechnology (including pharmaceuticals), agro-chemicals (including seed), high performance chemicals for the chemicals majors[90].

b) Problems of financing the modernization of the older petrochemical plants with public capital due to the decline of their cash-flow.

The parallel actions of the developing countries to increase their role in the world petrochemical industry give rise to the question concerning the new interdependencies which will be generated through the arbitrations of firms and governments on the occasion of new investment decisions.

The local social contexts will certainly have some weight when new projects in old petrochemical sites are evaluated in 1985. Medium and long-term mutual interests will certainly be the reason for a re-evaluation

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89/ The fiscally authorized depreciation being limited to the acquisition value (i.e. $ 1000/Ton for a unit constructed in 1975), the balance is to be met by means of additional cash-flow.

90/ Reference is made to the decisions of the EEC, Union Carbide (1978), Rhône-Poulenc (1980), Montedison (1981).

of these sites and lead to their case-by-case evolution into a general interdependent context.

B. Interdependency and the export of petrochemical engineering components

The interest of each of the operators responding to tenders announcements issued by the developing countries is to maintain a high export level. Several factors amplify the functions of these exports and contribute to stress restructuring among petrochemical companies in the market economy countries.

a) Considering the severe international competition at the stage of the tender announcement, the developing countries are in a position to diminish the traditional barriers when entering the petrochemical industry[91], and have thereafter new facilities at a time when the market economy countries' industry future is being examined.

b) Agreements, including commercial counterparts are becoming frequent, often at the initiative of the majors which incorporate such agreements in the restructuring process to their benefit.

In the absence of bilateral and/or regional agreements on industrial co-operation, these forms of interdependencies cannot develop freely with the consent of all concerned. Consequently, procedures/means of co-operation tend to lose their meaning and their effectiveness.

6.8 Synthesis: towards a collective management of interdependencies

The broadening and deepening of interdependencies lead to one of the following alternatives: (a) either the international petrochemical relations are exclusively given impulse by the factors breaking the preceding and dominant petrochemical structures; or (b) these relations

91/ Two examples are particularly significant:
- the COPESUL steam-cracker (Brazil): Technip-KTI were granted the contract through better conditions for the transfer of technology;
- HIMIC's LDPE project (Greece): ECN states in its 5/1/81 issue "HIMIC rejected the French LDPE offer because ATO had put restrictions on the marketing of the final product in Europe. HIMIC would have been permitted to sell only limited quantities of LDPE in Europe" (p. 19).

are reconsidered in the light of collective administration of interdependencies by the international community on a medium and long-term basis, to the mutual benefit of all.

The objective here is not to present two scenarios and to compare them. But before the ways and means of a system of "collective management of interdependencies" are analyzed, it seems useful to emphasize some essential implications regarding the inability of the international community to make such an alternative effective and efficient before 1985:

a) First implication. The restructuring process covers: the increasing internationalization of the petrochemical activities of the oil majors; and the absorption of the least advanced structures.

b) Second implication. The global integration of the activities of the oil majors reinforced by the governments' policies of the developing countries which have certain ties with them (through joint venture, counter trade, etc.) is accompanied by other opposing activities: certain protectionist measures which will achieve no visible success at the 1990-95 horizon, but which nontheless will inhibit all willingness to initiate fruitful negotiations, be it on a world-wide, regional or sectoral basis.

c) Third implication. Between the governments of the market economy countries and the developing countries certain barriers have developed, preventing the evolution of a useful dialogue. These barriers are examplified by: the oil majors as intermediaries, who monopolize the objectives of the North-South relations; the international prices as "means/causes" to "combat/reinforce" the barriers in international trade; and the costs of redeployment in so far as this measure was taken late.

Reaching beyond this chronical destabilization which is threatening the restructuring process, the reshaping of the international petrochemical industry implies a consensus on a certain number of considerations concerning:

i) the legitimacy of the development of this industry in developing countries;

ii) the legitimacy of the desire of market economy countries to control or deal with the mutations of their petrochemical industry in time and space;

iii) the specific role of government to government relations organizing the ways and means to the benefit of the mutual interests of the economies concerned;

iv) the specific role of the public enterprises in implementing the agreements between the governments concerned.

Taking into consideration that the international community tends towards such a consensus and that the preceding analysis brings to light an increasing process of interdependency in the decisions concerning the petrochemical industry and the functioning of this industry, the international co-operation concerning the future of this industry in the developing countries can be defined as a dynamic process leading to a "collective management of interdependencies in the international petrochemical industry". This definition summarizes all elements which will make such international co-operation a real alternative to the chronical destabilization which tends to exaggerate the conflicting interests of the international partners concerned.

By analyzing the approach to this international co-operation, four modalities of collective management of interdependencies are brought forward which conform to the expectations of developing countries but which also take into consideration the medium-term and long-term interests of the developed countries' petrochemical industry and are bound to evolve with or without co-operation. After having examined these modalities, one can suggest procedures to initiate a dialogue between developed and developing countries.

6.8.1 Ways and means of international co-operation in petrochemicals

The preceding analysis has shown that:

a) The responsibility of the governments is directly involved in the future in the search for new international relations in the petrochemical industry.

b) In spite of the weak petrochemical development in most developing countries, there is already at present room for international co-operation i.e. a possibility of dialogue to foster mutual interests in the framework of a growing interdependency regarding:

i) steam-crackers and more generally basic petrochemicals, and

ii) finished products, particularly plastic materials,

bearing in mind all specific constraints/interdependencies which they imply for the international community.

c) The future of the petrochemical industry in developing countries, apart from the main hydrocarbons exporters, presents some particular problems determined by: their economic structures and by their role in the evolution of the crisis. Consequently, it is suggested to review successively:

i) the possible role of governments;

ii) an approach to the interdependencies in plastic materials; and

iii) the future of a co-operation favouring developing countries with a weak petrochemical industry.

A. Possible role of the governments

International co-operation implies intervention by the States' authorities; in the case of petrochemicals, this intervention should be specific. In fact, this co-operation should at the same time: permit a certain type of restructuring in developed countries and foster a certain kind of petrochemical growth in developing countries.

Consequently, the objectives of governments' intervention would be:

(a) to prepare mutation in time, i.e. to organize the stages leading to a control of the interdependencies and to an operational development corresponding to joint interests;

(b) to search for suitable and efficient special steps in handling the issues related to the collective management of the interdependencies.

Apart from bilateral agreements, these steps could aim at: world-wide negotiations (like the multi-fribre international agreement); regional programmes (see Plan of Action for the implementation of the Monrovia Strategy for the Economic Development of Africa[92], Euro-Arab dialogue,

[92] Documents recommended to the First Economic Summit of the Assembly of Heads of States and Governments of the Organization of African Unity, Lagos, Nigeria, 28-29 April 1980.

etc.), and grouping of countries (see the Andean Pact, the ASEAN and the OAPEC countries[93/]).

(c) To mobilize the necessary actors and means in view of mutually beneficial interdependency, efficiently helping to bring about in the quickest possible way, inter-governmental agreements. For this purpose, two modalities of relations between actors should be examined for all projects and all approaches concerning co-operation:

the role of national companies[94/] and the advantage of establishing "groups of companies"[95/]

B. <u>Approach to the interdependencies in the production of basic petrochemicals</u>

The present and future interdependencies connected with the development of a production base in developing countries and the restructuring of production in industrialized countries are such that only a global approach of this part of petrochemicals could be allowed, taking into consideration the interests and constraints involved.

Proposing a global approach to this question means that none of the subjects can be discussed separately without one or another of the parties involved invoking other points reflecting their interest and interdependencies between the decisions to be taken. The key points of a global approach to the production of basic petrochemicals would be then as follows:

(a) gradual opening of the industrialized countries' markets to imports of refined oil products and petrochemicals from hydrocarbon exporting countries;

(b) redeployment of certain petrochemicals capacities from the industrialized to the developing countries and participation of

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93/ OAPEC and its "investment arm" APICORP, who have decided recently an inter-arab synthetic rubber project (50,000 t/y of SBR ECN 5/1/8)

94/ OPEC seminars on the role of national oil companies.

95/ Grouping of Japanese Majors to buy their naphta; APICORP established by OAPEC - Grouping of Asean group countries for an ammonia unit (production unit). It would be interesting to compare these with existing groups of coking supply of iron ore in developed countries.

of industrialized countries in the new projects of the hydrocarbon exporting countries, the forms of which are yet to be defined;

(c) security in terms of price and quantity, of supply to steam-crackers of industrialized countries by the oil exporting countries;

(d) participation of hydrocarbon importing countries in investments for exploration and exploitation of hydrocarbons in developing countries as well as joint participation of hydrocarbon exporting and importing countries in research and development activities in two principal areas, namely: conservation of hydrocarbons deposits, and refining of heavy crudes[96]

(e) For the entire group of projects realized by a number of companies acting as operators and setting up groups of enterprises, in which each ad hoc group receives the funds allocated to it by States or groups of States (e.g. EEC), and enjoys guarantees against "traditional" risks and "uncertaintities" (e.g. hydrocarbons exploration).

96/ The Project of report prepared by Exterior Economic Relations Commission of the European Parliament, "Trade Realtions among EEC and the Gulf States" (PE 69.583/2 and PE 70.635, 22/12/80 and 5/1/81) is a reference document for any global approach about energy/petrochemical interdependencies.

C. The interdependency approach to finished products, especially plastics

Until now, the export of finished (and intermediate) petrochemical products from developing to developed countries has been carried out via the trade policies of the importing countries, and in particular those of the EEC. These policies alleviate short-term strain on the profits of their local producers. Over the medium and long term, however, they are insufficient and in certain cases even unoperational:

(a) They do not meet the needs of developing countries, but are rather a handicap to these countries;

(b) They do not lead to a concerted reorganization of trade channels, but rather encourage the development of uncontrolable channels (for example, the requirements for enforcing the International Multifibre Agreement);

(c) They do not provide the engineering companies with a framework responsive to the propositions of "countertrade" and "buy-back" agreements with the developing countries.

The sum total of these insufficiencies has given rise to proposing a global approach to international co-operation in finished products, especially plastics, which comprises the following points:

(i) Monitored, step-by-step opening of the markets of the industrialized countries to the finished petrochemical products of the developing countries, bearing the following points in mind:

- the identity of the trading partners in the developing countries (to avoid, for example, allowing the negotiations' turning in favour of only the oil majors);
- the long-, medium and short-term need to export in order to ensure an effective level of operation of the units within the country; and
- the stage of development in the exporting countries.

(ii) Alteration of various petrochemical policies in the industrialized countries and participation in a way to be defined by these countries in various projects in the developing countries. This participation should involve the definition of an agreement framework for the entire operation of counter-trade and buy-back which would be included in these projects or would result independently thereof. Such an agreement framework:

- would be regional or applied to a group of countries; as a result, there would be several agreement frameworks;
- would be compatible with the first point in the global approach;
- would take into consideration all cases of counter-trade and buy-back agreements.

(iii) Trade agreements among national enterprises in each of the countries concerned, assuming that the same exists for other products, dealing with the procedures for regulation/negotiation of the prices, independent of fluctuations on the spot-market. As in the preceding case, groups of enterprises are envisaged in order to establish the set of measures involving enterprises as well as operators.

D. The future of petrochemicals in the non-oil-exporting developing countries

From now until 1986-1987, only 30 to 35 developing countries will be active in the world petrochemical industry. Among these many will just be entering the industry for the first time (approximately ten); the situation of the other among the newly-industrialized countries will depend upon the evolution of the energy situation in the industrialized countries. In addition, the position of developing countries which have not yet entered into this industry will be affected by the evolution of relationships in international petrochemical industry in their final decision upon developing their own petrochemical industry or establishing their own transformation industries with imported petrochemical products.

A specific global approach for developing countries which are not exporters of hydrocarbons could be initiated to deal with the security of their supplies; the "barriers" limiting their entry into this industry; and the improvement of conditions to facilitate the import of petrochemical products.

The terms of a global approach which takes as its objectives the abovementioned points would be as follows:

(a) Regional and interregional agreements with the OPEC countries[97] and Mexico with a view to:

- concluding direct contracts for the supply of crude oil to the benefit of countries or groups of countries;
- investing in joint-venture in crude refining;
- transferring technology to be used in hydrocarbon exploration;

(b) Creation of regional funds, or strengthening existing ones, by OPEC countries and the developed countries (or groups thereof) in order to finance projects in the developing countries concerned;[98]

(c) Controlled (gradual) opening of developed countries' markets to expected future exports by setting up an agreement framework which offers different treatment of exports according to their origin, i.e. export-oriented projects; regional/local projects with exports of a transitional or marginal nature; and projects financed through a regional fund. The monitored opening of the above-mentioned markets within these requirements necessitates co-operation between the developing countries concerned and the industrialized countries in the following areas:

- groups of enterprises should assume the responsibility of trade within the developed countries (division of risk);
- study of ad-hoc trade forms (buy-back, counter-trade) which will alleviate the burden of debt;

(d) Setting up funds to support research and development programmes dealing with technologies adapted to the socio-economic conditions in various groups of countries[99];

97/ The recommendations of OPEC's Long-Term Strategy Committee constitute the terms of reference for such agreements.

98/ Idem.

99/ The alternative experiences of some developing countries would be evaluated. For example, T.K. Roy, "Petrochemicals and Appropriate Technology", Second Arab Conference on Petrochemicals, League of Arab States, Abu-Dhabi, 15-22 March 1976, Paper No. 9 (P-1).

(e) Assistance in forming regional groups of buyers[100], based on agreement frameworks with the exports of petrochemical products which:

- list the conditions for revising the prices of imported products independent of the prices on the spot-markets;
- foresee the means of payment including those of counter-trade; and
- define the developed countries' petrochemical partners who guarantee these connexions.

6.8.2 Procedures for initiating the global approaches for co-operation in petrochemicals at the international level

The three global approaches proposed for the development of international co-operation make necessary a transitory phase which will allow:

(a) expression and confrontation of the diverse points of view, interests, projects (including their timetables) and situations;

(b) study of the possibilities for the most efficient agreements at the outset, bearing in mind the regional characteristics, the various dynamics and specific urgent needs;

(c) in the light of present and past experience, in-depth study of certain co-operation objectives common to the three global approaches, i.e. monitoring the opening of developed countries' markets, on the one hand, and new forms for developed countries' participation in projects in the developing countries, on the other hand, are deemed essential.

In order to attain these objectives three main procedures are proposed:

(a) Regional meetings encompassing developed and developing countries to pin-point the requirements for implementing the two global approaches dealing with the location of new steam-crackers and the production and marketing of finished petrochemical products;

100/ The experience of the countries members of the Caribbean Community in the field of pharmaceuticals should also be evaluated.

(b) A meeting of policy makers on the global approach for co-operation between OPEC member countries and other developing countries in the petrochemical industry;

(c) The establishment of two working groups to propose framework agreements which deal with monitoring the opening of developed countries' markets and new forms for developed countries' participation in developing the petrochemical industry in developing countries.

6.8.2.1 Regional meetings

Such meetings could be organized by UNIDO in co-operation with regional, governmental and United Nations economic and industrial organizations, provided that they are preceded by in-depth studies covering the present conditions and future possibilities for the development of the petrochemical industry in each region. These meetings should have the following objectives:

- to instate the two proposed global approaches into the actual context of each region, bearing in mind the multilateral and bilateral consultations/negotiations in progress which affect the decisions taken within the field of petrochemicals in each region, and the petrochemical programmes already decided upon;
- to specify each region's co-operation priorities by calling special attention to the possible support given by national operators for a programme of action, and the balance of relations with the counterpart operators from the developed countries, especially the direct and indirect role of the oil majors and the chemical majors in each region;
- with regard to the meeting of OPEC with other developing countries, to analyze the present access to petrochemical feedstocks (conditions, counterparts, guarantees, etc.); the establishment of financial, marketing and research and development regional organization;
- preparation, for the third procedure, of reports on the experience of the developing countries which deal with the topics taken up by the proposed two working groups, and propositions dealing with the timetables of the framework agreements, priority products, and priority participation.

The regional meetings would constitute a decentralized application of the two global approaches with a view to preparing some significant elements for the second and third procedures.

6.8.2.2 Meeting of policy-makers from OPEC and other developing countries

The diversity of situations within the developing countries with regard to questions concerning energy, economic recession and the restructuring of the world's economy necessitates a set of differentiated relationships between OPEC and the other developing countries.

Taking into consideration the results of the Second Consultation on Petrochemicals, and the recommendations of the OPEC Long-term Strategy Committee, as well as the conclusions of the regional meetings, the objectives of this meeting would be to make explicit the respective interests favouring co-operation and to formulate alternative co-operation schemes.

The synthesis of the respective interests favouring co-operation should facilitate:

(a) emphasizing the various national petrochemical policies as well as several multinational decisions, with a view to comparing co-operation needs within time and spatial limits;

(b) underlining the areas of possible interference in the decision-making of developing countries within the petrochemical industry as well as with regard to co-operation needs stemming from the world situation (i.e. overall economic situation of the developed countries; policies of the oil majors, etc.).

The formulation of alternative co-operation schemes for OPEC countries and other developing countries would comprise:

(a) evaluation of the expected results from measures already proposed by OPEC (and its Committees), and of the intervention on the part of various institutions created at the initiative of countries exporting hydrocarbons (e.g. IDB, various development funds, etc.);

(b) proposals for co-operation schemes based on different forecasts concerning means, counterparts, procedures, etc.

6.8.2.3 Working groups to formulate proposals for framework agreements

This proposal aims at rendering compatible the following two actual situations: the sovereignty and responsibility of States with regard to the choice of partners in co-operation, the means to be employed and their timetable; and the necessity of proposing to the International Community new ways for strengthening mutual interests.

A. Framework agreements for opening markets of industrialized countries to petrochemicals produced by the developing countries

The role of the proposed Ad-hoc Working Group would be as follows: After having evaluated the various solutions presently being employed, such as the International Multifibre Agreement, exchanges of petrochemical products among the countries of the EEC and those of the CMEA, and the application of GSP, to propose framework agreements for co-operation which make explicit the requirements for such market opening; the possible timetables; the role of governments and national companies; and the possible trade modalities in the markets of developed countries.

B. Framework agreements for new forms of developed countries' participation in the development of the petrochemical industry in developing countries

The formulation of such framework agreements should be in response to the following two main objectives:

(a) The mutual need of both developed and developing countries to expand, reform and increase the developed countries' participation in petrochemical projects in developing countries within the framework of the proposed global approaches;

(b) The necessity for establishing a framework of reference so that the ways and means of participating in these projects strengthen and respect the mutual interests of the parties concerned, and not only those of the companies involved,[101/] and do not create new types of international competition which could inhibit the participation of developed countries in an approach based on co-operation. (See the issue paper on long-term arrangements for the development of the petrochemical industry.)

101/ The Report of the Economic Commission for Europe on "East-West Industrial Co-operation and Technology Transfer in the Chemicals Industry" (Geneva, 22 September 1980) emphasizes this fact in para. 30: "Actually, the joint-venture is a pattern of business organization and not a form of industrial co-operation as such".

As a result, the Ad-hoc Working Group may be assigned the following tasks:

- to summarize the experience of the countries concerned in the light of the work/results of the regional meeting, adding where necessary an evaluation of the experience between countries of the EEC and those of the CMEA;
- to propose the bases for agreements, including those at a regional level, dealing with the buy-backs/counter-trade in payment for supplying equipment (or plants); co-operation in production and trade (in connexion with the preceding Ad-hoc Working Group); co-operation at the project level especially as concerns the transfer of technology; joint ventures.

6.8.2.4 Phasing the proposed procedure for global approaches for co-operation in petrochemicals

To expedite the process of moving towards a global approach for the restructuring of the petrochemical industry according to the previous propositions, it is suggested that a carefully planned procedure should be adopted whereby a logical continuation of a fruitful dialogue would be ensured. Towards this end it is proposed that a meeting at the level of policy-makers from OPEC member countries and other developing countries be convened at the initiative of OPEC by a joint invitation from the OPEC and UNIDO Secretariats. A working group would then be established by the meeting to work out in-depth studies on the main issues to be recommended by this meeting. Although such issues would concentrate on the interrelations between OPEC member countries and the other developing countries, it would at the same time bring out issues dealing with the relations between developed and developing countries as a whole in the field of hydrocarbons and the petrochemical industry. Such issues should include the exploration of new ways and means, including framework agreements for the development of global co-operation in the petrochemical industry aimed at restructuring the industry to the mutual benefit of the world community.

The burning issue which is facing both the developing and developed countries now and which will increasingly press upon them during this decade, i.e. the security of feedstock supply and the opening of the developed countries' markets to petrochemical products of the developing countries, should be tackled by another working group at a global level. The UNIDO Secretariat should undertake the responsibility for the preparation for such a meeting taking into consideration the work being done in this field by other specialized United Nations agencies and organizations. The global approach could then be dissegregated on regional level in order to pinpoint the needs of each region and/or economic grouping, according to the urgency of the situation, which would allow a gradual implementation of the programme, settling these issues within a global context of each region.

6.9 Summary and conclusions

The approach to co-operation in the field of the petrochemical industry prior to 1972 between the developed and developing countries was mainly based on direct investment of the major chemical companies in the developing countries. This approach achieved little results.

Since the 1973 increase in oil prices and the economic and energy crisis of the 1970s, the petrochemical industry has undergone major structural changes. The power positions of the different operators or would-be operators have changed, creating new conditions for the adoption of another approach towards international co-operation. Since feedstock and energy supply and prices are the major factors for the successful operation of the industry, those operators which control these two factors enhanced their positions, namely the oil majors and the oil-exporting countries (their national companies). Other operators, i.e. the major chemical companies and the independent hydrocarbons-chemical companies controlled by some governments of market economy developed countries, in their effort to maintain their positions in the industry have taken action in two directions, namely the chemical majors' moving into speciality petrochemical products and the independents' moving towards hydrocarbons and structural re-organization In the meantime, the developing countries with hydrocarbon resources are forging ahead with their plans of valorizing their resources, i.e. greater refining capacities and basic and intermediate petrochemicals. Other developing countries with established or yet to be established petrochemical industries want assurances for their energy and feedstock supply.

The fact that a high ratio of the production capacities of basic and intermediate petrochemicals in the developed countries is outdated and needs renewal under conditions of high inflation, economic recession and insecurity of raw materials and energy supply further compounds the problems of the industry.

The solutions to these problems, under conditions of an on-going process of restructuring, is seen to be a global approach to a collective management of inter-dependency serving the mutual interest of each and everyone in the industry. The direct role of the governments of both the developed and the developing countries is considered essential in implementing this approach. The basic elements of co-operation are energy and feedstock supply (price, quantities and quality), redeployment of basic and intermediate petrochemical capacities towards the sources of raw materials, opening of the markets of developed countries to petrochemical products from the developing countries and assisting developing countries with no hydrocarbon resources in developing their petrochemical and hydrocarbon industries.

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ANNEXES*

to

SECOND WORLD-WIDE STUDY ON THE PETROCHEMICAL INDUSTRY:

PROCESS OF RESTRUCTURING

Prepared by the secretariat of UNIDO

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CONTENTS

I. WORLD DEMAND FOR AND SUPPLY OF PETROCHEMICAL PRODUCTS: 1975 to 1990

Annex I

Introduction

The First Consultation on the Petrochemical Industry recommended that UNIDO establish a Permanent Working Group on World Supply of and Demand for Petrochemicals to assemble information on 10 basic petrochemical products and 15 intermediate and final petrochemical products. The information presented in the Annexes was compiled by UNIDO in response to this recommendation.

At the first meeting of the Working Group, convened in March 1980, participants (a) discussed the approach to be adopted and (b) agreed to help UNIDO by assembling the information required before 30 September 1980.

UNIDO gratefully acknowledges the information contributed by the following organizations and countries.

Region	Organization/Country
Japan	Japan Petrochemical Industry Association
Western Europe	Conseil Europeen des Federations de l'Industrie Chimique Association of Plastics Manufacturers in Europe
North America	Department of Commerce, United States Federal Government Canadian Chemical Producers' Association
USSR and Eastern Europe	Council for Mutual Economic Assistance
Other industrialized countries	Australia
Africa and the Middle East	Algeria, Egypt, Saudi Arabia Industrial Development Centre for Arab States Gulf Organization for Industrial Consulting
Asia	China, India, Indonesia Republic of Korea
Latin America	Instituto Petroquimico Latino Americano Secretariat of the Andean Group Brazil, Mexico

Product	Organization
Petrochemicals	Organization of the Petroleum Exporting Countries
Synthetic Fibres	Comite International de la Rayon et des Fibres Synthetiques
Synthetic Rubber	International Institute of Synthetic Rubber Producers

The Working Group felt that instead of the 25 products recommended by the First Consultation, the initial exercise should only cover 7 basic petrochemicals and 9 final products as follows:

Basic Petrochemicals	Ethylene, Propylene, Butadiene, Benzene, Ortho-xylene, Para-xylene, Methanol, Ammonia
Final Products	L-D Polyethylene, H-D Polyethylene, Polypropylene, PVC, Polystyrene; Polyamide, Polyester and Acrylic Fibres; all general purpose Synthetic Rubbers.

For each of the above products, except ammonia, estimates have been prepared of:

(a) demand in 1975, 1979, 1984 and 1990.

(b) production in 1975, 1979 and 1984.

(c) capacity in 1975, 1979 and 1984.

For this purpose, the world was divided into 11 regions. The allocation of countries to each region follows closely that adopted in the First UNIDO World-wide Study and the recommendations of the Working Group. The grouping is mainly on the basis of geography and hence does not necessarily follow other classifications, in particular as regards "developing" and "industrialized" countries.

Measuring Demand

The Working Group agreed on the following definition:

"For the basic and intermediate petrochemicals, demand shall be measured as the quantity required for all downstream production uses in the country. For final products, demand shall be measured as the quantity required for use in the country".

The estimate of future demand is an estimate of demand which can be satisfied either by local production or imports of the product. This estimate may be lower than the level of demand which would prevail in some developing countries if the product was more readily available.

The estimate of demand for final products such as plastic resins measures the volume used in the country at present; it excludes the petrochemical content of products that are imported in processed form (such as polyethylene sheets and pipes) even though these products may be produced locally in subsequent years.

Forecasts of Demand

Most participants only submitted forecasts of demand up to the year 1984. UNIDO has therefore had to make its own assumptions as regards the growth of demand for the period 1984-1990 for all regions and for the period 1979-1984 for all the developing countries regions except Latin America and for Eastern Europe. For industrialized countries, the same rate of growth as from 1979-1984 has been applied for the period 1984-1990. For developing countries, demand is expected to grow fast enough to absorb all the increase in local production (80 per cent of capacity).

Measuring Capacity

Capacity measures nameplate capacity at the end of the year in question based on 330 operating days. All statistical information is based on the concept of nameplate capacity except that of Western Europe for basic petrochemicals which is based on a concept of effective capacity in operation in the year in question.

Forecast of Capacity in 1984

UNIDO was supplied with estimates of total capacity up to 1984 for Japan, the United States, Canada and Western Europe. For other regions, UNIDO has prepared Tables estimating capacity in each country, including those presented in Chapter I. Both published and official sources have been used.

Measuring Production

UNIDO has collected historical data on production for the period 1970-1979 for most industrialized countries and for some developing countries. Definitions of the product were made by the Working Group, but submissions do not always follow this. For example, the information on plastics supplied by Western Europe excluded polystyrene copolymers whereas Japan and the United States included them.

Estimates of Production in 1984

For 1984 and for previous years where information is not available, production has been estimated at about 80 per cent of capacity.

Basic Assumptions

The estimates presented in the following tables include the data supplied by participants, even though in some cases more up-to-date information became available.

Accuracy of the Estimates

The UNIDO estimates are intended to give an order of magnitude of the level of demand and supply, and to indicate future changes. The estimates of regional and world total capacity and production are dependent on the accuracy of the data supplied or created by UNIDO. Estimates of the level of demand depend on the accuracy of estimates of demand in the base year (1979) as well as the growth rate forecast.

Improving the Estimates in the Future

The UNIDO secretariat would appreciate written comments on the information provided in these Annexes and Chapter I so that the estimates can be corrected or improved on future occasions.

COUNTRIES INCLUDED IN EACH GEOGRAPHICAL REGION

Developed countries

Japan

Western Europe

Austria, Belgium, Denmark, Finland, France, Germany (Federal Republic of), Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K.

North America

United States, Canada

USSR and Eastern Europe

Albania, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania, USSR, Yugoslavia

Other industrialized countries

Australia, Israel, New Zealand, South Africa

Developing countries

Africa

Angola, Benin, Botswana, Burundi, Cape Verde, Central African Empire, Chad, Comoros, Congo, Djibouti, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Togo, Uganda, United Republic of Cameroon, United Republic of Tanzania, Upper Volta, Zaire, Zambia

Middle East - North Africa

Algeria, Egypt, Libyan, Arab Jamahiriya, Morocco, Tunisia.

Middle East - West Asia

Bahrain, Democratic Yemen, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates

Asia

Afghanistan, Bangladesh, Bhutan, Burma, Cyprus, Democratic Kampuchea, Fiji, Hong Kong, India, Indonesia, Iran, Israel, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Singapore, Solomon Islands, Sri Lanka, Thailand, Turkey, Vietnam

China

Latin America

Antilles, Argentina, Bahamas, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Venezuela

Annex I.A.
UNIDO 8.5.81.

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ETHYLENE
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	5100	6000	6000	3400	4800	5200	3400	4800	5200	6200	8.9	1.7	3.0
W. EUROPE	12500	14700	17600	7900	12350	14000	7900	12200	13900	16600	10.6	2.6	3.0
N. AMERICA	13200	18000	22200	9700	14300	18500	9800	14200	18700	23600	9.7	5.9	4.0
USSR AND E. EUROPE	2700	3900	6500	2000	3000	5000	2000	3000	5000	8600	10.7	10.0	10.0
OTHER INDUSTRIALIZED COUNTRIES	300	600	1000	250	500	750	250	500	750	1500	19.9	9.0	9.0
TOTAL	33800	43200	53300	23250	34950	43450	23350	34700	43550	56500	10.4	5.8	4.3
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	-	-	-	300	-	-	-
MIDDLE EAST North Africa	-	120	450	-	100	400	-	100	400	800	-	-	12.2
MIDDLE EAST West Asia	-	100	800	-	50	650	-	50	650	2650	-	-	26.4
ASIA	300	1000	2300	250	900	1900	250	900	1900	3800	37.7	16.0	12.2
CHINA	400	540	950	300	430	700	300	430	700	1400	9.3	10.3	12.2
LATIN AMERICA	700	1600	3400	600	1200	2500	600	1200	2500	5000	18.9	15.8	12.2
TOTAL	1400	3360	7900	1150	2680	6150	1150	2680	6150	13950	24.0	17.6	14.9
WORLD TOTAL	35200	46560	61200	24400	37630	49600	24500	37380	49700	70450	11.2	6.2	6.0
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	4.0	7.2	12.9	4.7	7.2	12.4	4.7	7.2	12.4	19.8			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ....PROPYLENE..........................
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	3000	4300	4300	2300	3100	3100	2300	3000	3100	3300	6.8	0.7	1.0
W. EUROPE	6900	8100	9700	4100	6500	7200	4100	6300	7000	10000	12.0	3.0	3.0
N. AMERICA	7100	10000	12900	4400	7200	10000	4400	7400	10200	15000	12.0	6.6	6.6
USSR AND E. EUROPE	1400	2000	3000	1200	1500	2250	1200	1500	2250	3500	5.8	8.4	8.0
OTHER INDUSTRIALIZED COUNTRIES	160	280	410	120	230	350	120	230	350	600	17.6	8.7	9.3
TOTAL	18560	24680	30310	12120	18530	22900	12120	18430	22900	32400	8.7	4.4	5.9
DEVELOPING COUNTRIES													
AFRICA	-	-	30	-	-	30	-	-	30	60	-	-	12.2
MIDDLE EAST North Africa	-	-	50	-	-	50	-	-	50	100	-	-	12.2
MIDDLE EAST West Asia	-	40	100	-	30	80	-	30	80	160	-	-	12.2
ASIA	250	500	1160	200	450	900	200	450	900	1800	22.4	14.9	12.2
CHINA	90	230	410	70	210	350	70	210	350	850	31.6	13.5	16.0
LATIN AMERICA	400	750	1300	200	500	1000	200	500	1000	1500	25.7	14.9	7.0
TOTAL	740	1520	3050	470	1190	2410	470	1190	2410	4470	26.0	15.1	10.8
WORLD TOTAL	19300	26200	33360	12590	19720	25310	12590	19620	25310	36870	11.8	5.2	6.4
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	3.8	5.8	9.1	3.7	6.0	9.5	3.7	6.0	9.5	12.1			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR BUTADIENE
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	750	800	800	530	670	650	470	640	710	800	10.0	2.1	2.1
W. EUROPE	1890	2130	2250	1080	1710	1900	810	1150	1350	1650	7.9	3.4	3.4
N. AMERICA	2100	2400	2600	1250	1750	1900	1500	2000	2200	2500	7.4	2.0	2.0
USSR AND E. EUROPE	400	500	1000	300	400	800	450	600	1000	1500	7.4	7.0	7.0
OTHER INDUSTRIALIZED COUNTRIES	80	120	120	75	110	110	105	130	170	250	5.4	6.0	6.0
TOTAL	5220	5950	6770	3235	4640	5360	3335	4520	5430	6700	7.8	3.7	3.6
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	-	-	-	60	-	-	-
MIDDLE EAST North Africa	-	-	60	-	-	60	-	-	50	50	-	-	-
MIDDLE EAST West Asia	30	30	30	10	20	30	10	20	30	60	18.9	8.5	12.2
ASIA	100	150	300	80	110	240	80	110	240	500	8.2	16.9	13.0
CHINA	50	100	220	40	80	170	40	80	170	330	18.9	20.7	11.7
LATIN AMERICA	100	260	430	80	210	400	80	210	410	600	27.2	14.3	6.5
TOTAL	280	540	1040	210	420	900	210	420	900	1600	18.9	16.4	10.0
WORLD TOTAL	5500	6490	7810	3445	5060	6260	3545	4940	6330	8300	8.8	5.0	4.6
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	5.1	8.3	13.3	5.8	7.9	14.4	5.9	8.5	14.2	19.3			

ANNEX I.D

UNIDO 10.5.81

WORLD CAPACITY, PRODUCTION AND DEMAND FOR BENZENE.......
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	2700	3000	3000	1600	2000	2300	1480	2010	2220	2500	7.8	1.7	2.0
W. EUROPE	6100	6600	7200	3130	4860	6000	3260	5060	5800	7000	11.6	2.7	3.0
N. AMERICA	6400	8600	9600	3670	6400	7900	3740	6380	7750	10000	14.2	3.9	4.0
USSR AND E. EUROPE	3000	3300	5000	2150	2600	4000	2150	2600	4400	6000	4.9	9.0	5.0
OTHER INDUSTRIALIZED COUNTRIES	100	200	300	80	140	230	80	150	230	300	16.9	8.9	5.0
TOTAL	18300	21700	25100	10630	16000	20430	10710	16200	20400	25800	10.8	4.7	4.0
DEVELOPING COUNTRIES													
AFRICA	-	-	20	-	-	20	-	-	20	50	-	-	-
MIDDLE EAST North Africa	-	-	-	-	-	-	-	-	30	50	-	-	8.0
MIDDLE EAST West Asia	-	-	150	-	-	100	20	60	100	150	41.4	4.5	30.0
ASIA	200	450	800	180	360	650	200	400	700	1600	10.6	12.1	15.0
CHINA	400	500	800	200	320	700	280	340	700	1400	25.7	9.8	15.0
LATIN AMERICA	450	650	1400	300	500	1150	300	500	1150	1750	2.6	17.8	5.0
TOTAL	1050	1600	3170	680	1180	2620	800	1300	2700	5000	12.8	15.6	10.8
WORLD TOTAL	19350	23300	28270	11310	17180	23050	11510	17500	23100	30800	11.0	5.7	4.9
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	5.4	7.4	11.2	6.0	6.9	11.4	7.0	7.4	11.7	16.2			

UNIDO 10.5.81.

WORLD CAPACITY, PRODUCTION AND DEMAND FOR XYLENES
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	940	1110	1110	580	860	940	650	930	1020	1140	9.3	1.8	1.8
W. EUROPE	1930	2000	2110	960	1380	1560	1090	1590	1780	2040	9.2	2.3	2.3
N. AMERICA	1960	3050	3250	1450	2380	2850	1320	1950	2440	3320	10.3	4.5	4.5
USSR AND E. EUROPE	700	900	1700	600	800	1500	600	800	1500	2250	7.4	13.3	7.0
OTHER INDUSTRIALIZED COUNTRIES	30	40	90	20	30	60	20	30	60	100	10.7	14.9	8.8
TOTAL	5560	7100	8260	3610	5450	6910	3680	5300	6800	8850	9.3	5.1	4.5
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	-	-	-	100	-	-	-
MIDDLE EAST North Africa	-	-	40	-	-	30	-	-	50	100	-	-	12.2
MIDDLE EAST West Asia	-	-	200	-	-	150	-	50	150	300	-	24.6	12.2
ASIA	40	400	950	30	320	750	50	360	800	1200	-	17.3	7.0
CHINA	-	30	210	-	20	150	-	20	150	300	-	-	12.2
LATIN AMERICA	170	400	750	130	320	610	150	370	650	1000	25.2	11.8	7.4
TOTAL	210	830	2150	160	660	1690	200	800	1800	3000	41.4	17.6	8.8
WORLD TOTAL	5770	7930	10410	3770	6110	8600	3880	6100	8600	11850	11.8	7.1	5.6
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	3.6	12.6	21.7	4.2	10.8	19.7	5.1	13.1	20.9	25.3			

Annex I.F.

UNIDO 13.5.81

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ...METHANOL..........................
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	1400	1300	1300	700	900	1000	800	1200	1400	2100	10.7	4.2	5.0
W. EUROPE	2500	3700	5000	1900	3000	4500	2000	3000	4600	6000	10.7	8.9	5.0
N. AMERICA	3700	4150	8000	2500	3650	5300	2450	3650	5400	8400	10.5	7.6	7.6
USSR AND E. EUROPE	2200	3000	4850	2100	2800	4000	2100	2800	4000	5500	7.4	7.3	5.0
OTHER INDUSTRIALIZED COUNTRIES	nil	125	1350	nil	50	1200	50	150	1200	2000	31.6	34.0	7.0
TOTAL	9800	12275	20500	7200	10400	16000	7400	10800	16600	24000	10.1	11.4	6.3
DEVELOPING COUNTRIES													
AFRICA										50			
MIDDLE EAST North Africa		450	450		400	400	25	50	75	100	18.9	8.4	4.9
MIDDLE EAST West Asia			660			600	25	50	75	100	18.9	8.4	4.9
ASIA	100	500	600	90	400	550	100	300	600	1200	24.6	14.9	12.3
CHINA	180	260	400	140	210	350	150	240	350	700	12.5	28.4	12.3
LATIN AMERICA	120	350	1200	110	310	1000	150	300	700	1400	18.9	18.4	12.3
TOTAL	400	1560	3310	340	1320	2900	450	940	1800	3550	20.1	17.6	12.0
WORLD TOTAL	10200	13835	23810	7540	11720	18900	7850	11740	18400	27550	10.4	9.6	7.0
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	3.9	11.3	13.9	4.5	11.3	15.3	5.7	8.0	9.8	12.9			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ..LDPE.................................
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	1360	1570	1570	940	1370	1240	680	1200	1080	1080	15.2	-	-
W. EUROPE	4500	5700	6500	3000	4520	4800	2600	4000	4500	5190	9.0	2.4	2.4
N. AMERICA	3200	4200	6000	2380	3920	5000	2310	3460	4400	5860	10.6	4.9	4.9
USSR AND E. EUROPE	800	1400	2150	600	1130	1660	700	1130	1660	2500	12.7	8.0	7.1
OTHER INDUSTRIALIZED COUNTRIES	150	280	380	120	210	320	240	240	320	410	-	5.9	5.1
TOTAL	10010	13150	16600	7040	11150	13020	6530	10030	11960	15040	11.3	3.6	3.9
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	30	50	100	200	13.6	14.9	12.2
MIDDLE EAST North Africa	-	50	240	-	40	200	70	100	150	300	9.3	8.4	12.2
MIDDLE EAST West Asia	20	20	510	10	15	400	120	180	300	600	10.6	10.7	12.2
ASIA	150	400	840	100	330	660	410	900	1500	3000	21.7	10.7	12.2
CHINA	40	280	340	25	250	300	60	260	400	750	44.3	9.0	11.0
LATIN AMERICA	350	550	1330	320	450	1030	410	720	1300	2100	16.3	11.6	8.3
TOTAL	560	1300	3260	455	1085	2590	1100	2210	3750	6950	19.1	11.1	10.8
WORLD TOTAL	10570	14450	19860	7495	12235	15610	7630	12270	15710	21990	10.3	5.1	5.8
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	5.3	9.0	16.4	6.1	8.9	16.6	14.4	18.2	23.9	21.6			

Annex I.H.

UNIDO 8.5.81.

WORLD CAPACITY, PRODUCTION AND DEMAND FOR HDPE
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	890	900	900	350	800	840	220	680	720	770	32.6	1.1	1.1
W. EUROPE	1700	2100	2600	1350	1770	2000	950	1500	1850	2380	12.1	4.3	4.3
N. AMERICA	1700	2700	4260	1260	2560	3200	1190	2250	2900	3930	17.2	5.2	5.2
USSR AND E. EUROPE	180	360	930	130	280	760	150	300	700	1150	18.9	18.5	8.6
OTHER INDUSTRIALIZED COUNTRIES	50	130	190	40	100	160	80	110	160	210	8.3	7.8	4.6
TOTAL	4520	6190	8880	3130	5510	6960	2590	4840	6330	8440	16.9	5.5	4.9
DEVELOPING COUNTRIES													
AFRICA	–	–	–	–	–	–	10	10	20	40	–	14.9	12.2
MIDDLE EAST North Africa	–	–	140	–	–	110	20	20	40	80	–	14.9	12.2
MIDDLE EAST West Asia	–	–	140	–	–	110	40	50	100	200	5.7	14.9	12.2
ASIA	70	120	450	50	100	370	140	400	700	1400	30.0	11.8	12.2
CHINA	30	35	35	5	20	30	10	50	100	200	49.5	16.9	12.2
LATIN AMERICA	30	210	460	30	170	360	130	310	500	800	24.3	10.0	8.1
TOTAL	130	365	1225	85	290	980	350	840	1460	2720	24.4	11.4	11.2
WORLD TOTAL	4650	6555	10105	3215	5800	7940	2940	5680	7790	11160	17.9	6.5	6.1
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	2.8	5.6	12.1	2.6	5.0	12.3	11.9	14.8	18.5	24.4			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR Polypropylene
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	1050	1160	1160	590	1020	1140	440	930	1090	1320	20.8	3.2	3.2
W. EUROPE	1200	2200	2600	650	1530	2100	600	1300	2000	3350	21.3	9.0	9.0
N. AMERICA	1450	2330	3100	900	1850	2500	780	1550	2300	3690	18.7	8.2	8.2
USSR AND E. EUROPE	180	240	600	150	180	450	200	280	480	800	8.7	9.8	9.8
OTHER INDUSTRIALIZED COUNTRIES	-	70	120	-	60	100	40	80	100	130	18.9	4.6	4.5
TOTAL	3880	6000	7580	2290	4640	6290	2060	4140	5940	9290	19.0	7.7	7.6
DEVELOPING COUNTRIES													
AFRICA	-	-	35	-	-	30	10	20	40	80	18.9	14.9	12.2
MIDDLE EAST North Africa	-	-	70	-	-	60	10	20	30	60	18.9	8.4	12.2
MIDDLE EAST West Asia	-	-	60	-	-	50	20	50	100	200	25.7	14.9	12.2
ASIA	70	220	620	50	180	510	150	450	800	1600	31.6	12.2	12.2
CHINA	-	120	200	-	90	150	20	90	150	300	45.6	10.7	12.2
LATIN AMERICA	-	100	290	-	80	230	100	220	400	800	21.8	12.7	12.2
TOTAL	70	440	1275	50	350	1030	310	850	1520	3040	28.7	12.3	12.2
WORLD TOTAL	3950	6440	8855	2340	4990	7320	2370	4990	7460	12330	20.4	8.5	8.6
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	1.8	6.8	14.4	2.1	7.0	14.1	13.1	17.0	20.2	24.6			

Annex I.J

UNIDO 8.5.81.

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ....PVC....
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	1930	2080	2080	1130	1590	1790	1000	1520	1730	2020	-11.0	2.6	2.6
W. EUROPE	4500	5200	5600	3100	4320	4700	2800	3930	4550	5430	8.8	3.0	3.0
N. AMERICA	2630	3585	4870	1740	2970	4100	1710	2850	3900	5690	13.6	6.5	6.5
USSR AND E. EUROPE	1450	1850	2900	850	1500	2300	1000	1430	2000	2850	9.3	6.9	6.1
OTHER INDUSTRIALIZED COUNTRIES	120	350	400	100	250	320	200	300	330	430	10.7	2.0	4.5
TOTAL	10680	13065	15850	6920	10630	13210	6710	10030	12510	16420	10.6	4.6	4.6
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	30	50	100	200	13.6	14.9	12.2
MIDDLE EAST North Africa	-	60	200	-	50	160	70	100	150	300	9.3	8.4	12.2
MIDDLE EAST West Asia	-	50	200	-	40	160	130	150	300	600	3.6	14.9	12.2
ASIA	250	900	1670	200	740	1380	360	800	1500	3000	22.1	13.4	12.2
CHINA	300	400	800	220	350	700	250	360	700	1400	9.5	14.2	12.2
LATIN AMERICA	300	600	1070	250	420	820	320	650	1100	1700	19.4	11.1	7.5
TOTAL	850	2010	3940	670	1600	3220	1160	2110	3850	7200	16.1	12.7	11.0
WORLD TOTAL	11530	15075	19790	7590	12230	16430	7870	12140	16360	23620	11.4	6.2	6.3
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	7.4	13.9	19.9	8.8	13.0	19.6	14.7	17.4	23.5	30.5			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR POLYSTYRENE
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	1250	1390	1390	690	1230	1360	600	1130	1260	1450	17.1	2.4	2.4
W. EUROPE	2500	2800	3100	1300	1800	2200	1250	1700	2100	2700	8.0	4.3	4.3
N. AMERICA	2400	2560	2980	1270	1940	2600	1240	1900	2550	3640	11.2	6.1	6.1
USSR AND E. EUROPE	400	600	800	300	450	600	300	450	600	900	10.7	5.9	7.0
OTHER INDUSTRIALIZED COUNTRIES	50	90	110	40	70	90	40	70	90	120	15.0	5.1	4.9
TOTAL	6600	7440	9240	3600	5490	6850	3430	5250	6600	8810	11.2	4.7	4.9
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	20	20	40	80	-	14.9	12.2
MIDDLE EAST North Africa	-	-	-	-	-	-	20	20	30	60	-	8.4	12.2
MIDDLE EAST West Asia	-	20	40	-	20	30	40	50	100	200	5.7	14.9	12.2
ASIA	70	190	340	50	150	280	140	300	500	1000	21.0	10.7	12.2
CHINA	-	20	20	-	10	20	-	40	70	150	-	11.8	13.5
LATIN AMERICA	220	400	460	140	240	360	140	270	400	600	17.8	8.2	7.0
TOTAL	290	630	860	190	420	690	360	700	1140	2090	18.1	10.2	10.6
WORLD TOTAL	6890	8070	10100	3790	5910	7540	3790	5950	7740	10900	11.9	5.4	5.9
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	4.2	7.8	9.3	5.0	7.1	9.1	9.5	11.8	14.7	19.2			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR Acrylic Fibres
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	340	400	400	250	360	360	150	270	290	315	15.8	1.4	1.4
W. EUROPE	840	1000	1050	530	750	780	470	650	660	730	8.4	0.3	1.7
N. AMERICA	375	380	380	240	350	330	230	280	280	280	5.0	-	-
USSR AND E. EUROPE	150	200	400	120	150	300	120	180	300	450	10.6	10.7	7.0
OTHER INDUSTRIALIZED COUNTRIES	-	-	30	-	-	30	20	40	50	60	18.9	4.5	3.1
TOTAL	1705	1980	2260	1140	1610	1800	990	1420	1580	1835	9.4	2.1	4.0
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	10	15	20	30	10.6	5.9	7.0
MIDDLE EAST North Africa	-	-	-	-	-	-	10	15	20	30	10.6	5.9	7.0
MIDDLE EAST West Asia	-	-	-	-	-	-	10	20	30	40	13.9	8.4	4.9
ASIA	140	210	320	100	160	230	90	150	210	310	13.6	7.1	6.7
CHINA	10	60	60	10	45	50	40	70	100	150	15.0	7.4	7.0
LATIN AMERICA	70	120	230	60	100	170	70	120	170	250	14.4	7.1	6.7
TOTAL	220	390	610	170	305	450	230	390	550	810	14.1	7.1	6.6
WORLD TOTAL	1925	2370	2870	1310	1915	2250	1220	1810	2130	2645	10.3	2.8	3.6
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	11.4	16.4	21.2	13.0	16.0	20.0	18.8	21.5	25.8	30.6			

Annex I.M.

UNIDO 11.5.81

WORLD CAPACITY, PRODUCTION AND DEMAND FOR Polyamide (Nylon) Fibres
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	350	325	340	280	310	310	210	280	290	300	7.4	0.1	0.05
W. EUROPE	1000	970	910	620	720	660	570	690	660	680	4.9	0.1	0.05
N. AMERICA	1260	1470	1800	900	1300	1600	900	1200	1450	1450	7.4	3.8	-
USSR AND E. EUROPE	400	600	750	350	450	600	350	450	600	800	6.5	5.9	4.9
OTHER INDUSTRIALIZED COUNTRIES	40	40	50	30	30	50	30	40	50	60	7.4	4.5	3.1
TOTAL	3050	3405	3850	2180	2180	3220	2060	2660	3050	3290	6.6	2.8	1.3
DEVELOPING COUNTRIES													
AFRICA	-	20	20	-	15	20	20	35	50	65	15.0	7.4	4.4
MIDDLE EAST North Africa	10	10	20	10	10	20	20	30	40	60	10.6	5.9	7.0
MIDDLE EAST West Asia	20	35	30	15	30	30	40	50	60	80	5.7	3.7	4.9
ASIA	200	250	350	150	200	280	200	300	370	525	10.6	4.2	6.0
CHINA	-	10	60	-	5	50	-	5	50	100	-	58.5	12.2
LATIN AMERICA	180	220	260	130	170	210	150	200	240	320	7.4	3.7	4.9
TOTAL	410	545	740	305	430	610	430	620	810	1150	8.2	6.3	5.5
WORLD TOTAL	3460	3950	4590	2485	3240	3830	2490	3280	3860	4440	7.2	2.8	2.4
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	11.8	13.8	16.1	12.3	13.3	15.9	17.2	18.9	21.0	25.9			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR Polyester Fibres
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	520	690	740	450	630	680	280	510	570	650	15.8	2.2	2.2
W. EUROPE	1080	1040	1060	650	800	800	530	760	780	890	9.4	0.05	2.2
N. AMERICA	1800	2170	2400	1400	1950	2200	1350	1750	2180	2350	6.7	4.5	1.2
USSR AND E. EUROPE	400	500	800	280	400	700	300	400	650	900	7.4	10.2	5.6
OTHER INDUSTRIALIZED COUNTRIES	30	50	80	20	40	70	30	60	80	100	18.9	5.9	3.8
TOTAL	3830	4450	5080	2800	3820	4450	2490	3480	4260	4890	8.7	4.1	2.3
DEVELOPING COUNTRIES													
AFRICA	30	40	50	30	35	45	35	50	70	110	13.6	6.9	7.0
MIDDLE EAST North Africa	10	20	40	10	20	35	30	40	70	110	7.4	8.4	10.6
MIDDLE EAST West Asia	50	75	70	45	60	70	50	60	80	100	4.7	11.6	7.4
ASIA	500	650	1000	400	550	800	500	700	1000	1400	8.8	7.4	5.8
CHINA	-	15	450	5	70	350	40	250	350	700	58.1	6.9	12.2
LATIN AMERICA	250	400	540	210	330	460	240	360	540	720	10.7	8.4	4.9
TOTAL	840	1200	2150	700	1065	1760	895	1460	2110	3140	13.0	7.6	6.9
WORLD TOTAL	4670	5650	7230	3500	4885	6210	3385	4940	6370	7930	9.9	5.1	3.7
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	18.0	21.2	29.7	20.0	21.8	28.3	26.4	29.5	33.1	39.6			

WORLD CAPACITY, PRODUCTION AND DEMAND FOR ...SBR...
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	800	930	950	500	600	700	350	440	550	700	5.8	4.6	4.1
W. EUROPE	1450	1600	1600	1000	1150	1200	850	870	950	1000	0.5	1.8	0.8
N. AMERICA	1500	1800	2000	1170	1600	1750	950	1450	1600	1750	11.1	1.9	1.4
USSR AND E. EUROPE	1200	1600	2400	1100	1400	2000	1250	1610	2100	2800	6.6	6.8	4.9
OTHER INDUSTRIALIZED COUNTRIES	50	70	130	30	50	100	60	80	100	150	7.4	4.6	7.0
TOTAL	5000	6000	7080	3800	4800	5750	3460	4450	5300	6400	6.6	3.5	3.2
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	10	30	40	50	31.6	5.9	3.1
MIDDLE EAST North Africa	-	-	-	-	-	-	10	20	30	40	18.9	10.7	4.9
MIDDLE EAST West Asia	30	30	40	10	20	30	20	30	30	40	10.7	-	4.9
ASIA	100	130	220	80	100	170	180	290	400	500	12.6	6.6	3.8
CHINA	30	40	100	30	40	100	30	90	150	250	31.6	10.7	8.8
LATIN AMERICA	200	350	560	150	240	400	200	310	500	750	11.6	10.0	7.0
TOTAL	360	550	910	270	400	700	450	770	1150	1630	14.3	8.3	6.0
WORLD TOTAL	5360	6550	8000	4070	5200	6450	3910	5220	6450	8030	7.2	4.2	3.7
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	6.7	8.4	8.9	6.6	7.7	10.8	11.5	14.8	17.8	20.3			

Annex I.P.

UNIDO 8.5.81.

WORLD CAPACITY, PRODUCTION AND DEMAND FOR Polybutadiene
(in thousand metric tonnes)

	CAPACITY			PRODUCTION			DEMAND				INCREASE IN DEMAND (per cent per annum)		
	1975	1979	1984	1975	1979	1984	1975	1979	1984	1990	1975-79	1979-84	1984-90
DEVELOPED COUNTRIES													
JAPAN	200	230	230	150	150	170	100	120	170	220	4.7	7.1	4.3
W. EUROPE	320	360	360	250	270	320	210	240	290	320	3.3	3.9	1.6
N. AMERICA	400	500	600	350	450	520	300	430	500	550	6.0	3.0	1.6
USSR AND E. EUROPE	200	250	400	140	200	350	150	200	350	450	7.4	11.8	4.2
OTHER INDUSTRIALIZED COUNTRIES	20	30	30	10	20	20	10	20	20	30	18.9	-	7.0
TOTAL	1140	1370	1620	900	1090	1380	770	1010	1330	1570	7.0	5.6	2.8
DEVELOPING COUNTRIES													
AFRICA	-	-	-	-	-	-	-	10	10	20	-	-	12.2
MIDDLE EAST North Africa	-	-	-	-	-	-	-	10	10	10	-	-	-
MIDDLE EAST West Asia	-	-	-	-	-	-	-	10	10	10	-	-	-
ASIA	-	20	110	30	40	70	40	50	70	90	5.7	4.6	4.2
CHINA	-	-	50	-	-	40	-	-	40	50	-	-	3.1
LATIN AMERICA	60	100	120	40	60	90	50	70	110	170	8.8	9.4	7.5
TOTAL	60	120	280	70	100	200	90	150	250	350	13.7	16.7	5.8
WORLD TOTAL	1200	1490	1900	970	1190	1580	860	1160	1580	1920	7.8	6.3	3.2
SHARE OF DEVELOPING COUNTRIES IN WORLD TOTAL %	5.0	8.0	14.3	7.0	8.4	12.6	10.5	12.9	15.8	18.2			

Annex II.A

Level of annual export prices for petrochemicals per ton

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980[a]
Ethylene											
USA ($ US)	---	---	---	---	---	260	284	306	230	310	410
FRG (DM)	---	---	---	309	736	804	831	725	636	960	1334
($ US)	---	---	---	116	284	327	330	312	317	524	747
Propylene											
USA ($ US)	---	---	---	---	---	331	170	253	194	335	399
FRG (DM)	---	---	---	232	572	482	561	461	434	626	750
($ US)	---	---	---	87	221	196	223	198	216	342	420
Butadiene											
USA ($ US)	---	---	---	---	---	344	410	394	403	531	624
FRG (DM)	626	611	515	447	934	772	855	834	841	919	1096
($ US)	172	175	161	167	360	314	340	359	419	501	614
Benzene											
USA ($US)	66	59	64	108	341	250	242	217	208	459	488
FRG (DM)	258	210	204	258	902	834	667	560	598	971	1007
($ US)	71	60	64	97	348	339	265	241	298	530	564
Toluene											
USA ($ US)	48	54	51	87	189	122	162	154	169	331	415
FRG (DM)	178	179	174	288	640	406	492	435	400	748	817
($ US)	49	51	55	108	247	165	195	187	199	408	457
Styrene											
USA ($ US)	141	123	128	300	529	392	425	399	355	641	747
FRG (DM)	552	499	497	487	1169	1098	1137	1055	922	1431	1551
($ US)	151	143	156	182	451	446	452	455	459	781	868
Paraxylene											
USA ($ US)	---	---	---	152	253	317	368	319	254	497	607
FRG (DM)	553	475	453	501	1163	911	1016	706	575	1052	1210
($ US)	152	136	142	188	449	370	404	304	286	574	677
Orthoxylene											
USA ($US)	---	---	---	112	105	74	112	112	237	387	477
FRG (DM)	204	203	207	484	833	514	682	610	543	827	941
($ US)	66	58	65	181	321	209	271	263	270	451	527
Acrylonitrile											
USA ($US)	---	---	---	260	531	489	483	474	450	549	685
FRG (DM)	1350	923	915	736	1539	1379	1376	1309	1021	1162	1345
($ US)	370	265	287	275	594	560	546	564	508	634	753
Caprolactum											
USA ($ US)	414	420	443	478	1168	873	890	888	900	1215	1494
TPA/DMT											
USA ($ US)	333	311	311	315	558	500	516	438	373	658	685
FRG (DM)	1231	1335	1155	1119	1735	1331	1534	1146	969	1372	1487
($ US)	338	383	362	419	669	541	609	494	482	749	832
Methanol											
USA ($ US)	77	40	38	49	55	80	91	108	110	132	220
FRG (DM)	307	229	201	247	456	402	290	340	348	424	611
($ US)	84	66	63	92	175	163	118	147	174	231	342
Ammonia											
USA ($ US)	35	35	34	49	140	250	105	102	86	123	149
FRG (DM)	300	300	199	216	535	530	405	354	316	458	620
($ US)	82	65	62	81	206	215	164	152	158	250	347
LDPE											
USA ($ US)	296	301	265	369	748	583	610	595	571	841	980
FRG (DM)	1153	1053	833	954	1909	1355	1507	1112	1127	1742	2059
($ US)	316	302	261	357	736	551	598	479	561	950	1153
HDPE											
USA ($ US)	297	283	270	353	764	544	569	601	582	774	956
FRG (DM)	---	---	1076	1081	2039	1698	1722	1601	1412	2003	2231
($ US)	320	323	336	404	787	690	684	689	703	1093	1249
PVC											
USA ($ US)	300	300	220	570	753	629	607	673	742	845	873
FRG (DM)	1571	1306	1473	1526	2220	1620	1585	1570	1400	1698	2121
($ US)	431	375	462	571	857	659	630	676	697	926	1187
Polystyrene											
USA ($ US)	364	329	294	494	980	872	938	717	714	883	1070
FRG (DM)	1296	1237	1164	1295	2240	1931	1985	1906	1724	2355	2583
($ US)	355	355	365	485	864	784	788	821	858	1285	1446

Source: Foreign Trade Statistics, United Nations Publication.
Note: Rate of exchange is taken from "International Financial Statistics".
a/ Calculated for USA for 7 months and FRG for 9 months.

Annex II.B Level of annual contract and spot prices for petrochemicals

(in US dollars/per ton)

		1977	1978	1979	1980
Ethylene					
USA[c]		267-274	285-295	336-357	497-513
Western Europe	spot	---	420-425	620-630	---
	contract	323-342	352-372	565-602	732-754
Propylene					
USA[c]		198-209	220-231	250-269	320-346
Western Europe	spot	181-193	185-193	377-389	---
	contract	217-223	217-244	385-416	463-479
Butadiene					
USA[c]		416-449	453-469	497-530	598-682
Western Europe	spot	392-408	481-496	576-597	588-593
	contract	413-433	457-488	586-641	655-700
Benzene					
USA[c]		233-236	225-227	386-457	484-516
Western Europe	spot	224-228	259-267	574-589	502-516
	contract	255-262	238-247	503-522	556-566
Toluene					
USA[c]		154-157	167-179	327-344	404-405
Western Europe	spot	164-169	192-196	414-425	427-440
	contract	171-182	183-190	401-471	442-454
Styrene					
USA[c]		428-433	350-380	640-690	789-821
Western Europe	spot[a]	397-403	384-393	911-921	759-775
	spot[b]	419-424	407-420	939-952	797-819
	contract	428-453	399-417	848-913	863-896
Paraxylene					
USA[c]		330-338	260	453-554	571-620
Western Europe	spot	279-291	280-302	711-723	615-629
	contract	314-325	268-284	663-679	676-691
Orthoxylene					
USA[c]		243-253	242-253	371-410	475-506
Western Europe	spot	248-251	262-269	496-506	527-540
	contract	264-274	270-289	482-493	523-531
Ammonia					
USA[c]		108	98-100	120-125	135-145
Western Europe	spot	136-141	103-107	175-189	170-190
	contract	117-140	120-136	152-174	200-220
Methanol					
USA[c]		92-95	98-100	115-121	206
Western Europe	spot	103-111	100-120	183-218	235-245
	contract	113-142	121-128	173-184	238-262

Source: "European Chemical News".

Note: a/ Import subject to tariffs.
b/ Duty-free import.
c/ USA price range.

Annex II.C   Level of prices for basic petrochemicals in 1980 (in US dollars/per ton)

		January		February		June		July		November		December	
		Western Europe	USA	Western Europe	USA	Western Europe	USA	Western Europe	USA	Western Europe	USA	Western Europe	USA
Ethylene	contract	747-786	462-484	775-810	462-482	723-743	528-550	725-775	462-491	703	513	703	
	spot	...	...	...	...	...	...	...	...	...	...	...	
Propylene	contract	490-510	264-286	520-545	264-286	445-465	---	438-446	396-429	438-446	369-418	438-446	366-420
	spot	...	...	...	...	...	...	402-416	...	393	...	393	...
Butadiene	contract	---	636-660	710-770	638-660	676-692	638-660	660-730	682	607-611	704	607-611	778-783
	spot	595-605	...	...	...	...	...	...	...	618	...	670	...
Benzene	contract	620-636	495-510	625-635	495-540	575-592	495	531	465	505	---	505	...
	spot	605-615	...	...	...	480-490	...	420-450	...	550-570	510-540	560-565	510-542
Toluene	contract	490-495	412	455-510	412	450-465	382	422	382	425-430	---	425-430	...
	spot	510-525	...	...	...	370-395	...	375-385	...	460-470	420-430	450-460	420-430
Xylene	contract	500-510	416	500-510	416	460-456	416	---	416	---	---	---	...
	spot	510-525		490-495		380-385		365-410	...	510-530	450-475	500-520	450-475
Styrene	contract	---	795-836	970-1090	792-836	855-895	858-890	769	858-891	830	...	910-920	...
	spot	870-895 a/ 945-955 b/	...	...	...	660-730 a/ 700-725 b/	...	620-640 a/ 660-680 b/	...	760-780 a/ 800-830 b/	660-682	800-810 a/ 840-860 b/	660-682
P-xylene	contract	740-770	516-616	740-750	516-616	669-689	660-693	----	660-693	607-634	506-528	607-634	503-525
	spot	700-715	...	...	...	580	...	520-530	...	600-630	...	640-660	...
O-xylene	contract	545-575	440-506	590-610	440-506	530-540	484-506	476	484-506	496	484-506	496	484-506
	spot	550-560	...	...	...	425-430	...	415-420	...	525-530	...	550-560	...
Phenol	contract	---	748-770	1010	748-770	890-910	814-836	840	814-836	742-754	814-836	742-754	814-836
	spot	---	...	...	...	...	...	...	...	750-778	...	760-800 b/	...
Methanol	contract	225-235	206 c/	230-240	206 c/	245-259	206 c/	...	206 c/	240-302	206 c/	240-302	206 c/
	spot	220-245	...	...	...	220-250	...	...	...	210-215 a/ 235-245 b/	...	210-215 a/ 235-245 b/	...

Source: "European Chemical News", several issues.

Note: a/ Import subject to tariffs.
b/ Duty-free import.
c/ List prices.

Annex II.D (1)

Petrochemical production: conversion factors and capital costs

Product	Conversion factor (tons of starting material per ton of product)	Capacity (thousand tons per year)	Capital cost (million dollars): Battery limits	Capital cost (million dollars): Energy supply installations	Capital cost (million dollars): Sum
PRIMARY					
Ethylene (by steam cracking)	4 naphtha	50			14.5[a]
		100			20
Coproducts: 50% propylene		150			26
15% butadiene		200			32.5
Aromatics:					
benzene	1.88 platformate + 0.77 pyrolysis gasolene with dealkylation	102			21[a]
o-xylene		18			
p-xylene		30			
benzene	1.30 platformate + 0.56 pyrolysis gasolene without dealkylation	34	8	2	10[b]
toluene		12			
ethyl benzene		14			
o-xylene		14			
m-xylene		27			
p-xylene		14			
Methanol	0.7 natural gas	30	3	1.5	5
Chlorine	1.75 rock salt	3.5	1.1	0.5	1.6
Coproduct: 113% caustic soda	(+ 3350 kWh electricity + 2.1 kg graphite electrodes)	17.5	3.5	1	5
Oxygen		16	1.6	0.6	2.2

cont.

Annex II.D (ii)

Product	Conversion factor (tons of starting material per ton of product)	Capacity (thousand tons per year)	Capital cost (million dollars)		
			Battery limits	Energy supply installations	Sum
INTERMEDIATE					
Acetylene	4.3 methane	33	8.5	1.5	10.0
	+ 4.9 oxygen				
Styrene	1.00 benzene	24	5	1	6
	+ 0.36 ethylene	100	11.5	2.9	14.4
Vinyl chloride	0.50 ethylene	24	4	1	5
	+ 0.61 chlorine	100	9.5	2.4	11.9
Vinyl chloride	+ 0.60 acetylene				
	0.43 hydrogen chloride	20	3	1	4
Vinyl acetate	0.39 ethylene	12	3	1	4
	+ 0.33 oxygen	50	7.5	1.9	9.4
	+ 0.72 acetic acid				
Ethylene glycol	0.70 ethylene	40	3	1	4
	+ 0.95 oxygen				
Acrylonitrile	1.40 propylene	10	3.5	2.4	5.9
	+ 0.43 ammonia	45	8	6	14
Phenol/acetone 1.00/0.65 (cumene process)	1.0 benzene	25/15	6	2	8
	+ 0.6 propylene				
DMT	0.7 *p*-xylene	30	10	0.6	11
	+ 0.5 methanol				
Cyclohexane[c]	0.94 benzene	30	0.5	–	0.5
	+ 0.08 hydrogen				
Caprolactam[d]	1.0 cyclohexane	20	14	5	19
Coproduct:	+ 1.5 ammonia				
45% ammonium	+ 1.4 sulphuric acid				
sulphate	+ 0.7 sulphur				
Phthalic anhydride	0.97 *o*-xylene	50	10.5	3.1	13.6
	+ 0.92 naphthalene				
2-Ethyl hexanol	1.147 propylene	10	16	4	20
Coproducts:	+ 0.996 water gas				
16% isobutanol	+ 0.038 hydrogen				
30% isobutyraldehyde					
2.7% isooctanol					

cont.

Annex II.D (iii)

Product	Conversion factor (tons of starting material per ton of product)	Capacity (thousand tons per year)	Capital cost (million dollars) Battery limits	Energy supply installations	Sum
INTERMEDIATE *(cont'd)*					
Dioctyl phthalate	0.7 2-ethyl hexanol (or isooctanol) + 0.4 phthalic anhydride	10	1.0	0.1	1.1
END					
Plastics					
Polyethylene, HP	1.05 ethylene	40	17	7	24
Polyethylene, LP or Polypropylene (LP polymerization)	1.05 ethylene or 1.07 propylene	20 or 14	10	4	14
PVC	1.06 vinyl chloride	6	2.0	0.5	2.5
		26	6	2	8
Polystyrene	1 styrene	6	1.5	0.4	1.9
		24	4.0	1.0	5.0
Fibres					
Acrylic fibre	1.06 acrylonitrile	4	6.5	1.5	8.0
		30	20	2.5	22
Polyamide (nylon 6) chips	1.10 caprolactam	3	1.5	0.3	1.8
Polyamide (nylon 6) fibre	1.08 nylon 6 chips	3	8	1	9
Polyester chips	1.05 DMT + 0.4 ethylene glycol	10	4.5	0.5	5.0
Polyester fibre	1.05 polyester chips	4	3	0.7	4
		10	6.5	1.0	7.5
Elastomers					
BR	1.04 butadiene	8	8.5	3.4	11.9
SBR	0.78 butadiene + 0.33 styrene	16			

cont.

Annex II.D (iv)

Product	Conversion factor (tons of starting material per ton of product)	Capacity (thousand tons per year)	Capital cost (million dollars) Battery limits	Energy supply installations	Sum
END *(cont'd)*					
Others					
Thermosetting plastics	0.72 PF resin or 0.72 UF resin or 1.60 unsaturated polyester resin	2.5	1.2	0.3	1.5
Detergent alkylate	0.83 propylene + 0.34 benzene	13	2.5	0.5	3.0
Detergent alkylate, sulphonated		13	5.0	0.8	5.8

[a] These represent total investment costs for the steam-cracking and aromatic extraction plants shown; the costs of the refinery supplying the naphtha inputs are not included.

[b] This capital cost does not include the cost of the reformer. An allowance has therefore been made for this in computing the cost of specific plants.

[c] The profitability of this operation depends on the availability of cheap hydrogen.

[d] The profitability of this process is greatly affected by the price at which the ammonium sulphate can be sold.

Source: The Petrochemical Industry, UN. 1973, pp. 12-15

Annex II.E

Location factor calculations[1]

To illustrate the use of two approaches to calculate location factors they apply to a proposal of a 320,000 t/y methanol plant under conditions of a Gulf location. Overall investment is around U$S 50 million. Installation cost, buildings and structural supports are sub-contracted. The plant is an independent, new production unit and the technology is new to the area. The site has already been developed by the local industrial authority. However, access roads, telephone and telex are excellent. Repair shops are available for repairing construction tools. Staff is to be trained by the licensor.

The points allocated to the United States Gulf Coast at the Gulf locations are shown in the table 2.8 together with the considerations behind the Gulf allocations. From these data, three location facters can be calculated:

Construction cost location factor $L_C = \frac{\sum \text{items 4 to 10 Gulf}}{\sum \text{items 4 to 10 US Gulf Coast}} = \frac{145}{100} = 1.45$

Plant cost location factor $L_P = \frac{\sum \text{items 4 to 11 Gulf}}{\sum \text{items 4 to 11 US Gulf Coast}} = \frac{156}{100} = 1.56$

Fixed investment location factor $L_I = \frac{\sum \text{items 1 to 14 Gulf}}{\sum \text{items 1 to 14 US Gulf Coast}} = \frac{207}{128.5} = 1.61$

Detailed analytical method

Step 1 Define the project in relation to the product, the process, the developing country site, the plant capacity and its stream factor. The proposed plant has a capacity of 320,000 t/y and a stream of 0.8.

Step 2 Determine production capacity of a United States reference plant with the dimensions required to give the same output as the developing country unit (allowing for stream factor difference). In the United States, the developing country plant would produce

$$\frac{0.9}{0.8} = 320,000 = 360,000 \text{ t/y}$$

Step 3 Scale United States construction costs from 320,000 t/y plant to 360,000 t/y plant. A 320,000 t/y unit costs U$S 48,384 million, the reference plant (360,000 t/y) cost U$S 53,232 million.

[1] Construction, production and distribution costs of petrochemical projects, GOIC, Doha-Qatar, October 1979

Step 4 Break down United States construction cost into individual items:

	thousands of dollars
Machinery and equipment delivered plant site	26,459
Installation	10,332
Buildings, structural supports	10,873
Miscellaneous	2,417
Engineering	3,151
Total	53,232

Step 5 Determine component location factors for each cost component (for range applicable to Gulf conditions see table).

	Component Location factor
Machinery and equipment	1,373
Installation	1,194
Buildings, etc.	1.0
Miscellaneous	1.2
Engineering	3.70
Weighted average	1,392

Step 6 Convert United States components costs to the Gulf component costs using component location factors; determine overnight construction cost location[1] factors:

	thousands of dollars
Machinery and equipment	36,328
Installation	12,336
Buildings, etc.	10,873
Miscellaneous	2,900
Engineering	11,659
Total	74,096

Provision to inflation on a United States plant with this capacity is U$S 4,645 million. The corresponding figure for the reference plant is $ 5,110 million. Applying a location factor of 2,088 to allow for Gulf inflation, cost escalation provision rises to $ 10,670 million.

---

[1] Excludes provision for inflation and construction financing.

Construction financing for a United States plant with the same output is \$ 4.242 million, at the reference plant would need \$ 4.667 million. Because of low interest construction loans, the Gulf location factor is 0.981 bringing the construction financing provision to \$ 4.577 million.

Comparing total construction costs for the reference at the Gulf plants give the construction cost location factor:

$$L_C = \frac{(\$\ 74,096 + \$\ 10,670 + \$\ 4,577)}{(\$\ 53,232 + \$\ 5,110 + \$\ 4,667)} = \frac{(\$\ 89,343)}{(\$\ 63,009)} = 1.418$$

Step 7 Determine effect of plant operating efficiency using ratio of reference plant to same-sized United States plant costs as location factor:

$$L_E = \frac{(\$\ 63,009)}{(\$\ 48,384 + \$\ 4,645 + \$\ 4,242)} = \frac{(\$\ 63,009)}{(\$\ 57,271)} = 1.10$$

Step 8 Calculate plant cost location factor:

$$L_P = L_C \times L_E$$

$$L_P = 1,418 \times 1.10 = 1.56$$

Step 9 Add other capitalized costs, e.g. prefeasibility study, feasibility study, site development, paid up royalties and licenses, land, start up cost and other outside costs.

	United States reference plant (US 1000 dollars)	Gulf plant	
		Location factor	thousands of dollars
Prefeasibility study	0	-	200
Feasibility study	242	4.0	968
Site development	300	-	0
Start up cost	3123	1.628	5084
Other outside costs	0	-	500

Step 10 Calculate final investment location factor, L_I. Total final investment for same-sized United States plant:

$$I_{US} = (\$\ 57,271 + \$\ 242 + \$\ 300 + \$\ 3123) \times 10^3 = \$\ 60.936 \text{ million}$$

Total final investment for Gulf plant:

$$I_G = (\$\ 89,343 + \$\ 200 + \$\ 968 + \$\ 5084 + \$\ 500) \times 10^3 =$$
$$= \$\ 96,095 \text{ million,}$$

Thus,

$$I_I = \frac{I_A}{I_{US}} = \frac{96,095}{60,936} = 1.577$$

ANNEX II.F

Methodology

The competitiveness of petrochemical production at a given location depends on a broad range of factors: production costs in the country of origin, taxes on input factors and rebates on output, shipping and other transportation charges, import duties in the export market, additional costs deriving from non-tariff barriers, storage costs, and finally local sales and service charges. The following calculations are concerned only with the first stage - the relative advantages in production. The method used is the "cost difference" approach employed for feasibility studies comparing chemical and petrochemical operations at different locations. By taking the U.S. Gulf Coast as a reference location, a series of location factors and other multipliers together with local inputs for raw material, utilities and labour costs can be used to build up the cost structure for other locations. This method eliminates errors that would otherwise appear due to country-to-country and enterprise to enterprise differences. In addition, errors in the assumptions to some extent cancel out since they apply to all situations.

Two data sources [/] provided cost figures for 20 petrochemical products produced at three locations: the U.S. Gulf Coast, the Federal Republic of Germany and Japan. Data sets for each country were assembled for two base years (1980 and 1985) for several alternative processes and for three plant sizes. This provided the input to a UNIDO-developed computerized conversion programme that converted the data to developing country conditions. As this programme presently stands, production costs can be developed for any country if four groups of factors are known: location factor relating local to U.S. Gulf Coast investment costs; and the local cost and price of feedstocks, by-product credits, utilities (cooling water, process water, steam, electricity, fuel and inert gas). The results can also be converted to represent a range of plant sizes.

In this report the results are presented for the three industrialized countries - the Federal Republic of Germany being taken to represent Western Europe - and three developing countries: Indonesia, Mexico and Qatar.

[/] **1980 PEP International Yearbook** and **Estimates of Petrochemical Costs in 1985, SRI International, Zurich, 1980.**

All the developing countries together with the United States are able to base their petrochemical industry on low-cost associated gas. _/ They thus hold the best chance for establishing an internationally competitive olefins-based petrochemical industry.

The assumptions

The assumptions for the analysis of production costs are as follows:

Capital cost: comprised of two elements - inside battery limits (ISBL) and outside battery limits (OSBL) or minimum offsites. This breakdown, together with unit investment cost, is shown in table II/4.2.1.

ISBL capital costs: comprises the cost of pre-feasibility and feasibility studies, site development, equipment and materials (including spare parts), buildings, structural support, freight, labour, indirect costs, construction-related insurance costs, home office costs (including engineering), type of contract (e.g. lump sum or cost plus), contingency, escalation, construction, financing, start-up costs, and owner's expenses (royalties and licences). ISBL costs vary from one country to another according to a location factor (see below).

OSBL capital costs (minimum offsites): covers site preparation, auxiliary utilities, e.g. power transformers, land drainage, office, laboratory buildings, etc. Location factors are assumed the same as for inside battery limits (ISBL) capital cost.

Location factor: the ratio of investment costs for petrochemical production in a given country to the cost of building the same plant at a U.S. Gulf Coast location. The main factors influencing this ratio are the scope of the project; local exchange rates vs. the United States dollar; the size and complexity of the project; input costs; site conditions; capacity of local contractors; availability, efficiency and cost of local construction labour; impacts of local trade unions; fees and commissions; country rules and procedures; contractor risk. Two methods for calculating load factors in developing countries are described in chapter II. In this study the developing country location factors are those reported by the countries themselves. They are, however, in general agreement with the views of European engineering contractors. Industrialized country location factors are those submitted by the data source.

_/ For a full description of the opportunities offered by flared gas, see UNIDO report "Industrial Uses of Associated Gas", Vienna, 1981.

Depreciation: capital costs (ISBL plus offsites) are amortized over ten years, i.e. at a depreciation rate of 10 per cent. The possibility of other depreciation rates is foreseen in the UNIDO computer programme.

Working capital: composed of six elements - stores and cash (as a per cent of fixed capital); raw material inventory in days of consumption; feedstock and product inventory in days at direct cost plus overhead; accounts receivable in days at direct cost plus overhead; and amounts payable (deducted from the foregoing and estimated at number of days of raw materials consumption plus labour costs). Different assumptions are made for stores and raw materials inventory for developed and developing country locations.

The quantitative assumptions made for working capital are shown below. The interest on total working capital forms part of the fixed charges on each petrochemical plant and is assumed to be 10 per cent. However, the UNIDO computer programme foresees the possibility of zero interest rate to reflect situations where producers have access to working capital on such terms.

Working capital

Component	Developing country	Industrialized country
Stores	1% of fixed capital	0.5% of fixed capital
Cash	0.5% of fixed capital	
Raw material inventory	5 days at purchase value a/	5 days at purchase value
Finished product inventory	30 days at direct cost plus plant overhead	
Accounts receivable	40 days at direct cost plus plant overhead	
Accounts payable	30 days raw material consumption plus 11 days labour	

a/ 60 days for imported materials.

Feedstock: Over 100 different raw materials are needed to make the 18 products covered in this study. In many cases the major raw material is produced in another plant whose production cost has to be evaluated first.

In some cases, e.g. ethylene, there are several alternative raw materials; the production costs were investigated for each. In developing countries the primary feedstock is considered to be low-cost ethane extracted from associated gas. An ethane-propane mixture is offered as an alternative only to provide a local source of propylene for polypropylene plants. 1/ Developed countries are assumed to use an appropriate feedstock at current or 1985 market prices - naphtha or gas oil in Western Europe and Japan, ethane or ethane-propane in the United States.

Feedstock and by-product prices for petrochemical operations in the reference years 1980 and 1985 are listed in tables A.I.1 and 2. The prices shown are either those prevailing in the local market - the case for all the developed countries and to a lesser extent for Mexico - or those computed from prices elsewhere allowing for shipping charges.

All three developing countries are assumed to be gas based. As by-products of an LPG exporting sector, ethane and methane in Qatar and Indonesia are assigned an arbitrary low value of $25/ton for 1980 and $100/ton for 1985. Notional market prices for other feedstocks such as benzene and p-xylene in the developing countries are calculated assuming local production with prices determined by the opportunity costs in the nearest international market. Shipping costs are thus deducted 2/ from the price in the nearest industrialized region and the result reduced by a further 25 per cent to give local consumers access to intermediates at a favourable rate.

Petrochemical plants whose feedstocks are intermediates, i.e. the product of an upstream unit, are assumed to have access to those materials at one of three price levels - one based on local market prices, a second at the production cost or transfer price for the upstream unit calculated to include a 25 per cent return on investment and a third assuming a 5 per cent return on investment. These variations are the basis of table II.4.2.

By-products: Values of by-products are estimated similarly to feedstocks where quantities are large enough to transport. Otherwise the value is taken either as the next alternative use, e.g. propylene spiked into LPG exports, or fuel value. In some cases, values are computed assuming the same price ratios as in developed countries, e.g. polymer-grade to chemical-grade propylene and ethylene to purge ethylene. All by-product values are shown in tables A.I.1 and 2.

1/ Propane is normally exported directly as LPG. It would only be considered as a source of propylene where local demand justifies.

2/ If feedstocks are imported, shipping charges would be added to international prices. The practice of offering local producers feedstock at favourable prices is exemplified by Mexico where benzene is sold for $326 per ton as against the opportunity cost in the United States after deducting shipping charges of $475 per ton.

Other raw materials: Materials such as catalysts and subsidiary chemical inputs are assumed to be imported by developing countries at an average price of 1.25 times their cost in the United States. For 1985 these are assumed to have risen in price by 4 per cent annual in real terms for all countries.

Utilities: Utility consumption for each process considered is shown in table A.I.3. Utility costs (for cooling water, steam, process water, electric power and fuel) for 1980 are the values reported either by the data source (for developed countries) or by the developing countries themselves. They are listed in tables A.I.1 and 2 and included in "other direct costs" in the production cost breakdown. For 1985, steam, electricity and fuel oil are assumed to have risen in line with crude oil prices; natural gas will rise to parity with fuel oil; and both gas and oil prices in the United States will rise to world levels.

Maintenance materials: In all countries maintenance materials are estimated as a fixed percentage (3 per cent) of ISBL capital cost. [3/] Thus the location factor automatically builds in an extra allowance for their higher unit cost to developing countries. Maintenance materials are included in other direct costs.

Maintenance labour: also estimated at 3 per cent of ISBL capital cost for all countries. This could be subject to wide variations according to the cost and efficiency of labour (see operating labour below); their impact on total production cost is negligible, however. Maintenance labour is included in other direct costs.

Operating labour: Annual costs per man, as reported by country correspondents and the data source are listed in table A.I.1 and 2. Labour efficiency in all developing countries is assumed to be 60 per cent of that for petrochemical plants in the U.S. Gulf Coast, giving the following labour factors:

3/ Some sources apply 1.5 per cent of ISBL capital costs; see, for example, "Construction, Production and Distribution Costs of Petrochemical Products", op. cit., p. 42.

Country	Annual labour cost (1980) ($ per man-year)	Labour efficiency	Labour factor (1980)
U.S. Gulf Coast	29,500	1	1.00
Federal Republic of Germany	33,000	1	1.12
Japan	25,700	1	0.87
Algeria	...	0.6	...
Indonesia	5,000	0.6	0.28
Mexico	12,174	0.6	0.69
Qatar	20,000	0.6	1.13

Operating labour costs are included in other direct costs.

Operating supplies: estimated at 10 per cent of operating labour. This excludes operating materials such as catalysts and chemicals that are listed separately as other raw materials. Both are included in other direct costs.

Control laboratory: estimated at 20 per cent of operating labour and included in other direct costs.

Plant overhead: estimated at 80 per cent of total labour - covers joint services such as fire protection, security, canteens, cleaning, etc. Included in other fixed costs.

Taxes and insurance: Estimated at 1 per cent of total fixed capital for developing countries and 2 per cent for industrialized countries, this covers low local taxes only. Wide variations are found, with many developing countries applying zero taxes. Taxes and insurance are included in other fixed costs.

General overhead: Head office expenses covering general and administration charges, sales and R and D are arbitrarily estimated at 2.5 per cent of net cost of production for developing countries and 5 per cent for industrialized countries. 4/

4/ A more rigorous approach applies different percentages to a product sales price which is defined in turn as a net manufacturing cost plus the value of by-products. This would penalize liquid feedstock ethylene plants more than gas-fed units, and weighs more heavily on specialty chemicals than commodities:

Chemicals used captively	- 3%
Commodity chemicals	- 3%
Intermediates (non-commodity)	- 5%
Commodity plastics	- 10%
Speciality chemicals, plastics, rubber	- 15%

See "Estimates of Petrochemical Costs in 1985", SRI International, Zurich, 1980.

The calculations

The aim of the cost calculations is a transfer price at which a production plant could profitably sell locally or export product, i.e. which would include some return on investment in addition to covering fixed and variable costs. Such transfer prices were developed for the study by first calculating net manufacturing cost and then the net cost of production.

Net manufacturing cost is the result of adding five groups of unit costs for the plant, i.e. \$/ton on product produced: feedstock, energy, other direct costs (utilities, other raw materials, maintenance materials, operating supplies, operating labour, maintenance labour and control laboratory), depreciation and other fixed costs (plant overhead, taxes and insurance and interest on working capital).

Adding the charges for general overhead expenses to net manufacturing cost gives the net cost of production, which is the total expenditure to produce one ton of product at a given location assuming 100 per cent load factor. Except in periods of undersupply, few petrochemical plants operate at full capacity, however. Net cost of production is therefore also calculated at 85 per cent load factor 5/ as a more realistic level, and at 65 per cent load factor to show the impact of lower operating levels on costs. Low operating levels frequently occur in developing countries during the first years after commissioning.

To analyse competitivity it is necessary to make assumptions concerning the internal rate of return on investment. No interest rates, it may be noted, are applied to the fixed capital. Fixed investment charges in the net cost of production are therefore solely accounted for by depreciation. In lieu of interest, a pre-tax return of 25 per cent corresponds to the expectations of petrochemical companies in industrialized countries and also

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5/ Production costs at reduced load factor are higher because a lower output has to bear the same fixed costs. Unit cost is calculated using the following relationships:

at 85% load factor: $$NCP(85) = NRM - \frac{0.91\ U + FC}{0.85}$$

at 65% load factor: $$NCP(65) = NRM - \frac{0.79\ U + FC}{0.65}$$

where NRM = net raw material cost (raw materials - less by-product credit)
U = utilities cost
FC = fixed cost.

The assumption that if the plant is turned down to 85 and 65% of full capacity utilities consumption will drop to 0.91 and 0.79, respectively, is arbitrary.

some organizations in developing countries. In the interests of industrialization, downstream employment etc., some developing countries are prepared to invest domestically on terms much less stringent. The expectations of these countries are reflected in a pre-tax return of 5 per cent.

In the summary charts (annexes G and H), transfer prices in dollars per ton are thus computed for each product at each location at both rates of return and at 85 per cent load factor.

Deducting depreciation from net cost of production gives the cash cost cost of production which is the actual cash outlay per ton of product. This is often considered the minimum price at which the plant could operate without suffering immediate cash flow problems.[6]

6/ Some plant accountants also calculate the marginal cost of production. This includes only raw materials, utilities and by-product credits. Sometimes small lots of product are sold at prices between this marginal cost and the net cash cost.

Annex II.F.1.

PRICES OF FEEDSTOCKS, BY-PRODUCTS, UTILITIES AND OPERATING LABOUR AT SIX LOCATIONS (1980)

INPUT	UNITS	DEVELOPED COUNTRIES			DEVELOPING COUNTRIES		
		U.S. Gulf Coast	F.R.G.	Japan	Indonesia	Mexico	Qatar
FEEDSTOCK[a]							
ethane	$/t	215[a]	-	-	25[c]	56.5[a]	25[c]
L P G	$/t	-	-	-	-	-	-
ethane-propane	$/t	198[a]	-	-	90[c]	90[c]	90[c]
naphtha	$/t	280[a]	326[a]	344[a]	-	-	-
gas oil	$/t	245[a]	280[a]	295[a]	-	-	-
benzene	$/t	493[a]	564[a]	732[a]	500[c]	326[a]	500[c]
ethylene oxide	$/t	792[a]	984[a]	1140[a]	1515[b]	995[b]	1130[b]
ethylene	$/t	529[a]	754[a]	864[a]	640[b]	440[a]	480[b]
methane	$/t	228[a]	223[a]	314[a]	25	25.8[a]	25[c]
propylene (polymer grade)	$/t	441[a]	463[a]	672[a]	485[c]	315[a]	400[c]
styrene	$/t	788[a]	937[a]	1170[a]	1300[b]	652[a]	1090[b]
vinyl chloride (VCM)	$/t	485[a]	611[a]	836[a]	1214[b]	421[a]	865[b]
ethyl benzene	$/t	566[a]	687[a]	843[a]	885[b]	595	765[b]
chlorine	$/t	160[a]	156[a]	203[a]	350[b]	275[b]	220[b]
salt	$/t	11[a]	11.5[a]	24.9[a]	11[c]	11[c]	11[c]
ammonia	$/t	135-145[a]	200-220[a]	462[a]	320[b]	68[a]	240[b]
p-xylene	$/t	617[a]	714[a]	851[a]	625[c]	544[a]	695[c]
butadiene	$/t	705[a]	661[a]	728[a]	535[b]	500[c]	520[c]
dimethyl terephthalate (DMT)	$/t	705[a]	675[a]	1020[a]	1715[b]	1170	1315[b]
ethylene glycol	$/t	750[a]	743[a]	908[a]	215[b]	635[b]	
terephthalic acid (TPA)	$/t	772[a]	902[a]	1020[a]	1660[b]	1160[b]	1300[b]
FUEL (natural gas)	$1/ton cal.	0.0159[a]	0.0182[a]	0.0226[a]	0.001785[a]	0.001563[a]	0.00119[a]
BY-PRODUCTS							
propylene, chemical grade	$/t	419[a]	441[a]	659[a]	470[c]	300[c]	400[c]
C-4 fraction	$/t	544[a]	542[a]	608[a]	445[c]	400[c]	320[c]
pyrolysis gasoline	$/t	288[a]	337[a]	400[a]	290[c]	210[c]	235[c]
fuel oil	$/t	183[a]	210[a]	210[a]	-	-	-
caustic soda	$/t	165[a]	273[a]	309[a]	220[c]	120[c]	190[c]
sulfuric acid (65 pct)	$/t	26.9[a]	17.4[a]	23.8[a]	-	-	-
hydrogen (as fuel)	cts/ton cal	1.59[a]	1.55[a]	2.26[a]	0.238[c]	0.179[c]	0.119[c]
residual fuel	cts/ton cal	1.59[a]	1.55[a]	2.26[a]	0.238[c]	0.179[c]	0.119[c]
steam	$/t	14.11[a]	16.20[a]	18.19[a]	1.5[c]	1.59[c]	2.25[c]
diethylene glycol	$/t	694[a]	758[a]	908[a]	470[c]	300[c]	-
triethylene glycol	$/t	1040[a]	1190[a]	1190[a]	...[d]	...[d]	4.83[d]
propylene oxide	$/t	772[a]	772[a]	1240[a]	...[d]	...[d]	4.83[d]
propylene (dilute)	$/t	220[a]	220[a]	254[a]	...[d]	...[d]	
benzene	$/t	493[a]	564[a]	732[a]	535[c]	326[c]	550[c]
toluene	$/t	366-404[a]	467[a]	670[a]	492[c]	283[c]	507[c]
purge ethylene	$/t	476[a]	679[a]	778[a]	575[c]	395[c]	430[c]
UTILITIES							
cooling water	$/t	0.0139	0.0148	0.0317	0.012	0.0113	0.04
steam	$/t	14.11	16.20	18.51	1.5	1.59	2.25
process water	$/t	0.159	0.0629	0.317	0.80	0.489	0.30
electricity	mills/Kwh	32.40	42.90	68.20	30.0	26	10.00
inert gas	Cts/Nm^3	2.61	6.31	8.66	20.0	-	30.0
OPERATING LABOUR	$1/h	15.40	17.25	13.40	2.61	6.35	10.44

a/ Market price b/ calculated price at 25% ROI, 85% load factor c/ UNIDO estimate d/ fuel value

Annex II.F.2

ESTIMATED PRICES OF FEEDSTOCKS, BY-PRODUCTS, UTILITIES AND OPERATING LABOUR AT SIX LOCATIONS (1985)

INPUT	UNITS	DEVELOPED COUNTRIES			DEVELOPING COUNTRIES			
		U.S. Gulf Coast	F.R.G.	Japan	Algeria	Indonesia	Mexico	Qatar
FEEDSTOCK[a]								
ethane	$/t	350	-	-		100	70	100
L P G	$/t	-	-	-		-	-	-
ethane-propane	$/t	326	375	375		135	135	135
naphtha	$/t	439	445	379				
gas oil	$/t	353	353	353				
benzene	$/t	628	670	664		483	396	480
ethylene oxide	$/t							
ethylene	$/t							
methane	$/t	344	387	381		100	100	100
propylene (polymer grade)	$/t	582	582	595		403	141	396
styrene	$/t							
vinyl chloride (VCM)	$/t							
ethyl benzene	$/t							
chlorine	$/t							
salt	$/t	13.4	13.9	30.3		13.4	68	13.4
ammonia	$/t							
p-xylene	$/t	752	811	745		544	660	588
butadiene	$/t	908	994	992		729	606	725
dimethyl terephthalate (DMT)	$/t							
ethylene glycol	$/t							
terephthalic acid (TPA)	$/t							
FUEL	$/ton cal	0.0262	0.0290	0.0286		0.002224	0.001948	0.00148
BY-PRODUCTS								
propylene, chemical grade	$/t	551	551	564		388	126	374
C-4 fraction	$/t	608	798	796		-	442	-
pyrolysis gasoline	$/t	527	498	481		346	381	353
fuel oil	$/t	265	294	290			185	200
caustic soda	$/t	201	333	376		268	474	230
sulfuric acid (65 pct)	$/t	32.7	21.2	29		-	-	-
hydrogen (as fuel)	cts/ton cal	2.62	2.9	2.86		0.2224	0.1948	0.148
residual fuel	cts/ton cal	2.62	2.9	2.86		0.2224	0.1948	0.148
steam	$/t	21-47	24.05	23.74		1.87	1.98	2.80
diethylene glycol	$/t	845	923	1110		6.02	185	190
triethylene glycol	$/t	1260	1450	1450		6.02	185	190
propylene oxide	$/t	939	939	1500		-	-	-
propylene (dilute)	$/t	268	268	308		212	61	171
benzene	$/t	628	670	664		483	396	480
toluene	$/t	446	569	815		597	342	406
purge ethylene	$/t							
residual gas	$/G cal					2.96		
methanol	$/t	365						
recovered catalyst	$/t	2320	2670	2670		2900	2900	2900
UTILITIES								
cooling water	$/t	0.019	0.0193	0.037		0.015	0.0141	0.049
steam	$/t	21.47	24.03	23.74		1.87	1.98	2.80
process water	$/t	0.0581	0.0845	0.359		1.00	0.609	0.374
electricity	mills/kWh	32.4	42.9	69.3		37.4	32.4	12.5
inert gas	cts/Nm^3	2.61	6.87	5.9		25.0	12.46	37.4
OPERATING LABOUR	$/h	15.80	17.70	13.75		2.68	6.52	10.71

Table II.F.3

Utilities consumption in petrochemical products (per ton of product)
(1980)

	Feedstock		Fuel	Electricity	Steam	Cooling water
	Type	ton/ton	million kcal/ton	kWh/ton	ton/ton	cu m/ton
Amonia	natural gas	0.4180	3.528	18	-	239
	naphtha	0.5841	3.556	17	-	242
DMT	p-xylene	0.63	1.500	417	1.5	73
Ethyl benzene	(ethylene	0.270)		8.8	+1.30	8.7
	(benzene	0.743)	-0.106		-0.92 a/	
Ethylene	ethane	1.21				
Ethylene-propylene-butadiene-benzene	ethane-propane	1.56	944	40	2.1	221
	naphtha	3.17	-	79	-0.12 a/	280
	gas oil	3.904	-	99	0.84	304
Ethylene glycol	ethylene oxide	0.746	-	79	1.1	36
Ethylene oxide	ethylene	0.957	-	862	-4.6 a/	272
HDPE	ethylene	1.009	-	547	0.02	122
LDPE	ethylene	1.06	-	1113	-1.2 a/	132
LLDPE	ethylene	0.9271	0.5556	276	-	0.88
Methanol	natural gas	0.427	3.361	33	1.1	128
		0.525	4.194	40	-	125
Polyethylene terephthalate (PET)	(TPE	0.8563)	1.556	163	1.1	54
	(Ethylene glycol)	0.3594)				
Polyethylene terephthalate (PET)	(DMT	1.001)	0.994	165	1.4	53
	(ethylene glycol)	0.3594)				
Polypropylene	propylene	1.02	-	913	0.08	159
Polystyrene	styrene	1.02	-	106	0.41	27
PVC	VCM	1.025	-	390	3.5	233
SBR	(butadiene	0.728)	-	591	1.2	69
	(styrene	0.223)				
Styrene	ethyl benzene	1.148	1.000	77	4.2	88
Terephthalic acid (TPh)	p-xylene	0.672	2.222	650	1.7	193
Urea	ammonia	0.57	-	22	0.93	78
VCM	(ethylene	0.475)	3.222	71	1.8	183
	(chlorine	0.606)				

a/ Credit

Annex II.G Table 1. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ammonia from methane PLANT SIZE: 430,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	methane		methane		methane		methane		methane		methane	
FEEDSTOCK PRICE, $/ton	228.00 e/		223.00 e/		314.00 e/		25.00 f/		25.86 e/		25.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	125.70		144.60		113.20		264.00		157.12		188.55	
WORKING CAPITAL, $ million	12.42		13.19		16.22		10.04		6.70		7.97	
UNIT INVESTMENT COST, $ million/ton/a	292.3		336.3		263.2		613.9		365.4		438.5	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	95.44	41.5	93.35	38.1	131.44	44.7	10.46	7.4	10.82	11.6	10.46	9.4
ENERGY	56.10	24.4	64.21	26.2	49.73	27.1	6.30	4.4	5.51	5.9	4.20	3.8
BY-PRODUCT												
OTHER DIRECT COSTS b/	21.49	9.3	23.31	9.5	26.80	9.1	46.85	28.8	27.35	29.3	35.34	31.7
GENERAL OVERHEAD	10.94	4.8	11.67	4.8	14.01	4.8	3.46	2.4	2.28	2.4	2.72	2.4
OTHER FIXED COSTS c/	16.53	7.2	18.83	7.7	16.00	5.4	19.40	13.7	10.83	11.6	14.90	13.4
NET CASH COST	200.49	87.3	211.36	86.3	267.98	91.1	80.47	56.7	56.80	60.9	67.61	66.7
DEPRECIATION d/	29.23	12.7	33.63	13.7	26.33	8.9	61.40	43.3	36.54	39.1	43.85	39.3
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	229.73	100.0	244.99	100.0	294.31	100.0	141.87	100.0	93.34	100.0	111.46	100.0
AT 85% LOAD FACTOR	244.23		261.39		309.17		164.28		107.65		128.79	
AT 65% LOAD FACTOR	271.30		291.95		336.60		206.91		133.66		161.00	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	258.84		278.20		322.34		194.98		125.92		150.71	
WITH 25% ROI	317.31		345.46		374.99		317.77		199.00		238.41	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Table 2. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ammonia from naphtha   PLANT SIZE: 430,000 ton/year

LOCATION		F.R.G.		JAPAN				
FEEDSTOCK		naphtha		naphtha				
FEEDSTOCK PRICE, $/ton		326.00[e]		344.00[e]				
LOCATION FACTOR		1.15		0.90				
FIXED CAPITAL COST,[a] $ million		164.80		129.00				
WORKING CAPITAL, $ million		16.23		20.72				
UNIT INVESTMENT COST, $ million/ton/a		383.2		300.0				
PRODUCTION COST:		$/ton	%	$/ton	%			
FEEDSTOCK		136.46	45.3	200.93	53.3			
ENERGY		64.21	21.3	80.37	21.3			
BY-PRODUCT								
OTHER DIRECT COSTS[b]		26.15	8.7	28.97	7.7			
GENERAL OVERHEAD		14.35	4.8	17.95	4.8			
OTHER FIXED COSTS[c]		21.89	7.3	18.77	5.0			
NET CASH COST		263.07	87.3	346.99	92.0			
DEPRECIATION[d]		38.33	12.7	30.00	8.0			
NET COST OF PRODUCTION (NCP)								
AT 100% LOAD FACTOR		301.39	100.0	376.99	100.0			
AT 85% LOAD FACTOR		320.44		394.38				
AT 65% LOAD FACTOR		355.81		426.34				
TRANSFER PRICE AT 85% LOAD FACTOR								
WITH 5% ROI		339.60		409.38				
WITH 25% ROI		416.25		469.38				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G

Table 3. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

methanol transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: DMT PLANT SIZE: 100,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	p-xylene		p-xylene		p-xylene		p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton	617.00[e/]		714.00[e/]		851.00[e/]		625.00[f/]		544.00[f/]		520.00[f/]	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST,[a/] $ million	110.25		126.80		99.17		231.52		137.81		1[illegible].37	
WORKING CAPITAL, $ million	10.40		11.78		13.73		15.37		11.16		12.19	
UNIT INVESTMENT COST, $ million/ton/a	1102.5		1268.0		991.7		2315.2		1378.1		1853.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	388.71	47.3	449.82	48.4	536.13	50.2	393.75	41.6	342.72	48.9	327.60	43.6
ENERGY	23.85	2.9	27.30	2.9	33.90	3.2	2.68	0.3	2.34	0.3	1.78	0.2
BY-PRODUCT	-	-	-	-	-	-	-	-	-	-	-	-
OTHER DIRECT COSTS[b/]	194.47[g/]	23.7	206.46[g/]	22.2	286.01[g/]	26.8	214.95[h/]	22.7	146.94[h/]	21.0	172.18[h/]	22.9
GENERAL OVERHEAD	39.12	4.8	44.24	4.8	50.90	4.8	23.10	2.4	17.10	2.4	18.32	2.4
OTHER FIXED COSTS[c/]	65.17	7.9	74.48	8.0	62.81	5.9	81.03	8.5	54.13	7.7	66.05	8.8
NET CASH COST	711.33	86.6	802.30	86.3	969.75	90.7	715.50	75.5	563.24	80.3	585.94	78.0
DEPRECIATION[d/]	110.25	13.4	126.80	13.6	99.17	9.3	231.52	24.4	137.81	19.6	165.37	22.0
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	821.58	100.0	929.10	100.0	1,068.92	100.0	947.02	100.0	701.05	100.0	751.31	100.0
AT 85% LOAD FACTOR	989.38		1,099.58		1,325.62		1,137.35		826.76		900.46	
AT 65% LOAD FACTOR	1,129.68		1,253.79		1,493.60		1,333.25		952.56		1,050.91	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1,044.50		1,162.98		1,375.20		1,253.11		895.66		983.14	
WITH 25% ROI	1,265.00		1,416.58		1,573.54		1,716.15		1,171.28		1,313.88	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes methanol at market prices: U.S., $ 237/ton; Japan, $ 432/ton; Mexico, $ 160/ton.

h/ Includes methanol at calculated price: Far East $ 223/ton; Arabian Gulf, $ 172/ton.

g/ FRG, $ 223/ton

Annex II.G Table 4. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

methanol transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: DMT PLANT SIZE: 100,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton				625.00[f/]		530.00[e/]		520.00[f/]	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a/] $ million				231.52		137.81		165.37	
WORKING CAPITAL, $ million				14.36		10.45		11.46	
UNIT INVESTMENT COST, $ million/ton/a				2315.2		1378.1		1853.7	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				393.75	43.3	333.90	49.8	327.60	45.1
ENERGY				2.68	0.3	2.34	0.3	1.78	0.2
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS[b/]				181.46[g/]	19.9	127.16[g/]	19.0	147.82[g/]	20.4
GENERAL OVERHEAD				22.24	2.4	16.37	2.4	17.70	2.4
OTHER FIXED COSTS[c/]				80.02	8.8	53.42	8.0	65.32	9.0
NET CASH COST				680.14	74.6	533.20	79.5	560.22	77.2
DEPRECIATION[d/]				231.52	25.4	137.81	20.5	165.03	22.8
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				911.66	100.0	671.01	100.0	725.59	100.0
AT 85% LOAD FACTOR				1,062.27		773.19		845.84	
AT 65% LOAD FACTOR				1,245.37		891.31		986.98	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				1,178.03		842.09		928.52	
WITH 25% ROI				1,641.07		1,117.71		1,259.26	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes methanol at calculated price: Far East, $ 137/ton; Mexico, $ 93/ton; Arabian Gulf, $ 111/ton.

Annex II.G Table 5. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: ethyl benzene PLANT SIZE: 290,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				benzene		benzene		benzene	
FEEDSTOCK PRICE, $/ton				500.00 f/		318.00 f/		500.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				64.16		38.18		45.82	
WORKING CAPITAL, $ million				25.95		16.56		23.76	
UNIT INVESTMENT COST, $ million/ton/a				221.2		136.6		158.0	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				371.50	69.9	263.27	69.4	371.50	73.5
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-1.63	-0.3	-1.65	-0.5	-2.20	-0.4
OTHER DIRECT COSTS b/				115.98 g/	21.6	74.51 g/	21.9	94.25 g/	18.6
GENERAL OVERHEAD				13.06	2.4	8.30	2.4	12.32	2.4
OTHER FIXED COSTS c/				14.44	2.7	9.76	2.9	13.45	2.7
NET CASH COST				513.35	95.9	327.30	96.1	489.33	96.9
DEPRECIATION d/				22.12	4.1	13.17	3.9	15.80	3.1
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				535.47	100.0	340.36	100.0	505.13	100.0
AT 85% LOAD FACTOR				669.18		424.36		610.47	
AT 65% LOAD FACTOR				728.47		462.04		658.68	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				680.24		430.95		618.37	
WITH 25% ROI				724.49		457.28		649.97	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes ethylene at: Far East, $1375/ton; Mexico, $282/ton, Arabian Gulf, $290/ton.

Annex II.G

Table 6. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: ethyl benzene PLANT SIZE: 290,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	benzene		benzene		benzene		benzene		benzene		benzene	
FEEDSTOCK PRICE, $/ton	493.00 e/		564.00 e/		732.00 e/		500.00 f/		326.00 e/		500.00 f/	
LOCATION FACTOR	1.0		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	30.55		30.35		23.82		64.15		38.18		45.82	
WORKING CAPITAL, $ million	23.12		27.93		34.20		32.19		21.72		28.22	
UNIT INVESTMENT COST, $ million/ton/a	105.3		105.3		82.1		221.2		131.6		158.0	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	366.30	63.9	419.05	60.2	543.88	63.6	371.50	60.9	242.22	59.7	371.50	66.5
ENERGY												
BY-PRODUCT	-14.67	-2.6	-16.55	-2.4	-19.13	-2.2	-1.63	-0.3	-1.65	-0.4	-2.20	-0.4
OTHER DIRECT COSTS b/	170.19 g/	29.7	234.29 g/	33.7	265.37 g/	31.0	186.88 h/	30.6	130.48 h/	32.2	144.91 h/	25.9
GENERAL OVERHEAD	27.29	4.8	33.12	4.8	40.72	4.8	14.89	2.4	9.89	2.4	13.63	2.4
OTHER FIXED COSTS c/	13.38	2.3	15.14	2.2	16.02	1.9	16.59	2.7	11.54	2.8	14.99	2.7
NET CASH COST	562.48	98.1	685.06	98.5	846.85	99.0	588.22	96.4	392.48	96.7	542.83	97.2
DEPRECIATION d/	10.53	1.8	10.47	1.5	8.21	1.0	22.12	3.6	13.17	3.2	15.80	2.8
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	573.01	100.0	695.53	100.0	855.06	100.0	610.34	100.0	405.65	100.0	558.63	100.0
AT 85% LOAD FACTOR	755.79		951.73		1,146.92		828.16		556.09		724.07	
AT 65% LOAD FACTOR	831.83		1,053.07		1,261.10		914.55		615.25		791.65	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	761.05		956.96		1,151.03		839.22		562.67		731.97	
WITH 25% ROI	782.12		977.89		1,167.46		883.46		589.00		763.57	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Ethylene at local market price (U.S., $529/ton; FRG, $754/ton, Japan, $864/ton).

h/ Ethylene at UNIDO assumed price with 25% ROI Far East, $1640/ton; Mexico, $1440/ton; Arabian Gulf, $480/ton).

Annex II.G Table 7. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: **ethylene from ethane** PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethane				ethane		ethane		ethane	
FEEDSTOCK PRICE, $/ton	215.00 e/				25.00 f/		56.52 e/		25.00 f/	
LOCATION FACTOR	1.00				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	315.30				662.13		394.12		473.00	
WORKING CAPITAL, $ million	37.89				23.57		18.24		18.56	
UNIT INVESTMENT COST, $ million/ton/a	630.6				1324.3		788.2		946.0	
PRODUCTION COST:	$/ton	%			$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	264.45	59.4			30.75	11.5	69.52	32.2	30.75	14.5
ENERGY	88.88	20.0			9.98	3.7	8.74	4.0	6.65	3.1
BY-PRODUCT	-61.98	-13.9			-13.54	-5.1	-10.07	-4.7	-9.21	-4.3
OTHER DIRECT COSTS b/	34.51	7.7			60.50	22.7	38.79	17.9	54.19	25.6
GENERAL OVERHEAD	21.18	4.8			6.50	2.4	5.27	2.4	5.17	2.4
OTHER FIXED COSTS c/	34.71	7.8			39.88	15.0	25.04	11.6	29.86	14.1
NET CASH COST	381.75	85.8			134.06	50.3	137.29	63.5	117.42	55.4
DEPRECIATION d/	63.06	14.2			132.43	49.7	78.82	36.5	94.60	44.6
NET COST OF PRODUCTION (NCP)										
AT 100% LOAD FACTOR	444.81	100.0			266.49	100.0	216.11	100.0	212.02	100.0
AT 85% LOAD FACTOR	472.30				309.20		242.74		243.03	
AT 65% LOAD FACTOR	526.63				394.76		295.30		306.64	
TRANSFER PRICE AT 85% LOAD FACTOR										
WITH 5% ROI	563.83				375.41		282.15		290.33	
WITH 25% ROI	629.95				640.26		439.80		479.53	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Table 8. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ethylene from ethane-propane PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethane-propane				ethane-propane		ethane-propane		ethane-propane	
FEEDSTOCK PRICE, $/ton	198.06 e/				95.00 f/		95.00 f/		95.00 f/	
LOCATION FACTOR	1.00				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	327.11				686.93		408.88		490.66	
WORKING CAPITAL, $ million	43.10				41.52		30.65		35.02	
UNIT INVESTMENT COST, $ million/ton/a	654.2				1373.8		817.8		981.3	
PRODUCTION COST:	$/ton	%			$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	308.88	73.8			148.20	46.9	148.20	60.4	148.20	53.8
ENERGY	15.01	3.6			1.69	0.5	1.40	0.6	1.12	0.4
BY-PRODUCT	-95.78	-22.9			-96.67	-30.6	-69.36	-28.3	-78.44	-28.4
OTHER DIRECT COSTS b/	66.81	16.0			71.37	22.6	47.26	19.3	63.69	23.1
GENERAL OVERHEAD	19.93	4.8			7.71	2.4	5.98	2.4	6.72	2.4
OTHER FIXED COSTS c/	38.32	9.1			46.51	14.7	29.95	12.2	36.22	13.1
NET CASH COST	353.17	84.4			178.80	56.5	163.50	66.7	177.52	64.4
DEPRECIATION d/	65.42	15.6			137.39	43.4	81.78	33.3	98.13	35.6
NET COST OF PRODUCTION (NCP)										
AT 100% LOAD FACTOR	418.19	100.0			316.19	100.0	245.28	100.0	275.65	100.0
AT 85% LOAD FACTOR	449.35				362.56		274.50		311.06	
AT 65% LOAD FACTOR	510.82				455.64		332.39		381.66	
TRANSFER PRICE AT 85% LOAD FACTOR										
WITH 5% ROI	482.06				431.26		315.39		360.13	
WITH 25% ROI	612.91				706.03		478.94		556.39	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 9. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ethylene from gas oil PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN				
FEEDSTOCK	gas oil		gas oil		gas oil				
FEEDSTOCK PRICE, $/ton	245.00 e/		280.15 e/		295.00 e/				
LOCATION FACTOR	1.00		1.15		0.90				
FIXED CAPITAL COST, a/ $ million	463.62		533.18		417.32				
WORKING CAPITAL, $ million	153.22		170.55		193.49				
UNIT INVESTMENT COST, $ million/ton/a	927.2		1066.4		834.6				
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%			
FEEDSTOCK	956.48	198.2	1,093.12	182.2	1,151.68	270.5			
ENERGY	–	–	–	–	–	–			
BY-PRODUCT	-725.09	-150.2	-783.78	-130.6	-970.80	-229.5			
OTHER DIRECT COSTS b/	64.38	13.3	74.93	12.5	74.74	17.5			
GENERAL OVERHEAD	22.98	4.8	28.57	4.8	20.31	4.8			
OTHER FIXED COSTS c/	71.11	14.7	80.56	13.4	75.06	17.			
NET CASH COST	389.87	80.8	493.40	82.2	342.99	80.4			
DEPRECIATION d/	92.72	19.2	106.64	17.8	83.46	19.6			
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR	482.59	100.0	600.04	100.0	426.45	100.0			
AT 85% LOAD FACTOR	527.40		652.35		471.13				
AT 65% LOAD FACTOR	613.98		752.46		555.58				
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI	573.76		705.66		512.86				
WITH 25% ROI	759.21		918.94		679.79				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 10. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ethylene from naphtha PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN				
FEEDSTOCK	naphtha		naphtha		naphtha				
FEEDSTOCK PRICE, $/ton	280.00[e/]		326.00[e/]		344.00[e/]				
LOCATION FACTOR	1.00		1.15		0.90				
FIXED CAPITAL COST,[a/] $ million	421.23		484.41		379.10				
WORKING CAPITAL, $ million	130.65		147.00		166.49				
UNIT INVESTMENT COST, $ million/ton/a	842.5		968.8		758.2				
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%			
FEEDSTOCK	887.60	169.1	1,033.42	156.6	1,090.48	210.4			
ENERGY	-	-	-	-	-	-			
BY-PRODUCT	-568.99	-110.3	-625.69	-94.8	-789.38	-152.3			
OTHER DIRECT COSTS[b/]	43.76	8.3	52.21	7.9	50.13	9.7			
GENERAL OVERHEAD	24.99	4.8	31.43	4.8	24.68	4.8			
OTHER FIXED COSTS[c/]	63.16	12.0	71.8	10.9	66.49	12.8			
NET CASH COST	440.52	83.9	563.17	85.3	442.40	85.4			
DEPRECIATION[d/]	84.25	16.1	96.88	14.7	75.82	14.6			
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR	524.76	100.0	660.05	100.0	518.22	100.0			
AT 85% LOAD FACTOR	562.32		705.56		556.73				
AT 65% LOAD FACTOR	639.37		795.42		632.24				
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI	604.45		754.00		594.64				
WITH 25% ROI	772.94		947.76		746.28				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 11. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene oxide transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: ethylene glycol PLANT SIZE: 150,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide	
FEEDSTOCK PRICE, $/ton	750.00 e/		948.00 e/		1,140.00 e/		1,515.00		633.00 e/		1,130.00	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	29.25		33.68		26.34		61.42		36.56		43.87	
WORKING CAPITAL, $ million	13.05		16.28		19.19		25.36		11.39		19.22	
UNIT INVESTMENT COST, $ million/ton/a	195.0		224.5		175.6		409.5		243.7		292.5	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	559.50	83.9	707.21	84.8	850.44	86.7	1,130.19	89.6	472.22	85.4	842.98	88.7
ENERGY	-	-	-	-	-	-	-	-	-	-	-	-
BY-PRODUCT	-3.61	-0.5	-3.94	-0.5	-4.72	-0.5	-2.44	-0.2	-1.56	-0.3	-2.08	-0.2
OTHER DIRECT COSTS b/	38.94	5.8	44.33	5.3	47.49	4.8	34.07	2.7	28.40	5.1	32.35	3.4
GENERAL OVERHEAD	31.74	4.8	39.72	4.8	46.71	4.8	30.77	2.4	13.49	2.4	23.17	2.4
OTHER FIXED COSTS c/	20.55	3.1	24.28	2.9	23.40	2.4	28.15	2.2	16.23	2.9	24.31	2.5
NET CASH COST	647.12	97.1	811.59	97.3	963.31	98.2	1,220.74	96.7	528.78	95.6	920.74	96.9
DEPRECIATION a/	19.50	2.9	22.45	2.7	17.56	1.8	40.95	3.2	24.37	4.4	29.25	3.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	666.62	100.0	834.05	100.0	980.87	100.0	1,261.69	100.0	553.15	100.0	949.98	100.0
AT 85% LOAD FACTOR	690.71		862.49		1,009.43		1,292.64		575.23		976.81	
AT 65% LOAD FACTOR	726.56		905.03		1,052.21		1,339.20		603.60		1,014.92	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	705.46		873.72		1,018.21		1,313.11		587.42		991.43	
WITH 25% ROI	739.46		918.62		1,053.83		1,395.01		636.17		1,049.93	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 12. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene oxide transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: ethylene glycol PLANT SIZE: 150,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene oxide		ethylene oxide		ethylene oxide	
FEEDSTOCK PRICE, $/ton				1,251.00		787.00		943.00	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million				61.42		36.56		43.87	
WORKING CAPITAL, $ million				21.37		13.71		16.40	
UNIT INVESTMENT COST, $ million/ton/a				409.5		243.7		292.5	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				933.25	88.3	587.10	87.3	703.48	87.4
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-2.44	-0.2	-1.56	-0.2	-2.08	-0.3
OTHER DIRECT COSTS[b]				34.07	3.2	28.40	4.2	32.35	4.0
GENERAL OVERHEAD				25.78	2.4	16.40	2.4	19.64	2.4
OTHER FIXED COSTS[c]				25.50	2.4	17.78	2.6	22.43	2.8
NET CASH COST				1,016.15	96.1	648.13	96.4	775.82	96.4
DEPRECIATION[d]				40.95	3.9	24.37	3.6	29.25	3.6
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				1,057.10	100.0	672.50	100.0	805.06	100.0
AT 85% LOAD FACTOR				1,086.70		695.37		830.93	
AT 65% LOAD FACTOR				1,130.49		725.35		867.08	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				1,107.17		707.55		845.56	
WITH 25% ROI				1,189.06		756.30		904.05	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 13. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: ethylene oxide PLANT SIZE: 131,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	529.00 e/		754.00 e/		864.00 e/		640.00 f/		440.00 f/		480.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	108.00		124.23		97.19		226.81		135.01		162.01	
WORKING CAPITAL, $ million	11.35		14.65		17.30		19.35		13.24		14.71	
UNIT INVESTMENT COST, $ million/ton/a	824.4		948.3		741.9		1,731.4		1,030.6		1,236.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	506.25	71.6	721.58	78.0	826.85	79.1	612.48	61.3	421.08	62.2	459.36	60.9
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS b/	30.60	4.3	2.64	0.3	42.54	4.1	123.73	12.4	92.50	13.7	98.04	13.0
GENERAL OVERHEAD	33.60	4.8	44.03	4.8	49.81	4.8	24.38	2.4	16.52	2.4	18.39	2.4
OTHER FIXED COSTS c/	52.62	7.4	61.55	6.6	52.52	5.0	65.66	6.6	44.33	6.5	54.59	7.2
NET CASH COST	623.07	88.3	829.80	89.7	971.72	92.9	826.30	82.7	574.44	84.8	630.38	83.6
DEPRECIATION d/	82.45	11.7	94.83	10.3	74.19	7.1	173.14	17.3	103.06	15.2	123.67	16.4
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	705.52	100.0	924.63	100.0	1,045.91	100.0	999.44	100.0	677.50	100.0	754.06	100.0
AT 85% LOAD FACTOR	758.98		984.68		1,101.05		1,083.77		739.27		823.56	
AT 65% LOAD FACTOR	838.29		1,073.40		1,183.79		1,218.81		828.01		928.17	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	800.21		1,032.10		1,138.14		1,170.34		790.80		885.39	
WITH 25% ROI	965.11		1,221.78		1,286.52		1,516.61		996.92		1,132.73	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 14. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: ethylene oxide PLANT SIZE: 131,000 ton/year

ethylene transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton				375.00 f/		230.00 e/		290.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				226.81		135.01		162.01	
WORKING CAPITAL, $ million				14.78		9.63		11.44	
UNIT INVESTMENT COST, $ million/ton/a				1,731.4		1,030.6		1,236.7	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				358.87	48.8	220.11	47.0	277.53	49.1
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS b/				123.78	16.8	92.50	19.7	98.04	17.3
GENERAL OVERHEAD				17.95	2.4	11.43	2.4	13.78	2.4
OTHER FIXED COSTS c/				62.18	8.4	41.57	8.9	52.10	9.2
NET CASH COST				562.78	76.5	365.61	78.0	441.45	78.1
DEPRECIATION d/				173.14	23.5	103.06	22.0	123.67	21.9
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				735.92	100.0	468.68	100.0	565.12	100.0
AT 85% LOAD FACTOR				818.50		529.05		633.36	
AT 65% LOAD FACTOR				949.95		614.96		735.40	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				905.07		580.59		695.20	
WITH 25% ROI				1,251.34		786.71		942.54	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 15. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: HDPE PLANT SIZE: 75,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	529.00 e/		754.00 e/		864.00 e/		640.00 f/		440.00 f/		480.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	42.16		48.16		37.94		88.54		52.69		63.23	
WORKING CAPITAL, $ million	7.93		10.65		12.04		10.89		8.04		8.88	
UNIT INVESTMENT COST, $ million/ton/a	562.1		642.1		505.8		1,180.5		702.5		843.1	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	536.93	65.0	765.31	68.9	876.96	70.7	649.60	65.6	446.60	63.2	487.20	62.1
ENERGY	8.84	1.1	10.12	0.9	12.57	1.0	0.99	0.1	0.87	0.1	0.66	0.1
BY-PRODUCT												
OTHER DIRECT COSTS b/	138.83	16.8	164.02	14.8	193.55	15.6	151.53	15.3	136.09	19.3	147.48	18.8
GENERAL OVERHEAD	39.32	4.8	52.88	4.8	59.04	4.8	24.14	2.4	17.23	2.4	19.13	2.4
OTHER FIXED COSTS c/	45.49	5.5	53.86	4.8	47.06	3.8	45.42	4.6	35.58	5.0	45.46	5.8
NET CASH COST	769.42	93.2	1,046.19	94.2	1,189.17	95.9	871.68	88.1	636.38	90.0	699.94	89.2
DEPRECIATION d/	56.21	6.8	64.21	5.8	50.59	4.1	118.05	11.9	70.25	10.0	84.31	10.8
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	825.63	100.0	1,110.40	100.0	1,239.75	100.0	989.74	100.0	706.63	100.0	784.24	100.0
AT 85% LOAD FACTOR	920.55		1,212.22		1,353.01		1,108.63		812.24		896.65	
AT 65% LOAD FACTOR	1,010.85		1,326.34		1,458.37		1,222.00		898.37		996.73	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	948.66		1,251.33		1,378.31		1,167.65		847.36		938.80	
WITH 25% ROI	1,061.09		1,379.76		1,479.48		1,403.78		987.87		1,107.42	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 16. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 5 % ROI in developing countries;
developed countries at prevailing market price.

PRODUCT: HDPE PLANT SIZE: 75,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton				375.00[f]		230.00[e]		290.00[f]	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million				88.54		52.69		63.23	
WORKING CAPITAL, $ million				8.23		5.93		6.98	
UNIT INVESTMENT COST, $ million/ton/a				1,180.5		702.5		843.1	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				380.62	53.6	233.45	48.1	294.35	50.4
ENERGY				0.99	0.1	0.87	0.	0.66	0.1
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS[b]				151.53	21.3	136.09	28.0	147.48	25.3
GENERAL OVERHEAD				17.33	2.4	11.84	2.4	14.24	2.4
OTHER FIXED COSTS[c]				41.87	5.9	32.77	6.8	42.92	7.3
NET CASH COST				592.34	83.4	415.01	85.6	499.66	85.6
DEPRECIATION[d]				118.05	16.6	70.25	14.5	84.31	14.4
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				710.40	100.0	485.27	100.0	583.96	100.0
AT 85% LOAD FACTOR				827.46		589.43		695.06	
AT 65% LOAD FACTOR				937.08		672.58		792.44	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				886.49		624.55		737.21	
WITH 25% ROI				1,122.59		765.06		905.82	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Table 17. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: LDPE

PLANT SIZE: 200,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	529.00 e/		754.00 e/		864.00 e/		640.00 f/		440.00 f/		480.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	138.40		159.20		124.60		290.64		173.00		207.60	
WORKING CAPITAL, $ million	20.21		27.84		31.50		28.94		19.77		21.47	
UNIT INVESTMENT COST, $ million/ton/a	692.0		796.0		623.0		1,453.2		856.0		1,038.0	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	560.74	73.7	799.24	76.7	915.84	79.0	678.40	67.0	466.40	67.8	508.80	67.7
ENERGY												
BY-PRODUCT	-14.23	-1.9	-20.30	- 1.9	-23.26	-2.0	-	-	-	-	-	-
OTHER DIRECT COSTS b/	65.95	8.7	82.00	7.9	102.77	8.9	109.77	10.8	82.10	11.9	77.31	10.3
GENERAL OVERHEAD	36.25	4.8	49.64	4.8	55.17	4.8	24.71	2.4	16.78	2.4	18.33	2.4
OTHER FIXED COSTS c/	43.40	5.7	52.22	5.0	45.78	3.9	55.07	5.4	36.12	5.2	43.42	5.8
NET CASH COST	692.11	90.9	962.80	92.4	1,096.29	94.6	867.95	85.6	601.40	87.4	647.87	86.2
DEPRECIATION d/	69.20	9.1	79.60	7.6	62.30	5.4	145.32	14.3	86.50	12.6	103.80	13.8
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	761.31	100.0	1,042.40	100.0	1,158.59	100.0	1,013.27	100.0	687.90	100.0	751.67	100.0
AT 85% LOAD FACTOR	806.07		1,096.28		1,211.22		1,080.12		735.27		804.40	
AT 65% LOAD FACTOR	879.23		1,185.06		1,294.77		1,193.91		809.12		889.26	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	840.67		1,136.08		1,242.37		1,152.78		778.52		856.30	
WITH 25% ROI	979.07		1,295.28		1,366.97		1,443.42		951.52		1,063.90	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 18. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: LDPE PLANT SIZE: 200,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton				375.00 f/		230.00 e/		290.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				290.64		173.00		207.60	
WORKING CAPITAL, $ million				21.77		14.02		16.36	
UNIT INVESTMENT COST, $ million/ton/a				1,453.2		865.0		1,038.0	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				397.50	55.9	243.80	54.1	307.40	58.5
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-10.08	-1.4	-6.19	-1.4	-7.80	-1.5
OTHER DIRECT COSTS b/				109.77	15.4	82.10	18.2	77.31	14.5
GENERAL OVERHEAD				17.35	2.4	10.99	2.4	13.04	2.4
OTHER FIXED COSTS c/				51.49	7.2	33.25	7.4	40.87	7.6
NET CASH COST				566.03	79.6	363.90	80.8	430.81	80.6
DEPRECIATION d/				145.32	20.4	86.50	19.2	103.80	19.4
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				711.35	100.0	450.44	100.0	534.61	100.0
AT 85% LOAD FACTOR				776.27		496.28		585.97	
AT 65% LOAD FACTOR				886.09		567.00		667.98	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				848.93		539.53		637.87	
WITH 25% ROI				1,139.57		712.53		845.47	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 19. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: LLDPE - ethylene PLANT SIZE: 200,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	529.00 e/		754.00 e/		864.00 e/		640.00 f/		440.00 f/		480.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	92.70		106.00		83.00		193.62		115.24		138.30	
WORKING CAPITAL, $ million	18.46		25.07		27.87		28.20		20.88		23.12	
UNIT INVESTMENT COST, $ million/ton/a	463.5		530.0		415.0		968.1		576.0		691.5	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	490.44	67.7	699.03	71.3	801.01	74.1	593.34	64.9	407.92	62.7	445.01	61.5
ENERGY	0.88	0.1	1.01	0.1	1.26	0.1	0.10	0.1	0.09	0.1	0.07	
BY-PRODUCT												
OTHER DIRECT COSTS b/	117.54	16.2	140.10	14.3	149.00	13.8	160.90	17.6	139.89	21.5	156.38	21.6
GENERAL OVERHEAD	34.47	4.8	46.70	4.8	51.45	4.8	22.29	2.4	15.87	2.4	17.66	2.4
OTHER FIXED COSTS c/	34.27	4.7	40.86	4.2	36.25	3.	40.38	4.4	29.14	4.5	35.78	4.9
NET CASH COST	677.60	93.6	927.71	94.6	1,038.97	96.2	817.01	89.4	592.91	91.1	654.89	90.4
DEPRECIATION d/	46.35	6.4	53.00	5.4	41.50	3.8	96.81	10.6	57.62	8.8	69.15	9.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	723.95	100.0	980.71	100.0	1,080.47	100	913.82	100.0	650.53	100.0	724.04	100.0
AT 85% LOAD FACTOR	834.91		1,110.17		1,208.10		1,056.95		780.95		860.07	
AT 65% LOAD FACTOR	915.02		1,205.88		1,299.64		1,166.20		864.13		954.74	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	858.08		1,136.67		1,228.85		1,105.36		809.76		894.64	
WITH 25% ROI	950.78		1,242.67		1,311.85		1,298.98		925.00		1,032.94	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 20. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: LLDPE PLANT SIZE: 200,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton				375.00[f]		230.00[e]		290.00[f]	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million				193.62		115.24		138.30	
WORKING CAPITAL, $ million				21.57		15.63		18.36	
UNIT INVESTMENT COST, $ million/ton/a				968.1		576.0		691.5	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				347.66	52.8	213.23	47.6	268.86	46.7
ENERGY				0.10	0.0	0.09	0.0	0.07	0.0
BY-PRODUCT									
OTHER DIRECT COSTS[b]				160.90	24.4	139.89	31.2	156.38	28.9
GENERAL OVERHEAD				16.06	2.4	10.93	2.4	13.20	2.4
OTHER FIXED COSTS[c]				37.07	5.6	26.51	5.9	33.40	6.2
NET CASH COST				561.79	85.3	390.66	87.1	471.90	87.2
DEPRECIATION[d]				96.81	14.7	57.62	12.9	69.15	12.8
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				658.60	100.0	448.28	100.0	541.05	100.0
AT 85% LOAD FACTOR				800.05		577.36		675.87	
AT 65% LOAD FACTOR				905.84		657.81		768.07	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				848.45		606.17		710.45	
WITH 25% ROI				1,042.07		721.41		848.75	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Table 21. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: **methanol from methane** PLANT SIZE: 640,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	methane		methane		methane		methane		methane		methane	
FEEDSTOCK PRICE, $/ton	228.00[e]		223.00[e]		314.00[e]		25.00[f]		25.86[e]		25.00[f]	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million	131.80		151.60		118.60		276.78		164.74		197.70	
WORKING CAPITAL, $ million	19.40		20.74		25.56		10.41		7.35		8.84	
UNIT INVESTMENT COST, $ million/ton/a	205.9		236.9		185.3		432.5		257.4		308.9	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	97.38	43.4	95.24	39.7	134.11	45.9	10.68	10.8	11.04	15.8	10.68	13.0
ENERGY	53.44	23.8	61.17	25.5	75.96	26.8	6.00	6.00	5.25	7.5	4.00	4.9
BY-PRODUCT												
OTHER DIRECT COSTS[b]	29.71	13.2	34.16	14.3	37.12	12.7	23.80	24.0	17.44	25.0	24.09	29.3
GENERAL OVERHEAD	10.68	4.8	11.41	4.8	13.91	4.8	2.42	2.4	1.70	2.4	2.01	2.4
OTHER FIXED COSTS[c]	12.50	5.6	13.94	5.8	12.45	4.3	13.08	13.2	8.55	12.2	10.60	12.9
NET CASH COST	203.71	90.8	215.93	90.1	273.54	93.6	55.98	56.4	43.99	63.1	51.38	62.4
DEPRECIATION[d]	20.59	9.2	23.69	9.9	18.53	6.3	43.25	43.6	25.74	36.9	30.89	37.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	224.31	100.0	239.62	100.0	292.07	100.0	99.23	100.0	69.73	100.0	82.27	100.0
AT 85% LOAD FACTOR	236.86		254.06		305.75		115.21		80.59		95.22	
AT 65% LOAD FACTOR	259.43		279.59		327.70		144.14		99.03		117.95	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	247.12		265.90		315.02		136.83		93.46		110.67	
WITH 25% ROI	288.31		313.28		352.08		223.32		144.94		172.45	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G **Table 22.** COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: methanol from naphtha PLANT SIZE: 640,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN				
FEEDSTOCK	naphtha		naphtha		naphtha				
FEEDSTOCK PRICE, $/ton	280.00 e/		326.00 e/		344.00 e/				
LOCATION FACTOR	1.00		1.15		0.90				
FIXED CAPITAL COST, a/ $ million	143.90		165.50		129.50				
WORKING CAPITAL, $ million	23.82		26.09		29.53				
UNIT INVESTMENT COST, $ million/ton/a	224.8		258.6		202.3				
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%			
FEEDSTOCK	147.00	51.6	171.15	54.8	180.60	51.6			
ENERGY	66.68	23.4	61.17	19.6	9.78	27.1			
BY-PRODUCT									
OTHER DIRECT COSTS b/	20.03	7.0	22.39	7.2	22.74	6.5			
GENERAL OVERHEAD	13.57	4.8	14.88	4.8	16.65	4.8			
OTHER FIXED COSTS c/	15.23	5.3	17.08	5.5	14.92	4.3			
NET CASH COST	261.51	92.1	286.68	91.7	329.71	94.2			
DEPRECIATION d/	22.48	7.9	25.86	8.3	20.23	5.8			
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR	284.99	100.0	312.54	100.0	349.95	100.0			
AT 85% LOAD FACTOR	301.25		330.51		366.78				
AT 65% LOAD FACTOR	326.40		358.77		392.31				
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI	312.49		343.44		376.90				
WITH 25% ROI	357.46		395.16		417.37				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Table 23. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

DMT transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: PET from DMT

PLANT SIZE: 90,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	DMT		DMT		DMT		DMT		DMT		DMT	
FEEDSTOCK PRICE, $/ton	705.00 e/		675.00 e/		1,020.00 e/		1,715.00 f/		1,170.00 f/		1,315.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	74.50		85.60		67.00		156.45		98.12		111.75	
WORKING CAPITAL, $ million	16.09		16.00		22.02		39.13		23.74		30.26	
UNIT INVESTMENT COST, $ million/ton/a	827.8		951.1		744.4		1,738.3		1,090.2		1,241.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	705.70	59.1	675.67	56.5	1,021.02	66.9	1,716.71	65.2	1,171.17	70.0	1,316.31	64.8
ENERGY	15.80	1.3	18.09	1.5	22.46	1.5	1,77	0.1	1.55	0.1	1.18	0.0
BY-PRODUCT	-79.96	6.7	-75.24	-6.3	-145.76	-9.5			-			
OTHER DIRECT COSTS b/	350.12 g/	29.4	358.12 g/	29.9	418.29 g/	27.4	588.15 g/	22.3	298.96 g/	17.9	465.40 g/	22.9
GENERAL OVERHEAD	56.80	4.8	56.97	4.8	72.69	4.8	64.19	2.4	40.82	2.4	49.56	2.4
OTHER FIXED COSTS c/	61.50	5.2	67.70	5.6	63.35	4.1	87.09	3.3	58.35	3.5	75.52	3.7
NET CASH COST	1,109.95	93.1	1,101.31	92.1	1,452.06	95.1	2,457.92	93.4	1,570.34	93.8	1,907.98	93.9
DEPRECIATION d/	82.78	6.9	95.11	7.9	74.44	4.9	173.83	6.6	103.47	6.2	124.17	6.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1,192.73	100.0	1,196.42	100.0	1,526.50	100.0	2,631.76	100.0	1,673.81	100.0	2,032.15	100.0
AT 85% LOAD FACTOR	1,566.10		1,569.91		1,971.18		3,304.55		2,003.66		2,545.80	
AT 65% LOAD FACTOR	1,759.87		1,772.14		2,190.00		3,632.43		2,183.17		2,801.43	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1,607.49		1,617.64		2,008.40		3,391.47		2,055.39		2,607.88	
WITH 25% ROI	1,773.04		1,807.68		2,157.29		3,739.13		2,262.32		2,856.21	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes ethylene glycol at: U.S. Gulf, $75/ton; FRG, $743/ton; Japan, $908/ton; Far East $1395/ton; Mexico, $919/ton; Arabian Gulf, $1050/ton.

Annex II.G Table 24. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: PET from DMT PLANT SIZE: 90,000 ton/year

DMT transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

LOCATION	FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	DMT		DMT		DMT	
FEEDSTOCK PRICE, $/ton	1,178.00 f/		842.00 f/		928.00 f/	
LOCATION FACTOR	2.10		1.25		1.50	
FIXED CAPITAL COST,a/ $ million	156.45		93.12		111.75	
WORKING CAPITAL, $ million	29.74		20.32		25.94	
UNIT INVESTMENT COST, $ million/ton/a	1,738.3		1,090.2		1,241.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1,179.18	60.1	842.84	62.2	928.93	56.5
ENERGY	1.17	.2	1.55	0.1	1.18	0.1
BY-PRODUCT			-0.52	-0.0		
OTHER DIRECT COSTS b/	482.33 g/	24.6	320.07 g/	23.6	479.77 g/	29.2
GENERAL OVERHEAD	47.84	2.4	33.05	2.4	40.12	2.4
OTHER FIXED COSTS c/	76.66	3.9	54.56	4.0	70.72	4.3
NET CASH COST	1,787.79	91.1	1,251.55	92.4	1,520.72	92.5
DEPRECIATION d/	173.83	8.9	103.47	7.6	124.17	7.5
NET COST OF PRODUCTION (NCP)						
AT 100% LOAD FACTOR	1,961.62	100.0	1,355.02	100.0	1,644.89	100.0
AT 85% LOAD FACTOR	2,505.20		1,707.66		2,172.93	
AT 65% LOAD FACTOR	2,785.08		1,890.62		2,428.61	
TRANSFER PRICE AT 85% LOAD FACTOR						
WITH 5% ROI	2,592.11		1,759.39		2,235.01	
WITH 25% ROI	2,939.78		1,966.33		2,483.35	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes ethylene glycol at: Far East, $1313/ton; Mexico, $870/ton; Arabian Gulf, $991/ton.

Annex II.G Table 25. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

TPA transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: PET from TPA PLANT SIZE: 90,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	TPA		TPA		TPA		TPA		TPA		TPA	
FEEDSTOCK PRICE, $/ton	772.00 e/		902.00 e/		1,020.00 e/		1,660.00 f/		1,160.00 f/		1,300.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	60.95		70.18		54.93		127.99		74.93		91.42	
WORKING CAPITAL, $ million	13.81		15.49		17.29		34.81		21.04		27.25	
UNIT INVESTMENT COST, $ million/ton/a	677.2		779.8		610.3		1,422.1		832.5		1,015.8	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	661.06	54.8		57.2	873.43	58.2	1,421.46	62.5	993.31	68.3	1.113.19	62.4
ENERGY	24.74	2.1	28.32	2.1	35.17	2.3	2.78	0.1	2.43	0.2	1.85	0.1
BY-PRODUCT	-	-	-	-	-	-	-	-	-	-	-	-
OTHER DIRECT COSTS b/	340.38 g/	28.2	346.51 g/	25.7	407.35 g/	27.1	576.86 g/	25.4	289.12 g/	19.9	456.83 g/	25.6
GENERAL OVERHEAD	57.39	4.8	64.31	4.8	71.52	4.8	55.47	2.4	35.48	2.4	43.52	2.4
OTHER FIXED COSTS c/	53.96	4.5	61.1	4.5	53.52	3.6	75.48	3.3	51.24	3.5	67.47	3.8
NET CASH COST	1,137.54	94.4	1,272.63	94.2	1,440.98	95.9	2,132.04	93.7	1,371.59	94.3	1,682.86	94.3
DEPRECIATION d/	67.72	5.6	77.98	5.8	61.03	4.1	142.21	6.2	83.26	5.7	101.58	5.7
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1,205.26	100.0	1,350.61	100.0	1,502.01	100.0	2,274.25	100.0	1,454.84	100.0	1,784.44	100.0
AT 85% LOAD FACTOR	1,572.18		1,718.18		1,939.54		2,934.31		1,773.25		2,288.55	
AT 65% LOAD FACTOR	1,755.40		1,911.35		2,146.77		3,239.41		1,937.48		2,527.94	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1,606.04		1,757.17		1,970.05		3,005.42		1,814.87		2,339.34	
WITH 25% ROI	1,741.49		1,913.12		2,092.12		3,289.84		1,981.38		2,542.49	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes ethylene glycol at: U.S. Gulf, $75/ton; FRG, $743/ton; Japan, $908/ton; Far East $1395/ton; Mexico, $919/ton; Arabian Gulf, $1050/ton.

Annex II.G   Table 26. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

TPA transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: PET from TPA   PLANT SIZE: 90,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				TPA		TPA		TPA	
FEEDSTOCK PRICE, $/ton				1,202.00 f/		876.00 f/		972.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				127.99		74.93		91.42	
WORKING CAPITAL, $ million				26.93		18.74		21.78	
UNIT INVESTMENT COST, $ million/ton/a				1,422.1		832.5		1,015.8	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				1,029.27	59.0	750.12	61.1	832.32	58.9
ENERGY				2.78	0.2	2.43	0.2	1.85	0.1
BY-PRODUCT				-		-		-	
OTHER DIRECT COSTS b/				461.36 g/	26.4	313.29 g/	25.5	380.52 g/	26.9
GENERAL OVERHEAD				42.56	2.4	29.94	2.4	34.44	2.4
OTHER FIXED COSTS c/				66.72	3.8	48.68	4.0	61.39	4.3
NET CASH COST				1,602.68	91.8	144.47	93.2	1,310.52	92.8
DEPRECIATION d/				142.21	8.2	83.26	6.8	101.58	7.2
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				1,744.90	100.0	1,227.72	100.0	1,412.10	100.0
AT 85% LOAD FACTOR				2,265.25		1,573.14		1,823.76	
AT 65% LOAD FACTOR				2,520.69		1,743.19		1,030.04	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				2,336.36		1,614.76		1,814.55	
WITH 25% ROI				2,620.78		1,781.27		2,077.70	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes ethylene glycol at: Far East, $1313/ton; Mexico, $870/ton; Arabian Gulf, $991/ton.

Annex II.G Table [illegible]. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: polypropylene PLANT SIZE: 90,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	propylene		propylene		propylene		propylene		propylene		propylene	
FEEDSTOCK PRICE, $/ton	419.00 e/		463.00 e/		672.00 e/		485.00 f/		315.00 f/		400.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	79.90		91.90		71.90		167.79		99.87		119.85	
WORKING CAPITAL, $ million	8.20		9.45		12.14		12.57		8.33		11.07	
UNIT INVESTMENT COST, $ million/ton/a	887.8		1,021.1		798.9		1,864.3		1,109.7		1,331.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	427.38	60.4	472.26	58.42	685.44	67.1	494.70	52.8	321.30	54.4	408.00	50.7
ENERGY	-	-	-	-	-	-	-	-	-	-	-	-
BY-PRODUCT	-	-	-	-	-	-	-	-	-	-	-	-
OTHER DIRECT COSTS b/	101.23	14.3	130.41	16.1	151.06	14.8	171.20	18.3	120.96	19.7	185.95	23.1
GENERAL OVERHEAD	33.72	4.8	38.49	4.8	48.62	4.8	22.85	2.4	14.94	2.4	19.63	2.4
OTHER FIXED COSTS c/	56.93	8.0	65.02	8.0	56.03	5.5	61.59	6.6	44.33	7.2	57.93	7.2
NET CASH COST	619.25	87.5	706.18	87.4	941.15	92.2	750.34	80.1	501.52	81.9	671.50	83.4
DEPRECIATION d/	88.78	12.5	102.11	12.6	79.89	7.8	186.43	19.9	59.27	18.1	133.17	16.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	708.03	100.0	808.29	100.0	1,021.04	100.0	936.77	100.0	612.49	100.0	804.67	100.0
AT 85% LOAD FACTOR	764.26		873.69		1,083.08		1,019.20		671.80		877.42	
AT 65% LOAD FACTOR	857.04		982.01		1,184.10		1,160.06		765.25		998.45	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	808.65		924.75		1,123.03		1,112.41		727.28		944.00	
WITH 25% ROI	986.20		1,128.97		1,282.80		1,485.28		949.21		1,210.33	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 28. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: polystyrene PLANT SIZE: 200,000 ton/year

styrene transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	styrene		styrene		styrene		styrene		styrene		styrene	
FEEDSTOCK PRICE, $/ton	788.00 e/		937.00 e/		1,170.00 e/		1,300.00 f/		652.00 e/		1,090.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	69.15		79.53		62.27		134.61		85.44		103.72	
WORKING CAPITAL, $ million	24.39		28.90		34.91		39.99		21.04		33.98	
UNIT INVESTMENT COST, $ million/ton/a	345.7		397.6		311.3		673.0		422.2		518.6	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	803.76	84.1	955.74	84.4	1,193.40	87.3	1,326.00	88.1	665.04	84.9	1,111.80	87.3
ENERGY	-	-	-	-	-	-	-	-	-	-	-	-
BY-PRODUCT	-	-	-	-	-	-	-	-	-	-	-	-
OTHER DIRECT COSTS b/	35.83	3.7	41.43	3.7	38.82	2.8	35.18	2.3	29.36	3.7	38.59	3.0
GENERAL OVERHEAD	45.51	4.8	53.93	4.8	65.10	4.8	36.72	2.4	19.11	2.4	31.06	2.4
OTHER FIXED COSTS c/	36.63	3.8	41.59	3.7	38.63	2.8	40.31	2.7	27.30	3.5	40.04	3.1
NET CASH COST	921.13	96.4	1,092.69	96.5	1,335.94	97.7	1,438.21	95.5	740.81	94.5	1,221.49	95.9
DEPRECIATION d/	34.57	3.6	39.76	3.5	31.13	2.3	67.30	4.5	42.72	5.4	51.86	4.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	955.70	100.0	1,132.45	100.0	1,367.08	100.0	1,505.52	100.0	783.53	100.0	1,273.35	100.0
AT 85% LOAD FACTOR	981.50		1,162.40		1,396.07		1,536.75		804.04		1,301.51	
AT 65% LOAD FACTOR	1,034.41		1,223.85		1,455.56		1,600.81		846.11		1,359.29	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	998.78		1,182.29		1,411.64		1,570.40		825.40		1,327.44	
WITH 25% ROI	1,067.93		1,261.82		1,473.91		1,705.01		910.84		1,431.16	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 29. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

styrene transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: polystyrene PLANT SIZE: 200,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				styrene		styrene		styrene	
FEEDSTOCK PRICE, $/ton				939.00 f/		604.00 f/		831.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				134.61		85.44		103.72	
WORKING CAPITAL, $ million				30.05		19.72		26.85	
UNIT INVESTMENT COST, $ million/ton/a				673.0		422.2		518.6	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				957.78	85.3	616.08	84.1	847.62	84.9
ENERGY				-		-		-	
BY-PRODUCT				-		-		-	
OTHER DIRECT COSTS b/				35.18	3.1	29.36	4.0	38.59	3.9
GENERAL OVERHEAD				27.39	2.4	17.87	2.4	24.36	2.4
OTHER FIXED COSTS c/				35.34	3.1	26.63	3.6	36.47	3.7
NET CASH COST				1,055.69	94.0	689.95	94.2	947.05	94.8
DEPRECIATION d/				67.30	6.0	42.72	5.8	51.86	5.1
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				1,123.00	100.0	732.67	100.0	998.91	100.0
AT 85% LOAD FACTOR				1,151.70		752.84		1,025.26	
AT 65% LOAD FACTOR				1,210.59		794.23		1,079.32	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				1,185.36		774.20		1,051.19	
WITH 25% ROI				1,319.96		859.64		1,154.91	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 30. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: PVC PLANT SIZE: 75,000 ton/year

VCM transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	VCM		VCM		VCM		VCM		VCM		VCM	
FEEDSTOCK PRICE, $/ton	485.00 e/		611.00 e/		836.00 e/		1,214.00 f/		860.00 f/		865.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	65.87		75.78		59.30		138.32		82.33		99.80	
WORKING CAPITAL, $ million	7.96		9.68		11.93		17.30		12.14		14.13	
UNIT INVESTMENT COST, $ million/ton/a	878.3		1,010.4		790.7		1,844.3		1,097.7		1,330.7	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	497.12	61.3	626.27	63.3	856.90	70.8	1,244.35	74.9	881.50	75.9	886.62	68.0
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS b/	129.00	15.9	148.61	15.0	158.82	13.1	118.61	7.1	90.32	7.8	186.58	14.3
GENERAL OVERHEAD	38.62	4.8	47.09	4.8	57.60	4.8	40.54	2.4	28.33	2.4	31.81	2.4
OTHER FIXED COSTS c/	58.49	7.2	65.87	6.7	57.27	4.7	74.15	4.5	51.44	4.4	65.98	5.
NET CASH COST	723.23	89.2	887.85	89.8	1,130.60	93.5	1,477.65	88.9	1,051.59	90.5	1,170.99	89.8
DEPRECIATION d/	87.83	10.8	101.04	10.2	79.07	6.5	184.43	11.1	109.77	9.4	133.07	10.2
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	811.06	100.0	988.89	100.0	1,209.66	100.0	1,662.07	100.0	1,161.36	100.0	1,304.06	100.0
AT 85% LOAD FACTOR	870.55		1,058.08		1,275.60		1,746.92		1,222.33		1,381.12	
AT 65% LOAD FACTOR	969.81		1,172.32		1,381.53		1,892.51		1,318.94		1,510.72	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	914.46		1,108.60		1,315.14		1,839.13		1,277.22		1,447.65	
WITH 25% ROI	1,090.11		1,310.68		1,473.27		2,207.99		1,496.76		1,713.78	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 31. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

VCM transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: PVC PLANT SIZE: 75,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				VCM		VCM		VCM	
FEEDSTOCK PRICE, $/ton				1,083.00 [f]		411.00 [e]		768.00 [f]	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million				138.32		82.33		99.80	
WORKING CAPITAL, $ million				15.94		7.48		13.12	
UNIT INVESTMENT COST, $ million/ton/a				1,844.3		1,097.7		1,330.7	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				1,110.07	72.9	421.27	61.6	787.20	65.5
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS[b]				118.61	7.8	90.32	13.2	186.58	15.5
GENERAL OVERHEAD				37.14	2.4	16.66	2.4	29.29	2.4
OTHER FIXED COSTS[c]				1,485.45	97.6	45.23	6.6	64.64	5.4
NET CASH COST				1,338.16	87.9	573.49	83.9	1,067.71	88.9
DEPRECIATION[d]				184.43	12.1	109.77	16.1	133.07	11.1
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				1,522.58	100.0	683.26	100.0	1,200.78	100.0
AT 85% LOAD FACTOR				1,606.51		741.08		1,277.15	
AT 65% LOAD FACTOR				1,750.22		831.22		1,405.36	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				1,698.72		795.96		1,343.68	
WITH 25% ROI				2,067.58		1,015.51		1,609.81	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 32. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

styrene transfer price includes 25 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: SBR PLANT SIZE: 35,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	butadiene		butadiene		butadiene		butadiene		butadiene		butadiene	
FEEDSTOCK PRICE, $/ton	705.00 e/		661.00 e/		728.00 e/		535.00 f/		500.00 f/		520.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	46.60		53.60		41.90		97.86		58.24		69.90	
WORKING CAPITAL, $ million	6.22		6.64		6.44		8.40		5.86		7.82	
UNIT INVESTMENT COST, $ million/ton/a	1,331.4		1,531.4		1,197.1		2,796.0		1,664.0		1,997.1	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	513.24	39.4	481.21	34.7	529.98	38.1	389.48	30.9	364.00	39.1	378.56	32.3
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS b/	468.48 g/	35.9	545.79 g/	39.3	609.56 g/	43.9	452.60 g/	35.9	268.85 g/	30.8	437.95 g/	37.3
GENERAL OVERHEAD	62.06	4.8	66.11	4.8	66.16	4.8	30.71	2.4	22.73	2.4	28.60	2.4
OTHER FIXED COSTS c/	126.28	9.7	142.08	10.2	64.03	4.6	106.53	8.5	91.81	9.8	127.65	10.9
NET CASH COST	1,170.05	89.8	1,235.18	89.0	1,269.74	91.4	979.32	77.8	765.38	82.1	972.75	83.0
DEPRECIATION d/	133.14	10.2	153.14	11.0	119.71	8.6	279.60	22.0	166.40	17.8	199.71	17.0
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1,303.20	100.0	1,388.33	100.0	1,389.45	100.0	1,258.92	100.0	931.78	100.0	1,172.46	100.0
AT 85% LOAD FACTOR	1,746.55		1,903.29		2,035.33		1,716.38		1,181.86		1,571.04	
AT 65% LOAD FACTOR	2,024.42		2,221.59		2,332.31		2,026.30		1,383.28		1,855.38	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1,813.13		1,979.87		2,095.19		1,856.18		1,265.06		1,670.90	
WITH 25% ROI	2,079.41		2,286.15		2,334.61		2,415.38		1,597.86		2,070.32	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes styrene at: U.S. Gulf, $788/ton; FRG, $937/ton; Japan, $1170/ton; Far East, $1300/ton; Mexico, $650/ton; Arabian Gulf $1090/ton.

Annex II.G Table 33. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

styrene. transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: SBR PLANT SIZE: 35,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				butadiene		butadiene		butadiene	
FEEDSTOCK PRICE, $/ton				535.00 f/		487.00 f/		520.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				97.86		58.24		69.90	
WORKING CAPITAL, $ million				8.40		5.81		7.82	
UNIT INVESTMENT COST, $ million/ton/a				2,796.0		1,664.0		1,997.1	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				389.48	30.9	354.54	38.4	378.56	32.3
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS b/				452.60 g/	35.9	286.85 g/	31.1	437.95 g/	37.7
GENERAL OVERHEAD				30.71	2.4	22.49	2.4	28.60	2.4
OTHER FIXED COSTS c/				106.53	8.5	91.68	9.9	127.65	10.9
NET CASH COST				979.32	77.8	755.55	81.9	972.75	83.0
DEPRECIATION d/				279.60	22.2	166.40	18.0	199.71	17.0
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				1,258.92	100.0	921.95	100.0	1,172.46	100.0
AT 85% LOAD FACTOR				1,716.38		1,171.96		1,571.04	
AT 65% LOAD FACTOR				2,026.30		1,373.24		1,855.38	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				1,856.18		1,255.16		1,670.90	
WITH 25% ROI				2,415.38		1,587.96		2,070.32	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes styrene at: Far East, $1185/ton; Mexico, $794/ton; Arabian Gulf, $1008/ton.

Annex II.G Table 34. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethyl benzene transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: styrene PLANT SIZE: 260,000 ton/year

LOCATION	U.S. GULF COAST	F.R.G.	JAPAN	FAR EAST	MEXICO	ARABIAN GULF
FEEDSTOCK	ethyl benzene	ethyl benzene	ethyl benzene	ethyl benzene	ethyl benzene	ethyl benzene
FEEDSTOCK PRICE, $/ton	566.00 e/	687.00 e/	843.00 e/	885.00 f/	590.00 f/	765.00 f/
LOCATION FACTOR	1.00	1.15	0.90	2.10	1.25	1.50
FIXED CAPITAL COST, a/ $ million	70.26	80.78	63.18	147.55	87.82	105.39
WORKING CAPITAL, $ million	30.39	36.53	44.10	42.95	28.60	37.44
UNIT INVESTMENT COST, $ million/ton/a	270.2	310.7	243.0	567.5	337.8	405.3

PRODUCTION COST:	U.S. GULF COAST $/ton	%	F.R.G. $/ton	%	JAPAN $/ton	%	FAR EAST $/ton	%	MEXICO $/ton	%	ARABIAN GULF $/ton	%
FEEDSTOCK	649.77	81.4	788.68	82.2	967.76	85.1	1,015.98	90.3	677.32	89.7	878.22	91.4
ENERGY	15.90	2.0	18.20	1.9	22.60	2.0	1.78	0.1	1.56	0.2	1.19	0.1
BY-PRODUCT	-34.81	-4.4	-42.33	-4.4	-58.26	-5.1	-42.70	-3.8	-25.15	-3.3	-43.96	-4.6
OTHER DIRECT COSTS b/	78.98	9.9	90.33	9.5	99.75	8.8	35.75	3.2	28.61	3.8	36.06	3.7
GENERAL OVERHEAD	38.02	4.8	45.70	4.8	54.18	4.8	27.45	2.4	18.41	2.4	23.44	2.4
OTHER FIXED COSTS c/	23.46	2.9	27.54	2.9	27.45	2.4	30.57	2.7	20.1	2.7	25.74	2.8
NET CASH COST	771.32	96.6	928.71	96.8	1,113.47	97.9	1,068.83	94.9	720.83	95.5	920.69	95.8
DEPRECIATION d/	27.02	3.4	31.07	3.2	24.30	2.1	56.75	5.0	33.78	4.5	40.53	4.2
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	798.35	100.0	959.78	100.0	1,137.77	100.0	1,125.58	100.0	754.61	100.0	961.22	100.0
AT 85% LOAD FACTOR	825.63		991.55		1,170.13		1,100.62		776.89		987.46	
AT 65% LOAD FACTOR	872.58		1,046.44		1,226.24		1,209.01		811.30		1,030.01	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	839.15		1,007.08		1,182.28		1,184.99		793.78		1,007.73	
WITH 25% ROI	893.19		1,069.22		1,230.88		1,298.49		861.33		1,088.80	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G   Table 35.   COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethyl benzene transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: styrene   PLANT SIZE: 260,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethyl benzene		ethyl benzene		ethyl benzene	
FEEDSTOCK PRICE, $/ton				680.00 f/		431.00 f/		618.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				147.55		87.82		105.39	
WORKING CAPITAL, $ million				34.69		22.16		31.51	
UNIT INVESTMENT COST, $ million/ton/a				567.5		337.8		405.3	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				780.64	88.6	494.76	87.5	709.46	90.3
ENERGY				1.78	0.2	1.56	0.3	1.19	0.1
BY-PRODUCT				42.70	4.8	24.48	4.3	43.96	5.6
OTHER DIRECT COSTS b/				35.75	4.0	28.61	5.0	36.06	4.6
GENERAL OVERHEAD				21.49	2.4	13.80	2.4	19.17	2.4
OTHER FIXED COSTS c/				27.39	3.1	17.61	3.1	23.46	3.0
NET CASH COST				824.35	93.5	531.89	94.0	745.38	94.8
DEPRECIATION d/				56.75	6.4	33.78	6.0	40.53	5.1
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				881.10	100.0	565.67	100.0	785.91	100.0
AT 85% LOAD FACTOR				910.53		586.69		811.00	
AT 65% LOAD FACTOR				959.60		618.54		851.17	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				938.90		603.58		831.26	
WITH 25% ROI				1,052.40		671.13		912.33	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 36. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: TPA PLANT SIZE: 85,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	p-xylene		p-xylene		p-xylene		p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton	617.00[e/]		714.00[e/]		851.00[e/]		625.00[f/]		544.00[e/]		520.00[f/]	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST,[a/] $ million	92.51		106.42		83.24		194.27		115.63		138.76	
WORKING CAPITAL, $ million	9.11		10.82		11.89		13.17		9.91		10.89	
UNIT INVESTMENT COST, $ million/ton/a	108.8		125.2		97.9		228.5		136.0		163.2	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	416.62	50.4	479.81	51.5	571.87	56.2	420.00	45.0	365.57	52.6	349.44	46.3
ENERGY	35.33	42.3	40.44	4.3	50.22	4.9	3.97	0.4	3.47	0.5	2.64	0.3
BY-PRODUCT	-13.80		-13.80	-1.5	-13.80	-1.4	-14.96	-1.6	-14.96	-2.1	-14.96	-2.0
OTHER DIRECT COSTS[b/]	159.13	19.3	186.55	19.9	199.15	19.6	192.63	20.6	132.75	19.1	168.96	22.4
GENERAL OVERHEAD	39.21	4.8	44.73	4.8	48.46	4.8	22.78	2.4	16.95	2.4	18.42	2.4
OTHER FIXED COSTS[c/]	66.35	8.0	76.43	8.1	63.85	6.3	81.18	8.7	55.15	7.9	67.58	8.9
NET CASH COST	714.64	86.8	814.16	86.7	919.75	90.4	705.60	75.5	558.92	80.4	592.08	78.4
DEPRECIATION[d/]	108.84	13.2	125.20	13.3	97.93	9.6	228.55	24.5	136.04	19.6	163.25	21.6
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	823.48	100.0	939.36	100.0	1,017.68	100.0	934.15	100.0	694.96	100.0	755.33	100.0
AT 85% LOAD FACTOR	934.84		1,068.19		1,144.51		1,087.35		818.23		890.33	
AT 65% LOAD FACTOR	1,059.67		1,212.23		1,275.02		1,272.12		941.63		1,037.79	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	989.25		1,130.79		1,193.47		1,201.62		886.25		971.96	
WITH 25% ROI	1,206.92		1,381.19		1,389.33		1,658.73		1,158.32		1,298.45	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 37. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ammonia transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: urea PLANT SIZE: 680,000 ton/year

LOCATION	U.S. GULF COAST		F.R G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ammonia		ammonia		ammonia		ammonia		ammonia		ammonia	
FEEDSTOCK PRICE, $/ton	171.00		201.00		462.00		320.00		199.00		240.00	
LOCATION FACTOR	1.00		1.15		.90		2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million	63.61		73.13		57.23		133.58		79.51		95.41	
WORKING CAPITAL, $ million	12.37		14.46		27.98		20.38		12.89		15.89	
UNIT INVESTMENT COST, $ million/ton/a												
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	97.47	70.0	114.57	70.3	263.34	82.2	182.40	80.9	113.43	80.0	136.80	78.7
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b]	19.50	14.0	22.49	13.8	24.99	7.8	10.10	5.5	7.90	5.6	11.91	6.8
GENERAL OVERHEAD	6.63	4.8	7.76	4.8	15.25	4.8	5.50	2.4	3.46	2.4	4.24	2.4
OTHER FIXED COSTS[c]	6.36	4.6	7.40	4.5	8.17	2.5	7.87	3.5	5.29	3.7	6.70	3.8
NET CASH COST	129.97	93.3	152.23	93.4	311.75	97.4	205.87	91.3	130.15	91.7	159.64	91.9
DEPRECIATION[d]	9.35	6.7	10.75	6.6	8.42	2.6	19.64	8.7	11.69	8.3	14.03	8.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	139.32	100.0	162.98	100.0	320.17	100.0	225.51	100.0	141.84	100.0	173.68	100.0
AT 85% LOAD FACTOR	145.13		169.71		327.98		232.79		146.54		179.60	
AT 65% LOAD FACTOR	157.04		183.50		344.01		247.74		156.18		191.77	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	149.81		175.09		332.19		242.62		152.38		186.62	
WITH 25% ROI	168.51		196.59		349.02		281.90		175.77		214.68	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 38. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ammonia transfer price includes 5 % ROI in developing countries; developed countries at prevailing market price.

PRODUCT: **urea** PLANT SIZE: **680,000 ton/year**

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ammonia		ammonia		ammonia	
FEEDSTOCK PRICE, $/ton				195.00[f]		126.00[f]		151.00[f]	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST,[a] $ million				133.58		79.51		95.44	
WORKING CAPITAL, $ million				13.95		9.14		11.33	
UNIT INVESTMENT COST, $ million/ton/a				196.4		116.9		140.3	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				111.15	73.4	71.82	72.8	86.07	71.1
ENERGY				-	-	-	-	-	-
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS[b]				10.10	6.7	7.96	8.1	11.91	9.8
GENERAL OVERHEAD				3.70	2.4	2.41	2.4	2.95	2.4
OTHER FIXED COSTS[c]				6.93	4.5	4.74	4.8	6.03	5.0
NET CASH COST				131.87	87.0	86.93	88.1	106.96	88.4
DEPRECIATION[d]				19.64	13.0	11.69	11.9	14.03	11.6
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				151.51	100.00	98.62	100.00	120.99	100.0
AT 85% LOAD FACTOR				158.31		103.04		126.57	
AT 65% LOAD FACTOR				172.26		112.10		138.03	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				168.13		108.89		133.59	
WITH 25% ROI				207.42		132.27		161.65	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

Annex II.G Table 39. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 25% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: VCM from ethylene PLANT SIZE: 152,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	529.00 e/		754.00 e/		864.00 e/		640.00 f/		440.00 f/		480.00 f/	
LOCATION FACTOR	1.00		1.15		0.90		2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million	65.41		75.24		56.82		137.36		81.76		98.11	
WORKING CAPITAL, $ million	10.65		13.69		15.13		19.76		14.51		14.12	
UNIT INVESTMENT COST, $ million/ton/a	[illegible]		[illegible]		[illegible]		[illegible]		537.9		645.5	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	251.27	45.6	358.15	50.6	410.40	52.8	304.00	43.0	209.00	41.4	228.00	44.1
ENERGY	51.23	9.3	58.64	8.3	72.82	9.4	5.75	0.8	5.04	1.0	3.83	0.7
BY-PRODUCT	-	-	-	-	-	-	-	-	-	-	-	-
OTHER DIRECT COSTS b/	150.77 g/	27.4	175.18 g/	24.7	189.38 g/	24.4	253.82 g/	35.9	199.25 g/	39.5	178.31 g/	34.5
GENERAL OVERHEAD	26.21	4.8	33.73	4.8	37.01	4.8	17.24	2.4	12.31	2.4	12.60	2.4
OTHER FIXED COSTS c/	27.96	5.1	33.14	4.7	28.85	3.7	35.57	5.0	25.23	5.0	29.43	5.7
NET CASH COST	507.44	92.2	658.83	93.0	738.45	95.0	616.38	87.2	450.82	89.3	452.17	87.6
DEPRECIATION d/	43.03	7.8	49.50	7.0	38.70	5.0	90.37	12.8	53.79	10.6	64.55	12.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	550.48	100.0	708.33	100.0	777.15	100.0	706.75	100.0	504.61	100.0	516.72	100.0
AT 85% LOAD FACTOR	690.22		871.77		950.89		989.07		723.92		701.13	
AT 65% LOAD FACTOR	773.38		969.68		1,047.78		1,131.05		827.52		801.46	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	711.73		896.52		970.24		1,034.25		750.81		733.40	
WITH 25% ROI	797.80		995.52		1,047.63		1,214.99		858.39		862.49	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes chlorine at: U.S. Gulf, $160/ton; FRG, $186/ton, Japan, $203/ton; Far East, $350/ton; Mexico, $275/ton; Arabian Gulf, $217/ton.

Annex II.G Table 40. COMPARISON OF 1980 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

ethylene transfer price includes 5% ROI in developing countries; developed countries at prevailing market price.

PRODUCT: VCM from ethylene PLANT SIZE: 152,000 ton/year

LOCATION				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK				ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton				375.00 f/		230.00 e/		290.00 f/	
LOCATION FACTOR				2.10		1.25		1.50	
FIXED CAPITAL COST, a/ $ million				137.36		81.76		98.11	
WORKING CAPITAL, $ million				17.21		12.49		12.29	
UNIT INVESTMENT COST, $ million/ton/a				903.7		537.9		645.5	
PRODUCTION COST:				$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK				178.12	30.9	109.25	27.2	137.75	32.6
ENERGY				5.75	1.0	5.04	1.3	3.83	0.9
BY-PRODUCT				-	-	-	-	-	-
OTHER DIRECT COSTS b/				253.82 g/	44.1	199.25 g/	49.7	178.31 g/	42.2
GENERAL OVERHEAD				14.05	2.4	9.78	2.4	10.32	2.4
OTHER FIXED COSTS c/				33.90	5.9	23.90	6.0	28.22	6.7
NET CASH COST				489.64	84.3	347.22	86.6	358.43	84.7
DEPRECIATION d/				90.37	15.	53.79	13.4	64.55	15.3
NET COST OF PRODUCTION (NCP)									
AT 100% LOAD FACTOR				576.01	100.0	401.01	100.0	422.98	100.0
AT 85% LOAD FACTOR				857.47		619.63		606.77	
AT 65% LOAD FACTOR				997.69		721.84		705.84	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI				902.65		646.53		6 9.05	
WITH 25% ROI				1,083.39		754.11		768.14	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.1)

g/ Includes chlorine at: Far East, $162/ton; Mexico, $164/ton; Arabian Gulf, $82/ton.

Annex II.H Table 1. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ammonia from methane PLANT SIZE: 430,000 ton/year

LOCATION	U.S. GULF COAST			JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	methane			methane		methane		methane		methane	
FEEDSTOCK PRICE, $/ton	344.00			381.00		100.00		100.00		100.00	
LOCATION FACTOR	1.00			.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	133.40			126.80		242.78		157.40		182.7	
WORKING CAPITAL, $ million	17.58			19.57		11.66		8.83		10.01	
UNIT INVESTMENT COST, $ million/ton/a	310.2			294.9		242.8		366.0		424.9	
PRODUCTION COST:	$/ton	%		$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	144.00	44.4		159.49	44.9	41.86	24.5	41.86	31.9	41.86	28.6
ENERGY	92.43	28.5		100.90	28.4	7.90	4.6	6.87	5.2	5.2	3.6
BY-PRODUCT											
OTHER DIRECT COSTS[b]	22.57	7.0		30.21	8.5	42.02	24.6	29.72	22.7	38.01	26.0
GENERAL OVERHEAD	15.42	4.8		16.91	4.8	4.17	2.4	3.20	2.4	3.56	2.4
OTHER FIXED COSTS[c]	18.47	5.7		18.09	5.1	18.44	10.8	12.90	9.8	15.00	10.3
NET CASH COST	292.89	90.4		325.60	91.7	114.39	67.0	94.56	72.1	103.66	70.9
DEPRECIATION[d]	31.02	9.6		29.49	8.3	56.46	33.0	36.60	27.9	42.50	29.1
NET COST OF PRODUCTION (NCP)											
AT 100% LOAD FACTOR	323.91	100.0		355.09	100.0	170.85	100.0	131.16	100.0	146.16	100.0
AT 85% LOAD FACTOR	340.24			372.11		192.48		146.45		163.82	
AT 65% LOAD FACTOR	370.66			403.34		233.00		173.97		196.20	
TRANSFER PRICE AT 85% LOAD FACTOR											
WITH 5% ROI	355.75			386.86		220.71		164.75		185.07	
WITH 25% ROI	417.80			445.83		333.63		237.96		270.08	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 2. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ammonia from naphtha PLANT SIZE: 430,000 ton/year

LOCATION	U.S. GULF COAST	F.R.G.		JAPAN			—	
FEEDSTOCK	naphtha	naphtha		naphtha				
FEEDSTOCK PRICE, $/ton		445.00		379.00				
LOCATION FACTOR		1.15		.90				
FIXED CAPITAL COST,a/ $ million		167.30		144.40				
WORKING CAPITAL, $ million		21.56		23.70				
UNIT INVESTMENT COST, $ million/ton/a		389.10		335.80				
PRODUCTION COST:		$/ton	%	$/ton	%			
FEEDSTOCK		186.28	46.8	221.37	51.3			
ENERGY		102.31	25.7	101.70	23.6			
BY-PRODUCT								
OTHER DIRECT COSTSb/		27.92	7.0	32.88	7.6			
GENERAL OVERHEAD		18.94	4.8	20.54	4.8			
OTHER FIXED COSTSc/		23.37	5.9	21.26	4.9			
NET CASH COST		358.81	90.2	397.75	92.2			
DEPRECIATIONd/								
NET COST OF PRODUCTION (NCP)		38.91	9.8	33.58	7.8			
AT 100% LOAD FACTOR		397.72	100.0	431.33	100.0			
AT 85% LOAD FACTOR								
AT 65% LOAD FACTOR		418.31		450.95				
TRANSFER PRICE AT 85% LOAD FACTOR		456.44		487.08				
WITH 5% ROI		437.76		467.74				
WITH 25% ROI		515.58		534.90				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 3. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: DMT PLANT SIZE: 100,000 ton/year

methanol transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	p-xylene		p-xylene		p-xylene		p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton	752.00		811.00		745.00		544.00		660.00		588.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	117.03		128.66		109.84		212.94		138.06		154.44	
WORKING CAPITAL, $ million	13.13		14.46		13.37		14.60		12.80		13.01	
UNIT INVESTMENT COST, $ million/ton/a	1 170.30		1 286.60		1 098.40		2 129.40		1 380.60		1 544.40	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	473.76	45.9	510.93	45.1	469.35	45.2	342.72	39.0	415.80	51.8	370.44	46.5
ENERGY	39.30	3.8	43.50	3.8	42.90	4.1	3.36	.4	2.92	.4	2.22	.3
BY-PRODUCT												
OTHER DIRECT COSTS[b/ g/]	281.64	27.3	318.80	28.1	299.38	28.8	223.06	25.4	169.39	21.1	186.51	23.4
GENERAL OVERHEAD	49.13	4.8	54.00	4.8	49.43	4.8	21.43	2.4	19.55	2.4	19.44	2.4
OTHER FIXED COSTS[c]	70.87	6.9	78.11	6.9	67.17	6.5	75.14	8.6	55.83	7.0	63.85	8.0
NET CASH COST	914.70	88.7	1 005.34	88.7	928.23	89.4	665.79	75.8	663.49	82.8	642.45	80.6
DEPRECIATION[d]	117.00	11.3	128.66	11.3	109.84	10.6	212.94	24.2	138.06	17.2	154.44	19.4
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 031.70	100.0	1 134.00	100.0	1 038.07	100.0	878.65	100.0	801.55	100.0	796.89	100.0
AT 85% LOAD FACTOR	1 290.27		1 424.92		1 297.74		1 077.78		950.53		962.78	
AT 65% LOAD FACTOR	1 467.78		1 622.69		1 473.48		1 266.31		1 085.30		1 113.52	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 348.77		1 489.25		1 352.66		1 184.25		1 019.56		1 040.00	
WITH 25% ROI	1 582.77		1 746.57		1 572.34		1 610.13		1 295.68		1 348.88	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes methanol at prices: U.S. Gulf Coast, $ 423/ton; FRG $478/ton; Japan, $423/ton; Far East, $245/ton; Mexico, $182/ton; Arabian Gulf, $206/ton.

Annex II.H Table 4. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

methanol transfer price includes 5 % ROI in all countries.

PRODUCT: DMT PLANT SIZE: 100,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	p-xylene		p-xylene		p-xylene		p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton	752.00		811.00		745.00		544.00		660.00		588.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	117.00		128.66		109.84		212.94		138.06		154.44	
WORKING CAPITAL, $ million	12.85		14.14		13.16		13.76		12.22		12.32	
UNIT INVESTMENT COST, $ million/ton/a	1 170.30		1 286.60		1 098.40		2 129.40		1 380.60		1 544.40	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	473.76	46.9	510.93	46.1	469.35	46.0	342.72	40.4	415.80	53.2	370.44	47.9
ENERGY	39.30	3.9	43.50	3.9	42.90	4.2	3.36	.4	2.92	.4	2.22	.3
BY-PRODUCT												
OTHER DIRECT COSTS b/ g/	261.10	25.9	295.19	26.6	283.48	27.8	195.04	23.0	150.01	19.2	163.71	21.2
GENERAL OVERHEAD	48.09	4.8	52.80	4.8	48.63	4.8	20.71	2.4	19.05	2.4	18.85	2.4
OTHER FIXED COSTS c/	70.59	7.0	77.79	7.0	66.96	6.6	74.30	8.8	55.25	7.1	63.17	8.2
NET CASH COST	892.84	88.4	980.22	88.4	911.31	89.2	636.13	74.9	643.03	82.3	618.38	80.0
DEPRECIATION d/	117.00	11.6	128.66	11.6	109.84	10.8	212.94	25.1	138.06	17.7	154.44	20.0
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 009.84	100.0	1 108.88	100.0	1 021.15	100.0	849.07	100.0	781.09	100.0	772.82	100.0
AT 85% LOAD FACTOR	1 244.02		1 371.75		1 261.94		1 014.96		907.08		911.66	
AT 65% LOAD FACTOR	1 413.62		1 560.43		1 431.55		1 192.78		1 034.44		1 053.69	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 302.52		1 436.08		1 316.86		1 121.43		976.11		988.88	
WITH 25% ROI	1 536.52		1 693.40		1 536.54		1 547.31		1 252.23		1 297.76	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes methanol at calculated price: U.S. Gulf Coast, $369/ton; FRG, $416/ton; Japan, $382/ton; Far East, $166/ton; Mexico, $131/ton; Arabian Gulf, $146/ton.

Annex II.H Table 5. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Ethylene transfer price includes 25 % ROI in all countries.

PRODUCT: Ethyl benzene PLANT SIZE: 290,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	benzene		benzene		benzene		benzene		benzene		benzene	
FEEDSTOCK PRICE, $/ton	628.00		670.00		664.00		483.00		396.00		480.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	32.53		35.69		30.88		59.20		38.38		42.93	
WORKING CAPITAL, $ million	32.52		36.07		32.83		32.51		24.05		29.33	
UNIT INVESTMENT COST, $ million/ton/a	112.20		123.10		106.50		204.10		132.30		148.00	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	466.60	58.4	497.81	56.2	493.35	61.8	358.87	59.3	294.23	63.6	356.64	63.4
ENERGY												
BY-PRODUCT	-22.53	-2.8	-25.20	-2.8	-24.87	-3.1	-1.96	-.3	-2.03	-.4	2.73	-.5
OTHER DIRECT COSTS[b/] [g/]	288.49	36.1	339.58	38.4	265.03	33.2	197.10	32.6	133.55	28.9	164.63	29.3
GENERAL OVERHEAD	38.05	4.8	42.16	4.8	38.05	4.8	14.77	2.4	11.28	2.4	13.71	2.4
OTHER FIXED COSTS[c/]	17.14	2.1	18.80	2.1	16.76	2.1	16.26	2.7	12.36	2.7	15.11	2.7
NET CASH COST	787.75	98.6	873.15	98.6	788.32	98.7	585.04	96.6	449.39	97.1	547.36	97.4
DEPRECIATION[d/]	11.22	1.4	12.31	1.4	10.65	1.3	20.41	3.4	13.23	2.9	14.80	2.6
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	798.97	100.0	885.46	100.0	798.97	100.0	605.46	100.0	462.63	100.0	562.16	100.0
AT 85% LOAD FACTOR	1 112.41		1 255.81		1 081 27		834.76		616.34		749.87	
AT 65% LOAD FACTOR	1 234.70		1 398.29		1 193.96		923.91		677.29		824.07	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 118.01		1 261.96		1 086.60		844.96		622.96		757.28	
WITH 25% ROI	1 140.45		1 286.57		1 107.89		885.79		649.43		786.88	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Ethylene at calculated price: U.S. Gulf Coast, $927/ton; F.R.G., $1103/ton; Japan, $828/ton; Far East, $672/ton; Mexico, $443/ton; Arabian Gulf, $545/ton.

Annex II.H Table 6. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene from ethane PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST				FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethane				ethane		ethane		ethane	
FEEDSTOCK PRICE, $/ton	350.00				100.00		70.00		100.00	
LOCATION FACTOR	1.00				1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	325.55				592.49		384.14		446.00	
WORKING CAPITAL, $ million	53.31				27.84		19.31		23.87	
UNIT INVESTMENT COST, $ million/ton/a	651.10				1 185.00		768.30		892.00	
PRODUCTION COST:	$/ton	%			$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	423.50	80.2			121.00	36.1	84.70	37.8	121.00	41.5
ENERGY	59.29	11.2			5.07	1.5	4.4	2.0	3.35	1.1
BY-PRODUCT	-121.72	-23.1			-13.27	-3.9	-12.81	-5.7	-10.75	-3.7
OTHER DIRECT COSTS[b/]	36.69	6.9			57.68	-17.2	39.78	17.8	51.02	17.5
GENERAL OVERHEAD	25.13	4.8			8.18	2.4	5.46	2.4	7.11	2.4
OTHER FIXED COSTS[c/]	39.67	7.5			38.32	11.4	25.54	11.40	30.44	10.4
NET CASH COST	462.56	87.7			216.97	64.7	147.08	65.7	202.16	69.4
DEPRECIATION[d/]										
NET COST OF PRODUCTION (NCP)	65.11	12.3			118.50	35.3	76.83	34.3	89.20	30.6
AT 100% LOAD FACTOR	527.67	100.0			335.47	100.0	223.90	100.0	291.36	100.0
AT 85% LOAD FACTOR	557.77				375.83		251.05		321.66	
AT 65% LOAD FACTOR										
TRANSFER PRICE AT 85% LOAD FACTOR	617.04				455.54		303.66		383.80	
WITH 5% ROI	590.32				435.08		289.47		366.26	
WITH 25% ROI	720.54				672.07		443.12		544.66	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 7. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene from ethane-propane PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST					MEXICO		ARABIAN GULF	
FEEDSTOCK	ethane-propane					ethane-propane		ethane-propane	
FEEDSTOCK PRICE, $/ton	375.00					135.00		135.00	
LOCATION FACTOR	1.00					1.18		1.32	
FIXED CAPITAL COST,[a] $ million	347.07					409.53		475.49	
WORKING CAPITAL, $ million	68.08					34.31		41.17	
UNIT INVESTMENT COST, $ million/ton/a	694.10					819.10		951.00	
PRODUCTION COST:	$/ton	%				$/ton	%	$/ton	%
FEEDSTOCK	585.00	81.7				210.60	65.22	210.60	65.2
ENERGY	24.73	3.4				1.84	.6	1.40	.4
BY-PRODUCT	-128.46	-17.9				-60.32	-18.7	-95.86	-29.7
OTHER DIRECT COSTS[b]	85.97	12.0				50.26	15.6	67.05	20.8
GENERAL OVERHEAD	34.10	4.8				7.87	2.4	7.87	2.4
OTHER FIXED COSTS[c]	45.25	6.3				30.71	9.5	36.61	11.3
NET CASH COST	646.59	90.3				240.96	74.6	227.67	70.5
DEPRECIATION[d]									
NET COST OF PRODUCTION (NCP)	69.41	9.7				81.91	25.4	95.10	29.5
AT 100% LOAD FACTOR	716.00	100.0				322.86	100.0	322.77	100.0
AT 85% LOAD FACTOR	753.54					353.75		358.98	
AT 65% LOAD FACTOR	827.47					413.28		429.42	
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI	788.25					394.71		406.53	
WITH 25% ROI	927.07					558.52		596.72	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 8. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene from gas oil PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN	
FEEDSTOCK	gas oil		gas oil		gas oil	
FEEDSTOCK PRICE, $/ton	353.00		353.00		353.00	
LOCATION FACTOR	1.00		1.15		.90	
FIXED CAPITAL COST,[a] $ million	491.99		541.22		467.43	
WORKING CAPITAL, $ million	214.60		222.74		221.29	
UNIT INVESTMENT COST, $ million/ton/a	984.00		1 082.40		934.90	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 378.11	214.5	1 378.11	228.5	1 378.11	234.4
ENERGY						
BY-PRODUCT	1 025.14	159.5	1 087.72	180.4	1 081.75	184.0
OTHER DIRECT COSTS[b]	74.83	11.6	84.08	13.9	85.44	14.53
GENERAL OVERHEAD	30.59	4.8	28.72	4.8	28.00	4.8
OTHER FIXED COSTS[c]	85.69	13.3	91.65	15.2	84.67	14.4
NET CASH COST	544.09	84.7	494.84	82.0	494.47	84.1
DEPRECIATION[d]						
NET COST OF PRODUCTION (NCP)	98.40	15.3	108.24	17.9	93.49	15.9
AT 100% LOAD FACTOR	642.49	100.0	603.08	100.0	587.95	100.0
AT 85% LOAD FACTOR	693.86		658.81		639.30	
AT 65% LOAD FACTOR	792.67		765.13		736.22	
TRANSFER PRICE AT 85% LOAD FACTOR						
WITH 5% ROI	743.06		712.93		686.04	
WITH 25% ROI	939.85		929.42		873.02	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 9. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene from naphtha PLANT SIZE: 500,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN				
FEEDSTOCK	naphtha		naphtha		naphtha				
FEEDSTOCK PRICE, $/ton	439.00		445.00		379.00				
LOCATION FACTOR	1.00		1.15		.90				
FIXED CAPITAL COST,[a] $ million	446.96		491.69		424.70				
WORKING CAPITAL, $ million	192.18		199.03		183.40				
UNIT INVESTMENT COST, $ million/ton/a	893.90		983.40		849.40				
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%			
FEEDSTOCK	1 391.63	172.3	1 410.65	174.6	1 201.43	209.7			
ENERGY									
BY-PRODUCT	835.58	-103.4	-876.36	-108.48	-869.24	-151.7			
OTHER DIRECT COSTS[b]	46.20	5.7	53.80	6.6	54.84	9.6			
GENERAL OVERHEAD	38.46	4.8	38.47	4.8	27.28	4.8			
OTHER FIXED COSTS[c]	77.55	9.6	82.89	10.3	76.62	12.8			
NET CASH COST	718.26	88.9	709.45	87.8	487.93	85.2			
DEPRECIATION[d]									
NET COST OF PRODUCTION (NCP)	89.39	11.1	98.34	12.1	84.94	14.8			
AT 100% LOAD FACTOR	807.65	100.0	807.79	100.0	572.87	100.0			
AT 85% LOAD FACTOR	851.43		857.39		615.89				
AT 65% LOAD FACTOR	941.23		954.82		699.82				
TRANSFER PRICE AT 85% LOAD FACTOR									
WITH 5% ROI	896.12		906.55		658.36				
WITH 25% ROI	1 074.91		1 103.23		828.24				

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H **Table 10.** COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene glycol PLANT SIZE: 150,000 ton/year

Ethylene oxide transfer price includes 25% ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide	
FEEDSTOCK PRICE, $/ton	1 365.00		1 545.00		1 270.00		1 500.00		1 015.00		1 172.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	31.05		34.25		29.53		56.67		36.87		42.69	
WORKING CAPITAL, $ million	22.69		25.66		21.49		25.08		17.29		19.93	
UNIT INVESTMENT COST, $ million/ton/a	207.00		235.00		196.90		377.80		259.10		284.60	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 018.29	87.3	1 152.57	87.3	947.42	86.4	1 119.00	89.4	757.19	88.7	874.31	88.7
ENERGY												
BY-PRODUCT	-4.39	-0.4	-4.80	-0.4	-5.77	-0.5	-0.03		-0.96	-0.1	-0.99	-0.1
OTHER DIRECT COSTS[b]	48.90	4.2	55.36	4.2	56.68	5.2	37.09	3.0	32.17	3.8	35.59	3.6
GENERAL OVERHEAD	55.55	4.8	62.84	4.8	52.19	4.8	30.53	2.4	20.83	2.4	24.05	2.4
OTHER FIXED COSTS[c]	27.59	2.4	30.82	2.3	25.75	2.3	27.18	2.2	20.21	2.4	24.59	2.5
NET CASH COST	1 145.94	98.2	1 296.79	98.3	1 076.26	98.2	1 213.76	97.0	829.44	97.1		
DEPRECIATION[d]	20.70	1.8	[illegible]	1.7	19.69	1.8	27.18	2.2	24.58	2.9	28.46	2.9
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 166.64	100.0	1 319.62	100.0	1 095.95	100.0	1 251.54	100.0	854.02	100.0	986.00	100.0
AT 85% LOAD FACTOR	1 198.92		1 356.16		1 128.98		1 284.02		880.62		1 015.30	
AT 65% LOAD FACTOR	1 248.30		1 411.64		1 177.26		1 329.61		914.15		1 054.38	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 209.27		1 367.58		1 138.83		1 302.91		892.91		1 029.53	
WITH 25% ROI	1 250.67		1 413.25		1 178.20		1 378.47		942.07		1 086.45	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 11. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene glycol PLANT SIZE: 150,000 ton/year

Ethylene oxide transfer price includes 5% ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		ethylene oxide		cthylene oxide	
FEEDSTOCK PRICE, $/ton	843.00		1 151.00		928.00		944.00		655.00		761.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	31.05		34.25		29.53		56.67		36.87		42.69	
WORKING CAPITAL, $ million	14.80		53.96		16.33		16.68		11.85		13.72	
UNIT INVESTMENT COST, $ million/ton/a	207.00		235.00		196.90		377.80		259.10		284.60	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	628.88	83.6	858.65	85.3	692.29	84.0	704.22	85.8	488.63	85.0	567.71	85.1
ENERGY												
BY-PRODUCT	-4.39	-0.6	-4.80	-0.5	-5.77	-0.7	-0.03		-0.96	-0.2	-0.99	-0.1
OTHER DIRECT COSTS[b]	48.90	6.5	55.36	5.5	56.68	6.9	37.09	4.5	32.17	5.6	35.59	5.3
GENERAL OVERHEAD	35.82	4.8	47.94	4.8	39.26	4.8	20.02	2.4	14.03	2.4	16.28	2.4
OTHER FIXED COSTS[c]	22.33	3.0	26.85	2.7	22.30	2.7	21.58	2.6	16.59	2.9	20.45	3.1
NET CASH COST	731.54	97.2	984.00	97.7	804.76	97.6	782.88	95.4	550.45	95.7	639.03	95.7
DEPRECIATION[d]	20.70	2.3	26.85	2.7	19.69	2.4	37.78	4.6	24.58	4.3	28.46	4.3
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	752.24	100.0	1 006.83	100.0	824.44	100.0	820.66	100.0	575.03	100.0	667.49	100.0
AT 85% LOAD FACTOR	780.10		1 040.05		854.59		850.29		599.79		694.69	
AT 65% LOAD FACTOR	820.45		1 088.70		896.94		890.05		629.55		729.45	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	790.45		1 051.47		864.43		869.18		612.08		708.92	
WITH 25% ROI	831.85		1 097.13		903.81		944.74		661.24		765.84	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 12. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Ethylene transfer price includes 25 % ROI in all countries.

PRODUCT: Ethylene oxide PLANT SIZE: 131,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	927.00		1 103.00		828.00		672.00		443.00		545.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	114.65		126.11		108.88		208.65		135.28		151.34	
WORKING CAPITAL, $ million	17.43		19.65		16.27		19.68		13.60		15.74	
UNIT INVESTMENT COST, $ million/ton/a	875.20		962.60		831.10		1 592.70		1 032.70		1 155.30	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	887.14	81.7	1 055.57	85.0	792.40	79.0	643.10	63.3	423.95	61.4	521.57	64.3
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTSb/	1.92	0.2	-32.63	-2.6	25.12	2.5	127.31	12.5	101.33	14.7	100.60	12.4
GENERAL OVERHEAD	51.74	4.8	59.17	4.8	47.74	4.8	27.49	2.4	16.83	2.4	19.77	2.4
OTHER FIXED COSTSc/	58.12	5.3	64.16	5.2	54.26	5.4	62.00	6.1	44.65	6.5	53.07	6.5
NET CASH COST	998.92	91.9	1 146.26	92.3	919.51	91.7	857.20	84.3	586.76	85.0	695.00	85.7
DEPRECIATIONd/	87.52	8.1	96.27	7.7	83.11	8.3	159.27	15.7	103.27	15.0	115.53	14.3
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 086.44	100.0	1 242.53	100.0	1 002.62	100.0	1 016.48	100.0	690.02	100.0	810.53	100.0
AT 85% LOAD FACTOR	1 146.65		1 304.73		1 061.95		1 101.92		757.12		882.91	
AT 65% LOAD FACTOR	1 233.05		1 395.19		1 146.52		1 230.80		848.36		984.98	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 190.41		1 352.86		1 103.51		1 181.56		808.76		940.67	
WITH 25% ROI	1 365.45		1 545.40		1 269.74		1 500.11		1 015.29		1 171.72	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Table 13. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Ethylene oxide PLANT SIZE: 131,000 ton/year

Ethylene transfer price includes 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	590.00		907.00		658.00		435.00		289.00		366.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	114.65		126.11		108.88		208.65		135.28		151.34	
WORKING CAPITAL, $ million	11.62		16.27		13.35		15.59		10.94		12.65	
UNIT INVESTMENT COST, $ million/ton/a	875.20		962.60		831.10		1 592.70		1 032.70		1 155.30	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	564.63	76.0	868.00	83.2	629.71	75.9	416.30	53.3	276.57	51.5	350.26	55.4
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b/]	1.92	0.3	-32.63	-3.1	25.12	3.0	127.31	16.3	101.33	18.9	100.60	15.9
GENERAL OVERHEAD	35.39	4.8	49.66	4.8	39.50	4.8	19.04	2.4	13.09	2.4	15.43	2.4
OTHER FIXED COSTS[c/]	53.69	7.2	61.58	5.9	52.02	6.3	58.88	7.6	42.63	7.9	50.72	8.0
NET CASH COST	655.63	88.2	946.61	90.8	746.34	90.0	621.53	79.6	433.62	80.8	517.01	81.7
DEPRECIATION[d/]	87.52	11.8	96.27	9.2	83.11	10.0	159.27	20.4	103.27	19.2	115.53	18.3
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	743.15	100.0	1 042.87	100.0	829.45	100.0	780.80	100.0	536.89	100.0	632.53	100.0
AT 85% LOAD FACTOR	799.70		1 102.94		886.93		864.69		602.97		703.73	
AT 65% LOAD FACTOR	878.57		1 189.03		967.70		990.36		692.12		803.37	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	843.46		1 151.07		928.49		944.32		654.60		761.49	
WITH 25% ROI	1 018.50		1 343.61		1 094.71		1 262.87		861.14		992.55	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 14. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: HDPE PLANT SIZE: 75,000 ton/year

Ethylene transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	927.00		1 103.00		828.00		672.00		443.00		545.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	44.65		49.14		42.24		81.25		52.68		58.93	
WORKING CAPITAL, $ million	12.28		14.49		12.30		11.53		8.54		9.89	
UNIT INVESTMENT COST, $ million/ton/a	595.30		655.20		563.20		1 083.30		702.40		785.70	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	940.90	73.0	1 119.54	73.7	840.42	67.0	682.08	65.9	449.64	61.2	553.17	63.7
ENERGY	14.57	1.1	16.12	1.1	15.90	1.3	1.25	0.1	1.08	0.1	0.82	0.1
BY-PRODUCT												
OTHER DIRECT COSTS[b]	159.78	12.4	185.18	12.2	223.79	17.8	174.13	16.8	159.87	21.8	168.67	19.4
GENERAL OVERHEAD	61.38	4.8	72.30	4.8	59.77	4.7	25.25	2.4	17.93	2.4	21.17	2.4
OTHER FIXED COSTS[c]	52.83	4.1	59.67	3.9	59.04	4.7	44.06	4.2	36.27	4.9	45.50	5.2
NET CASH COST	1 229.46	95.4	1 452.82	95.7	1 198.92	95.5	926.75	89.5	664.79	90.4	789.33	90.9
DEPRECIATION[d]	59.53	4.6	65.52	4.3	56.32	4.5	108.33	10.5	70.24	9.6	78.57	9.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 288.99	100.0	1 518.34	100.0	1 255.24	100.0	1 035.09	100.0	735.03	100.0	867.90	100.0
AT 85% LOAD FACTOR	1 404.60		1 647.34		1 386.13		1 170.07		859.15		997.56	
AT 65% LOAD FACTOR	1 512.72		1 770.02		1 507.76		1 285.69		952.49		1 102.24	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 434.37		1 680.10		1 414.29		1 224.24		894.27		1 036.84	
WITH 25% ROI	1 553.43		1 811.14		1 526.93		1 440.90		1 034.75		1 193.99	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 15. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Ethylene transfer price includes 5 % ROI in all countries.

PRODUCT: HDPE PLANT SIZE: 75,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	590.00		907.00		658.00		435.00		289.00		366.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	44.65		49.14		42.24		81.25		52.68		58.93	
WORKING CAPITAL, $ million	8.89		12.52		10.59		9.14		6.99		8.09	
UNIT INVESTMENT COST, $ million/ton/a	595.30		655.20		563.20		1 083.30		702.40		785.70	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	598.85	64.7	920.60	70.5	667.87	62.3	441.52	56.2	293.33	51.2	371.49	54.7
ENERGY	14.57	1.6	16.12	1.2	15.90	1.5	1.25	0.2	1.08	0.2	0.82	0.1
BY-PRODUCT												
OTHER DIRECT COSTS[b/]	159.78	17.3	185.18	14.2	223.79	20.9	174.13	22.2	159.87	27.9	168.67	24.8
GENERAL OVERHEAD	44.05	4.8	62.22	4.8	51.03	4.8	19.15	2.4	13.97	2.4	16.57	2.4
OTHER FIXED COSTS[c/]	48.31	5.2	57.04	4.4	56.76	5.3	40.88	5.2	34.20	6.0	43.10	6.3
NET CASH COST	865.56	93.6	1 241.17	95.0	1 015.35	94.7	676.93	86.2	502.46	87.7	600.65	88.4
DEPRECIATION[d/]	59.53	6.4	65.52	5.0	56.32	5.3	108.33	13.8	70.24	12.3	78.57	11.6
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	925.09	100.0	1 306.69	100.0	1 071.67	100.0	785.26	100.0	572.70	100.0	679.22	100.0
AT 85% LOAD FACTOR	1 036.85		1 433.45		1 200.62		918.61		695.76		807.64	
AT 65% LOAD FACTOR	1 137.06		1 551.53		1 318.26		1 030.87		786.92		909.79	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 066.61		1 466.21		1 288.78		972.78		730.88		846.92	
WITH 25% ROI	1 185.68		1 597.25		1 341.42		1 189.44		871.36		1 004.07	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 16. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: LDPE PLANT SIZE: 200,000 ton/year

Ethylene transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	927.00		1 103.00		828.00		672.00		443.00		545.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	146.90		161.50		139.50		267.36		173.34		193.91	
WORKING CAPITAL, $ million	31.99		38.13		30.58		30.50		20.87		23.89	
UNIT INVESTMENT COST, $ million/ton/a	734.50		807.50		697.50		1 336.80		866.70		969.50	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	982.62	81.8	1 169.18	82.0	877.68	77.8	712.32	69.7	469.58	68.0	577.70	71.9
ENERGY												
BY-PRODUCT	-25.18	-2.1	-29.96	-2.1	-22.48	-2.0	-18.27	-1.8	-11.93	-1.7	-14.80	-1.8
OTHER DIRECT COSTS[b]	62.48	5.2	78.16	5.5	102.09	9.0	116.49	11.4	92.61	13.4	81.04	10.1
GENERAL OVERHEAD	57.24	4.8	67.89	4.8	53.77	4.8	24.92	2.4	16.84	2.4	19.59	2.4
OTHER FIXED COSTS[c]	51.35	4.3	80.75	5.7	48.41	4.3	52.69	5.2	36.72	5.3	42.78	5.3
NET CASH COST	1 128.51	93.9	1 344.92	94.3	1 059.47	93.8	888.15	86.9	603.82	87.4	706.31	87.9
DEPRECIATION[d]	73.45	6.1	80.75	5.7	69.75	6.2	133.68	13.1	86.67	12.6	96.95	12.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 201.96	100.0	1 425.67	100.0	1 129.22	100.0	1 021.83	100.0	690.49	100.0	803.26	100.0
AT 85% LOAD FACTOR	1 255.45		1 486.63		1 184.56		1 089.78		742.35		858.44	
AT 65% LOAD FACTOR	1 341.16		1 585.65		1 272.03		1 199.16		818.75		941.65	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 292.17		1 527.01		1 219.44		1 156.61		785.69		906.92	
WITH 25% ROI	1 439.07		1 688.51		1 358.94		1 423.97		959.03		1 100.83	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 17. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: LDPE   PLANT SIZE: 200,000 ton/year

Ethylene transfer price includes 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	590.00		907.00		658.00		435.00		289.00		366.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	146.90		161.50		139.50		267.36		173.34		193.91	
WORKING CAPITAL, $ million	22.35		32.52		25.72		23.71		16.46		18.77	
UNIT INVESTMENT COST, $ million/ton/a	734.50		807.50		697.50		1336.80		866.70		969.50	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	625.40	76.1	961.42	79.8	697.48	74.4	461.10	60.6	306.34	58.8	387.96	64.0
ENERGY												
BY-PRODUCT	-25.18	-3.1	-29.96	-2.5	-22.48	-2.4	-18.27	-2.4	-11.93	-2.3	-14.80	-2.4
OTHER DIRECT COSTS[b]	62.48	7.6	78.16	6.5	102.09	10.9	116.49	15.3	92.61	17.8	81.04	13.4
GENERAL OVERHEAD	39.13	4.8	57.36	4.8	44.64	4.8	18.56	2.4	12.71	2.4	14.78	2.4
OTHER FIXED COSTS[c]	46.53	5.7	56.85	4.7	45.98	4.9	49.30	6.5	34.52	6.6	40.22	6.6
NET CASH COST	748.37	91.1	1 123.82	93.3	867.71	92.6	627.17	82.4	434.24	83.4	509.20	84.0
DEPRECIATION[d]	73.45	8.9	80.75	6.7	69.75	7.4	133.68	17.6	86.67	16.6	96.95	16.0
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	821.82	100.0	1 204.57	100.0	937.46	100.0	760.85	100.0	520.91	100.0	606.15	100.0
AT 85% LOAD FACTOR	871.26		1 263.19		990.76		827.08		571.65		660.04	
AT 65% LOAD FACTOR	948.68		1 357.37		1 074.04		932.93		645.75		740.57	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	907.98		1 303.56		1 025.63		893.92		614.99		708.51	
WITH 25% ROI	1 054.88		1 465.06		1 165.13		1 161.28		788.33		902.42	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Table 18. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: LLDPE PLANT SIZE: 200,000 ton/year

Ethylene transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	927.00		1 103.00		828.00		672.00		443.00		545.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	97.80		107.60		93.00		178.00		115.40		129.09	
WORKING CAPITAL, $ million	28.99		34.37		27.60		30.12		22.40		26.01	
UNIT INVESTMENT COST, $ million/ton/a	489.00		538.00		465.00		890.00		577.00		645.40	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	859.42	75.4	1 022.59	75.9	767.64	71.6	623.01	64.8	410.71	60.4	505.27	62.6
ENERGY	1.46	.1	1.61	.1	1.59	.1	.12	.-	.11	.-	.08	.-
BY-PRODUCT												
OTHER DIRECT COSTS[b/]	134.81	11.8	159.12	11.8	167.17	15.6	185.89	19.3	165.43	24.3	182.06	22.5
GENERAL OVERHEAD	54.26	4.8	64.16	4.8	51.05	4.8	23.43	2.4	16.60	2.4	19.70	2.4
OTHER FIXED COSTS[c/]	40.52	3.6	46.04	3.4	38.07	3.6	39.37	4.1	29.93	4.4	36.07	4.5
NET CASH COST	1 090.46	95.7	1 293.52	96.0	1 025.52	95.7	871.83	90.7	622.77	91.5	743.18	92.0
DEPRECIATION[d/]	48.90	4.3	53.80	4.0	46.50	4.3	89.00	9.3	57.70	8.5	64.54	8.0
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 139.36	100.0	1 347.32	100.0	1 072.02	100.0	960.83	100.0	680.47	100.0	807.73	100.0
AT 85% LOAD FACTOR	1 274.60		1 502.12		1 221.84		1 126.45		835.38		967.37	
AT 65% LOAD FACTOR	1 371.28		1 613.08		1 322.60		1 240.29		927.25		1 068.96	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 299.05		1 529.02		1 245.09		1 170.95		864.23		999.64	
WITH 25% ROI	1 396.85		1 636.62		1 338.09		1 348.95		979.63		1 128.73	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H   Table 19. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: LLDPE   PLANT SIZE: 200,000 ton/year

Ethylene transfer price includes 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	590.00		907.00		658.00		435.00		289.00		366.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST, a/ $ million	97.80		107.60		93.00		178.00		115.40		129.09	
WORKING CAPITAL, $ million	20.55		29.47		23.34		24.19		18.55		21.53	
UNIT INVESTMENT COST, $ million/ton/a	489.00		538.00		465.00		890.00		577.00		645.40	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	546.99	67.8	840.88	72.9	610.03	67.5	403.29	55.1	267.93	50.3	339.32	53.4
ENERGY	1.46	.2	1.61	.1	1.59	.2	.12	.-	.11	.-	.08	.-
BY-PRODUCT												
OTHER DIRECT COSTS b/	134.81	16.7	159.12	13.8	167.17	18.5	185.89	25.4	165.43	31.1	182.06	28.7
GENERAL OVERHEAD	38.42	4.8	54.95	4.8	43.06	4.8	17.87	2.4	12.98	2.4	15.50	2.4
OTHER FIXED COSTS c/	36.30	4.5	43.59	3.8	35.94	4.0	36.41	5.0	28.00	5.3	33.83	5.3
NET CASH COST	757.98	93.9	1 100.15	95.3	857.79	94.9	643.57	87.9	474.46	89.2	570.79	89.8
DEPRECIATION d/	48.90	6.1	53.80	4.7	46.50	5.1	89.00	12.1	57.70	10.8	64.54	10.2
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	806.88	100.0	1 153.95	100.0	904.29	100.0	732.57	100.0	532.16	100.0	635.33	100.0
AT 85% LOAD FACTOR	938.57		1 306.69		1 052.33		896.68		686.08		793.84	
AT 65% LOAD FACTOR	1 028.01		1 413.43		1 149.43		1 007.44		775.95		893.10	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	963.02		1 333.59		1 075.58		941.18		714.93		826.11	
WITH 25% ROI	1 060.82		1 441.19		1 168.58		1 119.18		830.33		955.20	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 20. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Methanol from methane PLANT SIZE: 640,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	methane		methane		methane		methane		methane		methane	
FEEDSTOCK PRICE, $/ton	344.00		387.00		381.00		100.00		100.00		100.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	53.41		61.44		132.90		254.44		164.96		191.52	
WORKING CAPITAL, $ million	8.88		9.97		31.22		13.08		10.59		12.02	
UNIT INVESTMENT COST, $ million/ton/a	83.40		96.00		207.60		39.70		257.70		299.20	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	146.92	43.3	165.29	43.3	162.73	45.7	42.71	32.9	42.71	40.4	42.71	36.3
ENERGY	88.06	26.0	97.47	25.6	96.12	27.0	7.53	5.8	6.55	6.2	4.97	4.2
BY-PRODUCT												
OTHER DIRECT COSTS[b]	43.20	12.74	49.03	12.9	45.03	12.6	24.14	18.6	19.11	18.1	26.20	22.3
GENERAL OVERHEAD	16.15	4.8	18.15	4.8	16.94	4.8	3.17	2.4	2.58	2.4	2.87	2.4
OTHER FIXED COSTS[c]	18.06	5.3	20.58	5.4	14.22	4.0	12.61	9.7	9.1	8.6	10.85	9.2
NET CASH COST	312.39	92.1	350.52	91.9	335.04	94.2	90.16	69.4	80.02	75.6	87.60	74.5
DEPRECIATION[d]	26.70	7.9	30.72	8.0	20.77	5.8	39.76	30.60	25.77	24.4	29.92	25.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	339.09	100.0	381.24	100.0	355.81	100.0	129.91	100.0	105.79	100.0	117.53	100.0
AT 85% LOAD FACTOR	356.09		400.93		371.60		145.90		117.72		131.31	
AT 65% LOAD FACTOR	387.89		437.23		399.48		173.55		137.05		154.45	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	369.45		416.29		381.98		165.77		130.61		146.27	
WITH 25% ROI	422.86		477.73		423.52		245.29		182.16		206.12	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 21. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Methanol from naphtha PLANT SIZE: 640,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	naphtha		naphtha		naphta							
FEEDSTOCK PRICE, $/ton	439.00		445.00		379.00							
LOCATION FACTOR	1.00		1.15		0.90							
FIXED CAPITAL COST,[a] $ million	152.70		168.00		145.10							
WORKING CAPITAL, $ million	35.58		35.24		33.96							
UNIT INVESTMENT COST, $ million/ton/a	238.60		262.50									
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	230.47	54.3	233.62	55.6	198.97	49.4						
ENERGY	109.88	25.9	97.47	23.2	119.95	29.8						
BY-PRODUCT												
OTHER DIRECT COSTS[b]	22.11	5.2	23.94	5.7	25.25	6.3						
GENERAL OVERHEAD	20.20	4.8	20.01	4.8	19.18	4.8						
OTHER FIXED COSTS[c]	17.67	4.2	18.98	4.5	16.69	4.1						
NET CASH COST	400.34	94.4	394.03	93.7	380.04	94.4						
DEPRECIATION[d]	23.86	5.6	26.25	6.2	22.67	5.6						
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	424.20	100.0	420.28	100.0	402.71	100.0						
AT 85% LOAD FACTOR	443.41		440.17		421.71							
AT 65% LOAD FACTOR	472.96		471.56		450.42							
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	455.34		453.30		433.04							
WITH 25% ROI	503.06		505.80		478.39							

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 22. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: PET from DMT PLANT SIZE: 90,000 ton/year

DMT transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	DMT		DMT		DMT		DMT		DMT		DMT	
FEEDSTOCK PRICE, $/ton	1 583.00		1 747.00		1 572.00		1 610.00		1 296.00		1 349.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	79.00		86.90		75.10		143.78		93.22		104.28	
WORKING CAPITAL, $ million	31.68		33.80		30.13		39.03		28.28		32.25	
UNIT INVESTMENT COST, $ million/ton/a	877.80		965.50		834.40		1 597.50		1 035.80		1 158.70	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 584.58	66.4	1 748.75	69.2	1 573.57	70.2	1 611.61	66.7	1 297.30	67.5	1 350.35	67.4
ENERGY	26.04	1.1	28.83	1.1	28.43	1.3	2.2	.1	1.94	.1	1.47	.1
BY-PRODUCT	-142.72	-6.0	-161.28	-6.4	-143.06	-6.4	-82.66	-3.4	-.66	-.0	-69.50	-3.5
OTHER DIRECT COSTSb/ g/	634.31	26.6	603.81	23.9	517.01	23.0	582.08	24.4	410.56	21.3	480.39	24.0
GENERAL OVERHEAD	113.56	4.8	120.25	4.8	106.77	4.8	58.92	2.4	46.90	2.4	48.86	2.4
OTHER FIXED COSTSc/	81.1	3.4	88.28	3.5	76.03	3.4	83.73	3.5	63.43	3.3	75.81	3.8
NET CASH COST	2 296.92	96.3	2 428.63	96.2	2 158.75	96.3	2 255.90	93.4	1 819.46	94.61	1 887.37	94.2
DEPRECIATIONd/												
NET COST OF PRODUCTION (NCP)	634.31	26.6	96.56	3.8	83.44	3.7	159.76	6.6	103.58	5.4	115.87	5.8
AT 100% LOAD FACTOR	2 384.70	100.0	2 525.19	100.0	2 242.20	100.0	2 415.66	100.0	1 923.04	100.0	2 003.24	100.0
AT 85% LOAD FACTOR												
AT 65% LOAD FACTOR	3 092.76		3 189.48		2 801.03		3 078.49		2 383.54		2 531.90	
TRANSFER PRICE AT 85% LOAD FACTOR	3 416.59		3 509.06		3 074.13		3 395.28		2 607.01		2 789.06	
WITH 5% ROI	3 136.65		3 237.76		2 842.75		3 158.37		2 435.32		2 589.84	
WITH 25% ROI	3 312.21		3 430.87		3 009.64		3 477.88		2 642.48		2 821.57	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes ethylene glycol at: U.S. Gulf, $1251/ton; F.R.G., $1413/ton; Japan, $1178/ton; Far East, $1378/ton; Mexico, $942/ton; Arab Gulf, $1086/ton.

Annex II.H Table 23. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

DMT transfer price includes 5 % ROI in all countries.

PRODUCT: PET from DMT PLANT SIZE: 90,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	DMT		DMT		DMT		DMT		DMT		DMT	
FEEDSTOCK PRICE, $/ton	1 303.00		1 436.00		1 317.00		1 121.00		976.00		988.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	79.00		86.90		75.10		143.78		93.22		104.28	
WORKING CAPITAL, $ million	24.82		28.22		25.54		28.37		21.18		23.81	
UNIT INVESTMENT COST, $ million/ton/a	877.80		965.50		834.40		1 597.50		1 035.80		1 158.70	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 304.30	71.2	1 437.44	68.9	1 318.32	70.2	1 122.12	63.4	976.98	66.7	988.99	65.7
ENERGY	26.04	1.4	28.83	1.4	28.43	1.5	2.23	.1	1.94	.1	1.47	.1
BY-PRODUCT	-124.50	-6.8	-140.36	-6.7	-128.89	-6.9	-56.01	-3.2	-.66		-49.26	-3.3
OTHER DIRECT COSTSb/ g/	378.41	20.6	482.31	23.1	416.41	22.2	425.88	24.1	291.76	19.9	344.79	22.9
GENERAL OVERHEAD	87.28	4.8	99.34	4.8	89.43	4.8	43.15	2.4	35.73	2.4	36.71	2.4
OTHER FIXED COSTSc/	73.53	4.0	82.00	3.9	70.93	3.8	71.88	4.1	55.54	3.8	66.41	4.4
NET CASH COST	1 745.06	95.2	1 989.55	95.4	1 794.63	95.6	1 609.24	91.0	1 361.28	92.9	1 389.13	92.3
DEPRECIATIONd/	87.78	4.8	96.56	4.6	83.44	4.4	159.76	9.0	103.58	7.1	115.87	7.7
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 832.84	100.0	2 086.10	100.0	1 878.07	100.0	1 769.00	100.0	1 464.86	100.0	1 505.00	100.0
AT 85% LOAD FACTOR	2 233.86		2 602.66		2 314.59		2 243.19		1 782.22		1 870.33	
AT 65% LOAD FACTOR	2 452.78		2 868.41		2 543.15		2 493.44		1 955.80		2 070.61	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	2 277.75		2 650.94		2 356.32		2 323.07		1 834.01		1 928.27	
WITH 25% ROI	2 453.30		2 844.05		2 523.20		2 642.58		2 041.17		2 160.00	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes ethylene glycol at: U.S.Gulf, $1209/ton; F.R.G., $1368/ton; Japan, $1139/ton; Far East, $1303/ton; Mexico, $942/ton; Arab Gulf, $1086/ton.

Annex II.H   Table 24. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: PET from TPA   PLANT SIZE: 90,000 ton/year

TPA transfer price includes 25% ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	TPA		TPA		TPA		TPA		TPA		TPA	
FEEDSTOCK PRICE, $/ton	1 353.00		1 499.00		1 477.00		1 533.00		1 269.00		1 356.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	64.73		71.15		23.62		117.80		76.37		85.45	
WORKING CAPITAL, $ million	22.49		25.62				33.36		25.24		28.12	
UNIT INVESTMENT COST, $ million/ton/a	719.20		790.50		683.40		1 308.80		848.50		949.40	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 158.57	59.1	1 283.59	57.9	1 264.76	61.5	1 329.83	61.6	1 086.64	64.9	1 161.14	63.0
ENERGY	40.77	2.1	45.12	2.0	44.50	2.2	3.49	0.2	3.03	0.2	2.3	0.1
BY-PRODUCT												
OTHER DIRECT COSTS[b/ g/]	531.32	27.1	616.73	27.8	515.75	25.1	570.83	26.4	402.24	24.0	471.52	25.6
GENERAL OVERHEAD	93.40	4.8	105.62	4.8	52.66	4.8	52.66	2.4	40.82	2.4	44.92	2.4
OTHER FIXED COSTS[c]	65.42	3.4	87.84	4.0	68.47	3.1	71.18	3.3	56.09	3.3	66.85	3.6
NET CASH COST	1 889.48	96.3	2 138.91	96.4	1 986.32	96.7	2 027.99	93.9	1 588.82	94.9	1 746.74	94.8
DEPRECIATION[d]	71.92	3.7	79.06	3.6	68.34	3.3	130.89	6.1	84.86	5.1	94.94	5.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 961.40	100.0	2 217.96	100.0	2 054.67	100.0	2 158.88	100.0	1 673.68	100.0	1 841.68	100.0
AT 85% LOAD FACTOR	2 551.05		2 885.66		2 618.09		2 809.18		2 124.75		2 360.70	
AT 65% LOAD FACTOR	2 820.27		3 199.71		2 879.05		3 104.77		2 333.72		2 602.58	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	2 587.01		2 925.19		2 652.26		2 874.62		2 167.18		2 408.17	
WITH 25% ROI	2 730.85		3 083.30		2 788.95		3 136.40		2 336.89		2 598.06	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes ethylene glycol at: U.S.Gulf Coast, $1251/ton; F.R.G., $1413/ton; Japan, $1178/ton; Far East, $1378/ton; Mexico, $942/ton; Arab Gulf, $1086/ton.

Annex II.H Table 25. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: PET from TPA

PLANT SIZE: 90,000 ton/year

TPA transfer price includes 5% ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	TPA		TPA		TPA		TPA		TPA		TPA	
FEEDSTOCK PRICE, $/ton	1 132.00		1 245.00		1 258.00		1 132.00		997.00		1 040.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	64.73		71.15		61.51		117.80		76.37		85.45	
WORKING CAPITAL, $ million	18.18		21.40		19.96		24.03		19.20		21.17	
UNIT INVESTMENT COST, $ million/ton/a	719.2		790.5		683.4		1 308.8		848.5		949.4	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	969.33	61.2	1 066.09	57.7	1 077.23	62.1	969.33	60.9	853.73	65.3	890.55	62.8
ENERGY	40.77	2.6	45.12	2.4	44.50	2.6	3.49	0.2	3.03	0.2	2.30	0.2
BY-PRODUCT												
OTHER DIRECT COSTS b/g/	365.42	23.1	487.13	26.3	402.65	23.2	387.63	24.4	283.54	21.7	335.82	23.7
GENERAL OVERHEAD	75.40	4.8	88.03	4.8	82.61	4.8	38.80	2.4	31.86	2.4	34.57	2.4
OTHER FIXED COSTS c/	60.62	3.8	83.16	4.5	59.42	3.4	60.82	3.8	49.38	3.8	59.15	4.2
NET CASH COST	1 511.54	95.5	1 769.53	95.7	1 666.40	96.1	1 460.07	91.8	1 221.55	93.5	1 322.37	93.3
DEPRECIATION d/	71.92	4.5	79.06	4.3	68.34	3.9	130.89	8.2	84.86	6.5	94.94	6.7
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 583.47	100.0	1 848.59	100.0	1 734.74	100.0	1 590.96	100.0	1 306.40	100.0	1 417.32	100.0
AT 85% LOAD FACTOR	1 973.91		2 359.89		2 161.70		2 021.46		1 615.06		1 773.50	
AT 65% LOAD FACTOR	2 174.83		2 618.96		3 374.74		2 241.97		1 775.39		1 959.71	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	2 009.88		2 399.41		2 195.87		2 086.90		1 657.49		1 820.97	
WITH 25% ROI	2 153.72		2 557.53		2 332.56		2 348.68		1 827.20		2 010.86	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes ethylene glycol at: U.S.Gulf Coast, $1209/ton; F.R.G., $1368/ton; Japan, $1139/ton; Far East, $1303/ton; Mexico, $942/ton; Arab Gulf, $1086/ton.

Annex II.H Table 26. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Polypropylene PLANT SIZE: 90,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	propylene		propylene		propylene		propylene		propylene		propylene	
FEEDSTOCK PRICE, $/ton	582.00		582.00		595.00		403.00		141.00		396.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	84.80		93.20		80.50		154.96		100.06		116.17	
WORKING CAPITAL, $ million	10.38		11.00		11.29		11.73		6.51		11.49	
UNIT INVESTMENT COST, $ million/ton/a	942.20		1 035.50		894.40		1 721.80		1 111.80		1 290.70	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	593.64	66.0	593.64	63.0	606.90	63.7	411.06	48.2	143.82	32.3	403.92	49.0
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTSb/	107.45	11.9	132.05	14.0	151.85	15.9	191.54	22.4	137.65	30.9	213.13	25.9
GENERAL OVERHEAD	42.85	4.8	44.85	4.8	45.36	4.8	20.80	2.4	10.87	2.4	20.09	2.4
OTHER FIXED COSTSc/	61.75	6.9	67.69	7.2	59.00	6.2	57.33	6.7	42.35	9.5	57.40	7.0
NET CASH COST	805.68	89.5	838.23	89.0	863.11	90.6	680.73	79.8	334.68	75.1	694.54	84.3
DEPRECIATIONd/	94.22	10.5	103.56	11.0	89.44	9.4	172.18	20.2	111.18	24.9	129.08	15.7
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	899.91	100.0	941.79	100.0	952.55	100.0	852.90	100.0	445.86	100.0	823.62	100.0
AT 85% LOAD FACTOR	963.01		1 006.61		1 019.89		936.08		508.76		900.85	
AT 65% LOAD FACTOR	1 064.75		1 118.66		1 125.81		1 072.09		603.19		1 024.67	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 010.12		1 058.39		1 064.61		1 022.17		564.35		965.39	
WITH 25% ROI	1 198.56		1 265.50		1 243.50		1 366.52		786.70		1 223.54	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 27. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Styrene transfer price includes 25 % ROI in all countries.

PRODUCT: Polystyrene PLANT SIZE: 200,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	styrene		styrene		styrene		styrene		styrene		styrene	
FEEDSTOCK PRICE, $/ton	1 650.00		1 852.00		1 602.00		1 282.00		934.00		1 124.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	73.42		80.74		69.63		133.62		86.63		96.91	
WORKING CAPITAL, $ million	48.38		54.30				39.40		28.87		34.78	
UNIT INVESTMENT COST, $ million/ton/a	367.10		403.70		348.10		668.10		433.10		484.50	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 683.00	88.6	1 889.04	88.6	1 634.04	88.4	1 307.64	88.1	952.68	87.9	1 146.48	87.9
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTSb/	40.22	2.1	45.60	2.1	44.30	2.4	34.22	2.3	30.34	2.8	38.20	2.9
GENERAL OVERHEAD	90.46	4.8	101.50	4.8	88.03	4.8	36.20	2.4	26.44	2.4	31.82	2.4
OTHER FIXED COSTSc/	49.20	2.6	54.99	2.6	47.42	2.6	39.17	2.6	31.29	2.9	39.62	3.0
NET CASH COST	1 862.87	98.1	2 091.13	98.1	1 813.79	98.1	1 417.22	95.0	1 040.74	96.0	1 256.12	96.3
DEPRECIATIONd/	36.71	1.9	40.37	1.9	34.81	1.9	66.81	4.5	43.31	4.0	48.45	3.7
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 899.58	100.0	2 131.50	100.0	1 848.60	100.0	1 484.03	100.0	1 084.06	100.0	1 304.57	100.0
AT 85% LOAD FACTOR	1 936.45		2 172.70		1 884.55		1 514.60		1 106.74		1 332.05	
AT 65% LOAD FACTOR	2 012.08		2 257.22		1 958.28		1 577.31		1 153.28		1 388.41	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 954.81		2 192.89		1 901.96		1 548.01		1 128.40		1 356.28	
WITH 25% ROI	2 028.23		2 273.63		1 971.59		1 681.63		1 215.03		1 453.19	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.E Table 28. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Styrene transfer price includes 5 % ROI in all countries.

PRODUCT: Polystyrene PLANT SIZE: 200,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	styrene		styrene		styrene		styrene		styrene		styrene	
FEEDSTOCK PRICE, $/ton	1 566.00		1 758.00		1 522.00		1 128.00		834.00		1 009.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	73.43		80.74		69.63		133.62		86.63		96.91	
WORKING CAPITAL, $ million	46.06		51.71		44.96		35.16		26.12		31.61	
UNIT INVESTMENT COST, $ million/ton/a	367.10		403.70		348.10		668.10		433.10		484.50	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 597.32	88.3	1 793.16	88.4	1 552.44	88.1	1 150.56	87.1	850.68	87.0	1 029.18	87.0
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTSb/	40.22	2.2	45.60	2.2	44.30	2.5	34.22	2.6	30.34	3.1	38.20	3.2
GENERAL OVERHEAD	86.11	4.8	96.64	4.8	83.89	4.8	32.22	2.4	23.86	2.4	28.85	2.4
OTHER FIXED COSTSc/	48.04	2.7	53.70	2.6	46.32	2.6	37.04	2.8	29.91	3.1	38.04	3.2
NET CASH COST	1 771.69	98.0	1 989.10	98.0	1 726.95	98.0	1 254.04	94.9	934.78	95.6	1 134.26	95.9
DEPRECIATIONd/	36.71	2.0	40.37	2.0	34.81	2.0	66.81	5.1	43.31	4.4	48.45	4.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 808.40	100.0	2 029.47	100.0	1 761.77	100.0	1 320.85	100.0	978.10	100.0	1 182.72	100.0
AT 85% LOAD FACTOR	1 844.30		2 069.58		1 796.79		1 350.35		1 000.08		1 209.39	
AT 65% LOAD FACTOR	1 917.94		2 151.87		1 868.63		1 410.85		1 045.19		1 264.10	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 862.66		2 089.77		1 814.19		1 383.75		1 021.74		1 233.62	
WITH 25% ROI	1 936.08		2 170.51		1 883.82		1 517.37		1 108.37		1 330.53	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 29. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

VCM transfer price includes 25 % ROI in all countries.

PRODUCT: PVC PLANT SIZE: 75,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF
FEEDSTOCK	VCM		VCM		VCM		VCM		VCM		
FEEDSTOCK PRICE, $/ton	1 148.00		1 174.00		1 156.00		1 142.00		516.00		
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		
FIXED CAPITAL COST,a/ $ million	69.89		76.92		66.44		127.54		81.99		
WORKING CAPITAL, $ million	15.32		16.03		15.76		16.43		8.72		
UNIT INVESTMENT COST, $ million/ton/a	931.90		1 025.60		885.80		1 700.50		1 093.20		
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	
FEEDSTOCK	1 176.70	74.8	1 203.35	73.4	1 184.90	73.9	1 170.55	74.5	528.90	65.8	
ENERGY											
BY-PRODUCT											
OTHER DIRECT COSTSb/	158.82	10.1	180.85	11.0	186.44	11.6	122.83	7.8	98.73	12.3	
GENERAL OVERHEAD	74.90	4.8	78.10	4.8	76.31	4.8	38.32	2.4	19.59	2.4	
OTHER FIXED COSTSc/	69.04	4.4	75.30	4.5	66.18	4.1	69.27	4.4	46.67	5.8	
NET CASH COST	1 479.44	94.1	1 537.60	93.7	1 513.82	94.5	1 400.97	89.2	693.89	86.4	
DEPRECIATIONd/	93.19	5.9	102.56	6.2	88.59	5.5	170.05	10.8	109.32	13.6	
NET COST OF PRODUCTION (NCP)											
AT 100% LOAD FACTOR	1 572.63	100.0	1 640.16	100.0	1 602.41	100.0	1 571.02	100.0	803.21	100.0	
AT 85% LOAD FACTOR	1 646.56		1 721.90		1 680.80		1 655.64		866.14		
AT 65% LOAD FACTOR	1 769.71		1 856.78		1 805.69		1 793.60		959.59		
TRANSFER PRICE AT 85% LOAD FACTOR											
WITH 5% ROI	1 693.16		1 773.18		1 725.09		1 740.67		920.80		
WITH 25% ROI	1 879.53		1 978.30		1 902.26		2 080.78		1 139.44		

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Table 30. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

VCM transfer price includes 5 % ROI in all countries.

PRODUCT: PVC   PLANT SIZE: 75,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	VCM		VCM		VCM		VCM		VCM		VCM	
FEEDSTOCK PRICE, $/ton	885.00		974.00		982.00		858.00		332.00		620.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	69.89		76.92		66.44		127.54		81.99		96.09	
WORKING CAPITAL, $ million	12.59		13.96		13.95		13.49		6.81		11.93	
UNIT INVESTMENT COST, $ million/ton/a	931.90		1 025.60		885.80		1 700.50		1 093.20		1 153.20	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	907.12	70.6	998.35	70.2	1 006.55	71.3	879.45	69.3	340.30	56.0	635.50	59.8
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b]	158.82	12.4	180.85	12.7	186.44	13.2	122.83	9.7	98.73	16.3	211.94	19.9
GENERAL OVERHEAD	61.23	4.8	67.71	4.8	67.27	4.8	30.94	2.4	14.81	2.4	25.93	2.4
OTHER FIXED COSTS[c]	65.40	5.1	72.53	5.1	63.77	4.5	65.35	5.2	44.12	7.3	61.68	5.8
NET CASH COST	1 192.57	92.8	1 319.44	92.8	1 324.03	93.7	1 098.56	86.6	497.96	82.0	935.05	87.9
DEPRECIATION[d]	93.19	7.2	102.56	7.2	88.59	6.3	170.05	13.4	109.32	18.0	128.12	12.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 285.76	100.0	1 422.00	100.0	1 412.62	100.0	1 268.62	100.0	607.28	100.0	1 063.17	100.0
AT 85% LOAD FACTOR	1 356.64		1 501.43		1 488.98		1 351.24		668.92		1 142.98	
AT 65% LOAD FACTOR	1 473.52		1 631.54		1 609.73		1 485.11		759.72		1 271.07	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 403.23		1 552.71		1 533.27		1 436.27		723.58		1 207.04	
WITH 25% ROI	1 589.60		1 757.83		1 710.45		1 776.38		942.22		1 463.28	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H   Table 31. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

SBR transfer price includes 25 % ROI in all countries.

PRODUCT: SBR   PLANT SIZE: 35,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	butadiene		butadiene		butadiene		butadiene		butadiene		butadiene	
FEEDSTOCK PRICE, $/ton	908.00		944.00		992.00		729.00		606.00		725.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	49.40		54.40		47.00		89.90		58.29		65.20	
WORKING CAPITAL, $ million	8.19		9.10		9.11		9.85		8.34		9.64	
UNIT INVESTMENT COST, $ million/ton/a	1 411.40		1 554.30		1 342.80		2 568.50		1 665.40		1 862.80	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	661.02	38.3	723.63	37.8	722.18	37.7	530.71	36.3	441.17	36.3	527.80	37.1
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b/g/]	703.73	40.8	794.30	41.4	836.32	43.7	533.59	36.5	478.49	39.4	543.37	38.2
GENERAL OVERHEAD	82.12	4.8	91.25	4.8	91.08	4.8	35.66	2.4	29.63	2.4	34.68	2.4
OTHER FIXED COSTS[c]	136.48	7.9	151.66	7.9	128.75	6.7	105.11	7.2	98.92	8.1	129.55	9.1
NET CASH COST	1 583.36	91.8	1 760.85	91.7	1 778.32	93.0	1 205.07	82.4	1 048.21	86.3	1 235.39	86.9
DEPRECIATION[d]	141.14	8.2	155.43	8.1	134.29	7.0	256.86	17.6	166.54	13.7	186.29	13.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 724.50	100.0	1 916.28	100.0	1 912.61	100.0	1 461.93	100.0	1 214.75	100.0	1 421.68	100.0
AT 85% LOAD FACTOR	2 436.35		2 716.40		2 763.20		2 013.44		1 687.57		1 944.37	
AT 65% LOAD FACTOR	2 811.23		3 135.93		3 178.38		2 344.53		1 962.47		2 264.16	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	2 506.92		2 794.11		2 830.34		2 141.87		1 770.84		2 037.52	
WITH 25% ROI	2 789.21		3 104.97		3 098.82		2 655.58		2 103.92		2 410.09	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes styrene at: U.S.Gulf Coast, $1650/ton; F.R.G.,$1852/ton; Japan, $1602/ton; Far East, $1281/ton; Mexico, $934/ton; Arab Gulf, $1124/ton.

Annex II.H Table 32. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: SBR PLANT SIZE: 35,000 ton/year

SBR transfer price includes 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	butadiene		butadiene		butadiene		butadiene		butadiene		butadiene	
FEEDSTOCK PRICE, $/ton	908.00		994.00		992.00		729.00		606.00		725.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	49.40		54.40		47.00		89.90		58.29		65.20	
WORKING CAPITAL, $ million	8.10		9.02		9.03		10.54		8.87		10.29	
UNIT INVESTMENT COST, $ million/ton/a												
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	661.02	38.8	723.63	38.2	722.18	38.1	530.71	34.74	441.17	34.8	527.80	35.6
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b/g]	684.93	40.2	773.40	40.8	818.53	43.2	596.29	39.00	526.89	41.6	602.77	40.6
GENERAL OVERHEAD	81.17	4.8	90.19	4.8	90.17	4.8	37.27	2.4	30.88	2.4	36.21	2.4
OTHER FIXED COSTS[c]	136.22	8.0	151.37	8.0	128.50	6.8	107.08	7.0	100.45	7.9	131.42	8.9
NET CASH COST	1 563.34	91.7	1 738.59	91.8	1 759.38	92.9	1 271.36	83.2	1 099.38	86.8	1 298.19	87.5
DEPRECIATION[d]	141.14	8.3	155.43	8.2	134.29	7.1	256.86	16.8	166.54	13.2	186.29	12.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 704.48	100.0	1 894.02	100.0	1 893.66	100.0	1 528.22	100.0	1 265.92	100.0	1 484.48	100.0
AT 85% LOAD FACTOR	2 394.00		2 669.32		2 723.13		2 154.12		1 796.17		2 077.66	
AT 65% LOAD FACTOR	2 761.63		3 080.79		3 131.44		2 509.22		2 089.59		2 420.17	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	2 464.57		2 747.03		2 790.27		2 282.55		1 879.44		2 170.80	
WITH 25% ROI	2 746.86		3 057.89		3 058.84		2 796.27		2 212.52		2 543.37	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes styrene at: U.S.Gulf Coast, $1566/ton; F.R.G., $1759/ton; Japan, $1522/ton; Far East, $1128/ton; Mexico, $834/ton; Arab Gulf, $1009/ton.

Annex II.H Table 33. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Styrene PLANT SIZE: 260,000 ton/year

Ethyl benzene transfer price includes 25 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene	
FEEDSTOCK PRICE, $/ton	1 140.00		1 287.00		1 108.00		886.00		649.00		787.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	74.57		81.99		70.81		136.09		88.55		102.53	
WORKING CAPITAL, $ million	56.17		63.60		56.76		43.13		31.52		38.12	
UNIT INVESTMENT COST, $ million/ton/a	286.80		315.30		272.30		523.40		340.60		394.30	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 308.72	85.0	1 477.48	85.4	1 271.98	85.1	1 017.13	90.8	745.05	90.4	903.48	90.5
ENERGY	26.20	1.7	29.00	1.7	28.60	1.9	[illegible].24	0.2	1.95	0.2	1.48	0.1
BY-PRODUCT	-43.29	-2.8	-53.91	-3.1	-63.63	-4.2	-46.50	-4.1	-30.46	-3.7	-34.47	-3.6
OTHER DIRECT COSTS b/	111.83	7.3	125.37	7.2	125.53	8.4	37.71	3.4	32.21	3.9	40.09	4.0
GENERAL OVERHEAD	73.31	4.8			71.16	4.8	27.3	2.4	20.10	2.4	24.34	2.4
OTHER FIXED COSTS c/	34.00	2.2	38.13	2.2	33.41	2.2	29.58	2.6	21.28	2.6	25.73	2.6
NET CASH COST	1 510.77	98.1	1 698.45	98.2	1 467.06	98.2	1 067.47	95.3	790.13	95.7	958.65	96.0
DEPRECIATION d/	28.68	1.9	31.53	1.8	27.23	1.8	52.34	4.8	34.06	4.1	39.43	3.9
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 539.45	100.0	1 729.98	100.0	1 494.29	100.0	1 119.81	100.0	824.19	100.0	998.09	100.0
AT 85% LOAD FACTOR	1 578.50		1 773.62		1 534.13		1 151.09		848.53		1 025.78	
AT 65% LOAD FACTOR	1 647.72		1 851.01		1 603.77		1 201.66		884.88		1 068.99	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 592.84		1 789.38		1 547.75		1 177.26		865.56		1 045.49	
WITH 25% ROI	1 650.20		1 852.45		1 602.22		1 281.94		933.67		1 124.36	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 34. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Styrene PLANT SIZE: 260,000 ton/year

Ethyl benzenetransfer price [illegible] 5% ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene		ethyl benzene	
FEEDSTOCK PRICE, $/ton	1 118.00		1 262.00		1 087.00		845.00		623.00		757.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,a/ $ million	74.57		81.99		70.81		136.09		88.55		102.53	
WORKING CAPITAL, $ million	55.29		62.59		55.91		41.48		30.47		36.91	
UNIT INVESTMENT COST, $ million/ton/a	286.80		315.30		272.30		523.40		340.60		394.30	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	1 283.46	84.9	1 448.78	85.3	1 247.88	85.0	970.06	90.6	715.20	90.2	869.04	90.3
ENERGY	26.20	1.7	29.00	1.7	28.60	1.9	2.24	0.2	1.95	0.2	1.48	0.2
BY-PRODUCT	-43.29	-2.9	-53.91	-3.2	-63.63	-4.3	-46.50	-4.3	-30.46	-3.8	-36.47	-3.8
OTHER DIRECT COSTS b/	111.83	7.4	125.37	7.4	125.53	8.5	37.71	3.5	32.21	4.1	40.09	4.2
GENERAL OVERHEAD	72.03	4.8	80.93	4.8	69.93	4.8	26.12	2.4	19.35	2.4	23.47	2.4
OTHER FIXED COSTS c/	33.66	2.2	37.74	2.2	33.09	2.3	28.94	2.7	20.88	2.6	25.27	2.6
NET CASH COST	1 483.90	98.1	1 667.91	98.1	1 441.40	98.1	1 018.57	95.1	759.12	95.7	922.88	95.9
DEPRECIATION d/	28.68	1.9	31.53	1.9	27.23	1.9	52.34	4.9	34.06	4.3	39.43	4.1
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	1 512.58	100.0	1 699.44	100.0	1 468.63	100.0	1 070.92	100.0	793.18	100.0	962.31	100.0
AT 85% LOAD FACTOR	1 551.34		1 742.75		1 508.21		1 101.87		817.32		989.76	
AT 65% LOAD FACTOR	1 619.97		1 819.48		1 577.28		1 151.78		853.25		1 032.49	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 565.68		1 758.52		1 521.82		1 128.04		834.34		1 009.48	
WITH 25% ROI	1 623.04		1 821.59		1 576.29		1 232.73		902.46		1 088.35	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II,H Table 35. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Table..............

PRODUCT: TPA PLANT SIZE: 85,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	p-xylene		p-xylene		p-xylene		p-xylene		p-xylene		p-xylene	
FEEDSTOCK PRICE, $/ton	752.00		811.00		745.00		544.00		660.00		588.00	
LOCATION FACTOR	1.00		1.15		.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	98.14		107.96		93.28		178.61		115.80		134.45	
WORKING CAPITAL, $ million	10.95		12.37		12.13		12.61		11.26		11.81	
UNIT INVESTMENT COST, $ million/ton/a												
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	505.34	51.3	544.99	51.2	500.64	48.7	365.57	42.3	443.52	56.2	395.14	48.8
ENERGY	58.22	5.9	64.44	6.1	63.55	6.2	4.98	.6	4.33	.5	3.29	.4
BY-PRODUCT			-16.82	-1.6	-16.82	-1.6	-18.27	-2.1	-18.27	-2.3	-18.27	-2.3
OTHER DIRECT COSTS[b/]	186.90	19.0	214.55	20.2	252.67	24.6	204.47	23.7	146.76	18.6	184.95	22.8
GENERAL OVERHEAD	46.87	4.8	50.67	4.8	48.95	4.8	21.06	2.4	19.23	2.4	19.76	2.4
OTHER FIXED COSTS[c/]	71.49	7.3	79.22	7.4	69.27	6.7	75.45	8.7	56.81	7.2	67.27	8.3
NET CASH COST	868.83	88.3	937.05	88.1	918.26	89.3	653.26	75.7	652.37	82.7	652.13	80.5
DEPRECIATION[d/]	115.46	11.7	214.55	20.2	109.74	10.7	210.13	24.3	136.24	17.3	158.18	19.5
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	984.29	100.0	1 064.07	100.0	1 028.00	100.0	863.39	100.0	788.61	100.0	810.31	100.0
AT 85% LOAD FACTOR	1 113.65		1 210.89		1 203.11		1 027.35		928.97		960.85	
AT 65% LOAD FACTOR	1 252.65		1 365.80		1 356.98		1 205.72		1 058.93		1 111.69	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 171.38		1 274.39		1 257.98		1 132.41		997.08		1 039.93	
WITH 25% ROI	1 402.29		1 528.42		1 477.46		1 552.67		1 269.55		1 356.29	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

 Table 36. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Ammonia transfer price includes 25 % ROI in all countries.

PRODUCT: Urea PLANT SIZE: 680,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ammonia		ammonia		ammonia		ammonia		ammonia		ammonia	
FEEDSTOCK PRICE, $/ton	418.00		516.00		535.00		334.00		238.00		270.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	67.56		77.22		64.17		122.96		79.72		89.17	
WORKING CAPITAL, $ million	26.13		32.08		32.63		20.91		15.00		17.45	
UNIT INVESTMENT COST, $ million/ton/a	99.30		113.50		94.40		180.80		117.20		131.10	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	238.26	80.0	294.12	80.4	304.95	81.9	190.38	82.1	135.66	81.9	153.90	80.5
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b]	26.93	9.0	31.66	8.7	30.93	8.3	10.32	4.4	8.70	5.3	12.87	6.7
GENERAL OVERHEAD	14.19	4.8	17.42	4.8	17.73	4.8	5.66	2.4	4.04	2.4	4.66	2.4
OTHER FIXED COSTS[c]	8.60	2.9	11.26	3.1	9.23	2.5	7.58	3.3	5.61	3.4	6.71	3.5
NET CASH COST	287.97	96.7	354.47	96.9	362.84	97.5	213.94	92.2	154.01	92.9	178.15	93.1
DEPRECIATION[d]	9.94	3.3	11.36	3.1	9.44	2.5	18.08	7.8	11.72	7.1	13.11	6.9
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	297.91	100.0	365.82	100.0	372.28	100.0	232.03	100.0	165.74	100.0	191.26	100.0
AT 85% LOAD FACTOR	306.09		375.85		381.35		238.97		170.65		197.14	
AT 65% LOAD FACTOR	322.87		396.42		399.96		253.22		180.74		209.21	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	311.06		381.53		386.07		248.01		176.51		203.70	
WITH 25% ROI	330.93		404.24		404.94		284.18		199.96		229.93	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 37. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: Urea

PLANT SIZE: 680,000 ton/year

Ammonia transfer price includes 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		MID EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ammonia		ammonia		ammonia		ammonia		ammonia		ammonia	
FEEDSTOCK PRICE, $/ton	356.00		438.00		468.00		221.00		165.00		185.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a/] $ million	67.56		77.22		64.17		122.96		79.72		89.17	
WORKING CAPITAL, $ million	22.95		28.08		29.20		15.11		11.25		13.09	
UNIT INVESTMENT COST, $ million/ton/a	99.3		113.5		94.4		180.8		117.2		131.1	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	202.92	78.0	249.66	78.4	266.76	80.4	125.97	76.3	94.05	76.7	105.45	74.8
ENERGY												
BY-PRODUCT												
OTHER DIRECT COSTS[b/]	26.93	10.3	31.66	9.9	30.93	9.3	10.32	6.3	8.70	7.1	12.87	9.1
GENERAL OVERHEAD	12.40	4.8	15.17	4.8	15.79	4.8	4.03	2.4	2.99	2.4	3.44	2.4
OTHER FIXED COSTS[c/]	8.13	3.1	10.68	3.4	8.72	2.6	6.73	4.1	5.06	4.1	6.07	4.3
NET CASH COST	250.38	96.2	307.17	96.4	322.21	97.2	147.05	89.0	110.80	90.4	127.83	90.7
DEPRECIATION[d/]	9.94	3.8	11.36	3.6	9.44	2.8	18.08	11.0	11.72	9.6	13.11	9.3
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	260.31	100.0	318.52	100.0	331.65	100.0	165.13	100.0	122.52	100.0	140.94	100.0
AT 85% LOAD FACTOR	268.09		328.05		340.29		171.64		127.15		146.49	
AT 65% LOAD FACTOR	284.05		347.58		358.02		184.99		136.66		157.88	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	273.06		333.73		345.01		180.68		133.02		153.05	
WITH 25% ROI	292.93		356.44		363.88		216.85		156.46		179.28	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

Annex II.H Table 38. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

Ethylene transfer price includes 25% ROI in all countries.

PRODUCT: VCM PLANT SIZE: 152,000 ton/year

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		FAR EAST		MEXICO		ARABIAN GULF	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	927.00		1 103.00		828.00		672.00		443.00		545.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	69.46		76.29		65.90		126.41		81.95		91.85	
WORKING CAPITAL, $ million	16.43		17.72		16.30		18.66		7.65		13.67	
UNIT INVESTMENT COST, $ million/ton/a	457.0		501.9		433.5		831.6		539.1		604.3	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	440.32	52.0	523.92	57.5	393.30	47.2	319.20	46.5	210.42	60.8	258.87	49.6
ENERGY	84.42	10.0	93.44	10.2	92.15	11.1	7.22	1.1	6.28	1.8	4.77	0.9
BY-PRODUCT												
OTHER DIRECT COSTS[b/g/]	202.66	23.9	164.90	18.1	233.78	28.0	226.29	33.0	46.08	13.3	157.29	30.1
GENERAL OVERHEAD	40.30	4.8	43.42	4.8	39.70	4.8	16.73	2.4	8.44	2.4	12.74	2.4
OTHER FIXED COSTS[c]	32.97	3.9	36.05	3.9	31.33	3.8	33.16	4.8	20.75	6.0	28.15	5.4
NET CASH COST	800.67	94.6	861.73	94.5	790.25	94.8	602.59	87.9	291.97	84.4	461.82	88.4
DEPRECIATION[d]	45.70	5.4	50.19	5.5	43.36	5.2	83.16	12.1	53.91	15.6	60.43	11.6
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	846.37	100.0	911.92	100.0	833.61	100.0	685.75	100.0	345.89	100.0	522.25	100.0
AT 85% LOAD FACTOR	1 034.17		1 048.81		1 047.58		934.14		381.49		679.10	
AT 65% LOAD FACTOR	1 140.93		1 144.56		1 161.71		1 062.06		426.28		769.26	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	1 057.02		1 073.90		1 069.26		972.72		408.45		709.31	
WITH 25% ROI	1 148.42		1 174.28		1 155.97		1 142.05		516.28		830.17	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes chlorine at calculated prices: U.S.Gulf Coast, $142/ton; F.R.G., $220/ton; Japan, $198/ton; Far East, $302/ton; Mexico, $17/ton; Arab Gulf, $181/ton.

Annex II.H Table 39. COMPARISON OF 1985 PETROCHEMICAL MANUFACTURING COSTS AT DIFFERENT LOCATIONS

PRODUCT: VCM PLANT SIZE: 152,000 ton/year

Ethylene transfer price [illegible] 5 % ROI in all countries.

LOCATION	U.S. GULF COAST		F.R.G.		JAPAN		[illegible]		MEXICO		[illegible]	
FEEDSTOCK	ethylene		ethylene		ethylene		ethylene		ethylene		ethylene	
FEEDSTOCK PRICE, $/ton	590.00		907.00		658.00		435.00		289.00		366.00	
LOCATION FACTOR	1.00		1.15		0.90		1.82		1.18		1.32	
FIXED CAPITAL COST,[a] $ million	69.46		76.29		65.90		126.41		81.95		91.85	
WORKING CAPITAL, $ million	13.19		15.84		14.67		16.38		6.16		11.95	
UNIT INVESTMENT COST, $ million/ton/a	457.00		501.90		433.50		831.60		539.10		604.30	
PRODUCTION COST:	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%	$/ton	%
FEEDSTOCK	280.25	41.5	430.32	53.0	312.55	41.8	206.62	36.3	137.27	50.9	173.85	40.1
ENERGY	84.42	12.5	93.44	11.5	92.15	12.3	7.22	1.3	6.28	2.3	4.77	1.1
BY-PRODUCT												
OTHER DIRECT COSTS[b/g]	202.66	30.0	164.90	20.3	233.78	31.3	226.29	39.8	46.08	17.1	157.29	36.2
GENERAL OVERHEAD	32.19	4.8	38.71	4.8	35.60	4.8	13.87	2.4	6.58	2.4	10.58	2.4
OTHER FIXED COSTS[c]	30.84	4.6	34.81	4.3	30.25	4.0	31.66	5.6	19.78	7.3	27.02	6.2
NET CASH COST	630.35	93.2	762.68	93.8	704.34	94.2	485.66	85.4	215.99	80.0	373.51	86.1
DEPRECIATION[d]	45.70	6.8	50.19	6.2	43.36	5.8	83.16	14.6	53.91	20.0	60.43	13.9
NET COST OF PRODUCTION (NCP)												
AT 100% LOAD FACTOR	676.05	100.0	812.87	100.0	747.69	100.0	568.83	100.0	269.91	100.0	433.94	100.0
AT 85% LOAD FACTOR	862.05		948.70		960.75		816.44		305.01		590.20	
AT 65% LOAD FACTOR	965.10		1 042.30		1 073.01		942.79		348.78		679.18	
TRANSFER PRICE AT 85% LOAD FACTOR												
WITH 5% ROI	884.90		973.79		982.43		858.02		331.97		620.42	
WITH 25% ROI	976.29		1 074.17		1 069.14		1 024.35		429.80		741.27	

a/ Battery limits plus offsites

b/ Includes other raw materials, utilities, maintenance materials, operating supplies, operating labour, maintenance labour, control laboratory.

c/ Includes plant overhead, taxes and insurance, interest on working capital, general administration charges, R and D.

d/ At 10% per annum

e/ Local market price

f/ UNIDO assumption (see annex II.F.2)

g/ Includes chlorine at: U.S.Gulf Coast, $142/ton; F.R.G., $220/ton, Japan, $198/ton; Far East, $302; Mexico, $17/ton; Arab Gulf, $181/ton.

Annex III.A

Imports of selected petrochemicals

Product	Region	EEC a)	Japan
Ethylene	World	27391	2402
	CPE	0	0
	Developing	16852	2402
	Developed	10539	0
	EEC	1327778	0
	Japan	0	-
	USA	10	0
Propylene	World	162197	0
	CPE	0	0
	Developing	0	0
	Developed	162197	0
	EEC	945791	0
	Japan	0	-
	USA	0	0
Butadiene	World	30338	35216
	CPE	84	0
	Developing	250	0
	Developed	28666	35216
	EEC	288383	30699
	Japan	5914	-
	USA	7044	4517
Benzene	World	368631	5155
	CPE	107282	2196
	Developing	24067	2959
	Developed	237282	0
	EEC	815726	0
	Japan	47692	-
	USA	79984	0

to major DMEC markets in 1979 (in tons)

USA	Other DMEC b)	Import to all developed regions: Total	Import to all developed regions: Percentage
38388	19489	87670	100.0
0	0	0	0.0
0	0	19254	22.0
38388	19489	68416	78.0
0	18961	18961	21.6
0	0	0	0.0
-	526	536	0.6
238938	1151	402286	100.0
0	0	0	0.0
0	0	0	0.0
238938	1151	402286	100.0
0	59	59	N.i.
0	0	0	0.0
-	1092	1092	0.3
342457	53807	461818	100.0
0	0	84	N
4532	0	4782	1.0
337925	53807	455614	98.6
236211	3249	270159	58.5
6864	13414	26192	5.7
-	37144	48705	10.5
225337	12776	611899	100.0
0	0	109478	17.9
17308	0	44334	7.2
208029	12776	458087	74.9
54294	25	54319	8.9
16555	NA	64297	10.5
-	12751	92735	15.2

Product	Region	EEC	Japan	USA
Xylene	World	394721	99421	205976
	CPE	32610	1789	3988
	Developing	24102	15395	13949
	Developed	338009	82237	188039
	EEC	453316	3945	5453
	Japan	993	-	6894
	USA	277361	78292	-
Methanol	World	440062	286611	207781
	CPE	59453	5353	0
	Developing	284855	196366	79953
	Developed	95754	84892	127828
	EEC	540210	0	4571
	Japan	0	-	0
	USA	38776	18319	-
Ammonia	World	789500	32	1769852
	CPE	426419	0	705012
	Developing	226179	0	580038
	Developed	136902	32	484002
	EEC	577033	0	0
	Japan	0	-	0
	USA	43839	32	-
Polyethylene	World	379157	12838	61666
	CPE	55263	221	0
	Developing	3088	4637	1992
	Developed	320806	7980	59674
	EEC	2091586	1789	29671
	Japan	1573	-	995
	USA	54142	4624	-

Other DMEC	Import to all developed regions	
	Total	Percentage
57076	757194	100.0
4066	42453	5.6
0	53446	7.1
53010	661295	87.3
18683	28081	3.7
959	8846	1.2
33142	388795	51.3
185338	1119792	100.0
20004	84810	7.6
0	561174	50.1
165334	473808	42.3
127308	131879	11.8
0	0	0.0
32371	89466	8.0
511487	3070851	100.0
109875	1241306	40.4
151199	958218	31.2
250393	871329	28.4
43814	43814	1.4
1	0	0.0
187352	231223	7.5
397289	850950	100.0
7555	63039	7.4
2254	11971	1.4
387480	775940	91.2
190932	222392	26.1
294	2862	0.3
85598	144364	17.0

Product	Region	EEC	Japan	USA
Poly-propylene	World	96362	11019	9157
	CPE	3329	315	18
	Developing	1005	1454	163
	Developed	92028	9250	8976
	EEC	477024	4061	2590
	Japan	5610	-	5824
	USA	14039	4730	-
Poly-styrene	World	79089	31390	9755
	CPE	5418	714	0
	Developing	4106	12582	3
	Developed	69565	18094	9752
	EEC	1059014	3688	1096
	Japan	11621	-	248
	USA	19615	12488	-
PVC	World	249018	34768	88054
	CPE	64103	1523	0
	Developing	33950	26627	36157
	Developed	150965	6618	51897
	EEC	1387425	2741	28827
	Japan	3303	-	9318
	USA	8785	3626	-
Polyester Fibres	World	61444	11542	1446
	CPE	10640	0	0
	Developing	850	11222	888
	Developed	49954	320	558
	EEC	122033	3	362
	Japan	886	-	37
	USA	21011	316	-

Other IMEC	Import to all developed regions	
	Total	Percentage
84229	200767	100.0
162	3824	1.9
286	2908	1.5
83781	194035	96.6
31242	37893	18.9
1792	13226	6.6
44143	62912	31.3
94556	214790	100.0
316	6448	3.0
395	17086	8.0
93845	191256	89.0
35122	39906	18.6
2968	14837	6.9
49835	81938	38.1
225328	597168	100.0
5997	71623	12.0
2775	99509	16.7
216556	426036	71.3
95444	127012	21.3
1718	14333	2.4
59822	72233	12.1
55732	130164	100.0
48	10688	8.2
2015	14975	11.5
53669	104501	80.3
8615	8980	6.9
17235	18158	14.0
26179	47506	36.5

Product	Region	EEC	Japan	USA	Other IMEC	Import to all developed regions Total	Percentage
Polyamide Fibres	World	13137	1117	1537	14381	30172	100.0
	CPE	923	0	0	0	923	3.0
	Developing	0	112	30	0	142	0.5
	Developed	12214	1005	1507	14381	29107	96.5
	EEC	64735	231	1079	2855	4165	13.8
	Japan	23	-	299	221	543	1.8
	USA	6368	774	-	9944	17086	56.6
SBR	World	7235	233	18230	41777	67475	100.0
	CPE	316	0	0	0	31[illegible]	0.5
	Developing	966	0	2	0	968	1.4
	Developed	5556	233	18228	41777	65794	97.5
	EEC	183691	15	3067	30927	34009	50.4
	Japan	61	-	13	95	171	0.3
	USA	1106	218	-	261	1585	2.3

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a) Imports to EEC from the World and developed countries exclude EEC intra-trade which enters by itself in EEC export to EEC.

b) Other IMEC include Australia, Austria, Canada, Finland, New Zealand, Norway, Sweden and Switzerland, although not necessarily all included for each entry.

Source: UNCTAD Computer Run Data, UNIDO Calculations

Annex III.B

DMEC Capacity, Production, Consumption and Trade in Selected Petrochemical Products, 1979 (in tons)

Product	DMEC	Capacity	Production	Consumption	Exports	Imports		Import Share [a] (%)		
						Total	Developing Countries	Total	Developing Countries	Export/ Production
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Ethylene	W. Europe	14709	12358	12211	184	17	17	0	-	1.5
	Japan	6000	4784	4794	2	2	2	0	-	0.04
	USA	16800	13226	13261	3	38	0	0	0	0.02
Propylene	W. Europe	8066	6532	6164	393	25	0	0	0	6.02
	Japan	4300	3112	3016	96	0	0	0	0	3.1
	USA	9200	6460	6696	603	239	0	4	0	9.3
Butadiene	W. Europe	2131	1712	1174	612	74	0	4	0	35.7
	Japan	800	670	688	17	35	0	5	0	2.5
	USA	2000	1612	1818	136	342	5	21	-	8.4
Benzene	W. Europe	6609	4858	5062	122	326	24	7	-	2.5
	Japan	2970	2179	2011	173	5	3	-	-	7.9
	USA	8000	5769	5943	51	225	17	4	-	0.9
Xylene	W. Europe	1991	1377	1586	195	404	24	30	2	14.1
	Japan	1110	857	NA	NA	99	15	12	2	-
	USA	3050	2382	1950	638	206	14	9	-	26.8
Methanol	W. Europe	NA	3000	3000	449	449	285	63 [b]	40 [b]	15
	Japan	1281	940 [d]	1303 [d]	E [d]	287	196 [d]	31 [d]	21 [d]	-
	USA	4200	3361	3369	200	208	80	6	2	6.0
Ammonia	W. Europe	NA	NA	NA	NA	1145	377	NA	NA	-
	Japan	NA	NA	NA	NA	0	0	NA	NA	-
	USA	NA	NA	NA	NA	1770	581	NA	NA	-
Polythylene	W. Europe	NA	6290	5520	580	245	5	4 [c]	[c]	9.2
	Japan	2470	2165	1869	386	13	5	1	-	17.8
	USA	6250	5894	5206	750	62	2	1	-	12.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Polypropylene	W. Europe	NA	1530	1310	295	75	1	5	-	19
	Japan	1160	1023	934	100	11	1	1	-	10
	USA	2200	1742	1379	372	9	0	1	0	42
Polystyrene	W. Europe	NA	1400	1270	243	113	5	8	-	17
	Japan	1390	1227	1129	129	31	13	3	1	11
	USA	2400	1817	1772	55	10	0	1	0	3
PVC	W. Europe	NA	4320	3930	597	207	37	5	-	14
	Japan	2078	1592	1527	100	35	27	2	2	6
	USA	3325	2821	2675	234	88	40	3	1	8
SBR	W. Europe	NA	NA	NA	NA	8	1	4 b/	- b/	-
	Japan	1460	1107	911	196	0	0	0	0	18
	USA	2200	1725	1672	71	18	0	1	0	4

Source: Data on Capacity, Production and Consumption were provided by members of the UNIDO Working Group; import data were provided by UNCTAD secretariat calculations based on computer data provided by member governments; export data was calculated as (production + imports - consumption = exports) and verified by published national data where possible.

a/ Defined as imports divided by production.

b/ Defined as extra - W. Europe imports divided by intra - W. Europe imports.

c/ Defined as imports divided by consumption.

d/ The figures are inconsistent and obviously contain an error since the calculated export figure is negative -- an impossibility.