OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

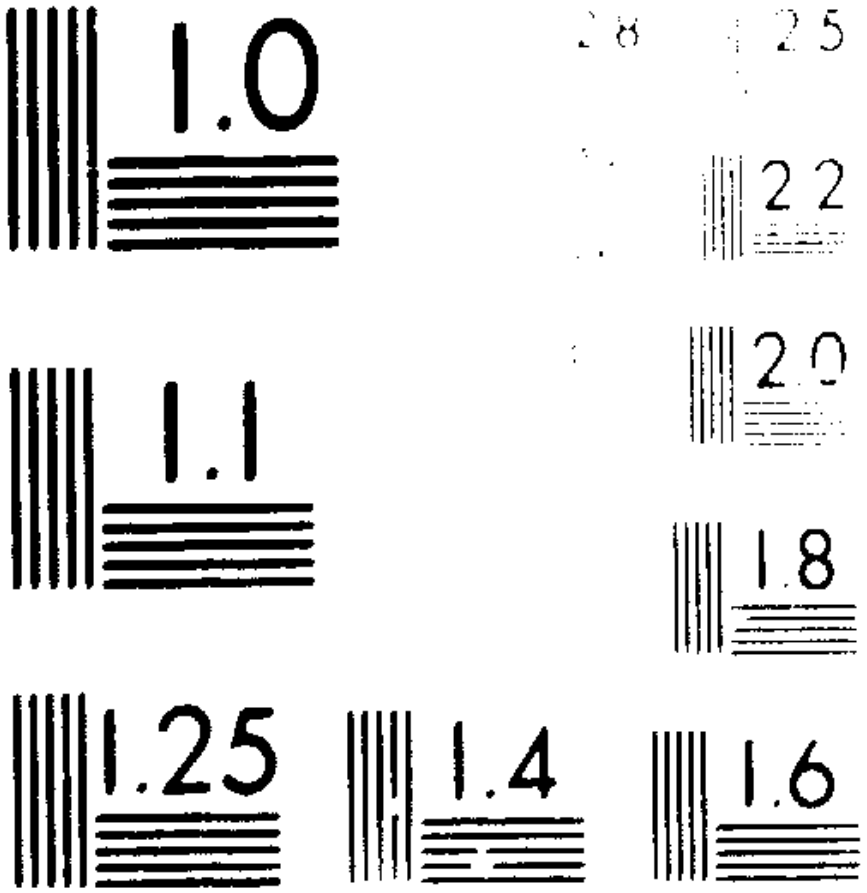
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org


1.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

OPEC/UNIDO/OPEC FUND

12263

SEMINAR

ON CO-OPERATION AMONG DEVELOPING COUNTRIES IN PETROCHEMICAL INDUSTRIES

Vienna, March 7-9, 1983

19

UNIDO/OPEC FUND

Opportunities for Co-operation among Developing Countries for the Establishment of Petrochemical Industries.

This document has been reproduced without formal editing.

The designations employed and the presentation of material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or its authorities, or concerning the delimitation of its frontiers.

The views expressed in this report are those of the consultant and do not necessarily reflect the views of the Secretatariat or of the Government of any of the countries mentioned in the report.

Mr. E. Bahari, UNIDO Consultant, has contributed to the preparation of this paper.

Table of contents

List of Tables

Abreviations

HDPE	High density polyethylene
LDPE	Low density polyetylene
OPEC	Organization of the Petroleum Exporting Countries
PVC	Polyvinyl chloride
R & D	Research and development
SBR	Styrene butadiene rubber
t.p.a.	Metric tons per anum

References

Second World-Wide Study on the Petrochemical Industry: Process of Re-structuring - UNIDO ID/WG.336/3, 19 May 1981.

Annexes to above - UNIDO ID/WG.336/3/Add.1, 20 May 1981.

Annual Report 1980, Organization of the Petroleum Exporting Countries.

FAO Commission on Fertilizers, Seventh Session, FERT/81/3, June 1981.

Supplement to the Second World-Wide Study on Fertilizers; 1975-2000 - UNIDO/ICIS.81/Add.1, July 1980.

The Industrial Uses of Associated Gas - UNIDO/Gulf Organization for Industrial Consulting, 30 April 1980.

World Bank Statistics - 1982.

Consumption of Petrochemicals: An Index to the Standard of Living of Any Nation - G.D. Wilson; Petrochemicals Symposium, Lagos, Sept. 1982.

The Petrochemical Industry: A Gateway to Acquisition of High Technology - R.F. Raymond; Petrochemicals Symposium, Lagos, Sept. 1982.

Foreword

The data used in this report regarding the future consumption of petrochemicals are based on the "Second World-Wide Study on Petrochemical Industry: Process of Restructuring", UNIDO ID/WG.336/3 and Add. 1, May 1981. Due to the continuing depression of the world economy the growth envisaged in that report has to be revised downwards, particularly for developed countries. Another paper, containing up-dated figures of consumption and capacities of petrochemical plants as well as new projections, is therefore also presented to this seminar. A brief presentation of the new estimates are made in this paper wherever necessary. Where no explicit comments are made, it is assumed that deviations from the projections presented in 1981 are not of a size to invalidate the basic findings of this report and the resulting proposals concerning co-operation among developing countries for the development of their petrochemical industry.

The downward revisions of trends in demand and consumption of petrochemicals will affect the scope (financial, technical and organizational) of co-operation but will not alter the need for and the desirability of such co-operation. In fact, the present adverse global economic situation would emphasize even more the need for close economic co-operation between developing countries. It would certainly not change a need for such co-operation concerning petrochemical products covered in this report.

The UNIDO Secretariat is at present undertaking a new study, aiming, inter alia, at projecting future demands for the more important petrochemical products. It is hoped that this study would be finalized by the end of this year.

OPPORTUNITIES FOR CO-OPERATION BETWEEN DEVELOPING COUNTRIES FOR THE PRODUCTION OF PETROCHEMICALS

1. Summary and conclusions

Estimated future demand for petrochemicals in the developing countries shows that a large number of petrochemical production facilities of varying capacities will be needed to meet the expected increase in demand between 1984 and 1990. Table 1 shows the number of new plants needed to meet the expected increase of demand in the developing countries during the period 1985-1990 for some key basic and intermediate petrochemical products. Two cases are considered; one based on the results obtained in the "Second World-Wide Study on the Petrochemical Industry: A process of Restructuring", and the other on up-dated figures of capacities and demand forecast considered in 1983.[1/] The roughly estimated total cost of these plants according to the projection of demand made in UNIDO second world-wide study referred to in the foreword is around 37 billion dollars, with the foreign exchange element representing approximately 23 billion dollars. Even with the implementation of these, the share of developing countries in the world's petrochemical production would still be very small with only marginal improvement in their comparatively meager present per capita consumption.

This report shows that co-operation among developing countries for the development of petrochemical industry in their regions is not only useful but essential. Proposals for establishing joint enterprises between developing countries such as joint engineering, construction, research and development, marketing and manpower training facilities on co-operative basis are discussed in detail and the merits of such activities are explained.

The requirement for funds to cover the cost of studies needed at the pre-investment stages to the final implementation of petrochemical projects, in developing countries is estimated and broken down into three distinct

---

1/ UNIDO ID/WG. 336/3, 19 May 1981, and ID/WG.336/3, Add. 1, 20 May 1981, presented simultaneously to this seminar.

stages. Various ways of financing are proposed. The establishment of a joint corporation for funding chemical development is considered a useful tool for the promotion of this industry in the developing countries.

It is further argued that the development of petrochemicals in the developing countries will be to the advantage of all concerned, including the developed countries. OPEC countries, in particular, can play a very important and mutually advantageous role in this process of development.

It is suggested that opportunity studies be started as soon as possible to pin-point possible co-operation on regional and/or sub-regional bases, followed by detailed feasibility studies of potential projects. The actual implementation of feasible projects could then be considered by the interested parties.

2. Overview

Uses and application of petrochemical products in industry and everyday life has become so prominent that it is inconceivable to visualize life style and the present standard of living without them. The development and growth of petrochemicals essentially started after World War Two with spectacular growth after 1950. For example, ethylene and propylene as major basic petrochemicals had a growth rate of 17 per cent per year between 1950 and 1973. Ethylene consumption in OECD region increased by 40 times during this period compared to the total industrial production rise of only about 3 times. As further examples, between 1950 and 1970 the world consumption of synthetic fibres increased by 68 times and that of plastics and synthetic rubbers by 18 and 9 times respectively. The consumption of low-density polyethylene (LDPE) in Western Europe increased from just under 100,000 tons per year in 1955 to just over 3,000,000 tons per year in 1973.[2/]

Whilst the growth rate of petrochemicals consumption in developed countries has almost levelled off at around 3-4 per cent, the developing countries are still at a stage of growth comparable to the 1955-1960 period for the industrialized countries. However, with the projected demand for 1990, the future growth rate in developing countries would be very modest. Table 4 (page 41) shows the consumption of some of the more important petrochemicals in the developed and developing countries for 1979-1990. It can be seen clearly that in 1979 the developing countries' share of olefins, aromatics, plastics synthetic fibres, synthetic rubbers, methanol and ammonia was only 6.9, 8.9, 16.4, 24, 14.4, 8 and 40.5 per cent of world consumption respectively, while their population was 65 per cent of the world in the same year. Even with this optimistic growth rate of consumption the developing countries' share in the 1990s world consumption would only become 17.3 per cent for olefins, 8.7 per cent for aromatics, 27.5 per cent for plastics, 34 per cent for synthetic fibres, 19.9 per cent for synthetic rubbers, 12.9 per cent for methanol, and 44.9 per cent for ammonia. The 1990 *per capita* consumption of these products in the developing countries would be 5, 2.1, 5.5, 1.3, 0.5, 0.9 and 11.7 kg. respectively, which, expressed as

---

2/ UNIDO's Second World-wide Study on the Petrochemical Industry: Process of restructuring, ID/WG.336/3 and ID/WG.336/3/Add.1.

Table 1 Increase in demand and of estimated new investment in developing countries by 1990 for major petrochemicals
(in thousand metric tons)

	WORLD			DEVELOPING COUNTRIES					
	1979 Demand	1984 Demand	1990 Demand	1979 Demand	1984 Capacity	1990 Demand	Increased 1990 demand over 1984 capacity	Number of new units and capacity	Investment cost of new units $ million
OLEFINS	61940	81340	115620	4290	11990	20020	8030	10000 (23)	10350
AROMATICS	23600	31700	42650	2100	5320	8000	2680	*	*
PLASTICS	41100	55060	80000	6710	10560	22000	11440	10850 (124)	14201
POLYESTER SYN. FIBRES	4940	6370	7930	1460	2150	3140	990	975 (27)	1727
SBR SYN. RUBBER	5220	6450	8030	770	910	1630	720	725 (23)	1623
METHANOL	11740	18400	27550	940	3310	3550	240	250 (1)	90
AMMONIA	74220	86720	104340	30070	31612	46860	15248	16900 (56)	9090
TOTAL									37081

See Tables 4 and 5 for details

* Included in Olefins plants

Table 2 Summary of consumption, capacity and demand for major petrochemicals categories in developing countries (1,000 tons)

	World consumption/demand			Developing countries							
				consumption/demand				production capacity		1990 increased demand over 1984 and 85 capacity	
	1979	1981	1990	1979	1981	1990 A[1]	1990 B[2]	1984 A[1]	1985 B[2]	A[1]	B[2]
Olefins	61 940		115 620	4 290		20 020		11 990		8 030	
ethylene	37 380	35 253	70 430	2 680	3 010	13 950	11 600	7 900	9 403	6 050	2 197
propylene	19 620		36 870	1 190		4 470		3 050	3 123	1 420	
butadiene	4 940		8 300	420		1 600		1 040		560	
Thermoplastics	41 100	37 262	80 000	6 710	7 170	22 000	16 350	10 560	10 152	11 440	6 198
Synthetic fibers[3]	10 030	12 069	15 015	2 470	2 770	5 100	5 660		3 538		2 122
polyesters	(4 940)		(7 930)	(1 460)		(3 140)		(2 150)		990	
Synthetic rubber[4]	6 380	8 427	9 950	920	1 005	1 980	1 765		1 207		558
S.B.R.	(5 220)		(8 030)	770		(1 630)		(920)		((710)	

1/ data included under (A) were based on the information and scenario presented in the Second World-Wide Study on the Petrochemical Industry (1981)

2/ data included under (B) based on UNIDO's paper "The development of the petrochemical industry in the developing countries" presented at this seminar

3/ Synthetic fibers include polyamides, acrylic and polyester fibers

4/ Data for synthetic rubber includes SBR and PBR.

Table 3 · Per capita consumption of major petrochemical products

1979, 1981, 1990

	World				Developed countries				Developing countries			
	1979	1981	1990		1979	1981	1990		1979	1981	1990	
			A	B			A	B			A	B
Ethylene	11.9	7.9	13.5	-	30.2	25.7	46.7	-	1.2	0.9	3.5	3.0
Thermoplastics	12.1	9.4	15.4	-	30.4	24.7	48.0		3.1	2.2	5.5	4.2
Synthetic fibres	3.0	2.7	2.9	-	6.5	7.6	8.2		1.2	0.8	1.3	1.5
Synthetic rubber	1.9	1.9	1.9	-	4.8	6.1	6.6		0.4	0.3	0.5	0.4
Methanol	3.5	2.7	5.3	-	9.7	-	19.8		0.4	-	0.9	-
Ammonia	21.8	13.8	20.1	-	38.4	-	47.5		13.6	-	11.7	-

percentage of the per capita consumption of the developed countries estimated for the same year, will be 6.3 per cent for olefins, 7.3 per cent for aromatics, 11.5 per cent for plastics, 15.9 per cent for synthetic fibres, 7.6 per cent for synthetic rubbers, 4.5 per cent for methanol, and 24.6 per cent for ammonia. It is evident, from these figures, that the assumed growth of consumption for developing countries, however optimistic it may be, is needed if there is to be an improvement in their standard of living and stability in the world economy. In fact, the 1990 per capita consumption for petrochemicals projected for developing countries will still be much less than that of Spain in 1980 and also below that of Turkey in 1980 for most products.

Today, the petrochemical products and their derivatives run into many hundreds ranging from fertilizers, solvents, plastics, fibres, rubbers, detergents, dyestuffs, explosives, drugs, synthetic, proteins, chemicals, to many derivatives which find application in various parts of industry and everyday life. In fact the limitations, and in some cases diminishing of natural resources such as wood, metals, fibres and minerals, will further bolster the needs for petrochemicals. In the developing countries in particular where food production is generally inadequate and land erosion prevalent, the use of petrochemical fertilizers and pesticides will improve production and stop land erosion; while substituting plastics, synthetic fibres, and other petrochemicals for wood, cotton, etc., will release more land for food production.

The range of petrochemical products and the accompanying processing industry is so vast that it allows for a wide range of industries in type and size to be established according to requirements. It can, on the processing end, be as simple as a two-man machine for making say plastic cups to a more sophisticated large scale olefins-aromatic complex employing 2,000 people. Fig. I (page 48) shows the range of products and their application based on ethylene. Similar figures can be drawn for other basic olefin and aromatic products. Generally, the basic petrochemicals are economically produced in large capacity plants and as one moves further downstream to end products, the economic capacity becomes smaller and smaller. The petrochemical industry and the accompanying processing industry represent an ideal case for co-operation

among developing countries allowing practical development with vertical integration and horizontal linkages.

In any developing country, some petrochemical manufacturing units can be installed to suit its capacity, market demand and resources. The nature of petrochemical products is such that once they are introduced into any market, they initiate a fairly rapid growth not only for established uses but in many cases for new applications as well.

The developing countries could be classified into three groups for the development of petrochemicals depending on their market and raw materials availability:

(i) Developing countries with abundant and comparatively cheap raw materials, most of which fall within the OPEC group. In these countries, the raw materials advantage and the more easily available financial resources make it attractive for them to build basic and intermediate petrochemicals units mainly for export. The establishment of further downstream operation will depend to a great extent on local market conditions.

(ii) Developing countries with small domestic market and less developed petrochemical industry. In these countries the best course would be to first expand the petrochemical processing industry and, once sufficient consumption has developed, to proceed with the establishment of intermediate products and later on move to basic products if found attractive. These countries can co-operate between themselves, with group (iii) below or with some of the countries in group (i) above to develop their petrochemical industry.

(iii) Developing countries with potentially good markets and some experience in the petrochemical industry. In these countries the better approach would be to install production capacity for products somewhere in the middle of the range, intensify the development of the processing industry and gradually integrate

upwards to the level of producing major intermediate and basic petrochemical products. For example, production of textiles by importation of yarn will not be, on the long term, as attractive as setting up a spinning factory based on imported chips. Once consumption in the processing industry has sufficiently increased, a plant for the production of a petrochemical end product (polyester or polyamide chips) can be installed. The same could apply to other products such as plastics, solvents, etc.. Once consumption of the intermediate products has grown sufficiently enough production of basic petrochemicals at economically large scale units could start. These countries can usefully co-operate with groups mentioned in (i) and (ii) above.

In planning the development of the petrochemical industry in developing countries, it will not always be practical or correct to use the same technical and economic considerations with regard to selecting the type and size of plants as is currently applied in the developed countries. On the contrary, developing countries may have to protect the young local industry in order to enable it to take root and grow to become competitive. Attention to the problem of scale in developing countries may result in the development of suitably sized plants for some products to make use of various favourable conditions there such as ease and speed of financing, construction time and the use of the modest availability of raw materials, infrastructure, skilled manpower and other resources. The recent UNIDO sponsored conference on fertilizer industry held in Lahore - Pakistan has demonstrated this point clearly for ammonia production, where it was demonstrated that even a 100-ton/day ammonia plant becomes in certain circumstances feasible and attractive.[3/]

Feedstocks considerations

The basic feedstocks for petrochemical production are mostly obtained from crude oil refining and natural gas production with a small group of developing countries having most of the world's reserves and the present

---

3/ UNIDO/p.c. 61, 8 December 1982

export. Nearly thirty million tons of naphtha, a major petrochemical feedstock, was consumed in Western Europe in 1982 alone.[4/] Since most of the olefins production in Western Europe is tied to oil refineries it is therefore linked up with the major oil companies. Similar tie-up also applies to the production of benzene. Natural gas produced in association with crude oil or as dry gas is another important hydrocarbon feedstock which is also available in sufficient quantities in oil producing countries for petrochemical production. Although petrochemicals account for only a small portion of hydrocarbons consumed today, the fact is that with depleting hydrocarbon resources and the development of alternative sources of energy the importance and value of hydrocarbons as feedstocks for the growing petrochemical production will become more prominent in the future. It is due to these, and some other considerations, that this report considers a close co-operation between OPEC and other developing countries to be an essential and mutually advantageous element in the promotion of petrochemical industry in the developing countries.

With the adjustment of oil prices since 1973, the raw materials component has come to assume an appreciable portion of the petrochemical production cost. For example, in the case of ethylene production, the cost of naphtha feedstock in 1972 was more than compensated by the high credit value of by-products, whereas at present the feedstock cost forms nearly 60 per the total production cost. This drastic change is leading to a restru of petrochemicals production in favour of producers possessing or having access to more favourable petroleum and natural gas resources. It is therefore very important to review the raw material situation and to assess its impact on the petrochemical industry in the future[5/].

The most important petrochemical feedstocks are natural gas and liquid petroleum products, mainly naphtha. Natural gas is obtained either: i) as associated gas produced in conjunction with crude oil, or ii) as dry gas from natural gas domes.

4/ PNC, 24 January 1983.

5/ "The availability of natural gas in developing countries for petrochemical purposes", OPEC.

Methane forms the major portion of natural gas but some heavier components are also contained in associated gas. These are separated out as liquefied petroleum gas (LPG), as natural gas liquids (NGL) which are used as a blend for gasoline or as feedstock for the petrochemical industry, or simply as fuel. However, since their quantity is comparatively small, they will not be further considered here.

The ratio of associated gas to crude oil production varies from field to field and it diminishes with progressive crude oil production until a time comes when it becomes necessary to reinject the gas into the oil field to maintain crude oil recovery. In the past, due to low energy prices, where there was no use for this gas as fuel, in most OPEC countries, the major portion of this gas was flared. In recent years most of the oil producing countries have been involved in building plants for the utilizations of their gas but due to the time lag between the feasibility study and the execution of projects, a good deal of this gas is still being flared in many oil-producing developing countries. The present uses for this gas, in the order of quantity, is export by means of pipelines, as liquified natural gas (LNG), as feedstock for the production of ammonia and as feedstock for making methanol. In terms of profits to the oil exporting developing countries which are at a long distance from the major areas of consumption, the order will be ammonia, methanol, piped or LNG export. The question arises as to what will be the effect of the steadily decreasing supply of associated gas on the feasibility of these uses. Could the production of methanol or export of gas by pipeline or as LNG still remain economically attractive? What will happen to these investments when all the associated gas is required for reinjection?

Fortunately, there are substantial reserves of dry natural gas in several areas, particularly in some OPEC countries. The production of this gas can be fully controlled, independently from crude oil production and, therefore, unlike associated gas, natural gas will not have to be sold at a distressed value or simply flared. The assessment of the intrinsic value of gas under these circumstances will depend on the needs and commitments of each country to use and to sell this type of natural gas and on the supply/demand balance of crude oil. Such an assessment would require a detailed global study, which would be useful to both producers and consumers. Another case which merits

attention is the competition between methanol as fuel and other liquid petroleum products, and its effect on the intrinsic value of natural gas. Could future developments in the use of methanol as feedstock give it a greater value? However, with a distressing situation of subsiding sale of associated gas and rising value of natural gas, what will happen to ammonia production where natural gas is the best feedstock? What will be the compounding effect of insufficient crude oil supply compared to demand? Would this transform the whole geography and strategy of ammonia and (indeed) fertilizer production in the world? Such questions are of strategic dimensions and need thorough and detailed studies.

As far as liquid hydrocarbon petrochemical feedstock is concerned, although some LPG and heavy refinery streams are used for this purpose, the main feedstock is by far naphtha. There are mainly two sources of naphtha:

(i) From refineries, specially designed and geared to meet market demand on product mix with certain by-product surpluses. This type of operation is usually the case for developed countries, where naphtha surplus sparked off the rapid growth of petrochemicals during the 1950's and 1960's.

(ii) From refineries, mainly in developing countries, where the consumption pattern makes a good proportion of the naphtha stream as well as heavier oil as surplus. There are however a number of export refineries designed to balance this situation. The outstanding examples of such refineries are those in Venezuela, Italy and Singapore, each serving different markets. In the past the large refinery in Abadan, Iran, served the same purpose to some extent. Because of this situation, it will be mutually advantageous for developing countries to co-operate in this area in order to balance their refinery output to their demand pattern[6/]. Furthermore, the building of petrochemical refinery complexes in the future should be geared to the regional demand pattern of developing countries co-operating in this field.

6/ Refer to the "Caracas Programme of Action", paragraph 31.

Ethylene is the most important single basic petrochemical product used as feedstock for many other products and therefore its future and potential trade deserves consideration. At present, trade in ethylene is restricted and is small as compared to its total production. Most of the produced ethylene is converted in downstream plants in the same complex or, in few cases, is piped on hort distances to other plants. This restriction is due to its high inflammability and low liquefaction temperature. Since the number of small downstream plants built in the developing countries does not justify, in many cases, ethylene production, the possibilities of future trade in ethylene deserve careful consideration, including handling, shipping, piping and storage, particularly in larger quantities and where the consumer is at a good distance from the supplier.

What has been said for ethylene also applies, although to a lesser extent, to propylene.

OPEC countries, due to their favourable position in raw materials and finance, have embarked on extensive development programmes of the petrochemical industries, prominently in basic and intermediate products. Because of the low domestic consumption and the diminishing advantage of cheap raw material as one moves further downstream in the production of petrochemicals, many OPEC countries cannot at present be competitive in downstream end products, and most of their basic and intermediate products are therefore available for export. OPEC's ethylene capacity in 1981 was 726,000 tons, which, with the completion of all their ethylene projects by mid-1980's, will increase to about 4.0 million tons, representing some 40 per cent of the developing countries' envisaged potential production and 6.0 per cent of the industrialized world's capacity. Aromatics production capacity of OPEC countries by mid-1980's is also expected to reach about 1.8 million tons. Methanol and ammonia production capacity in OPEC countries by mid-1980's is expected to be about 9.1 and 2.6 million tons respectively, representing approximately 10.0 per cent and 4 per cent of the world total capacity, with most of it probably available for export[7/]. There are also several projects

---

7/ Figures are taken from OPEC paper presented to this seminar. "The Availability of Natural Gas in Developing Countries".

for production of basic plastic, and intermediates for synthetic fibre and synthetic rubber which would also offer sizeable export quantities by mid-1980's. For example, the production capacities for LDPE, HDPE and PVC is slated to be 1.7, 0.64 and 1.45 million tons respectively. Thus the access by developing countries to cheap raw material available in OPEC countries and by OPEC to assured markets for their basic and intermediate petrochemicals makes joint co-operation between these groups of countries very attractive. Moreover, such co-operation could be bilateral or multilateral between two or more countries within the two groups.

In many developing countries, due to limitations of resources and domestic markets, the setting up of certain upstream intermediate or basic products does not seem to be promising. For developing countries, one way of getting over this problem in a market region is to agree to allocate the production of various products for the joint market between themselves. One country, for example, can produce some plastics intermediate, one synthetic fibres intermediate, and the other fertilizers for the specified joint market. However, the success of such arrangements would depend on the degree of equitable and mutual benefit to be gained by the partners in these arrangements.

It should be stressed that economic consideration, important as it may be, should not be the overriding criterion to be considered when establishing a new industry in a developing country. An infant industry in a developing country cannot be expected to favourably compete with its mature counterpart in the industrialized countries without adequate assistance and support. It is essential, therefore, for the developing countries to conceive a general industrial strategy supported by policies to nurture and develop the industry during its formative years. Attention to education, development of infrastructure, tax incentives, import regulation, and financing are some of the elements to be considered. It must be realized that local inputs to any project which may otherwise remain largely idle and unutilized are very important in assessing the viability of a project. Any added value obtained by the employment of local manpower and materials constitute a positive contribution to GNP. On the other hand, in assessing the foreign exchange cost of the industry in developing countries, it must be borne in mind that the first few projects would have an important value in the form of technical

training of local manpower. This in fact constitutes the most important step in the transfer of technology. The advantage of establishing industrial projects such as petrochemicals as compared to some other infrastructural projects is that industrial plants contribute to the training of many skilled personnel over a long period of time in addition to the income derived from their products. However, this does not mean that infrastructure should be neglected. On the contrary a correct balance in the development of various sectors of the economy should be attained in order to avoid bottlenecks and to attain smooth development

2.1 Size of demand

Table 4 (page 41) shows the total and per capita consumption for some 17 major petrochemicals in the developing countries in comparison with the developed countries and the world as a whole[8/]. The data are tabulated using the actual 1979 consumptions and the estimated 1990 demand for the three groups. Table 5 (page 42) gives the estimated increase in demand for the same 17 petrochemical products between 1984 and 1990. Table 6 (page 43-45) shows the size of the estimated increased demand for the major petrochemicals in the developing countries divided into six geographical regions, the number of the most suitable size units needed to satisfy the increased demand, together with the capital cost of the new units broken down into foreign exchange and local cost elements. It must be pointed out at the outset that the estimates, particularly sizes and costs of the new units, are approximate figures assumed for typical conditions in each region. However, they should be sufficient to illustrate the order of magnitude of the size of demand to be planned for the 1990's.

Two additional tables (Tables 5 and 6 (pp. 42 and 43) have also been prepared using updated data for consumption (1981), capacities (up to 1985)

8/ Based on the "Second World-wide Study on the Petrochemical Industry. Process of restructuring", UNIDO/ID/WG.336/3 and ID/WG.336/3/Add.1.

and projections of demand (1990).[9/] The detailed work concerning investment requirements and co-operation possibilities has been carried out on the data presented in UNIDO's second world-wide study on the petrochemical industry. The investment funds required to construct plants needed in the developing countries for the production of key petrochemical products to close the gap between supply and demand in 1990 have been estimated. As explained in the foreword, it can be assumed that the updated figures would not have radical effect on the implications arising from the need to redress the 1990 supply/demand imbalance. In fact, any downward revision of demand estimates may stress even further the need for closer co-operation among developing countries in the petrochemical sector. The implication of the updated projection on demand[9/] as compared to the one used in UNIDO's second world-wide study is, however, that a smaller number of plants needs to be built in the future.

It can be seen from Table 4 that the developing countries' consumption of olefins and aromatics in 1979 at 1.9 and 1.0 kg per capita, were only 3.8 and 5.3 per cent of that in the developed countries which stood at 50.1 and 18.7 kg per capita. Plastics and synthetic fibres consumption at 3.1 and 1.2 kg per capita in the same year for developing countries compares with 30.4 and 6.5 kg per capita for developed countries which is only 10 and 18 per cent respectively. The estimated consumption growth for the developing countries by 1990, would in most cases only marginally improve these ratios while for some other products their per capita consumption share compared to developed countries will, in fact, be reduced. It is, therefore, considered that the growth of demand assumed for developing countries by 1990 is necessary if the standard of living in these countries is to improve.

Table 4 also shows that the 1990 demand in the developing countries will be around 20.02 million tons of olefins, 8 million tons of aromatics, 22 million tons of plastics (5 types shown), 5.1 million tons of synthetic fibres

---

9/ These figures are presented in detail in another paper prepared for this seminar, namely: The Development of the Petrochemical Industry in the Developing Countries", by the UNIDO Secretariat.

(3 types shown), 1.98 million tons of synthetic rubbers (2 types shown), 3.55 million tons of methanol, and 46.86 million tons of ammonia. It is assumed that other downstream plants could also be built up to produce the products listed in Table 4.

The implication of reduced growth rates of demand is that per capita consumption of petrochemical products in developing countries as compared to developed countries would be further downgraded, particularly for plastics. With the updated greowth rate the expected level of per capita plastic consumption in developing countries in 1990 would be less than 14 per cent of that achieved in the developed countries in 1979.

Assuming that active co-operation between the developing countries as proposed in this report could become effective as of 1984, the magnitude of this co-operation for the following six years up to 1990 is demonstrated in Table 6. In this table, the estimated increase in demand between 1984 and 1990 for some basic and major intermediate petrochemicals for various regions of the developing world is given. The number and size of plants needed for each region to satisfy this increased demand is roughly worked out and the capital cost requirements, based on currently known prices, broken down into foreign exchange and local elements, are estimated. As can be seen, the allocation of production capacity and the size of units for each region has taken into account the comparatively more favourable raw materials and other resources in each region. For example, it is assumed that OPEC member countries will be exporting a good deal of olefins-aromatics derivatives to other developing countries and some developing countries will supply further downstream and end products needed in OPEC countries. In fact, OPEC countries will be able to export a good deal of their production to the developed countries and it is expected that the developed countries will also be supplying some of the needs of the developing countries, particularly in downstream products.

As stated earlier, the production stages from downstream projects to the final products are numerous (example fig. 1, page 48). The projects falling within the processing stages can often be of small size units geared to local demand and, therefore, are not dealt with in this report. However, there will

be, no doubt, many other downstream projects which can benefit from co-operation between some developing countries. Co-operation in these can be on a regional or sub-regional basis or even between two or more countries with common interests.

2.2 Feasible projects

As a rule, three major factors must be considered in determining the feasibility of a project. First, potential markets for the end products. Second, the practical and technical aspects related to raw materials, utilities, and other local inputs and the products specifications. The third and perhaps most important element of the project is its economic viability. Arrangements for providing the necessary financing could then be worked out.

Adequate markets exist for many petrochemicals and derivative products, to justify their production in any one country.

The initial choice from the range of petrochemicals for each country varies according to its condition regarding the three basic factors outlined above. In countries such as OPEC, the abundance of cheap raw materials makes the production of large scale basic petrochemicals favourable. In such cases, the development of the industry starts at the two extreme ends of the petrochemical spectrum and gradually grows to fill up the full range. In the smaller less advanced developing countries without appreciable raw material resources, the industry would generally have to start from the downstream end and work upwards. In countries in between these two extreme groups, it might often be attractive to combine the processing activities with some of the middle of the range production and proceed to integrate upwards. Thus, there are good grounds for co-operation between the three groups within the developing world.

Table 6 indicates roughly the suggested number and size of plants for the production of some 14 major petrochemicals in six geographic regions of the developing countries which would be needed to satisfy the growth in demand in these regions between 1984 and 1990. They represent some 250 units of varying sizes and costs. From a point of view of pure demand, these projects are

considered attractive. However, financial and in some cases technical assistance is needed for their implementation. There would be, of course, many additional feasible projects for the production of other petrochemical products within the region.

The unit sizes here have been arrived at with due consideration for presently known and accepted economic and technical viability for each product in any region. However, at present, attention is being paid to develop smaller economic size units to suit the developing countries, and it is expected that by 1990 there will be more flexibility in sizing of plants. However, the viability of some of these projects will depend upon co-operation between some countries to meet the join market requirements. Otherwise, it would be difficult to implement them independently.

Once general understanding for co-operation is established between a group of developing countries, suitable projects could be worked out on the basis of feasibility studies.

When planning petrochemical development in a country, the project capacity is usually fixed to meet the expected demand for a few years ahead. Thus within that country, there would usually be shortage of demand for the product during the first few years of plant production and will gradually move to cover demand and under capacity in later years until the expansion of an existing plant or the erection of another plant becomes feasible. One useful way of co-operation between countries in a regional or sub-regional market will be to co-ordinate their production capacities to fill the gaps and at the same time ensure full capacity utilization to their mutual advantage.

2.3 Need for investment funds

The capital cost for the construction of new petrochemical plants to satisfy the increased demand between 1984-1990 for 14 of the more important petrochemical products in the developing countries is estimated to total around $37 billion measured at 1980 prices. The investment for some other products and downstream processing activities could require that much again.

The cost estimate for each individual product in each of the six developing regions is given in Table 6. For each case, the capital cost is broken down roughly into foreign exchange and local cost elements. It is further assumed that the foreign exchange proportion of these projects in an average developing country will be about 60 per cent of the total cost and is assumed to range 58 to 65 per cent according to the level of development of the developing countries.

Diminishing availability of funds in the international money markets accessible for the industrial development of the developing countries constitutes a formidable restricting factor preventing the development of petrochemicals in those countries. It is often the case that some of these countries would only need a primer through the injection of a reasonable amount of funds which is necessary to catalyse their development and enable them to repay the loans with the income from the added value to their resources. On the other hand, the developed countries have reached a stage which makes it difficult for them to sustain a reasonable economic growth without sufficient export earnings, potential markets in the developing countries could absorb much of their exports. Some of the OPEC countries enjoy a favourable position for developing their industry with particular emphasis on oil and petrochemical projects. It is clear, however, that unless the world economy improves and sufficient markets are developed to absorb OPEC petrochemical exports at a reasonable price, OPEC investment in this sector would eventually become unrentable. Nonetheless, the substitution of the income now emanating from the diminishing oil resources by other products, notably petrochemicals, is imperative for most OPEC members in order to sustain a reasonable growth in their future economy.

It should be pointed out here that the development of secure markets for petrochemical products coming from large complexes in the developing countries, in particular oil exporting developing countries, constitutes the most important single factor in making or breaking the economy of these complexes. It is not that there exists no demand for these products, in the developed or in the developing countries, but the fact that these markets have been traditionally controlled by few producers and trading enterprises makes it very difficult for newcomers to penetrate them. Co-operation among developing countries in the field of petrochemical marketing thus assumes, at this stage of development, the most important element in any co-operation arrangement between developing countries. It also constitutes an important pre-requisite for establishing a common forum in negotiating with the developed countries. The last round of negotiation at GATT on the Multi-fibre Agreement demonstrates this point quite clearly.

Once potential agreement on marketing the output of a possible joint petrochemical projects is foreseen the funding for the construction of such a project should not pose such a formidable task and could also be organized on a co-operative basis. A typical case of joint project funding might be for a developing country to bear the local construction cost of the joint project, an industrialized country selling and partially financing know-how and equipment, and an OPEC country participating in the joint project meeting the balance of the funds as well as providing the feedstock, basic and/or intermediate petrochemicals on a favourable long term basis for the joint plant. It is realized that the practical steps to be taken for this type of co-operation will be long and laborious at the beginning.

Before considering the feasibility of any project for joint co-operation between prospective partners, there are some preliminary expenses involved in carrying out the necessary opportunity and pre-feasibility studies. For projects in an average developing country, these expenses amount to about 0.5 - 1.0 per cent of the total project cost. Small as it may be, the funding for this part of the project could be crucial in getting it off the ground. It is suggested that funds be raised for carrying out this type of study by an

internationally independent qualified consulting organization, in order to determine projects for possible co-operation.[10/]

In a narrower sense, co-operation in financing and implementing a joint project between two or more developing countries within a geographical region should be more attractive when none of these countries can afford and economically justify such a project on purely national basis. In such cases, a fair sharing of the projects benefits has to be worked out so that each country can have its proportional share of the industry on an agreed long term basis.

Considering the preceding statement, it seems that joint funding of the initial promotion of activities would be a useful means for the development of petrochemical industry in the developing countries. Contribution to this end could come from OPEC and non-OPEC developing countries as well as from developed countries. The initial contribution, future funding and the share of each member will have to be agreed upon between the partners. The funds would be used for the preparation of feasibility studies of petrochemical projects to be implemented in developing countries and if such projects are found to be economically attractive appropriate steps including mobilization of capital investment resources would then be taken for their physical implementation.

2.4 Engineering and construction requirements

Activities under this heading can be broken down into several distinct types and phases as listed below. In the majority of these fields co-operation among developing countries offers obvious advantages.

10/ "Follow-up of the decisions and recommendations of the Third General Conference of UNIDO. Proposal for an industrial project preparation facility", (UNIDO ID/B/245, 1980) and (UNIDO ID/B/261 Add. 5, 1981).

2.4.1 Basic engineering

This is the result of some considerable research and development by highly skilled scientists and engineers and is normally provided under a patent. This function is usually performed by the licensor of the process or for more established process by licensee engineering organizations as well. However, there are some well established technologies involving processes which have now become 'open art' and can be designed by skilled engineers anywhere. While few of the developing countries can, more or less, perform the latter type of design, they need to depend on advanced industrialized countries for the more sophisticated and new technologies until such time when their research and development activities reach a stage that enables them to undertake full process design.

Process license fee and design cost normally form a small percentage of the project cost in the petrochemical industries. However, in the case of some highly advanced technologies, or in the production of some high value speciality products, the fees can be considerable.

2.4.2 Detailed engineering

This requires skilled and experienced chemical or process engineers and is normally carried out by the licensor or the engineering contractor responsible for the project. Few of the more advanced developing countries have acquired local capabilities to perform this work independently. However, more experience with actual projects will be needed to make developing countries self sufficient in this respect. Although the proportional cost of this element in the project is relatively small, errors in judgement regarding procurement, inspection, erection and general supervision could lead to considerable increases in cost.

The design and engineering costs of this part alone usually constitute about 10 per cent of the project cost, while the machinery and equipment supply can form another 40 per cent of the costs. The full range of engineering and fabrication skills are required for this part of the job, with some elements requiring a high degree of skill and sophistication. At

present, most of the developing countries do not have appreciable capacity for these functions and, for many years to come, have to rely on the developed countries. However, fairly good progress has been made in a small number of the more advanced developing countries which may also have some potential surplus capacity to undertake overseas projects. This could form a useful element in co-operation between some developing countries.

2.4.3 Plant construction

This requires the full range of skilled manpower such as fitters, welders, electricians, masons, carpenters, instrument technicians, crane operators and lifting specialists, and above all competent and well experienced supervisors and managers. Although at present there is not sufficient skilled manpower in the developing countries to undertake the execution of the petrochemical projects mentioned here, nevertheless it is possible, with greater mobility of labour to acquire and to train the required number of people to meet the demand within a region. However, since the training of construction supervisors and managers takes time and can only be achieved by work on actual projects they can initially be obtained from industrialized countries.

Two distinct activities are performed in this field. One relates to civil engineering and construction work which is relatively easy and could be undertaken by local contractors and indigenous labour in a large number of developing countries. The other activity is plant erection and it needs greater skills and experience which are scarce in most developing countries. Nonetheless, the more advanced developing countries (newly industrialized developing countries) could provide assistance in this field of activities to the developing countries.

It is essential to emphasize here the important role of well prepared advanced planning and cost control for project implementation which requires highly experienced and skilled people in the field. The cost element of plant construction varies according to location and local availability of supporting services and of skilled labour. On average, it can be around 35-45 per cent of the project total cost. The magnitude of the total cost in each region can be obtained from Table 6.

2.5 Marketing needs

Normally, the market for any given product is the most important single factor in determining the viability of a project. It is usually essential to have an assured and preferably captive market for at least 50 per cent of the plant output. The markets for petrochemical products discussed in this paper can be broadly divided into three geographical types:

2.5.1 Local or national market

Petrochemicals products are either used as intermediate inputs in downstream manufacturing facilities or as end products ready for the processing industries. In either case, it is important to develop and/or adapt the plant output to suit the market. Market development can be achieved by encouraging the establishment of captive downstream operations and the processing industry which could absorb the end products in currently established uses or in new uses according to the specific local requirements. It must be ensured that new processing facilities to be established in the country are geared in type and specification to use the locally produced product. Existing uses should also be converted well in advance of the plant operation to use the plant output.

It should be pointed out that penetration of the local markets would not automatically be achieved. The existing suppliers to these markets, mainly from developed countries, would not so simply surrender the markets which they have developed over the years to the new local producers. Nor would the local processors or producers who have been accustomed to the services of their traditional suppliers necessarily welcome the new product. Much work would be needed, even before starting operation, to secure sizable outlet in the local market for new petrochemical products in order to ensure the operation of the plant at a reasonably accepted rate.

In developing countries, government investment promotion policies are of considerable importance to encourage marketing for petrochemical products and help generate sufficient demand thus enabling both forward and backward integration of the petrochemical industry as well as the expansion of the

processing industry to absorb the bulk of local production of the petrochemical industry. The result of a successfull industrial policy would be greater value added, less import, higher employment and higher GDP. The subsequent increase in the purchasing power of the population will lead to further increase in demand. This multiplier effect has been demonstrated in the developed countries during the 1950-1980 period.

2.5.2 Regional market

Careful planning and a good deal of co-ordination is necessary to establish complementarity and to avoid the creation of a glut or severe undersupply in the region. As outlined under 2.2 above (page 18), co-ordinated planning on the basis of co-operation in the establishment of new capacities in countries within one market region could match up oversupply from a new plant during its initial years of operation in one country with the supply from another plant in another country during its later years of operation, thereby ensuring good capacity utilization and a better return on investment.

It is important in this respect to refer to the priorities set out in the "Caracas Programme of Action"[11/] regarding the establishment of multinational marketing enterprises and co-operation in the construction of new industrial projects where petrochemicals, chemicals, fertilizers and pharmaceuticals were singled out among the priority sectors.

Premarketing, the downstream development, and end use promotion for the regional marketing will, more or less, be the same as for local market, particularly between countries co-operating in the establishment of a project. It should be pointed out, however, that the difficulties which may be faced at the local marketing level will be multiplied here several times, maybe even more than the number of countries involved in the joint project. Since the stakes are higher the resistance of traditional suppliers and their

---

11/ "Caracas Programme of Action", adopted by the High Level Conference on Economic Co-operation among Developing Countries, Caracas, Venezuela, 13-19 May 1981.

local beneficiaries will be much fiercer and the capacity to promote the sale of the products should be much higher. Sometimes, long-term agreement between the co-operating countries will be essential for the orderly development of their market.

2.5.3 International market

International marketing of petrochemicals is mainly realized in two forms, namely long-term agreements and spot sales. Whenever a sizeable portion of a plant output has to be exported, long-term agreements having suitable variation clauses are usually concluded between the supplier and the purchaser. However, in cases where only a marginal part of the production is exported, marketing is usually done on spot sales basis. In both cases, a good degree of marketing knowledge is required. International marketing activities would involve trading with the developed countries. Joint action and co-ordination of the developing countries may be needed to tackle the problems of trade policies. Certain degree of harmonization of such policies may be required at the start between a group of countries in one region and then to develop later to other regions.

International marketing of petrochemicals is controlled by a small number of joint chemical and oil/chemical multinational corporations and trading houses. It is very difficult for new producers from developing countries to operate in this field outside the influence of these multinationals. Few developing countries have chosen to join forces with them in joint ventures of varying degrees of participation in order to secure the marketing of their products through the world-wide marketing networks of these multinational corporations. Few other developing countries are trying independently to secure markets for the products of their plants. It may be interesting to undertake a study evaluating these two types of marketing arrangements.

2.5.4 Marketing supporting activities

The development of infrastructure, such as roads, jetties, other communication facilities etc. is an important element in the marketing of the products. The cost of such facilities is usually very high and it would not

be logical to charge these expenses to the petrochemical projects alone, particularly when they are needed for the industrial development of the country.

It must be emphasized here that the technical and after-sale services, particularly for the newly established industries in the developing countries, is of paramount importance for the correct and rapid development of the market. Technical services would be necessary to help the processing industry in the applications of petrochemical end products produced locally or those purchased from another developing country. Such services may involve the adjustment of the processing machines, advice on the purchase of new units, applications of tools and instructions on the introduction of new end uses. Market segmentation policies adopted by the highly advanced manufacturers in the developed countries to captivate the use of specific products should be avoided in order to maximize the use of bulk petrochemicals produced in the developing countries.

3. Examples of possible co-operation activities

3.1 Joint engineering

The possible establishment of joint engineering enterprises for the design and procurement of petrochemical projects in the developing countries is worthy of consideration as a field where joint action could easily be undertaken by the developing countries. The magnitude of the cost of this activity is approximately 10 per cent of the project cost. However, the total cost of this element for all the projects proposed in Table 6 is a sizeable one amounting to 3.7 billion dollars.

Today, engineering skills are the basic tools for the establishment of any industry and are imperative for the development of any country. The developing countries can be divided into three broad groups with respect to the availability of engineering skills:

(a) Developing countries which have achieved a relatively advanced industrialization level and enjoy the availability of surplus engineering skills.

(b) Developing countries with moderate industrialization but with inadequate number of skills to meet their own demand.

(c) Less advanced developing countries with low industrialization level and lack of skills.

The surplus available from group (a) can only meet part of the deficiency in groups (b) and (c). Therefore, for some time to come, engineering assistance will be needed from the developed countries to satisfy the needs of the developing countries in skilled manpower requirements.

The developing countries can establish on an inter-regional or intra-regional basis joint engineering enterprises with or without the participation of industrialized countries according to their requirements. Such enterprises for each group or region can be located in a country which has better access to skilled manpower and/or where most of the future projects are to be located. They can start with a modest size, initially to deal with less sophisticated engineering and procurement for off-site facilities, with a view to grow eventually enough to undertake the full range of engineering activities. It is important to provide the necessary financial and political support to these enterprises during their formative years.

The joint engineering enterprise can be organized either on a general multi-disciplinary or on a project basis. Whichever is the case, it will be important to have at least a branch office within the country where a project is located, where proper consideration is given to local conditions essential for the success of the project. Such local branches may become the nucleus of an eventual and complete engineering service within that country. Financial and personnel contribution of each country to these enterprises has to be worked out in accordance with their needs and capabilities but the estimate aim should be to develop the engineering capability of member countries so that they can eventually be able to form their own enterprise when the need arises for this.

An important benefit of joint participation by the developing countries in this field is that it enables them to acquire the necessary know-how for

obtaining the appropriate design and equipment which are most suitable to meet the specific conditions of the country in question. Furthermore, such arrangements would also permit the much needed feedback of information for improving future designs to better suit the evolving conditions. An important initial step in this direction could be attained easily through the adoption of a programme involving regular exchange of experiences and information and mutual on-the-job training courses for personnel from developing countries within a region and/or on intra-regional basis.

A joint enterprise of this sort will also permit full utilization of its staff by planning its schedule and recruitment according to the planned implementation of a programme of projects in the member countries.

Furthermore, a close co-operation between engineering enterprises and equipment manufacturing establishment is very important and useful in the promotion and expansion of local equipment fabrication. It should be stressed that stringent quality control measures are needed in order to avoid delays in construction, trial testing and plant operation.

Another advantage of co-operation in this area between developing countries is that it enables the adoption of common standards for a wide range of equipments and parts to be used in plants built in the participating countries, thereby effecting a useful economy in the implementation of the projects. This can also lead to provision of common spare parts and maintenance facilities with subsequent savings in production costs. Even in the absence of standardized equipment, quite important work could be performed by centralized workshop for the production of spare parts, particularly for critical equipment, on the basis of blue prints obtained at the time of construction and procurement.

Apart from cost considerations involved in this work, perhaps its most important and lasting aspect is the inherent transfer of technology and the valuable aspects of skills development attached to it.

3.3. Joint construction companies

Construction work and plant erection form an important part of petrochemical projects both from cost and time point of views. It constitutes roughly about 40 per cent of the total project cost and in developing countries it takes as much as 70 per cent of the total project implementation.

The construction of petrochemical plants in developing countries becomes extremely costly when undertaken by contractors from the developed countries due to the high contingencies added to the cost of the project. This is partly due to differences in the material and cultural conditions existing between the two regions, the expatriates' attitudes and expectations of home comforts and facilities, inadequate communication and limited ability to motivate the local manpower. But of greater importantance is the lack of effective communications with the local counterparts and institutions which lead to delays, cost overruns and sometimes to an inferior job.

Construction activity can be broken down into three main components:

(a) Building and construction materials, equipments and tools.
(b) Management and supervision.
(c) Skilled manpower and labour.

In most developing countries, there is only a moderate supply of (a) and (b). However, many newly industrialized developing countries have developed beside the skilled labour a good supply of experienced management and supervisory personnel as well as a sizeable stock of equipment and tools required for building and construction. But in many cases the labour market in developed countries still fills in the gaps whenever needed. When viewed on a regional or subregional level, the developing countries could pool together these resources and thus improve to a large extent the level of local participation in implementing their plans in this sector, while reducing the cost of investment and upgrading their competitiveness.

Joint construction companies can be established between the various groups of countries as mentioned earlier in 3.2. (a), (b) and (c). The joint

company thus created needs only to retain supervisory and basic skilled staff while recruiting and training the artisans and skilled labour at the location where the plant is to be constructed whenever needed.

The construction costs, approximately 40 per cent of the project costs, can be calculated for the various petrochemical plants proposed in this paper for different regions in Table 6. The overall expenditure for civil engineering and construction work for these plants is in the order of 15 billion dollars. Using a very rough rule of the thumb for every $100 million project cost or $40 million construction cost, the construction labour requirement amounts to about 400 man year. Thus the total manpower requirement for the implementation of all the projects proposed here is estimated at 150,000 man year.

For the construction of large petrochemical projects in the developing countries most contractors from the industrialized countries often allow for the importation of most of the construction equipment and tools required for the project and usually charge their full cost to the project. Some of the more specialized construction equipment may only be required for a short period on the job and will stand idle for the rest of the time. In many cases, a good proportion of expatriate supervisory staff is also freshly recruited for the job on a very high pay scale. In a joint construction company, owned and staffed by partners from the developing countries, the construction equipment can be utilized for several jobs and the permanent supervisory personnel will ensure continuity of experience. Furthermore, the joint construction company can also undertake projects other than petrochemicals when its capacity permits, thereby ensuring full and continuous employment for its men and equipment. All this will appreciably reduce construction costs.

Apart from the initial capital needed for the establishment of such joint construction companies, there should not be any further need for financing by the partners. Each company should operate on an independent profit-making basis.

3.4. Joint research and development

Today, more than ever, world progress and the well being of any nation depends on scientific and engineering innovations and inventions. The pace of scientific development and new inventions is so rapid that the much talked about transfer of technology from industrialized countries to developing nations will not be sufficient to sustain a durable development of the latter, unless it is backed by sufficient research and development of their own. Among the important industries of this century, petrochemicals and electronics industries are arguably the newest and fastest growing ones and, therefore, deserve full effort in R and D.

The gap between developing and developed countries in R and D is perhaps greater than in any other area, a fact which requires from the developing countries a greater effort in this area if they intend to narrow this gap. R and D in developing countries must be geared to their specific conditions and needs with greater emphasis on the use of local resources. Petrochemical processes and products can be adapted and/or developed to suit local needs, in type and in scale.

Although there are some able and qualified scientists and engineers from the developing countries who, due to lack of opportunity in their own countries, utilize their talents in the service of the developed countries, many developing countries would not have sufficient qualified men and resources to establish a meaningful R and D by themselves. It would be advisable, therefore, to co-operate in setting up joint R and D establishments. Co-operation can be achieved by pooling manpower and equipment, joint financing and co-sponsoring specific fields of development and research or even by contributing to any of the activities and functions of R and D in general.

Since close co-operation between industry and R and D is essential for all practical purposes, the selection of the location of a joint R and D centre would be optimal when it is near to an operating petrochemical plant. R and D requires manpower of high qualification and ability in many scientific and engineering disciplines, and above all it needs skillful management and

clear orientation. It will be important, therefore, to attract the right type of people for this work and provide them with adequate material and moral incentives, and proper motivation for the attainment of clearly set goals.

Present day R and D would also require sophisticated equipment and pilot plant facilities which can be very costly and, therefore, not within the means of many individual developing countries. The pooling of resources of several developing countries would overcome these restrictions and would provide wider scope and incentives for the joint R and D establishment.

It is a fact that R and D may not be run purely on a profit/or return on expenditure basis for any one single project. But, on the whole, R and D costs could be recouped by the incomes acruing from several projects such as improving petrochemical operations, license fees and royalties.

R and D in petrochemicals can broadly be directed to deal with products and processes in several areas according to products categories i.e.:

Category of Petrochemical Products		R and D Activities
a) Basic Products:		
Olefins) Raw materials		
Aromatics		) Processes
Fertilizers		) Products
b) Polymers:		
Plastics		) Processes
Synthetic Fibres		) New types and/or,
Synthetic Rubbers		) New applications
c) Solvents and Chemicals	(speciality products)	) Processes
d) Medicinal Products	(speciality products)	) Products
e) Other groups of chemicals		

In each area, emphasis can be laid on factors and conditions prevailing in the region of the joint co-operation, for example, the development of small-size economic units to suit limited local demand for certain products.

3.5. Joint marketing

It goes without saying that the market for a product is the basic "raison d'être" of any petrochemical project. Joint marketing and market development among the developing countries with restricted markets and resources in each individual country will have many advantages. When joint projects are built for a collective market, co-operation in marketing becomes essential. However, even without the existence of joint production plants, joint marketing has its advantages.

As stated earlier, joint co-operation between developing countries generally becomes beneficial when no single country has sufficient market to justify an economic size project. Furthermore, in order to have an equitable allocation of projects among the co-operating countries for the production of various petrochemicals with due consideration of the markets and resources of each country, a good knowledge of the present and potential future markets in each is essential.

As explained in 2.5 above, to ensure the economic success of a project, it is essential to undertake some marketing studies paying particular attention to local conditions and potential uses, so that the production from any proposed plant could be absorbed quickly in the market. This will involve a good deal of investment promotion, customer education, and end-use developments which could be beyond the capability of most developing countries.

A joint marketing organization can be set up in an agreed location with personnel and financial allocations mutually agreed upon by member countries. The governing body of the organization could be made up of one person from each country plus the head of the joint marketing organization which will be responsible for setting pricing policy, scope of activity and budget for the organization. It will also be useful to have a small branch office in each

country to assist in the marketing work needed for that country. This would form the basis for the eventual set up of an independent marketing organization in the country concerned.

The development of joint storage, transportation, and shipping facilities will also form an important part of the organization function. The adoption of a common policy regarding tariffs and duties between the partners as well as with other countries will help to ensure smooth and durable relationships among themselves and with the outside world.

In order to ensure the orderly development of the petrochemical industry in general and in developing countries in particular co-ordination between the suppliers of raw materials and the downstream users becomes imperative. In this regard, OPEC members could co-operate with joint groups from other developing countries in order to plan and co-ordinate their projects to meet the market requirements. Jointly, they can programme and promote upstream/downstream activities in the vertical or horizontal integration of petrochemical projects.

The activities of the joint marketing establishment can be organized on a regional or on product basis. An effective means of interchange of information and experience in petrochemicals market development amongst the members of such establishments will be to the advantage of the joint enterprise.

3.6. Manpower Training

The various categories of manpower requirements for petrochemical industry are listed below:

- Highly qualified scientists and engineers, mostly with graduate or post-graduate degrees, for R and D.
- Graduate engineers and technical diploma holders with varying degrees of experience for plant operation and maintenance.
- Experienced engineers, technicians and artisans for plants construction.

- Marketing studies graduates or trained technical men for marketing.
- Experienced administrative personnel.
- Accountants and lawyers.
- Experienced economist and engineers for planning.

The extent of training and experience needed for each category and each function within a category will vary. The basis for all is however education, starting with primary schools for lower skill and moving up to higher education for professionals. Educational facilities are basically established on a national basis with sometimes joint co-operation between countries in the higher education facilities. Joint co-operation in the establishment of higher education in technical fields can be advantageous for some groups of less developed countries, in order to enhance the facilities and the quality of education. Joint training facilities, centres and programmes could also serve skill upgrading, specific skill development and general training of new personnel.

Among the manpower categories listed above, training and experience is of paramount importance for operation and maintenance personnel because it can greatly influence the efficiency of operation, plant output and on-stream factor and have high impact on the unit cost of production. With the highly competitive nature of the petrochemical industry, often the last 10 per cent of production capacity can make or break the economic viability of a project. Next in importance with regard to experience and training comes construction personnel who should have a wide range of skills as outlined in 3.3 above.

The best way to train people is to have them work on actual industrial job. But as this is not always available within developing countries having no petrochemical plants, it will be necessary to provide training facilities in appropriate schools or on plants in other countries. And as the required skills are in short supply in these countries, it is not always possible or economically attractive to set up the needed training establishments in each country. However, a joint facility for manpower training between two or more countries provides a good solution to the problem. The facility can be as simple as teaching carpenty or welding, or as advanced as using demonstration

plants, models, and simulating equipment for training of operators and maintenance men. This latter type of facility will require a good deal of investment in capital and teaching manpower.

It will be most effective, wherever possible, to utilize existing operational plants for training of personnel. Co-operation between countries with such facilities and other developing countries will be of great help. This could be organized on the basis of a programme of exchange of experience and plants visits as well as elaboration of on-job or plant training programmes. Similarly, on-the-job training or school training can be organized for the other categories of skills needed.

Organizing joint seminars to discuss common problems and experiences will be valuable as some problems could be particular to the developing countries and not always understable or solvable by industrialized countries. These seminars can cover the full spectrum of skills from the operators' level to the highest management level.

One very important factor to be taken into account when assessing the viability of a petrochemical project in a developing country embarking on this industry is the training and experience this country gains. An operating plant can provide a significant number of highly needed trained people for a lifetime. It can also be a valuable source of experienced labour for future expansion or outside assistance.

4. Special funding arrangements for co-operation projects in petrochemicals

The scope of new petrochemical projects needed to satisfy the increased demand in developing countries between the years 1984-1990 is given in Table 6. This shows some 254 projects requiring a total investment in the order of 37 billion dollars with the foreign exchange portion representing some 23 billion dollars. These funds are required for some of the more important petrochemicals only and there will be demand for many other intermediate and downstream projects which may require an equal amount of funds.

As proposed under 2.3 above pp. 20-22), co-operative funding of petrochemical projects could provide the necessary means for the promotion of petrochemicals in developing countries.

Three stages are envisaged under this, which would need to be funded consecutively:

(i) The first stage would consist of an opportunity study to be undertaken on a regional or sub-regional basis, covering all the developing countries, in order to determine the number and type of desirable projects and the possibilities of joint co-operation for their implementation to the mutual advantage of the partners concerned. This will cost approximately five million dollars and could be completed within 12 months from the date of its initiation.

(ii) After the completion of the above study and the identification of potential joint projects, prefeasibility studies should be undertaken for each of these projects covering the marketing, capacity, technical and financial requirements and the economics of the project so that a decision can be taken on its viability and possible implementation. It is estimated that funds in the order of $ 50 million will be needed at this stage. The funds could be provided by the countries interested in these joint-venture projects. It is proposed, however, that initial financial contribution would have to be made from existing development funds such as OPEC Fund for International Development and other regional funds. The time required for this stage of implementation of the studies will vary according to the project under consideration and nature of co-operation. In general, nearly one year should be allowed for this.

(iii) Following stage (ii) above, when the type, size, capital cost estimate and the nature of co-operation between the countries concerned are determined, the actual financing and

implementation of the project could proceed. The most important element at this stage will be financing. It may be considered, however, that the local cost component of a project would not represent a great difficulty since it may be provided by the host country. But the foreign exchange costs which will be around 60 per cent of the total project cost should pose a problem for most developing countries. This can be provided by some or all of the following arrangements.

(a) Individual OPEC member states providing some development credit to projects in which they choose to participate or to assist only. Payment for such credit could be made through petroleum exports to the countries participating in the joint venture projects. Credit payment or repayment could also be tied up with the export of feedstocks, basic and/or intermediate petrochemical products required for the operation of the plants as well as buy-back arrangements of final products of these plants. Such exchange arrangements would also offer a viable means for vertical integration in petrochemical production. World Bank loans and development aids may also be sought whenever possible.

(b) Another source of financing could be suppliers' credit provided by the countries selling equipment and engineering. This element of the project cost forms around 60 per cent of the total cost and would be spent mostly in the industrialized countries. Suppliers credit is expected therefore to come from the developed countries. However, it may be necessary to establish a certain mechanism to guarantee such credit arrangements.

(c) Advance purchase of products to be produced by the joint-venture project, on a long-term basis, can also provide a useful proportion of the capital cost. Co-operation between some developing countries could be organized on such basis when establishing joint purpose projects.

It is estimated that the time required to complete a project will be around four to six years from the moment a firm decision is taken for its implementation. The funds required for the project will therefore be spread over this period of time.

It should be made clear that the development of petrochemicals in the developing countries will be in the interest of the developed countries as well. This could provide a valid ground for South/South and South/North co-operation to the mutual advantages of all. The development of petrochemicals in the developing countries, among others, will help stimulate the presently stagnant industrial activities in the industrialized countries, provide a good outlet for the downstream and petrochemical feedstock produced in large quantities in OPEC countries and above all, promote the development of developing countries, and hence increasing their standard of living and purchasing power. The consequence of all this would be to stimulate and improve the economies of all concerned.

TABLE 4 MAJOR PETROCHEMICALS CONSUMPTION IN DEVELOPED & DEVELOPING COUNTRIES IN 1979 & ESTIMATED 1990 AT TOTAL & PER CAPITA

(per capita consumption figures shown to nearest decimal)

PRODUCTS	WORLD				DEVELOPED COUNTRIES (1)				DEVELOPING COUNTRIES (2)			
	1979		1990 Estimate		1979		1990 Estimate		1979		1990 Estimate	
	Total 1000 tons	Per capita Kg.	Total 1000 tons	Per capita Kg.	Total 1000 tons	Per capita Kg.	Total 1000 tons	Per capita Kg.	Total 1000 tons	Per capita Kg.	Total 1000 tons	Per capita Kg.
OLEFINES:	61940	18.2	115620	22.2	57650	50.1	95600	79.0	4290	1.9	20020	5.0
Ethylene	37380	11.0	70450	13.5	34700	30.2	56500	46.7	2680	1.2	13950	3.5
Propylene	19620	5.7	36870	7.1	18430	16.0	32400	26.8	1190	0.5	4470	1.1
Butadiene	4940	1.5	8300	1.6	4520	3.9	6700	5.5	420	0.2	1600	0.4
AROMATICS:	23800	6.9	42650	8.2	21500	18.7	34650	30.6	2100	1.0	6000	2.1
Benzene	17500	5.1	30850	5.9	16300	14.1	25800	21.3	1200	0.6	5050	1.9
Xylenes	6100	1.8	11850	2.3	5300	4.6	8850	7.3	800	0.4	3000	0.8
PLASTICS:	41100	12.1	80000	15.4	34290	30.4	58000	48.0	6710	3.1	22000	5.9
LDPE	12240	3.6	21990	4.2	10030	9.0	15040	12.4	2210	1.0	6950	1.7
HDPE	5680	1.7	11160	2.1	4843	4.2	8440	7.0	840	0.4	2720	0.7
Polypropylene	4990	1.5	12330	2.4	4140	3.6	9290	7.7	850	0.4	3040	0.8
PVC	12140	3.5	23620	4.5	10030	9.0	16420	13.6	2110	1.0	7200	1.8
Polystyrene	5950	1.7	10900	2.1	5250	4.6	8810	7.3	700	0.3	2090	0.5
SYNTHETIC FIBERS:	10030	3.0	15015	2.9	7560	6.5	10015	8.2	2470	1.2	5100	1.3
Acrylic Fibres	1810	0.5	2645	0.5	1420	1.2	1835	1.5	390	0.2	810	0.2
Polyamide Fibres	3290	1.0	4440	0.9	2660	2.3	3290	2.7	620	0.3	1150	0.3
Polyester Fibres	4940	1.5	7930	1.5	3480	3.0	4890	4.0	1460	0.7	3140	0.8
SYNTHETIC RUBBERS:	6330	1.9	9950	1.9	5460	4.8	7970	6.6	920	0.4	1980	0.5
SBR	5220	1.5	8030	1.5	4450	3.9	6400	5.3	770	0.3	1630	0.4
Polybutadiene	1160	0.3	1920	0.4	1010	0.9	1570	1.3	150	0.1	350	0.1
ETHANOL	11740	3.5	27550	5.3	10800	9.7	24000	19.8	940	0.4	3550	0.9
AMMONIA	74220	21.8	104340	20.1	44150	38.4	57480	47.5	30070	13.6	46860	11.7
Year	1980/81		1990/91		1980/81		1990/91		1980/81		1990/91	

Source: UNIDO's Second World-wide Study; A process of restructuring

(1) includes European centrally planned economies

(2) includes Asean centrally planned economies

Table 5 Demand for major petrochemicals in developed and developing countries (in thousand metric tons)

PRODUCTS	WORLD				DEVELOPED COUNTRIES (1)				DEVELOPING COUNTRIES (2)			DEVELOPING COUNTRIES	
	DEMAND			INCREASE IN DEMAND	DEMAND			INCREASE IN DEMAND	DEMAND			Production 1984	INCREASED 1990 DEMAND ON 1984 PRODUCTION
	1979	1984	1990	1984 to 1990	1979	1984	1990	1984 to 1990	1979	1984	1990		
OLEFINS													
Ethylene	37380	49700	70450	20750	34700	43550	56500	12950	2680	6150	13950	6150	7800
Propylene	19620	25310	36870	11560	18430	22900	32400	9500	1190	2410	4470	2410	2060
Butadiene	4940	6330	8300	1970	4920	5430	6700	1270	420	900	1600	900	700
AROMATICS													
Benzene	17500	23100	30800	7700	16200	20400	25800	5400	1300	2700	5000	2620	2380
Xylenes	6100	8600	11850	3250	5300	6800	8850	2050	800	1800	3000	1690	1310
PLASTICS													
LDPE	12240	15710	21990	6280	10030	11960	15040	3080	2210	3750	6950	2590	4360
HDPE	5690	7790	11160	3370	4840	6330	8440	2110	840	1460	2720	980	1740
Polypropylene	4990	7460	12330	4870	4140	5940	9290	3350	850	1520	3040	1030	2010
PVC	12140	16360	23620	7260	10030	12510	16420	3910	2110	3850	7200	3220	3980
Polystyrene	5950	7740	10900	3160	5250	6600	8810	2210	700	1140	2090	690	1400
SYNTHETIC FIBRES													
Acrylic Fibres	1810	2130	2645	515	1420	1580	1835	255	390	550	810	450	360
Polyamide Fibres	3280	3860	4440	580	2660	3050	3290	240	620	810	1150	610	540
Polyester Fibres	4940	6370	7930	1560	3480	4260	4890	630	1460	2110	3140	1760	1380
SYNTHETIC RUBBERS													
SBR	5220	6450	8030	1580	4450	5300	6400	1100	770	1150	1630	700	930
Polybutadiene	1160	1530	1920	340	1010	1330	1570	240	150	250	350	200	150
METHANOL & AMMONIA													
Methanol	11740	18400	27550	9150	10800	16600	24000	7400	940	1800	3550	2900	650
Ammonia	74220	86720	104340	17520	44150	49750	57480	8730	30070	36960	46860	31612	15248
Year	1980/81	1984/85	1990/91		1980/81	1984/5	1990/91		1980/81	1984/85	1990/91	1984/85	

(1) Includes European centrally planned economies

(2) Includes Asian centrally planned economies

TABLE 6 NEW PLANTS, INVESTMENT AND EXCHANGE REQUIREMENT IN DEVELOPING COUNTRY REGIONS BY 1990 FOR MAJOR PETROCHEMICALS

	Capacity 1984 X 1000 tons	Demand 1990 X 1000 tons	Increased 1990 demand over 1984 capacity X 1000 tons	Number and size of new units 1984-1990 X 1000 tons per year[1]	Capital cost of new units 1980 prices $ million[2]	Foreign exchange element $ million[3]	Local cost element $ million
OLEFINES							
ETHYLENE							
Africa	-	300	300	2 x 200	1 000	650	350
Mid. East, N. Africa	450	800	350	1 x 500	500	300	200
Mid. East, West Africa	800	2 650	1 850	3 x 500 2 x 300	1 800	1 080	720
Asia	2 300	3 800	1 500	4 x 300 3 x 200	4 000	2 600	1 400
China	950	1 400	450	2 x 300	750	450	300
Latin America	3 400	5 000	1 600	2 x 500 2 x 300 2 x 200	2 300	1 335	965
TOTAL	7 900	13 950	6 050	7 400	10 350	6 415	3 935
PROPYLENE							
Africa	30	60	30	Included with ethylene production units above. See notes on feedstock.			
Mid East, N. Africa	50	100	50				
Mid. East, West Africa	100	160	60				
Asia	1 160	1 800	640				
China	410	850	440				
Latin America	1 300	1 500	200				
TOTAL	3 050	4 470	1 420				
BUTADIENE							
Africa	--	60	60	As for propylene			
Mid. East, N. Africa	60	50	(-10)				
Mid East, West Asia	30	60	30				
Asia	300	500	200				
China	220	330	110				
Latin America	430	600	170				
TOTAL	1 040	1 600	560				
AROMATICS							
BENZENE							
Africa	20	50	30	Assumed tied to naphta crackers in ethylene production above. See notes on feedstock			
Mid. East, North Africa	-	50	50				
Mid. East, W. Asia	150	150	-				
Asia	800	1 600	800				
China	800	1 400	600				
Latin America	1 400	1 750	350				
TOTAL	3 170	5 000	1 830				
XYLENES							
Africa	0	100	100	As for Benzene			
Mid. East, North Africa	40	100	60				
Mid. East, West Africa	200	300	100				
Asia	950	1 200	250				
China	210	300	90				
Latin America	750	1 000	250				
TOTAL	2 150	3 000	850				
PLASTICS							
LDPE							
Africa	-	200	200	(2) 2 x 50	210	140	70
Mid. East, N. Africa	240	300	60	1 x 200[3]	420	250	170
Mid. East, W. Asia	510	600	90	3 x 200 2 x 100[3]	910	550	360
Asia	840	3 000	2 160	4 x 200[4] 3 x 100	1 675	1 090	785
China	340	750	410	2 x 200	420	250	170
Latin America	1 330	2 100	770	2 x 200 4 x 100	840	490	350
TOTAL	3 260	6 950	3 690	3 400	4 475	2 770	1 905

Table 6 (continued)

	Capacity 1984 X 1000 tons	Demand 1990 X 1000 tons	Increased 1990 demand over 1984 capacity X 1000 tons	Number and size of new units 1984-1990 X 1000 tons per year[1]	Capital cost of new units 1980 prices $ million[6]	Foreign exchange element $ million[6]	Local cost element $ million
HDPE				[2]			
Africa	-	40	40	2 x 25	90	58	32
Mid. East, N. Africa	140	80	(- 60)	1 x 50 [3]	48	29	19
Mid. East, W. Asia	140	200	60	3 x 100 [3] 2 x 50	336	200	136
Asia	450	1 400	950	3 x 100 4 x 50 [4]	443	288	155
China	35	200	165	2 x 100	160	96	64
Latin America	460	800	340	2 x 100 4 x 50	308	180	128
TOTAL	1 225	2 720	1 495	1 600	1 385	851	534
POLYPROPYLENE				[2]			
Africa	35	80	45	2 x 25	130	85	45
Mid. East, N. Africa	70	60	(-10)	1 x 50 [3]	75	45	30
Mid. East, W. Asia	60	200	140	3 x 100 2 x 50 [3]	410	245	165
Asia	620	1 600	980	4 x 100 3 x 50	990	640	350
China	200	300	100	2 x 50	150	90	60
Latin America	290	800	510	2 x 100 3 x 50 2 x 25	500	290	210
TOTAL	1 275	3 040	1 765	1 550	2 255	1 395	860
PVC				[3]			
Africa	-	200	200	2 x 50 5 x 25	530	345	185
Mid. East, N. Africa	200	300	100	2 x 100	340	205	135
Mid. East, W. Asia	200	600	400	3 x 150 [3] 2 x 100	1 010	600	410
Asia	1 670	3 000	1 330	4 x 100 [4] 3 x 50	1 320	860	460
China	800	1 400	600	2 x 150 [4] 2 x 100	790	475	315
Latin America	1 070	1 700	630	3 x 150 5 x 50	1 030	615	415
TOTAL	3 940	7 200	3 260	2 825	5 020	3 100	1 920
POLYSTYRENE							
Africa	-	80	80	2 x 50	100	65	35
Mid. East, N. Africa	-	60	60	1 x 100	65	39	26
Mid. East, W. Asia	40	200	160	3 x 100 2 x 50	270	162	108
Asia	340	1 000	660	2 x 100 5 x 50	420	273	147
China	20	150	130	2 x 50	75	45	30
Latin America	460	600	140	4 x 50	130	75	55
TOTAL	860	2 090	1 230	1 350	1 060	659	401
POLYESTER FIBRES							
Africa	50	110	60	3 x 25	174	113	61
Mid. East, N. Africa	40	110	70	1 x 50 2 x 25	165	99	66
Mid. East, W. Asia	70	100	30	2 x 25	88	53	35
Asia	1 000	1 400	400	4 x 50 4 x 25	630	410	220
China	450	700	250	5 x 50	385	230	155
Latin America	540	720	180	2 x 50 4 x 25	285	165	120
TOTAL	2 150	3 140	990	975	1 727	1 070	657

Table 6 (continued)

	Capacity 1984 X 1000 tons	Demand 1990 X 1000 tons	Increased 1990 demand over 1984 capacity X 1000 tons	Number and size of new units 1984-1990 X 1000 tons per year 1/	Capital cost of new units 1980 prices $ million 6/	Foreign exchange element $ million 6/	Local cost element $ million
SBR							
Africa	-	50	50	2 x 25	150	98	52
Mid. East, N. Africa	-	40	40	2 x 25	112	67	45
Mid. East, W. Asia	40	40	-	-	-	-	-
Asia	220	500	280	2 x 50 7 x 25	745	480	265
China	100	250	150	2 x 50 2 x 25	276	165	111
Latin America	560	750	190	2 x 50 4 x 25	340	200	140
TOTAL	920	1 630	710	725	1 623	1 010	613
METHANOL							
Africa	-	50	50	-			
Mid. East, N. Africa	450	100	(-350)	-			
Mid. East, W. Asia	660	100	(-560)	-			
Asia	600	1 200	600	Can be supplied from OPEC more economically			
China	400	700	300				
Latin America	1 200	1 400	200	1 x 250	90	52	38
TOTAL	3 310	3 550	240	250	90	52	38
AMMONIA				7/			
Africa	546	1 335	789	3 x 300	420	270	150
Near East	3 205	4 492	1 287	2 x 500 2 x 300	700	420	280
Far East	8 437	14 082	5 645	6 x 500 10 x 300 5 x 200	3 530	2 290	1 240
Asia centrally planned	16 061	20 638	4 577	4 x 500 12 x 300	2 890	1 700	1 140
Latin America	3 363	6 313	2 950	12 x 300	1 600	930	670
TOTAL	31 612	46 860	15 248	18 700	9 140	5 610	3 480

1/ Allowing for 80% capacity production in 1990
2/ Tied to new ethylene plants
3/ Export capacity from OPEC countries due to favourable position
4/ Allows import from OPEC countries
5/ Tied to new ethylene plants and imported EDC/VC
6/ Cost estimates are approximate order of magnitude for typical conditions (See Appendix 2)
7/ Some based on methane and some on naphtha as feedstock (See appendix 2).

Table 7 Population data (from World Bank Statistics) used in Table 1

	1979		1990 (estimated)	
	Million	per cent	Million	per cent
Total World	3 400	100	5 200	100
Developed countries including European centrally planned economies	1 150	33.8	1 210	23.4
Developing countries including Asian centrally planned economies	2 218	65.2	3 990	76.6

Source: World Bank Development Report, 1982

Table 8 Assumptions used for plant cost estimates in table 5

Location factors:

U.S. Gulf Coast	= 1
Latin America	= 1.3
Mid East and China	= 1.5
Africa and Asia	= 2.0

Ethylene Plant Capital Cost	US $ million
500,000 tpa in Mid. East and China based on ethane/propane feed	490
300,000 " " " " " " " " "	370
200,000 " " " " " " naphtha	375
500,000 " in Latin America based on ethane/propane	425
300,000 " " " " naphtha	410
200,000 " " " " " "	325
300,000 " in Africa and Asia based on naphtha	630
200,000 " " " " " "	500

Ammonia Plant Capital Cost	US $ million
500,000 tpa unit in Mid. East, N. Africa and W. Asia based on methane	= 210
300,000 " " " " " " " " " " " "	140
500,000 tpa unit in far East and China based on naphtha	230
300,000 " " " " " " "	160
300,000 " Latin America based on methane	120
300,000 " " " " " " naphtha	140

Polystyrene Plant Capital Cost	US $ million
100,000 tpa unit in Mid. East	65
50,000 " " " " and China	37
50,000 " " Africa and Asia	50
50,000 " " Latin America	32

LDPE Plant Cost in 1980	US $ million
200,000 tpa unit in Mid. East and China	210
200,000 " " Asia	280
200,000 " " Latin America	180
100,000 " " Mid. East	140
100,000 " " Asia	185
100,000 " " Latin America	120
50,000 " " Africa	105

HDPE Plant Cost in 1980	US $ million
100,000 tpa unit in Asia	105
100,000 " " Mid. East and China	80
100,000 " " Latin America	70
50,000 " " Mid. East	48
50,000 " " Asia	64
50,000 " " Latin America	42
25,000 " " Africa	45

Polypropylene Plant Cost in 1980	US $ million
100,000 tpa unit in Mid. East	130
100,000 " " Asia	173
100,000 " " Latin America	113
50,000 " " Mid. East and China	75
50,000 " " Asia	100
50,000 " " Latin America	65
25,000 " " Africa	65
25,000 " " Latin America	42

PVC Plant Cost in 1980	US $ million
150,000 tpa unit in Mid. East and China	224
150,000 " " Latin America	195
100,000 " " Mid. East and China	170
100,000 " " Asia	225
50,000 " " Africa and Asia	140
50,000 " " Latin America	90
25,000 " " Africa	100

Polyester Fibre Plant Cost in 1980	US $ million
50,000 tpa unit in Mid. East and China	77
50,000 " " Asia	100
50,000 " " Latin America	67
25,000 " " Africa and Asia	58
25,000 " " Mid. East	44
25,000 " " Latin America	38

SBR Plant Cost in 1980	US $ million
50,000 tpa unit in Asia	110
50,000 " " China	82
50,000 " " Latin America	72
25,000 " " Africa and Asia	75
25,000 " " Mid. East and China	56
25,000 " " Latin America	49

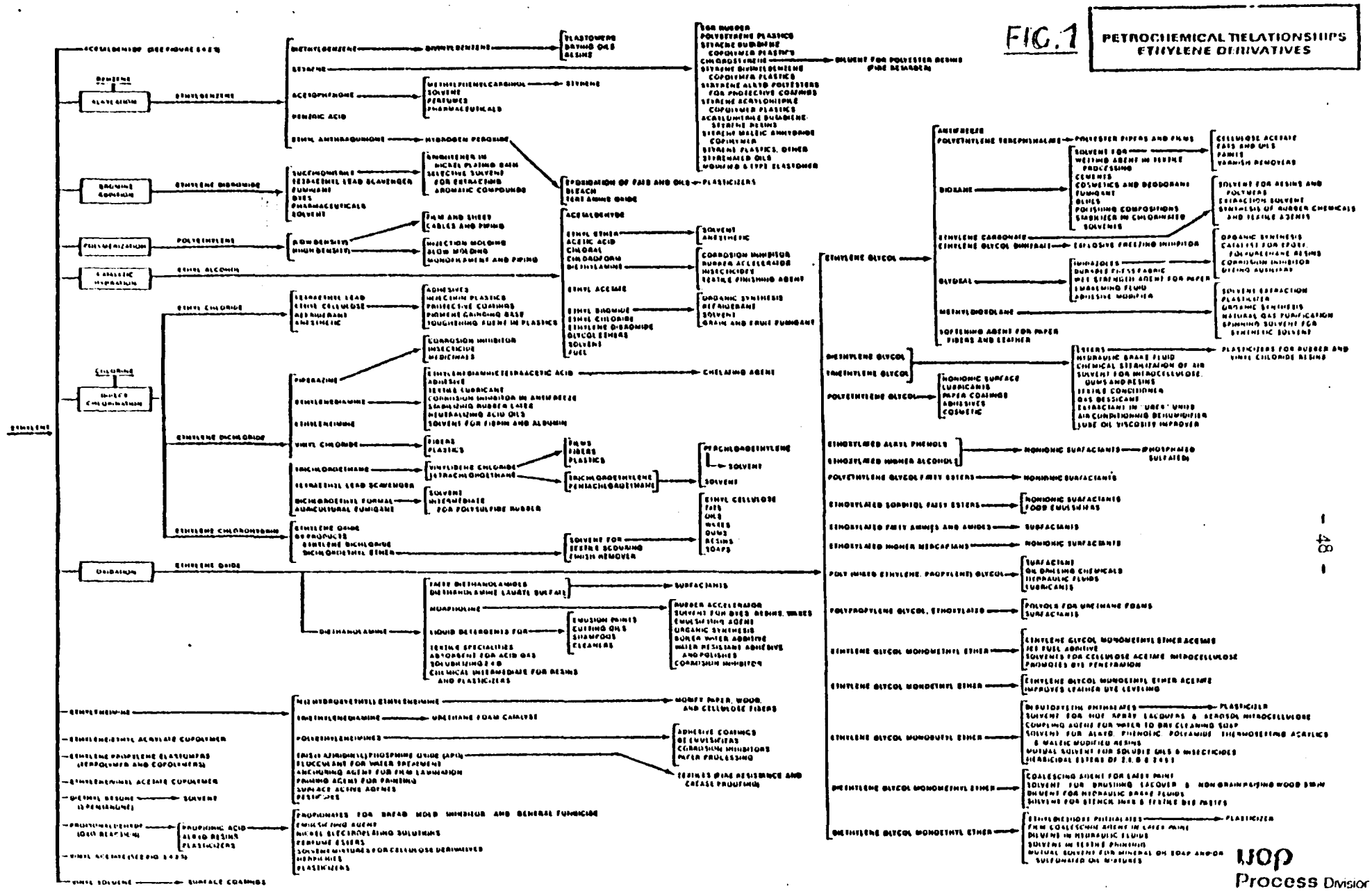


FIG. 1

PETROCHEMICAL RELATIONSHIPS ETHYLENE DERIVATIVES

UOP Process Division
UOP Inc