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THE DEVELOPMENT OF INTEGRATED PETROCHEMICAL INDUSTRY IN THE ARAB REGION*

Prepared by

the UNIDO Secretariat **

* This document has not been edited

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Introduction

One of the most potential and challenging enterprises of our modern age is the petrochemical industry, emerging from a vast wealth of natural resources and inviting endless opportunities for development in all of its facets. In addition to devising advanced technical procedures to deal with basic petrochemical improvement, the industry of today has also become vigorously involved in creating new products which not only compete with, but surpass traditional materials. For example, commodity resins, particularly rubber, elastomers and engineering polymers serve as excellent substitutes for metals, wood, and other construction materials in a variety of applications. Polymers are also being widely used as glazing materials, panels, parts in transportation hardware, components in computers, other electronics, and irrigation hardware, and as packaging materials in substitution for paper and natural fibers. Synthetic fibers and rubbers have now largely outclassed traditional materials in both performance and economy.

In Arab countries, it is evident that the petrochemical industry is a vital key to the future industrialization and development of this region, since such a great number of economic sectors and activities are being served by a large variety of petrochemical products.

It is worth mentioning that food- and agricultural-related industries which are particularly important to the Arab region depend on petrochemical products for their expansion such as fertilizers, plastic materials for irrigation, farm and greenhouse materials, agricultural and processed food product packaging, etc. It is also clear that the Arab petrochemical market which is still nascent has great potential for petrochemical products.

The availability of crude oil, natural gas and other hydrocarbon products as petrochemical raw materials and cheap energy sources also renders it very attractive for Arab countries to enter this field of industry. This was not enough by itself for the Arab countries to start production of petrochemicals. They had to face a large host of problems such as inadequate physical and human infrastructure, high construction costs, operation and maintenance difficulties, limited R + D facilities, lack of efficient planning and marketing problems. Inspite of all these problems many Arab countries went ahead and built, alone or in ventures with foreign associates, a host of petrochemical plants, particularly during the late 1970's and early 80's. Once these plants have been materialized and their products have had to be placed on the marketplace another type of obstacles had to be faced by the new producers. The steep drop in the prices of hydrocarbons have eroded many of the inherent advantages of Arab producers, to this was added the protectionist measures adopted by the traditional markets in Western Europe in particular.

It became evident that in order to maintain their viability as producers the Arab countries needed a higher and more intensive level of co-operation and co-ordination on national, regional and interregional scales. The adoption of such a policy by Arab petrochemical producers would involve relatively different and newer concepts of industrial strategy concerning various means of co-operation, co-ordination and integration.

The purpose of the present study is to analyze the main factors involved in the development of an integrated petrochemical industry in the Arab region which could contribute to the assurance of the stability, continuity and profitability of the Arab petrochemical industry of the future.

History

In reviewing the development of the Arab petrochemical industry during the last few decades, it is notable, in the first place, that apart from a few gas-base ammonia units constructed in the late 1960's only a very few Arab countries invested directly in this industry. Unfavourable economic parameters were obviously at fault; in the first place, most of the hydrocarbon feed was not of crucial significance in the manufacturing cost of most bulk petrochemicals. Secondly, the prevailing commercial plant size surpassed that of the domestic market in most, if not all, of the OAPEC member states. Thirdly, the required investment finance in most OAPEC countries was not available, and infrastructure, both physical and human, was inadequate [1/].

Other factors associated with restrictive conditions in co-operating with host governments and the high cost of royalties and license fees imposed by international owners of technology added to the delay during those years.

The upsurge, or actual history of the Arab petrochemical industry, may

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1/ Alwattari, Abdelaziz, Oil Downstream: Opportunities, Limitations, Policies, Kuwait, 1980, pp.3-032.

probably be dated from the period of the oil price rise in 1973-74 and the subsequent higher costs of energy and feedstock, when the manufacturing costs of many basic and intermediate chemicals became favourable in Arab oil and gas producing countries, and thus sufficient funds were available to meet the high investment requirements of the petrochemical industry. Market size was also enlarged as a result of the increased rate of economic growth in the Arab oil producing countries in particular and Arab region in general and was able to soon catch up with the economic plant size required for a number of petrochemical commodities. Also, opportunities for exports were better.

The comprehensive survey and study sponsored by the Arab Industrial Development Organization (AIDO) on the status and prospects of the development of petrochemical industries in the Arab region in 1982-83 revealed that some 70-72 petrochemical projects were being installed and under construction in the Arab region with a total designed production capacity of about 9,287,200 tons per year, in addition to some thirteen petrochemical projects which were under study. In 1981, the actual total production of Arab petrochemicals amounted approximately to 386,000 tons covering fourteen products.2/

Table 1

Installed, under construction and planned petrochemical projects in the Arab region in the early 1980's

Stage of projects	Number of projects	Total design capacity 1000 tons	Total production 1000 tons 1981
Installed projects	27	1510,4	386
Under construction	45	7776,8	
At study stage	13	1844,5	

The study has also indicated that a radical change in Arab petrochemical production is expected to be witnessed in 1985 when production by most of the big petrochemical projects will start. Table 1 indicates that the total designed capacity of the projects under construction is about 7.8 million tons, most of which were scheduled to produce during mid 1980's.

2/ Al-Saudi Consulting House: Study on the present status and future prospects of petrochemical industries in the Arab countries: a sectoral study sponsored by AIDO, vol.5, page 23-24

The most recent study on the Arab petrochemical industry concluded at the end of 1988 by AIDO through a team of experts, pointed out that at the mid 1980's the number of installed petrochemical projects in the Arab region reached 35 projects with a total designed production capacity of 10.7 million tons/year, most of which are at normal production status or completed and ready for operation. The production of the said 35 projects covers about 23 petrochemical products 3/ (phenol and polyamide fibers are not counted because of their very low production capacities, 1000 tons and 4000 tons/year respectively). Details on the present status and future prospects of the petrochemical industry in Arab countries will be discussed later in a separate chapter.

World trends in the petrochemical industry

The revival of the petrochemical industry after the setbacks of the early 1980's was truly global in scope and international in trade, characteristics which caused both problems and opportunities. Moreover, the new petrochemical sector is market-driven and impacted as never before by geopolitics; and a restructuring of the industry throughout the world is ongoing. On the other hand, technological innovation, the obsession of the 1950's, 1960's and 1970's, has surrendered, to a considerable extent, to matters of supply, demand, distribution and international trade 4/.

Thus, it appears that the determining factor in the development of the oil refining and petrochemical industries will center around commercial and business strategies rather than technology in the 1990's 5/.

In a statement by Mr. Peter H. Spitz, the author of the comprehensive book entitled "Petrochemicals - the rise of an industry", he noted that low profits and reduced demand growth for petrochemicals have dampened manufacturers, enthusiasm for new product technology. Moreover, many current routes for the

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3/ Draft of up-dated sectorial study on the Arab petrochemical industry (present status and future prospects), Vol.1, pp.47; 74

4/ Vervalin, C.H. Petrochemical Industry's Outlook, Hydrocarbon Processing, May 1986, p.41-43

5/ Jenkings, Gilbert (of Chem. systems international). Paper delivered at the International Oil and Gas Forum held in London, April 21, 1988 in OPEC Bulletin, June-July 1988.

production of key petrochemicals are close to their limits in catalyst efficiency and reactor design. Nevertheless, the level of process development work for petrochemicals is now increasing again, with several objectives identified. An important new target is the use of ethane and propane as feedstocks for certain olefin derivatives (vinylchloride, acrylonitrile) and aromatics (see ref. no 4). In many large chemical companies, there is much greater interest in diversification through acquisitions or in entering the production of speciality and performance chemicals with higher profit margins than in producing basic petrochmicals (see ref. no 5).

In the fields of research and development, efforts seem to be directed from immediate to longer-range problems, with the focus on future-oriented innovations. While some R + D efforts remain in traditional petrochemistry, increasing competition from energy-rich newcomers in base and commodity materials has spurred a shift towards downstream activities.

This indicates that the petrochemical industry can and will adapt to changing situations on the raw material side and new opportunities on the product side; and the revival efforts in R + D will lead to an array of new products on a higher value level than the traditional commodities.

In the United States, the chemical industry in general experienced a record year in 1987. Supply and demand came back into good balance, speciality chemicals in particular. Continuing the measures of rationalizing production, particularly in basic chemicals and plastics, reduction in capital expenditures to prevent further overcapacity and the concentration of efforts in a reduced products line were some of the measures which mainly participated in the recovery of the United States petrochemical industry.

A real element on the horizon was that most of the world chemical companies were concentrating on specific products instead of feeling that they must produce every product to stay in the market (plastics are a good example). More and more companies were trying to stick with what they did best; and consolidation of efforts became the order of the day. In addition, companies in the United States have turned to joining forces, as in Western Europe; restructuring has involved mergers and joint ventrues to create more specialized companies and a more orderly marketing scenario (see ref. no. 4).

As for the near future prospects of United States petrochemicals, United

States chemical producers are anticipating a mild economic downturn but not a recession in 1989. However, demand for petrochemicals has been seen to continue to grow; and increased supplies would not get out of hand. In general, most producers are debottlenecking existing plants and adding capacity increments rather than building large grass-roots facilities. 6/

As for Western Europe, petrochemical capacities are now in near balance with demand, but with enough in reserve to permit increased output without major expansion projects. (see no.4) Petrochemical companies in Europe posted good profit levels in 1987; and in mid 1988 there were no signs of any slowing down, yet a restless situation was noticed on the part of some producers.

Western Europe is still facing the challenge of the emergence of new producers based on low cost ethane feedstock, mainly from the Middle East. From an European standpoint, it was seen that Saudi Arabia would become the strongest competitor, and indeed, a substantial proportion of Saudi's production arrived in Europe compared with much lower tonnage being delivered to Japan and the United States. Thus, the Western European petrochemical industry will need to continue to make further adjustments to establish its balance. This remains one of the most difficult ongoing challenges for the highly integrated strategic petrochemical producers in Western Europe 7/.

However, it is unlikely that restructuring of the 1980's which involved unit closures will continue; since now the restructuring is aimed for consolidation (i.e. joint ventures and mergers).

Japan's petrochemical industry, which suffers from the increasing influx of petrochemicals from resource-rich countries, requires intensive R+D. In 1985, methanol imports met some 80% of the domestic demand; and for the same year, the volume of ethylene derivative imports, calculated in terms of ethylene, surpassed the corresponding expert volume, making Japan a net importer of ethylene for the first time.

6/ Chemical Week/Sept. 21, 1988, p.30-33, Focusing on Future Petrochemical Strategies

7/ Association of petrochemicals producers in Europe: Situation and outlook of the petrochemical industry in Europe, June, 1988

Production facilities for ethylene and several other petrochemicals were drastically curtailed in and after 1979 with a reduction of some 30% in nameplate capacities. The industry in Japan has since then maintained relatively high operating rates, of 80-90%.

For the longer term, however, measures such as synthesis of petrochemicals using methanol and synthesis gas as feedstock, conversion of barrel bottoms - including vacuum residue - to feedstock for olefin plants, increasing the use of refinery by-products, shift in product portfolio to avoid competitions with the products of resource-rich countries and diversification into high technology fields such as electronics and biochemistry would have to be considered (see ref.no 4).

At the days of the rapid development of the petrochemical industry in the world, the main producing and consuming areas were the United States, Western Europe, and Japan. These three areas, at the same time, represented the major exporters of petrochemicals. More recently, however, petrochemical manufacturing capacity in other parts of the world has increased and led to a new trend in which new exporters have entered international markets and many traditional exporters have become not only less important as sources for petrochemical materials but also, in some cases, net importers.

In the first half of the 1980's, Mexico, Canada and the Middle East (Saudi Arabia in particular) were building large export-oriented petrochemical plants based on low-priced ethane feedstock. The normal export markets for Mexico are the Americas, for Canada is the United States, and for Saudi Arabia is Western Europe. Japan, as well, is a targeted market by Taiwan (the province of China) and Korea's plans for major expansions in their petrochemical industries.

One of the most outstanding of the present scenes of the world petrochemical trade is the advance of Saudi Arabia's products to West European markets. Low feedstock price, as was mentioned before, is the major advantage of the Saudi producers who are now diverting their abundant natural gas output to make petrochemicals instead of flaring. For example, Saudi downstream ethylene-fed plants are now making large volumes of products such as ethylene glycol and polyethylenes which are largely exported because of little domestic demand. Western Europe's imports from Saudi Arabia rose from practically nothing in 1984 to a volume which made the Kingdom the largest single source of imports into Western Europe for specific products in 1985. Moreover, the Saudi products continued to advance their position in 1986, a situation which reinforced Arab producers' view of Europe as a strategic outlet [8/].

Trends in feedstocks

Although LPG (natural gas liquids) and naptha have been to a greater extent, the preferred feedstocks for ethylene synthesis in the petrochemical industry, naphtha follows a declining trend in favour of new ethane-based ethylene capacity in gas rich areas. With the drop of naphtha prices from around US$ 300 per ton in 1983 to US$ 155 per ton in 1987, the shift in feedstock from naphtha has been slowed down, and hence naphtha based producers located near markets will be able to compete with plants based on natural gas liquids. According to the projected future increase in crude prices, naphtha should come back to the US$ 200-US$ 250 ton price range by 1995, while natural gas tied to its opportunity cost will vary considerably from region to region, ranging from very low in the Middle East to low in Latin America and the Pacific Basin, to high in Western Europe where it is associated with premiums for cleanliness, easiness of utilization and high opportunity values. The value of ethane/propane and other higher molecular weight hydrocarbons will typically depend on the cost of extraction and the availability of alternative markets.

Table 2 indicates the current and projected prices for naphtha and natural gas [9/].

8/ Association of Petrochemicals Producers in Europe: A Profile of the West European Petrochemical Industry, Autumn 1986, pp. 16-18

9/ Vergara, Walter and Brown, Donald: The new Face of the World Petrochemical Sector: World Bank Technical Paper, no. 84, July 1988, pp.5-6

Table 2

Natural gas and naphtha prices (current and projected) (in US$, 1986)

	1987[a]	1990	1995
Naphtha (US$/ton)[b]	155	206	250
Natural gas (US$ MMBTU)			
Wellhead USA	1.4	1.75[c]	1.83
Factory gate West Europe	2.30	2.80	3.20
Middle East			
Petrochemical feedstock	0.50	0.50	0.50

a) first quarter 1987
b) equivalent to 150% of the crude oil prices
c) US Gulf Coast, low case scenario as per SRI, 1986

All indications point to the fact that natural gas will remain the preferred feedstock for new ethylene plants; and as a result, gas-rich developing countries with rich domestic markets on which to base world-scale petrochemical complexes are in a position to gain the most from the trends in feedstock prices. Lower feedstock costs in gas-rich countries lead to a substantial advantage in production cost of ethylene and significant savings in the production costs of downstream petrochemicals. This situation has enabled Canada and Saudi Arabia to become world-scale producers recently.

If naphtha prices, as projected, increase in the future, this will affect the availability of propylene and butadiene, and other alternative sources should be considered, such as propylene recovery from refinery operations (particularly the use of FCC units) and the development of synthesis processes from propane (propane dehydrogenation process). If this trend does not develop progressively and propylene prices increase as a result of feedstock limitation, then heavy fractions of crude oil cracking will be used as feedstocks.

In Europe the trend towards lighter feedstocks is predicted to continue, but at a much slower rate than in the recent past (Table 3) [10/].

10/ Middle East energy and chemicals - the next phase: A Chem Systems planning seminar, Bahrain, April 12-13, 1988.

Table 3

Ethylene feedstocks (percent)

	Naphtha/ Gas oil	Propane/ Butane	Ethane/ Refinery gas	Other
West Europe				
1986	82.8	9.9	7.3	
1990	80.3	11.0	8.7	
1995	79.7	11.3	9.0	
United States				
1986	30.9	20.5	48.6	
1990	29.8	28.4	41.8	
1995	33.0	30.4	36.6	
Global				
1986	60.3	11.7	27.7	0.3
1990	59.4	14.5	25.8	0.3
1995	59.6	15.2	24.8	0.3

The increasing world-wide surplus of LPG should justify further investment in LPG cracking facilities, mainly for propane, in Europe as a flexible alternative to naptha, particularly in the Mediterranean area. However, this trend depends upon the satisfactory economies of the delivered price of propane or butane, which is required to be lower than the break-even value for the feedstock relative to naphtha.

In the USA the use of LPG (both propane and butane) will increase; and in the rest of the world the trend will vary. In the Far East - Taiwan (Province of China) South Korea, China -, the emphasis is on naphtha crackers; in regions such as the Middle East, the use of ethane has been favoured, but the use of heavier feedstocks may be considered increasingly.

Finally, the trends in the production of propylene and butadiene indicate that the proportion of propylene obtained as a co-product of ethylene will rise, particularly in the United States, in contrast with the trend in Europe where increased quantities of propylene will need to be obtained from refinery sources. Butadiene production will depend on ethylene cracker by-products in both Europe and the United States (Table 4 and 5) (see reference no. 10).

Table 4

Propylene production

(percentages)

	Ethylene co-product	Refinery	Dehydrogenation
Western Europe			
1980	85.3	14.7	
1990	82.5	17.5	
1995	80.2	19.8	
United States			
1986	53.7	46.3	
1990	57.6	42.4	
1995	61.0	39.0	
Global			
1986	74.7	25.3	
1990	75.8	24.2	
1995	76.1	23.9	

Table 5

Butadiene production
(see reference no. 10)
(percentages)

	Ethylene co-product	Dehydrogenation
Western Europe		
1986	100.0	
1990	100.0	
1995	100.0	
United States		
1986	98.3	1.7
1990	100.0	
1995	100.0	
Global		
1986	92.4	7.6
1990	94.5	5.5
1995	85.2	4.8

Aromatics, on the other hand, are produced by extraction from oil refinery streams resulting either from the processing of crudes with high aromatic content or from the cracking and reforming of refinery fractions. While the precise operating conditons can be tuned for optimal production of benzene, the overall economics of the cracking or reforming process and therefore the availability of aromatics feedstocks are usually determined by the volume and octane quality requirements of gasoline. The widespread lead phasedown programmes for automotive fuels in the industrialized countries have placed a premium on the value of these feedstocks as octane enhancers for gasoline and forced competition for aromatics between the fuel and chemical industries. Aromatics are also tied to the production of synthetic fibers, xylenes and rubbers.

World petrochemical capacity: production, consumption and demand

Product classification

Although it may be difficult to devise a simple classification system which includes all petrochemicals, the various products are, first of all, generally identified as belonging to three broad categories: namely basic, intermediate and final or end-products. The main basic petrochemical products are the olefins (ethylene, propylene, butadiene), aromatics (benzene, toluene, xylene) and methanol. Plastics, synthetic fibers and synthetic rubber are the main petrochemical end-products. Ethylene and propylene are the principal input substances used for the making of plastics, aromatics in the production of synthetic fibers, butadiene and benzene in the production of synthetic rubber, and methanol (converted into formaldehyde) in the manufacture of adhesives.

World supply of and demand for petrochemicals in this paper will be focussed on basic and end products in particular; however, references to main intermediates will be made when necessary.

Olefins

a) Ethylene

Ethylene, still considered the main foundation material of the petrochemical industry, has remained predominant in demand and capacity in the world market in spite of the high growth rate of other high-tonnage olefins and other basic petrochemicals. The current world nameplate capacity of ethylene, excluding Eastern Europe, is estimated at nearly 48 million tons, down from a peak of 52 million tons at the end of 1980 (see ref. 9), this reduction in capacity emanating from the rationalization and restructuring policies adopted in Western Europe, Japan, and the United States in particular, as well as in the other industrialized countries after 1980 following the world economic recession. Table 6 shows world ethylene capacity by region and countries in 1986, 1987 and 1988 11/.

Table 6

World ethylene capacity by region

(Million metric tons/year)*

Area	1986	1987	1988
North America	19.020	19.020	10.343
Latin America	3.581	3.615	3.742
Western Europe	14.786	14.911	15.466
Asia-Pacific (excluding Japan)	2.430	2.434	2.434
Japan	5.418	5.357	4.295
Others	2.916	2.916	3.486
World total	48.151	48.295	48.766

* Centrally-planned economy countries are not included.

11/ Oil and gas journal, 5 September, 1988, p.41

Total ethylene capacity in Eastern Europe was estimated at 7.19 million tons in 1987, USSR ethylene capacity alone accounting for approximately 3.8 million and the remainder being distributed among other Eastern European countries (Table 7).

Table 7*

Ethylene and propylene capacity in Eastern Europe
(1987 in million tons)

Country	Ethylene	Propylene
Bulgaria	0.45	0.18
Hungary	0.25	0.13
Poland	0.34	0.15
East Germany	0.44	0.15
Romania	0.78	0.40
Czechoslovakia	0.78	0.36
USSR	3.80	1.94
Yugoslavia	0.35	0.10
TOTAL	7.19	3.41

* Original sources: Information chemie manual November 1987, quoted from World Bank technical paper, 1988 (see ref. 9)

Between the years 1980-1985, world ethylene capacity was reduced by about 7 million tons; 2 million tons capacity cut having occurred in the United States, 2 million tons in Japan, and 3 million tons in Western Europe. The majority of these capacity cuts in ethylene occurred during the period of 1982-1984.

Meanwhile, the addition of new ethylene capacities in other parts of the world amounted to about 5 million tons shared among Saudi Arabia (1.6 million tons), Asia (1.3 million tons), Canada (600,000 tons) and others (1.5 million tons). Table 8 indicates world ethylene capacity cut (scrapped or stopped) 12/.

12/ Hiroshi Sagawa: Booming petrochemical industries in the Far East, June, 1987

Table 8

World ethylene capacity evolution between 1980-1985 and the forecast for 1990 (million tons/year)

Capacity end 1980*	Scrap-stop and built	Capacity in 1985	Forecast 1990
53 capacity utilization 74%	Scrap or stop (tons) USA 2 million W.Europe 3 million Japan 2 million TOTAL 7 million Capacity built Saudi Arabia 1.6 Asia 1.3 Canada 0.6 Others 1.5 TOTAL 5.0	51 capacity utilization 86%	55 capacity utilization 93% - at an assumed production growth rate of 3% a year. It will be 2% a year capacity utilization will be 88%

* UNIDO Data base, 1985.

As for the near future, the forecast for ethylene capacity is estimated at about 66.64 million tons in 1992, with about 30.7% of the world ethyelene capacity being in the United States and 25% in Western Europe; while Japan will occupy only 7.3%. Table 9 indicates world ethylene capacity in 1988, capacity additions in Western Europe, the United States, Japan and the rest of the world between 1988-1992 and the total world capacity in 1992.

Table 9

Forecast for world ethylene capacity, 1992
(1,000's tons)

Region	Current capacity 1988	Additions announced 1988/1992	Capacity 1992
Western Europe	14,535	2,055	16,590
USA	16,500	4,005	20,505
Japan	4,295	0,600	4,895
ROW	18,670	5,980	24,650
WORLD TOTAL	53,990	12,640	66,640

The rest of the world's capacity additions will be concentrated mainly in the Far East (2,953,000 tons), Latin America (1,722,000 tons), Middle East (750,000 tons), Eastern Europe (400,000 tons), and others (about 155,000 tons) 13/.

Ethylene consumption and future demand

World ethylene consumption is very much connected with the requirements of ethylene-based intermediate and end-products petrochemicals. Therefore, the figures involved may lack the same accuracy as those for capacity estimations. However, world ethylene consumption was estimated at 44 million tons in 1987, excluding Eastern Europe (see ref.9). Eastern Europe ethylene consumption for 1987 was calculated at approximately 4.5 million tons (calculation based on historical demand 1982-1985 indicated in UNIDO data base 1985.)

On a world-wide basis, ethylene consumption grew at a rate of 4% per annum between 1980-1987. Developing countries had the highest rate of growth (Latin America 15.4% per annum, Asia 13.8%, Africa 52.0%) in contrast with the industrialized countries where the growth rate for ethylene consumption is

13/ European chemicals into the 1990's: capacity creep versus replacement. The European Petrochemical Association, 22nd Annual Meeting, Monte Carlo, 25-28 September 1988, with several other sources.

ranging from very low in Japan to a low rate in the USA and Western Europe, mainly because the market for ethylene based petrochemical products has reached a state of maturity in these regions.

As for the future demand for ethylene, projections made for the near future by a number of international organizations concerned, taking into account the recent historical growth, future world economic outlook and the near saturation of the regional market, revealed that the world ethylene demand in 1990 is expected to be near to 48 million tons (excluding Eastern Europe) reflecting an annual growth rate of 3.1%. A relatively lower growth rate (2.9% per annum) is expected up to 1995.

In conclusion the outlook for world ethylene indicates that no further rationalization measures are any more required and, in fact, the situation allows some room for debottlenecking and good prospects for absorbing the new capacity for ethylene mostly installed in the developing countries. In 1995 world ethylene capacity may not meet the demand which will be close to 61 million tons (based on a 2.9% growth rate per annum). Projected world ethylene demand in 1990 is 48 million tons excluding Eastern Europe (see reference 9). Eastern Europe demand for 1990 is about 5.2 million tons according to UNIDO data base 1985 adding to a total world consumption of 53.2 million tons which is forecasted to grow at 2.9% up to 1995 amount to a total world ethylene demand in 1995 to about 61.4 million tons. This will call for new capacity plans to be considered for 1995.

On the regional basis, the Middle East and the industrialized countries will continue to contribute to most of the exports of ethylene derivatives; while Latin America and the developing countries in Asia will continue to be the largest net importers. Latin America's demand has risen at relatively high rates during the 1980's for both basic and downstream petrochemical products. Ethylene consumption in the Latin American region was estimated at 3.3 million tons in 1987 against a nominal capacity of 3.2 million tons. New capacities are being built for ethylene production, yet capacities expected in 1990 will hardly meet the demand.

In North America, ethylene consumption has grown slowly (2.4% per annum during 1980-1987) and future demand is expected to grow at 1.8% per annum, which could be met by debottlenecking and capacity creep.

Japan's current consumption of ethylene is estimated at 4.6 million tons which represents only a 4% growth since 1980 (i.e. ethylene demand increased from 4,300,000 tons in 1980 to 4,600,000 tons in 1987). Future demand for ethylene in Japan is expected to grow at 2% per annum.

Asia has been among the fastest growing markets for petrochemicals during 1980-1987. Ethylene demand for 1987 was estimated at 3.66 million tons (7% of world demand) and is projected to grow at 7% per annum for the near future (1987-1990).

Africa's consumption of ethylene is still small, although the consumption rate is growing fast. Demand for 1990 is estimated at a little less than one million tons which requires almost doubling the present capacities there (see reference 9).

Propylene

Propylene is the second largest basic olefin in volume of tonnage after ethylene; and its supply is largely dependent on the output from ethylene crackers as well as on the economics of oil refineries' use of propylene in motor fuel or petrochemical production. Thus, the production capacity of propylene is quite difficult to determine precisely since it is mainly a co-product or even by-product of ethylene production and refinery operations, depending on both the feedstocks used for ethylene production and the operating conditions. When naphtha is exclusively used in ethylene crackers as feedstock, about a pound of propylene for every pound of ethylene is produced. Moreover, conditions of operation affect the level of propylene production: high temperatures favour ethylene formation, while at lower temperatures relatively more propylene is produced.

While petroleum prices remain low, propylene availability will increase as a result of the feedstock shift toward the use of heavier hydrocarbons (the naphtha price in 1988 was about US$ 155).

In the meantime, an increase in the demand for propylene has recently been due to the strong trends in Europe and other countries in reducing the amount of lead in motor gasoline for environmental reasons. By 1990, only 20% of West European gasoline is expected to remain leaded at the 0.4g/L level; 40% at the 0.15g/L level; and the remaining 40% will be lead-free. Consequently, the "clear octane" value of the gasoline pool must rise.

Another factor contributing to the increase in world propylene production is the move toward the construction of fluidized catalytic cracking units in the refining industry, this being a case which is still not very well developed within the Arab oil refineries.

Prices of propylene in relation to ethylene have drastically changed in favour of propylene. In 1970, propylene prices were about 40% of ethylene prices, becoming 80% in 1986 [14/]. The strength of the propylene prices came as a surprise to many producers but may be attributed to the rapidly increasing demand for polypropylene. Propylene demand is growing faster than ethylene by 0.5-0.75% per year [15/].

In 1987, world total propylene capacity was estimated at 25 million tons while consumption amounted to 24 million tons. Nameplate capacity of propylene associated with ethylene crackers was only 20 million tons (the figures above not including Eastern Europe of which the propylene capacity was estimated at about 3.41 million tons) (see reference 9) versus an approximate consumption of 3.15 million tons (calculation based on 1985 propylene demand and average growth rate up to 1990 (UNIDO data base, 1985).

In the United States, capacity to purify propylene to chemical and polymer grades totalled about 9.5 million tons in early 1988. Capacity additions which are expected to be completed in 1988 will increase the propylene capacity in the United States to as much as 10.1 million tons by the beginning of 1989.

While propylene consumption in the United States could reach 9.1 million tons in 1988, polypropylene will account for about 37% of all propylene used in chemicals and polymers, which put much pressure on the demand for propylene [16/].

The prices of propylene, as well, will be pulled up by the strong demand for polypropylene and may remain higher than ethylene prices. The United States will increasingly become the supplier of propylene, though most likely in the form of derivatives (polypropylene, cumene, IPA (isopropyl alcohol),

14/ C+En., November 3, 1986, pp.21-22
15/ Chemical Week, July 22, 1987
16/ C+EN, July 18, 1988

acetone and acrylonitrile, acrylic acid and esters, and the fast-growing ethylene-propylene co-polymers).

Propylene production in the United States rose about 10% in 1987 to about 8.7 million tons, while ethylene production rose 3.8% 17/. About 57% of US propylene is produced in ethylene plants and 43% is produced in oil refinieries (see reference 15).

World propylene production capacity as a co-product from ethylene crackers was estimated at 18 million tons as of June 1988, while total world ethylene capacity up to that date was estimated at 48.766 million tons excluding the centrally planned economies (see reference 11).

Western Europe's nameplate capacity for propylene was estimated at 8.5 million tons in 1985; production amounted to 7 million tons, and consumption was 7.270 million tons. Net foreign trade was -270,000 tons. Most of the propylene produced in Western Europe is used for the production of polypropylene (34.4%); and the rest is consumed for the production of acrylonitrile, cumene, propylene oxide, isopropyl alcohol, and others (Table 10) 18/.

Table 10

Propylene and propylene derivatives in Western Europe

(1000 metric tons of propylene equivalent, 1985)

Propylene derivative	Propylene equivalent	Percentage
Polypropylene	2,500	34.4
Acrylonitrile	1,250	17.2
Cumene	650	8.9
Propylene oxide	770	10.6
Isopropyl alcohol	450	6.2
Others	1,650	22.7
TOTAL	7,270	
Production	7,000	
Balance	- 270	

17/ Oil and gas journal, March 21, 1988, p.42

18/ Oil and gas journal, September 7, 1987, p.40

The balance, 270,000 tons, was imported mainly from Eastern Europe, Latin America and the United States. The large proportion of propylene in Europe (72%) came from ethylene crackers, and the remainder from refineries (see reference 14).

Butadiene

Butadiene, the third basic olefin and the main raw material for synthetic rubber, is also produced as a by-product during the production of ethylene; thus, butadiene yield is dependent on the feedstock used in the ethylene crackers. Heavier feedstock increases butadiene formation level (cracking naphtha gives about 15% butadiene, while ethane gives only 3%). Dehydrogenation of 4-carbon atom parafins and olefins is also used to a lesser extent for butadiene production (approximately 10%).

During 1986, a swift change was noticed in the butadiene market from surplus to tightness, causing world-wide opinions to agree that the butadiene market would be characterized by considerable variability in both its short and long term.

Apart from the short period, 1986-1987, of butadiene market tightness, it is expected that butadiene supply will grow faster than demand. Nevertheless, the United States, Far East, Mexico and South Africa will continue to be major net importers of butadiene, while only Europe maintains being a major source of spare material [19/].

Although it is difficult to forecast the future butadiene production because of its dependence on ethylene crackers' feedstock (crackers are not operated for butadiene alone), forecasters noticed that United States crackers were as close as they could be to maximize butadiene output with the available feedstock in 1987; thus, the United States will not be able to develop a surplus in the 1990's unless new crackers are added. Other forecasters expect a surplus of 230,000 tons of butadiene in 1995; yet such a phenomenon may not actually occur. Ethylene producers will certainly take all possible measures for the adjustments in the feedstocks to avoid building of butadiene surplus.

19/ Chemical week, September 23, 1987, p.26

Moreover, such an assumption of future surplus may very well be based also on the slow-growing demand of butadiene (1.5% per year) compared to an average growth of 3% per year for ethylene.

World capacity of butadiene extraction in 1987 was estimated at about 7.5 million tons (see reference 19) while consumption was estimated at about 5 million tons.

European consumption was estimated at 1.1 million tons/year versus a capacity of 1.3-1.4 million tons/year.

Aromatics

The trends in aromatics, represented here by benzene, present the same problems as propylene; sources and demands are in both oil refineries and petrochemical operations. Half of the aromatics capacity in most industrialized countries is based on the naphtha reforming process (in BTX units) by both petrochemical producers and oil refineries. In addition, oil refiners produce aromatics as a by-product of petrocoke and pyrolysis gasoline operations [20/].

The economics of aromatics are closely linked to the economics of oil refining and gasoline. In Europe, about fifty percent of all benzene is produced by extraction from pyrolysis gasoline, an ethylene co-product. The balance comes from reforming and hydrodealkylation (see reference 9).

The demand for benzene is growing very slowly in industrialized countries where many outlets for benzene and its derivatives are in mature industries, such as housing, textiles, and other industries having well-developed infrastructure. Only in the areas such as engineering thermoplastics there may be a rapid growth; yet such a growth is still limited and will not change the picture (see reference 20).

The major derivatives of benzene are ethylbenzene, a raw material for polystyrene (55%) and isopropyl benzene (20%).

The demand for benzene in the United States, Western Europe, and Japan has

20/ Current world situation in petrochemical, UNIDO/PC 126, 14 November, 1984 shown a slight change in recent years. In 1987, benzene demand in the regions of North America, Western Europe, and Japan was about 13.65 million tons versus 12.45 million tons in 1980. Moreover, demand has somewhat increased lately in newly industrialized countries of the Far East in particular, and because of the good performance of engineering polymers.

In developing countries, where the outlets for benzene are still very immature, benzene has a great potential, and in fact, growth rates at least in Asia (8%) and Latin America (5%) for the period 1980-87 have been quite high. (Figures on benzene demand calculated from several references). Demand for xylene (especially para-xylene) is tied up mostly to the demand for synthetic fibers (polyester).

Total world production of benzene in 1985 was about 18 million tons, the same production level being maintained in 1986. However, 1987's world production amounted to 20 million tons (Table 11) 21/.

Table 11

World production of benzene

Region	Unit thousand tons 1985	1986	1987	Projections 1991
Western Europe	4,950	4,880	5,245	5,605
Eastern Europe	3,195	3,375	3,420	3,825
North America	5,320	5,310	6,105	6,610
Latin America	896	934	1,057	1,140
Oceania	50	45	50	60
Africa	70	50	165	
Asia/Middle East	205	217	209	245
Asia/Far East	3,359	3,488	3,799	
WORLD TOTAL	18,045	18,300	20,050	
World capacity and demand in 1985	25,940) (see 16,970) reference 20)			

21/ United Nations/Economic and Social Council, CHEM/R 129/Add.1, 7 Sept., 1988 and CHEM/R 141/Add.1, 3 Aug. 1989

The total world capacity for benzene has been estimated in 1987 at about 24.2 million tons, while available information indicates that the total world benzene production in 1987 was around 20.5 million tons (calculated from references number 9, 20 and 21).

Future growth to 1995 for benzene in North America and Japan is expected to an average of 2% per year; while in Western Europe 1.6%. The potential region for future growth is Asia (8% per year), and in Latin America, demand is expected to grow at 4% per year.

World demand in 1990 is projected at 18.1 million tons, (see reference 20) and for 1995 at 22.6 million tons (World Bank staff estimate for the world with figure for Eastern Europe quoted from UNIDO data base for 1990).

Hence, world-wide, the current growth rates indicate no need or justification for expansion of production capacity until after the second half of the next decade.

As for toluene and xylene, world production for 1987 was estimated at 7.284 and 7.060 million tons respectively. Table 12 indicates world toluene and xylene production for the years 1985-1987 and the projection for 1991 (see reference 21).

Table 12

World production of toluene and xylenes

(1000 metric tons)

Region	Toluene 1985	Toluene 1986	Toluene 1987	Toluene 1991 Projection	Xylenes 1985	Xylenes 1986	Xylenes 1987	Xylenes 1991 Projection
West Europe	1,210	1,395	1,225	1,350	1,550	1,595	1,725	1,830
East Europe	925	935	935	1,000	1,060	1,065	1,140	1,210
North America	2,775	3,040	3,040	3,130	2,285	2,305	2,430	2,140
Japan	829	830	814	800	899	910	1,060	1,200
Others	730	745	870	-	645	680	705	-
World total	6,469	6,945	6,884	-	6,434	6,555	7,060	-

Methanol

The scenario for the world supply and demand of methanol for the years 1986-1990 shows less interest in building new methanol capacity. Nameplate capacity of the world methanol was estimated at around 20.4 million tons in 1986 and expected to maintain almost the same level until 1989-1990, while demand was estimated at 15.65 million tons in 1986 and to grow to about 18.56 in 1990 (Table 13) 22/.

Table 13

World methanol supply and demand
(1000 s of metric tons)

	1986	1987	1988	1989	1990
- Demand	15,646	16,435	17,297	17,845	19,301
- Name plate capacity	20,419	20,399	20,479	20,479	21,179
- 90% of capacity	18,377	18,359	18,431	18,431	19,061
- % utilization					
name plate capacity	77	81	84	87	88
90% of name plate capacity	85	90	94	97	97

About 89% of global methanol is used for the production of various chemicals and 11% for fuel uses (5% for MTBE production and 6% for gasoline blending). Methanol blending at 5% was practiced in West Germany and Austria as well as France up to 3%.

World demand for MTBE grew at 16% per year for the last two years. Future demand is expected to continue high, as many other countries followed the United States and Europe in low-lead or free-lead gasoline use because of environmental restrictions.

22/ Hydrocarbon processing, September 1986, p.19

However, in gas-rich developing countries, methanol production still represents an attractive outlet for the associated gas, rather than flaring it to complete waste.

The major chemical derivatives of methanol are formaldehyde (for adhesives, plastics, etc.), acetic acid (for paints and adhesives), methyl methacrylate (for transparent plastics), and methyl halides and amines (for silicones and refrigerants, etc.).

Methyl-teriary butyl ether (MTBE), which is made by reacting methanol with isobutylene, is considered an important development in recent years and may have bright market prospects since it is a ready substitute for the tetraethyl lead which is being phased out of gasoline in many countries.

However, the prospects of MTBE production depend considerably on the availabity of cheap isobutlyene (from refineries), in order to sustain a reasonable profit margin.

As for the patterns of methanol production, consumption and trade, data obtained for 1986 indicate that about 63% of the world methanol is consumed by the developed countries (USA, Western Europe and Japan), 23% by Eastern Europe and 14% by the rest of the world. The production pattern is quite different, however, with the developed countries' total production being 32%, Eastern Europe 27% and the rest of the world 41%.

Around 50% of the methanol produced is traded internationally, the major exporters being Saudi Arabia, Canada, Libya, the USSR, Malaysia and Bahrain.

Table 14 shows methanol consumption, production and trade patterns for 1986 23/.

23/ Pyke, Geoff. Ammonia and methanol - improving prospects? Chem Systems International Ltd.

Table 14

Methanol consumption/production/trade patterns in 1986

(percentage global consumption/production)

	Consumption	Production	Net trade
United States	27	20	- 7
Western Europe	27	10	-17
Japan	9	2	- 7
Eastern Europe	23	27	+ 4
N/S Americas	4	14	+10
Mid East/Africa	2	17	+15
Far East	8	10	+ 2
TOTAL	100	100	

Petrochemical end products

The main segments of the petrochemical downstream sector are: plastics, synthetic fibers, and synthetic rubber. Plastics have the highest tonnage among these three downstream petrochemical products, and are generally characterized by continuous introduction of new products and improved applications.

Plastics

On the basis of the way in which they can be processed (e.g. molded), and whether or not they can be thermally reshaped, plastics are divided into two broad classes: thermoplastics and thermosets. Although slower growing, thermsets have paved the way for engineering applications, particularly where higher temperatures and electrical resistance are called for. During the past decade, some of these engineering uses and many newer ones have been taken over by the group of so-called engineering thermoplastics, which include: ABS (acrylonitrile butadiene styrene), polycarbonate, polymethyl methacrylate, nylon, polyacetals, PTFE, polybutylene terephthalate, polysulfones, polyamides, imides and polyphenyl-suphides, different grade of which are developed with reinforcing fibers and fillers for specific applications.

The main five thermoplastics: high density polyethylene (HDPE), low density polyethylene (LDPE) including linear low density polyethylene (LLDPE), polyproylene (PP), polyvinylchloride (PVC) and polystyrene (PS) which are so-called commodity plastics account for approximately 70% of the total world plastics (see reference 20).

Although the world consumption growth rate for commodity plastics has slowed down recently (5.7% per annum) for the period of 1980-1987 compared with the earlier growth rate (8.7% per annum) for the period of 1975-1980, (see reference 9) the demand for plastic meterials has very well kept basic petrochemical plants at good utilization level world wide (see reference 17).

World consumption of the five main thermoplastics in 1987 amounted to approximately 57 million tons (Table 15).

Table 15

World consumption of commodity plastics by regions
(1000's tons) in 1987 24/

	HDPE	LDPE	PP	PVC	PS	Total consumption of commodity plastics by region	
North America	3,437	4,678	2,535	3,882	2,348	TOTAL:	16,880
West Europe	2,275	4,622	2,561	4,207	1,443		15,108
East Europe	937	1,804	551	909	689		5,890*
Japan	694	1,078	1,297	1,447	748		5,273
Latin America	560	1,430	380	880	350		3,600
Africa (1985)**	180 (193)	400 (428)	200 (214)	500 (535)	100 (107)		1,380* (1,477)
Asia	1,180	1,780	1,530	2,490	810		7,790
Middle East*** (1986)	135	301	120**	305	80		941
TOTAL	9,398	16,102	9,174	15,620	6,568	TOTAL:	56,962 (56,959)

* Eastern Europe consumption for 1987 based on 1985 consumption quoted by UNIDO data base plus 7%.
** UNIDO data base 1985
*** ECN: November 3, 1986, p.7

24/ Modern Plastics International, January 1988, p.20-34

In spite of the surge in growth rates experienced by commodity polymers during 1987, recent use of these plastics in industrialized countries shows a long term slow down, indicating product maturity status and market saturation with the obvious exception of polypropylene which has maintained a relatively high growth rate.

Developing countries are making good progress in plastics processing, with most countries, even the least developed, having processing plants. Nevertheless, per capita consumption is still very low compared with the developed countries (Table no. 16).

Table 16

Per capita consumption of commodity plastics 1987 based on population of 1986 (see reference 9)

Region	LDPE/LLPE kg	HDPE kg	PP kg	PS kg	PVC kg	TOTAL kg
North America	17.5	12.8	9.5	8.8	14.5	63.1
West Europe	13.0	6.4	7.2	4.1	11.5	42.4
Japan	9.9	7.0	11.6	7.1	12.6	48.2
Latin America	3.4	1.3	0.9	0.8	2.1	8.6
Asia	0.6	0.4	0.5	0.3	0.9	2.7
Africa	0.7	0.3	0.4	0.2	0.8	2.4

Since the markets for plastics are not yet near maturity in developing countries, an enormous potentiality for the use of plastic material will be associated with the development of their economies and the relevant sectors consuming these products: such as agriculture, the construction industry, and regional infrastructure. In Western Asia, Latin America and the Far East, installed plastics capacity has increased in response to growing demand.

Demand for commodity plastics in Latin America has grown at a compound rate of 5.3% per annum over the period of 1980-1986. The total consumption in 1987 was 3.6 million tons, with capacity estimated at 3.5 million tons. Total import in 1986 was estimated at 400 thousand tons, and all individual resins are expected to grow in the 2% to 7% per annum range until 1995. Demand for 1990 is estimated at 4.1 million tons and at 5.9 million tons in 1995.

Thus, it appears that Latin America, under optimistic conditions, will continue to be a net importer of commodity plastics in spite of planned capacity expansion.

Commodity plastics have grown at very high rates in East Asia during the period of 1980-1987 (LDPE and PP grew at 15% and 17% per year respectively). Future growth should continue to be very high as a result of current plant capacity expansion in China, India, Taiwan (Province of China), South Korea and Thailand, and because of the low per capita consumption. The region will continue to be a net importer of plastics through 1990.

Western Asia is considered a large net exporter of petrochemicals, especially Saudi Arabia where capacity of methanol is 1,410,000 tons as of 1988 and polyethylenes, LD, HD, and LLDPE reached 900,000 tons. Although Africa has the lowest per capita consumption of plastics (2.4 kgs) in the world, the situation indicates that it will remain a net importer of the five main thermoplastics even if the current projects in Egypt, Libya and Nigeria are completed.

As for the developed countries, the following trends may be mentioned. In the USA, plastics which account for more than two-thirds of the polymer group production totals, continued their vigorous growth in 1987, with production being up 9.9% from 1986. The strongest growth among the plastics was seen with the thermoplastic resins, up to 10%.

Polypropylene continued to demonstrate the highest growth, up to 14%; followed by HDPE, up to 12%; PVC and copolymers, up to 9,9%; LDPE up to 8,3%; and polystyrene up to 7,7%. Thermosetting resins grew 7,4% in 1987, of which melamine resin made a spectacular recovery, up to 23%.

Over all production of plastics, synthetic fibers, and synthetic rubber polymers reached a record high of 23,2 million tons in 1987. Between 1982 and 1987, the plastics segment grew at an annual compound rate of 8,5%, and for the ten years from 1977 to 1987 at an annual compound rate of 5,4%.[25/]

25/ Chem.+Eng. news, April 11, 1988

Total United States thermoplastics resin capacity in 1987 was 15,960,000 tons, and total consumption was about 15,492,000 while total polymer resins (plastics, synthetic rubber, and synthetic fibers) production in the US for the year 1987 was estimated at 23,2 million tons (see reference 24).

Table 17

United States consumption (demand) for selected plastics
(1000's tons)

Plastics	1986	1987	Nameplate capacity as of 1/1/1988
HDPE	2,797	3,182	3,168*
LDPE	3,902	4,203	3,192*
PP	2,147	2,386	3,135
PS	1,987	2,187	2,595
PVC	3,295	3,534	3,870
Total main thermoplastics	14,128	15,492	15,960
Other plastics			
ABS	473	511	(see reference 24)

* LLD/HD is not included

Japan's consumption of commodity and engineering thermoplastics continues to climb; and domestic sales of products with high plastic content are expanding. The weak US dollar has led Japanese plastic manufacturers to shift some of the automative and durable materials production to the United States; yet no real effect is caused by this shift on domestic sales.

All commodity thermoplastics demonstrated a growth in consumption except high density polyethylene. The consumption growth of specific thermoplastics is steered by the market orientation; e.g. low density polyethylene film consumption in Japan was unchanged, but tonnage in injection and blow molding continued to rise; expanded use of wire and cable insulation lifted PVC consumption, etc.

Japan's consumption and export of engineering plastics (ABS) rose, during the period 1986-1987, from 451,000 tons to 475,000 tons (the largest portion being for automotive and machine parts). Other engineering plastics: nylon 6, nylon 6/6, 11 and 12, and reinforced polyester registered significant gains in consumption (Table 18), (see reference 24).

Table 18

Japan's consumption (demand) for selected plastics in 1000's tons

Plastic products	1984	1985	1986	1987
HDPE	700	750	846	844
LDPE	1,050	1,100	1,134	1,138
PP	1,100	1,150	1,404	1,417
PS	600	650	864	868
PVC	1,200	1,300	1,504	1,527
Total main thermoplastics	4,650	4,950	5,752	5,844

Western European consumption of both commodity and engineering plastics recorded substantical gains during the period 1985-1987. High density polyethylene had risen to 12.7% surpassing polypropylene which previously had been holding the lead of the commodity plastics.

Nevertheless, polypropylene is still maintaining a healthy growth rate of about 10%, while low density polyethylene including LLDPE began moving up to more than a 5% gain.

PVC consumption in Western Europe rose by almost 6% mainly in rigid grades for bottles, sheets, and profile extrusion. Polystyrene witnessed a rise of a little over 5% due to increased use in packaging.

Total consumption of thermoplastics in Western Europe amounted to 15,308,000 tons in 1987 (Table 19).

Table 19

Western Europe's consumption (demand) of selected plastics

(1000 s m/t)

Commodity thermoplastic	1984	1985	1986*	1987*
HDPE	1,600	1,700	2,019	2,275
LDPE	4,100	4,200	4,403	4,822
PP	1,800	1,900	2,283	2,561
PS	1,700	1,750	1,373	1,443
PVC	3,800	3,900	3,980	4,207
Total main thermoplastics	13,050	13,450	14,055	15,308
Other selected plastics				
Resins				
Polyurethane			1,174	1,216
ABS			422	451
Nylon			268	281
Reinforced plastics			858	915
Expandable polystyrene			433	449

* Modern plastics international: January 1988, p. 20-21
** UNIDO data base - 1985

Synthetic rubber

Both production and consumption of world synthetic rubber for the past several years reflect modesty in rate of growth and maturity of this industry. Total world production of synthetic rubber in 1981 was estimated at 8.4 million tons (see reference 20), in 1986 reached 9,2 million tons, and in 1987 was 9.475 million tons (Table 20) 26/.

26/ IRSG Rubber Statistical Bulletin, 1988

Table 20

World production of synthetic rubber (1000 s tons)

Year	Total production (1000 s tons)
1981	8,400 *
1982	7,825
1983	8,275
1984	9,055
1985	8,955
1986	9,205
1987	9,475

* See reference 20

World consumption of synthetic rubber has shown an almost similar pattern of sluggish growth for the past several years. Total world consumption in 1981 was 8.4 million tons; and in 1987 consumption was estimated at 9.555 million tons (Table 21). The forecast for the next five years for worldwide rubber consumption calls for an average growth of 2% per year, although the rate for 1987 had exceeded 2%. Apparently, the synthetic rubber industry will have few spectacular development in demand for its products through the early 1990's. [27]

27/ C+En. March 21, 1988, p.25

Table 21

Current world production and consumption of synthetic rubber by regions (1000 s tons)

Region	Production 1986	Production 1987	Consumption 1986	Consumption 1987
North America	2,306.2	2,361.9	2,209	2,217.5
Western Europe	1,984	1,993.5	1,843	1,932.9
Eastern Europe	2,785	2,831.1**	2,885	2,925
Japan	1,150.1	1,191.9	910	946
Others*	946.6	1,097.6***	1,448	1,533.8
World total	9,205	9,475	9,295	9,555.2

* Others (production 1986) including: China (186.6), Brazil (270.8), Mexico (130), Republic of Korea (120.5), Other Asia (124.1), Argentina (52.9), India (34.8) and South Africa (44.9).

** Eastern European countries: October and December production of Czechoslovakia estimated as September

*** Brazil is estimated for 1987 at 291,000 tons.

The low average growth rates in developed market economies may be attributed to recent developments in the tyre industry where introduction of radial tyres and other improvements have dramatically extended tire life to 65,000 kilometers lately and expected to reach 160,000 kilometers in the near future 28/. In addition, the average weight of each tyre has declined from 13 kgs in 1973 to 9.8 kgs in 1983 29/.

In regions other than the industrialized countries, synthetic rubber will show a better performance with consumption growing at about 2.8% annually 30/.

As for the developing countries, although many, such as Argentina, Brazil, China, India, Republic of Korea, Mexico and Turkey, have rubber producing facilities, only a few large producers attempt synthetic rubber production mainly because of the complexity of its technology (see reference 20).

Synthetic rubber capacity also will grow moderately, and most capacity additions in North America will be for smaller volume and speciality rubbers.

28/ Chemical week, March 16, 1985, p.28

29/ Chemical and engineering news, April 30, 1984, p.46

30/ Petrochemical news, January 1985, p.3

In 1987, global consumption of synthetic rubber (centrally planned economy countries included) increased about 3.1% from that of 1986 to become 9.75 million tons.

Synthetic rubber demand is forecasted to grow in the United States and Canada, but only modestly at a 1.5% increasing over the next five years to 2.56 million metric tons.

In other parts of the world, consumption is expected to grow much faster. In Latin America, synthetic rubber demand is forecasted to grow at almost 20% in the five year period of 1987-1992 from 541,000 metric tons in 1987 to 648,000 metric tons in 1992.

In the Asian-Oceanian region, excluding centrally planned economy countries, consumption is forecasted to grow 16% overall to 1.74 million tons by 1992.

Combined use in Western Europe, Africa and the Middle East is expected to increase about 7.5% during the same period to 2.12 million metric tons. Total rubber consumption in all centrally planned economy countries is forecasted to increase 16% during the next five years to nearly 4.7 million tons in 1992, with 20% increase in natural rubber.

China and other Asian centrally planned economy countries will remain the only areas of the world where more natural rubber than synthetic rubber is consumed in spite of the fact that the consumption rate of synthetic rubber is increasing faster than that of natural rubber (see reference 27). About 68% of all new rubber consumed worldwide in 1987 was synthetic.

Styrene-butadiene rubber (SBR) will continue to be the largest volume synthetic rubber produced and consumed in market economy countries, followed by polybutadiene rubber which runs second to SBR in volume used. Total consumption of SBR in these countries was estimated by IISRP (International Institute for synthetic rubber producers) at 2.632 million tons in 1987 and polybutadiene consumption comes next in volume, amounting to 1.06 million tons.

Table number 22 reflects types of synthetic rubber consumption in market economy countries for the year 1987 and the future forecast for the year 1992 (see reference 27).

Table 22

World synthetic and natural rubber consumption in 1987 and future forecast for 1992
in 1000 s metric tons (excluding communist countries)

Type of rubber	US+Canada		Western Europe		Latin America		Asia+Oceania		Africa+Middle East		Total	
	1987	1992	1987	1992	1987	1992	1987	1992	1987	1992	1987	1992
Styrene-butadiene	839	833	727	745	329	386	674	783	63	72	2,632	2,819
Carboxylated styrene-butadiene	447	458	335	370	21	29	125	152	5	6	933	1,015
Polybutadiene	422	424	240	257	109	131	270	309	19	21	1,060	1,142
Ethylene-propylene diene	204	216	170	195	11	16	107	126	2	3	494	556
Polychloroprene	86	85	81	77	19	23	68	78	5	5	259	268
Nitrile	68	66	81	85	13	17	51	66	3	4	216	238
Other synthectics	457	479	216	244	39	46	197	223	22	33	931	1,025
TOTAL SYNTHETIC	2,523	2,561	1,850	1,973	541	648	1,492	1,737	119	144	6,525	7,063
Natural	872	871	945	980	247	296	1,568	1,804	140	180	3,771	4,131
TOTAL RUBBER	3,395	3,432	2,460	2,953	788	944	3,060	3,541	259	324	10,296	11,194

Eastern Europe consumption of synthetic rubber was estimated at 2,925 million tons in 1987.
(See reference 26)

About 50% of all rubber consumption goes into making tyres. In market enconomy countries, tyres and tyre products consume 43% of all synthetic rubber and 62% of natural rubber. In North America (US and Canada) tyres and tyre products account for 43% of synthetic rubber consumption and 72% of natural rubber consumption; in Western Europe 35% of synthetic rubber consumption goes into tyres along with 60% of natural rubber; and in Latin America tyres and tyre products take the largest share of rubber consumption among all areas of the world, at 62% of synthetic and 77% of natural rubber.

Worldwide total synthetic rubber capacity in 1987 was estimated at 12.473 million tons: (US and Canada capacity estimated at 3.107 million tons; Mexico, Central America, the Caribbean area and South America at 0.594 million tons; Western Europe, Middle East and Africa at 3.106 million tons; centrally planned economy countries 3.579; and Asia and Oceania at 2.087) (see references 26 and 27). The above data indicate a relatively low capacity utilization of about 74%.

Synthetic fibers

The worldwide production of non-cellulosic synthetic fibers (except olefins), polyester, acrylic and polyamide fibers constituted about 36% of all types of fibers produced in the world in 1985 (man-made and natural fibers), against a ratio of 21% in 1970.

The world total production of non-cellulosic synthetic fibers (which means and includes in this petrochemical study; polyester, acrylic and polyami es "nylon") was estimated at about 12,515,000 tons in 1985. Polyester fibers alone count for about 52%, acrylic 20% and nylon fibers 28%.

This increase in world non-cellulosic synthetic fibers production indiciates the fast growing demand and importance of these fibers among other man-made and natural fibers inspite of the obvious increase in cotton fibers production.

Table 23 illustrates the world production of textile fibers (cellulosic, non-cellulosic, and natural fibers) from 1979 to 1985.

Table 23

World production of textile fibers
1000 metric tonnes 31/

Type of fiber	1979	1980	1981	1982	1983	1984	1985
Cellulosic fibers	3,371	3,242	3,204	2,945	3,029	3,094	2,999
% of world fibers	11.4%						8.6%
Non-cellulosic fibers except olefin	10,601	10,476	10,827	10,147	11,120	11,898	12,515
% of world fibers	35.7%						36%
Natural fibers	15,711	15,654	16,976	16,323	15,913	20,797	19,272
% of world fibers	52.9%						55.4%
WORLD TOTAL	29,683	29,372	31,010	29,415	30,062	35,789	34,786
% of world fibers	100%						100%

In review of the world situation of the three main synthetic fibers: polyester, nylon and acrylic, it was noticed that the strain of the competition, in polyester market, particularly by exports from countries with low labour costs, and of over-capacity bore heavily on the prime traditional manufacturers from the mid-1970's onward, resulting in the abandonment of production of general purpose polyester textile fibers by a number of North American and West European concerns and their concentration instead on specialized higher value grades. As an indicator of these changes whereas in 1970 the Americas and Western Europe produced 77% of the world manufactured polyester fibers, this ratio was dropped to about 45.2% in 1985.

Polyester fibers represent at present some 52% of all synthetic non-cellulosic fibers, 40% of which is produced in the form of continuous filament yarn and 60% as staple fiber. 32/

Total world polyester production capacity is estimated at 8,955,000 tons in 1987 and about 9,321,000 tons in 1988, (Table no. 24).

The merits of polyester fibers are their relatively high melting and glass-transition temperatures, insensitivity to moisture and common solvents,

31/ Textile organon - vol. 57, no.6, June 1986.
32/ Encyclopedia of polymer science and engineering vol.12, pp. 19-21.

and the wide range of mechanical properties attainable by variations of molecular weight, orientation, and crystalinity, giving characteristics suitable for uses in apparel, (in blend with cellulosic fibers), curtains, and upholstry as well as for industrial applications such as sewing threads, tire cords and filter fabrics.

Table 24

World polyester production and production capacity
1000s tons 33/

Country / Year	1984	Actual production 1985	1986	1986	Production capacity 1000 tons 1987	1988	
West Europe		922	940	947	1,155	1,169	1,182
East Europe		584	672	726	953	1,011	1,030
USA	1,538	1,516	1,499	1,876	1,731	1,716	
Other Americas		447	451	476	643	639	638
Japan		647	652	632	794	793	793
China, PRC		359	516	605	(	756	756
Other Asia		1,457	1,695	1,973	(3,326	2,655	2,993
Middle East,		120			(		
Africa, Oceania			129	132	(	201	213
TOTAL	6,074	6,571	6,990	8,747	8,955	9,321	

The world wide production of acrylic and modacrylic fibers has grown very rapidly from 130 thousand metric tonnes in 1960 to 1,800,000 tons in 1982. This rapid growth has been driven by the advantages of acrylics: Their special properties, i.e. their wool-like appearance and feel, and their favourable economic position owing to the relatively low cost of acrylonitrite. In the last few years, the growth curve for acrylic fibers has essentially flattened out. This slow growth is primarily a result of the world-wide recession that affected all man-made fibers. The production of acrylic fibers in Western Europe, the United States and Japan have significantly declined since 1978, whereas the production in Central and South America, India, South Korea and others, increased substantially. Table 25 reflects the world acrylic fiber production by regions since 1987.

33/ Textile organon - June issues, 1986-1987-1988

Table 25

World acrylic fibers production and current production capacity by regions*

1000's tons

Regions	Actual production					Production capacity		
	1978	1980	1982	1984	1986	1986	1987	1988
West Europe	794	737	725	866	935	1,022	1,057	1,057
East Europe	200	217	213	232	289	342	362	382
USA	329	355	283	304	279	264	293	298
Other Americas	82	114	121	140	142	198	200	203
Japan	310	353	347	369	397	431	431	431
Others	162	284	369	398	428	581	573	585
TOTAL	2,021	2,060	2,058	2,309	2,470	2,838	2,916	2,956

The market share for nylon fibers versus the total of all non-cellulosic fiber production has declined from 50% in 1966 to a constant 30-32%, primarily because of the more rapid growth of polyester fibers in the period 1966-1975. The main market for nylon fibers includes carpets, industrial yarns and tire reinforcements, and various applications such as hosiery.

Worldwide total production of polyamide fibers in 1986 amounted to 3,500,000 tons and the production capacity was 4,308,000 tons. Table 26 indicates the production of world polyamide fibers in 1984-1986 as well as the total production capacity in 1986, 1987, and 1988. Table 27 illustrates polyamide fiber production and production capacities by regions.

The total world production of synthetic fibers (polyester, acrylic and polyamide) grew from 4.7 million tons in 1970 to about 12.96 million tons in 1986.

In 1970, the industrialized regions accounted for almost 91.8% of the world total production of synthetic fibers and only 8.5% was produced in other parts of the world. In 1985, the share of the industrialized world has dropped to 63.5% mainly because of the rapid increase of the synthetic fibers production in the developing region of the world. Out of the 13.78 million tons of non-cellulosic fibers production in the world in 1987, the USA had the target share of 3.1 million tons (22%) down from 27% in 1983 while the actual production was almost the same tonnage (3.02) indicating that the other part of the world had increased their production; mainly the Republic of Korea, the People's Republic of China and the rest of Asia which increased their share of synthetic fibers production since 1983 (Table 28) 34/.

34/ Textile organon, May 1988, Datagram

Table 26

World polyamide fiber production and production capacity*

Production and year / synthetic fibers	World total in 3 synthetic fibers (1000 tons)	World total in 3 synthetic fibers (%)	Polyester (1000 tons)	Polyester (%)	Acrylic fiber (1000 tons)	Acrylic fiber (%)	Nylon (1000 tons)	Nylon (%)
Production capacity								
1988	16,821	100	9,321	55.4	2,956	17.6	4,544	27
1987	16,303	100	8,955	55	2,916	18	4,432	27
1986	15,893	100	8,747	55	2,838	18	4,308	27
Actual production								
1986	12,960		6,990	54	2,470	19	3,500	27
1985	12,874		6,571	51	2,406	22.6	3,397	26.4
1984	11,707		6,074	52	2,309	20	3,324	28

* See reference 33

Table 27

World-wide polyamide fibers production and production capacity by regions*

1000 s tons

Year / Regions	Actual production 1979	1980	1981	1982	1983	1984	1985	1986	Production capacity 1986	1987	1988
West Europe	719	649	650	572	603	629	664	667	831	831	853
East Europe	445	516	533	539	572	605	624	646	747	753	764
USA	1,234	1,070	1,058	874	1,097	1,094	1,062	1,140	1,292	1,340	1,386
Other Americas	228	231	201	203	202	231	240	250	392	392	404
Japan	313	318	301	283	289	307	315	279	356	356	359
Others	335	367	396	383	403	458	492	518	690	760	778
TOTAL	3,274	3,151	3,139	2,854	3,166	3,324	3,397	3,500	4,308	4,432	4,544

* Compiled from several sources, mainly textile organon June issues.

Table 28

The leading synthetic (non-cellulosic) fiber producing countries 1987 34/

Country	Production (million tons)		Shares of world total	
	1988	1987	1983	1987
USA	3.01	3.1	27%	22%
Japan	1.32	1.34	12%	10%
Korea Republic of	0.67	0.97	6%	7%
China PRC	0.39	0.91	3%	7%
The rest of Asia	0.83	1.4	7%	10%

Nylon production was leading the world synthetic fibers in 1960's accounting for more than 56% of the total world synthetic fibers production, while polyester's share did not exceed 16% and acrylic fiber constituted 18%.

In 1970, the polyester fibers production had increased tremendously to 38% of world synthetic fibers and nylon's share was dropped to 48%. The increase of polyester production continued during the years of seventies to reach to about 48.3-48.9% of the world synthetic fiber in 1979 and it maintained at the level of 50-52% during the early and mid eighties. The ratio of nylon fibers has dropped lately to 26.6 down from 56% in 1960. Acrylic fibers have maintained their percentage level of production during these years.

World demand for non-cellulosic synthetic fibers was estimated at 13,113,000 tons in 1986. Below is the estimated demand for non-cellulosic fibers in 1982-1986 (Table 29).

Table 29

World demand for non-cellulosic synthetic fibers

Year	Demand (1000 tons)
1982	10,146
1983	11,116
1984	11,848
1985	12,558
1986	13,113

Petrochemical Industry in the Arab Region: Present Status and Future Prospects

Several Arab countries occupy, today, top positions on the world oil and gas reserves list as well as in crude oil and natural gas production. Total crude oil reserves of Arab oil producing countries were estimated at 503,600 million barrels at the end of 1988, constituting about 55% of the total world crude oil reserves estimated for the same year at 916,600 million barrels.

Arab natural gas reserve is also considered high in amount, being estimated at about 21,900 thousand million standard cubic meters thus sharing the world total natural gas reserve by 19.57%. Arab oil and gas production account for approximately 26.69% and 5.93% of world production respectively (Tables 30 and 31).

The evaluation of world crude oil reserve for the period of 1966 to 1988 indicates a proven amount of 916,600 million barrels against 388,616 million barrels in 1966 and that most of the world reserve comes from the Middle East (571,600 million barrels), Latin America (122,100 million barrels) and the Centrally Planned Economy Countries (CPEs) (83,900 million barrels).[35/]

While the world oil reserve is decreasing due to the increasing production of approximately 57 to 58 million barrels per day (21-22 billion barrels per year), the undiscovered oil reserves are centered around the Arabian Gulf, North America, and the USSR. Moreover, 61.2% of Africa's crude oil reserves are originally located in Africa's Arab countries: Algeria, Lybia, Egypt and Tunisia. These phenomena certainly placed Arab countries with their richness in oil and gas reserves in an advantageous position for petrochemical production and offer a strong incentive for the development of petrochemical industries in the area.

Arab countries have realized the importance of the petrochemical industry sector in the economic development of the region as well as the vital role which this industry could assume in encouraging stronger relationships and enhancing various forms of economic co-operation in the region. Moreover, such an attitude was emphasized at several occasions on certain Arab governmental levels at Arab institutional organizations involved in economic and industrial development.

35/ BP Statistical Review of world energy, July 1989; BP Review of world gas, August 1989

Table 30

World proven crude oil and natural gas reserves at end of 1988

Region or country	Crude oil reserves (thousand million barrels)	Natural gas reserves 1000 million s. m^3
North America	43.6	8,000
Latin America	122.1	6,700
Western Europe	17.7	5,700
Middle East		
Abu Dhabi	92.1	5,200
Dubai	4.0	100
Iran	92.9	14,000
Iraq	100.0	2,700
Kuwait	91.9	1,200
Neutral Zone	5.2	
Oman	4.1	
Qatar	3.2	4,400
Saudi Arabia	170.0	4,100
Syria	1.7	
Others	6.4	1,700
Total Middle East	571.6	33,400
Africa		
Algeria	8.4	3,000
Angola	2.0	
Egypt	4.3	300
Libya	22.0	700
Nigeria	16.0	2,400
Tunisia	1.8	
Others	1.7	700
Total Africa	56.2	7,100
Total Asia and Australasia	21.5	6,800
Total Centrally Planned Economcy Countries	83.9	44,200
TOTAL WORLD	916.6	111,900
Total Arab countries	503.6	21,900
Arab countries percentage	54.94%	19.57%

*) Information compiled from several energy sources, Oil and gas journal, Dec. 26, 1988, and BP energy and gas review, 1989.
- Whenever information was not available for 1988, the figures for the previous year have been taken.

Table 31

World crude oil and natural gas production, 1988

Region or country	Crude oil production thousand barrels/day	Natural gas production million s. cubic meters
North America	9,888	569,000
Latin America	6,236	96,700
Western Europe	4,135	168,900
Middle East		
Bahrain	42	
Iran	2,034	17,800
Iraq	2,674	
Kuwait	1,100	5,100
Oman	582	
Qatar	329	
Saudi Arabia	4,238	25,700
Syria	250	
United Arab Emirates	1,173	
Yemen, North	146	
Yemen, South	10	
Others	306.0	24,900
Total	12,884	73,500
Africa		
Algeria	626	44,200
Egypt	853	
Libya	1,000	5,700
Tunisia	99	
Others	2,274	9,900
Total	4,852	59,800
Asia - Pacific	3,122	121,800
CPES	15,674	863,800
WORLD TOTAL	56,791	1,953,500
Total Arab countries	15,156	
Arab countries percentage	26.69%	5.93%

During the 11th Arab summit meeting held in Amman, Jordan in 1980, the petrochemical industry development in Arab countries was placed as one of the main objectives of the joint Arab economic strategy. The Arab Industrial Development Organization (AIDO) had in its fifth Arab Industrial Development Conference recommended to take immediate initiatives for the development of the petrochemical industry in the Arab area and proposed to carry out required surveys and studies in order to set-up practical plans for the development of petrochemical industries in accordance with the prevailing circumstances and potentialities of each individual Arab country. Several other Arab organizations closely interested in the economical and industrial development and co-operation among Arab countries such as the Arab Economic Unity Council, the Gulf Co-operation Council (GCC), the Organization of Arab Petroleum Exporting Countries (OAPEC) and the Gulf Organization for Industrial Consultation (GOIC) have taken initiatives and progressive steps towards the establishment and inhancement of this sector.

At the present time, several Arab oil and gas producing countries already possess quite a well-developed oil refining and petrochemical industry. The total production capacity of the Arab petrochemical industry is estimated at about 10.7 million tons per year of basic, intermediate and end-products (Table 32). Some 28 petrochemical products are now produced in Arab countries including seventeen in Saudi Arabia's plants.

Table 33 indicates Arab countries refining facilities versus world total refinary production capacity (see reference 35).

Table 32

Existing petrochemical facilities in Arab countries with their production capacities as of February 1989*)

1000 metric tons

Products	Algeria	Saudi Arabia	Iraq	Qatar	Libya	Egypt	Bahrain	Morocco	Total Arab region
Basic olefins									
Ethylene	120	1,610	130	280	330				2,470
Propylene				5	170				175
Aromatics									
Benzene	90	245	25			15			385
Toluene	15		7			4			26
Mix.xylenes	247								247
Para-xylene	38								38
Alcohols									
Methanol	100	1,410			660		396		2,566
Ethanol		281							281
Intermediates									
Ethylene glycol		580							580
Styrene		360							360
Vinyl chloride monomer (VCM)	40	300	66		60	100		25	591
Ethylene oxide		390							390
Formaldehyde	20	5				25			62
									12 Tunisia
Ethylene di-chloride	64	454	105		95	160		40	918

*) Expert Group Meeting on evaluation of up-dated sectoral study on Arab petrochemical industry - AIDO/Baghdad, February 1989

**) Kuwait melamine plant 15,000 tons stopped for past 3 years

Table 32 continued

Products	Algeria	Saudi Arabia	Iraq	Qatar	Libya	Egypt	Bahrain	Morocco	Total Arab region
<u>Final products</u>									
<u>Plastics</u>									
HDPE		91	30		80				201
LDPE+LLDPE	48	595	60	140					843
PP					68				68
PVC	35	200	60		60	80		25	460
Polystyrene		100							100
Melamine		20							35 Kuwait 15**
<u>Synthetic fibers</u>									
Polyester f.						26.5			26.5
Polyamide f.						4			4
<u>Others</u>									
MTBE		500							500
Alkyl benzene			50			40			90
Unsaturated polyester resin		12							29 +)
Alkyd resins	12	7							40 ++)
Polyvinyl Acetate resin		8	3					6	17 Kuwait 5 Jordan 10 U.A.E. 6
Formaldehyde resin	14.4								14.4 Jordan 1.6
									10,652*

*) Ethylene dichloride intermediate is not added to the total
+) (Kuwait 6 Jordan 8, and Syria 3000 tons)
++) (Kuwait 5, Jordan 6 and Tunesia 10,000 tons)
35/ Feasibility study on aromatic production in Arab countries, GOIC-AIDO, November 1988

Table 33

World refinery capacity 1986
(thousand barrels per calender day)

Region or country	Refinery capacity 1986	1987
North America	17,269.6	17,565.9
Latin America	7,083.5	7,222.0
Western Europe	14,411.8	14,735.2
Middle East		
Bahrain	243.0	243.0
Islamic Rep. of Iran	615.0	615.0
Iraq	365.5	365.5
Kuwait	720.0	720.0
Qatar	63.0	63.0
Saudi Arabia	1,490.0	1,490.0
United Arab Emirates	162.0	162.0
Others	1,023.9	1,023.9
Africa		
Algeria	471.2	471.2
Egypt	452.1	452.1
Libia	342.0	342.0
Others	1,275.4	1,275.4
Asia and Far East	9,758.8	9,473.9
Oceania	680.1	718.8
CPEs	17,010.5	16,989.0
TOTAL WORLD	73,194.5	73,810.5
Total Arab countries	4,065.8	4,308.8
Arab countries percentage	6.1%	5.8%

Consumption of and demand for petrochemical products in Arab region

The consumption of petrochemical products in the Arab region is closely connected with the availability of the products, the level of prices, the development of economic sectors using petrochemical materials and the general economic status of the country. Several other factors contribute as well to the promotion of the petrochemical consumption such as the availability of R + D centers and their capability to cope with the fast changing mode of application and trends of the petrochemical products and the policies adapted by each individual country for substituting conventional materials with the equivalent petrochemical substances. Therefore, data on the present consumption and the future demand for the petrochemical products in the Arab region may not have the same accuracy as that of the production capacity.

Markets for most petrochemical products in the Arab region are far from reaching maturity, potential economic sectors for petrochemicals are still not well developed, R + D activities are inadequate and per capita consumption of all types of petrochemicals is very low compared with the level reached in the developed countries.

Nevertheless, many serious attempts have been made to estimate the actual consumption of petrochemical products and the expected future demand. The most up-to-date and comprehensive study on the Arab petrochemical industry which was sponsored by the Arab Industrial Development Organization (AIDO), 1988, reflects the level of the present petrochemicals consumption, the expected future demand and the supply/demand balance in accordance with the latest plans set for the development of the petrochemical industry in the Arab region.

A brief review of the situation of the basic petrochemical products and their derivatives in the Arab region indicating present consumption and future demand are summarized hereunder.

Ethylene and its main derivatives in the Arab region

The total installed capacity of ethylene in Arab region amounts to 2,470,000 metric tons based on rich ethane natural gas with the exception of the 330,000 tons plant in Libya where naphtha is used as feedstock. The present Arab consumption of ethylene is estimated at about 2,119,000 tons mainly for the production of ethylene derivatives, polyethylenes, PVC, ethylene glycol and styrene.

New plans for the establishment of ethylene production in the Arab region are in progress. Saudi Arabia is expanding its production to 1,970,000 tons (higher than design cap.) and adding a naphtha-based cracker for production of 500,000 tons ethylene and 265,000 tons propylene. Iraq declared adding a 420,000 tons ethylene unit using different liquid hydrocarbon feedstock and Egypt is planning to build a 200,000 tons ethylene plant. Therefore, by 1995, the total Arab ethylene production capacity will amount to about 3,590,000 tons. Inspite of this, future shortage is foreseen even if all plans for ethylene based petrochemical products are executed.

In regard to ethylene derivatives, at present (1989), production capacity of high density polyethylene (HDPE) in Arab countries is about 201,000 tons, low density polyethylene (LDPE) including linear low density polyethylene (LLDPE) 843,000 tons and polyvinylchloride PVC 460,000 tons per year (see Table 32).

While demand for 1990 was estimated at 946,000 tons for all types of polyethylenes and 705,000 tons for PVC, indicating a serious shortage in PVC supply amounting to about 250,000 tons, the indicated shortages in the supply of the PVC and polyethylenes, will be met by the newly planned projects in the Arab region for the near future (1995). Iraq has anounced their plans for building 160,000 tons/year of different polyethylene units and 90,000 tons PVC. Libya will add 80,000 tons of LDPE, Egypt planned a 30,000 tons LDPE, and Saudi Arabia will increase their 200,000 tons PVC per year to 300,000 tons.

Apparently, there will be no need for further expansion in polyethylenes production: on the contrary, a surplus is expected. The supply/demand gap in the PVC will be narrowed from a shortage of approximately 250,000 tons per year to about 60,000 tons, a situation which will still invite Arabs to build further PVC capacities.

Propylene and its derivatives

Apart of the 170,000 tons propylene produced in the Ras-Lanuf plant in Libya and 5,000 tons propylene per year in Qatar, there is no propylene production in the Arab region at present. Propylene demand, for 1990 was estimated at 410,000 tons based on the propylene intermediate and end-products demand (Table 34).

Table 34

Propylene demand for Arab region in terms of propylene intermediate and end-products

1000 s of tons 36/

Product	Demand 1990	Required amount of propylene
Polypropylene	211	220
Acrylonitrile	92	110
Propylene oxide	93	80
TOTAL		410

The imbalance of about 235,000 tons of propylene will be met by the newly announced plans of several Arab countries to produce propylene (Iraq decided to install a 254,000 tons plant, Saudi Arabia is committed for building 265,000 tons propylene and Kuwait confirmed to go ahead with their 80,000 tons polypropylene based on the propylene produced in their refineries). Together with the existing capacity of 175,000 tons per year, the Arab region will acquire in 1995 a total production capacity of propylene near to 769,000 tons which exceeds the total Arab demand by about 300,000 tons. It is also important to indicate that there is no production of any propylene derivatives at present in the Arab region, but a 68,000 tons of poly-propylene per year in Libya and a 10,000 tons polyol plant are expected to commence production in the early nineties.

The total consumption of polypropylene in the Arab region was estimated at 63,000 tons in the mid eighties and expected to rise to 92,000-100,000 tons in 1990.

Besides Libya's 68,000 tons of polypropylene which is ongoing, Saudi Arabia had concluded the feasibility study for a 160,000 tons PP plant at Ibin Zahar Complex, Iraq included a one hundred thousand ton project (100,000 tons)

36/ Fourth Arab Energy Conference (AIDO paper, page 31), 14-17 Nov.1988, Baghdad Iraq of PP with its newly ambitious petrochemical development plan and finally, Kuwait had decided to go ahead with their long delayed planned 80,000 tons of polypropylene. Therefore, the total expected Arab polypropylene production capacity in the nineties will exceed 400,000 tons. These phenomena will completely reverse the picture of supply/demand balance of PP in the Arab region from a net importer to a major exporter. Unless close co-ordination among Arab petrochemical producers is commenced, the problem of disposing such a great quantity of PP in the international market will be very complicated. This situation also seriously calls Arabs for greater integration in their plans for petrochemical expansion.

Butadiene and its main derivatives

There is no actual butadiene production in the Arab region at present, neither has it been considered in the near future plans. Although there exists an already planned project of 45,000 tons butadiene in Libya, there is no indication that it will be implemented and Saudi Arabia seems, as well, to have put off their planned 125,000 tons butadiene project in Ibin Zahar Complex *.

The two widely used synthetic rubber in the world are the polystyrene butadiene rubber (SBR) and polybutadiene rubber (BR). The total consumption of (SBR) and (BR) in the Arab region in 1990 was estimated at 42,113 tons and 25,046 tons respectively. Table 35 indicates the estimated SBR, polybutadiene, polyisoprene and butyl rubber consumption in the Arab region for 1990, 1995 and 2000.

*) EGM for the evaluation of the up-dated sectorial study on petrochemical industry in Arab region. AIDO-Baghdad-Iraq, 14-16 February 1989.

Table 35

Synthetic rubber consumption in the Arab region 1990-2000*

Year	Styrene butadiene rubber SBR	Polybutadiene rubber BR	Polyisoprene rubber	Butyl rubber	Total
1990	42,113	25,046	13,904	33,566	114,629
1995	49,402	29,385	16,083	39,389	134,259
2000	58,284	34,671	18,975	46,473	158,403

*) Data have been quoted from the up-dated sectoral study on Arab petrochemical industry and checked during the experts group meeting sponsored by AIDO in Baghdad, Iraq, 14-16 February 1989.

Inspite of the relatively high consumption of synthetic rubber in the Arab region, particularly in car tyres and tubes industry, there is no production of any type of synthetic rubber based on the basic ingredients; (butadiene, styrene, isoprene and chlorprene) at present. Car tyres and tubes projects in the Arab region (Morroco, Algeria, Tunisia, Libya, Egypt, Sudan, Syria and Iraq) are importing their requirements of synthetic rubber from the industrialized countries. The total imports of rubber goods by Arab countries in 1980 amounted to 337,600 tons and in 1984 was about 336,181 tons. Tyres and tubes in general constitute about 85% of the total rubber goods imports.

Most of the car tyres and tubes factories in the Arab countries are using styrene butadiene rubber SBR and polybutadiene rubber BR, while polyisoprene is some times used in small quantities. However, the consumption of different types of synthetic rubber depends on the recipe used in the tyre manufacturing industry.

If the recipe used in the Goodyear plant in Morocco for tyre production was followed to estimate the synthetic rubber demand for the car tyres projects in the Arab region for the year 2000, total synthetic rubber required for car tyres and tubes industry in the Arab region is estimated at 64,466 tons. Consumption of SBR alone is estimated at 40,792 tons, polybutadiene 5,309 tons and butyl rubber is 18,365 tons (Table 36).

Table 36

Synthetic rubber consumption by car/tyres and tubes factories in the Arab countries in the year 2000

Arab countries	Capacity 1000 tyres	Expected consumption of synthetic rubber in the year 200			
		SBR	Butadiene r.	Butyl r.	TOTAL
Morocco	1,800	4,279	577	1,926	6,762
Tunisia *)	440	1,046	136	471	1,653
Algeria *)	5,000	11,886	1,547	5,351	18,784
Libya *)	990	2,353	306	1,059	3,718
Egypt	2,650	6,299	821	2,836	9,956
Sudan	300	713	93	322	1,128
Syria *)	680	1,616	210	728	2,554
Iraq	1,300	3,091	402	1,391	4,884
Arab Gulf States	4,000	9,509	1,237	4,281	15,027
TOTAL	17,160	40,792	5,309	18,365	64,466

*) The actual consumption of SBR and BR is little less because isoprene is used (see reference 3).

Aromatics and their derivatives in the Arab region

The development of many essential industrial sectors in the world as well as in the Arab region, depend on the availability of the basic aromatics (benzene, toluene and xylenes), such as synthetic fibers (polyester, polyamides and acrylic fibers), plastic materials (polystyrene, polycarbonate, acrylonitrile-butadiene-styrene, ABS, and polyurethane), synthetic rubber "SBR", phenols, phenol resins, alkyd resins, unsaturated polyester resins, synthetic detergents and plasticizers, etc.

Basic aromatics are produced by a number of well known and established processes from petroleum products especially naphtha (in different ranges), pyrolysis gasoline, kerosene and gasoil. All these petroleum products are produced practically in all Arab countries and in large quantities. The selection of the proper manufacturing processes and the suitable feedstocks depend on several factors. For instance, if the purpose were only to produce the basic aromatics, light naptha or light-medium naphtha reforming process associated with separation and purification, would be the convenient method, as it is already practiced in Algeria, Saudi Arabia and Iraq. If olefins and aromatics are sought, then steam cracking of light-medium naphtha would be the most suitable method. This trend is followed in Libya where light-medium naphtha is used as a feedstock in the ethylene steam cracker.

The existing oil refineries in Arab countries, produce several types of naphtha, light, light-medium, medium-heavy, and light-medium-heavy naphtha (full range of boiling points).

Light naphtha is not usually used in reforming process units, but it forms very suitable feedstock for stream cracking to produce olefins. Pyrolysis gasoline is also produced through this process as liquid by-product rich in basic aromatics.

Since aromatics are also used to raise the octane number of car fuel gasoline, the treated naphtha which is rich in aromatics is used either in increasing the octane number of the car fuel gasoline or to produce aromatics, depending on production economics and the policy of the oil refiners.

Table 37 indicates the medium term production - consumption balance in petroleum products in Arab countries in 1990 and 1995 37/.

Table 37

Production/consumption balance of petroleum products in Arab countries in 1990 and 1995
1000 s tons

Year/Arab region	Naphtha	Gasoline	Kerosine	Gasoil
1990				
Eastern Arab countries	7,070	9,234	14,500	27,501
Central Arab countries	1,290	327	286	(1,755)
Western Arab countries	6,089	188	2,268	2,092
1995				
Eastern Arab countries	7,072	5,852	12,168	22,674
Central Arab countries	732	(195)	(554)	(3,818)
Western Arab countries	6,219	(800)	2,544	(3,141)

Notes: -Figures in parenthesis imply a deficit (consumption exceeds production)
-Eastern Arab countries: Bahrain, Iraq, Kuwait, Saudi Arabia and United Arab Emirates)
-Central Arab countries: Egypt, Jordan and Syria)
-Western Arab countries: Algeria, Libya, Morocco, Tunisia

37/ Feasibility study of aromatic production from naphtha in Arab countries, AIDO and GOIC, executive summary, November 1988, p.20

Inspite of the availability of a wide range of raw materials for the production of basic aromatics in Arab countries, few of them possess today production units for basic aromatic production (only Algeria, Saudi Arabia, Iraq and Egypt), mainly used for their own internal industrial requirements (see Table 32).

Table 37 reflects the excess of naphtha in the Eastern Arab countries (Saudi Arabia, Bahrain, Iraq and Kuwait), while excess naphtha in the Western Arab countries is mainly centered in Libya. Consequently, these countries have some advantage for the implementation of production units.

Production and consumption analysis made of some 23 aromatic products in Arab countries revealed that there is an obvious deficit of local production of aromatic compounds in all Arab countries. The imbalance will be more serious if no attempts are made for rectification, particularly for those products which are of high consumption volumes and being imported at present such as polystyrene, SBR, phenol, phenoplast, polyamide, TDI, terphthalic acid, polyester, phthalic anhydride, epoxy resins, alkyd resins and unsaturated polyester (see reference 37).

As for the consumption of aromatics and aromatic compounds, the task is rather more complicated because it is connected with so many unpredictable factors in Arab countries; such as stability of per capita consumption, the immaturity of downstream industries which utilize aromatic compounds, different level of development of various economic sectors that are potential consumers of aromatic petrochemicals, the extreme variation in the G.D.P. level from one Arab country to another, etc. However, an attempt has been made by AIDO-GOIC to estimate the consumption of aromatics and aromatic compounds in the Arab region for the years 1990, 1995, 2000, 2005 and 2010. This estimate was made during the preparation of the feasibility study on the production of aromatics from naphtha in Arab countries carried out in 1988 taking into consideration all possible influencing factors (variables) such as gross domestic production.

The most optimistic forecast for aromatics and aromatic compounds consumption in Arab countries for the period 1990-2010 reflected a serious deficit in a number of aromatic products at present (1989-1990) and in the near future. Table 38 summarizes the consumption forecast for aromatics and aromatic compounds in the Arab region until the year 2010 (see reference 37).

Table 38

Consumption forecast for BTX and derivatives
Total Arab world
tonnes

Products Years	1985	1990	1995	2000	2005	2010
Basic*)						
Benzene	14,107	15,378	18,239	20,792	23,095	25,125
Toluene	22,136	25,083	32,354	38,857	46,035	54,069
Xylenes	22,692	28,641	35,977	42,460	48,321	53,638
Intermediate						
Benzoic Acid	2,763	2,441	2,966	3,422	3,826	4,191
Cumene	-	-	-	-	-	-
Toluene Diisocyanate	38,881	43,250	49,639	56,385	62,687	68,829
Terephthalic Acid	-	-	-	-	-	-
Nitrotoluene	4,735	6,126	7,663	9,027	10,255	11,370
Phenol	1,000	1,974	2,363	2,710	3,022	3,306
Phthalic Anhydride	12,231	11,953	13,923	15,670	17,234	18,657
Linear Alkylbenzenes	81,686	99,396	119,391	137,635	152,584	166,753
Maleic Anhydride	-	-	-	-	-	-
Styrene	1,496	1,654	2,038	2,368	2,658	2,916
Dimethyl Terphthalate	17,107	19,680	25,837	31,321	36,259	40,754
Final						
Styrene Butadiene Rubber	68,104	83,896	98,471	112,404	123,594	135,011
Dioctylphthalates	35,343	49,292	59,011	67,656	75,536	82,655
Alkyd Resins	73,954	108,213	130,760	150,784	168,835	185,421
Epoxide	15,028	15,689	18,154	22,007	24,592	26,925
Polyamide	38,733	48,580	57,316	64,806	70,565	77,641
Phenoplasts	12,798	10,193	11,100	12,058	12,894	13,664
Polyesters	141,603	189,552	225,682	257,558	286,092	312,005
Polystyrene	114,680	117,225	141,459	162,966	188,944	207,427
Polyurethanes	14,552	21,303	25,646	29,455	32,873	35,976
Unsaturated Polyesters	19,000	21,150	27,300	32,580	37,260	41,330

*) Demand shown is for direct use and not for derivatives requirement.
Source: See reference 37

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Table 39

Expected production of the aromatic petrochemical compounds in Arab countries in the year 2010 including existing capacities
1000 s tons

Type of products	Production capacity 1000 of tonnes
Benzene	103
Toluene	29
Xylenes	286
Phenol	1
LAB	140
Plastizysers	88
Styrene	470
Alkyd resins	48
Polyamide	3
Phenplast	6
Polyester	76
Unsaturated polyester	17
Polystyrene	100
Phthalic anhdyride	158
DMT	50
Terphthalic acid	49
Cumene	125
Maleic anhdyride	75

Table 40*

Current supply/demand balance of aromatics and aromatic compounds in Arab region in 1990 (1000 tons)

1989-1990 Products	Production Capacity	Consumption 1990	Balance	Remarks
Benzene	385	464	(79)	112 thousand tons
Toluene	26	46	(20)	under cons/ no shortage
P-Xylene	38			
Mix-xylenes	247			
Polystyrene	100	117	(17)	
SBR	-	84	(84)	
Polyamide	4	48.6	(44.6)	
TDI	-	43.3	(43.3)	
TPA	-	-	-	
PES	26.5	189.5	(163)	
DMT	-	19.7	-	
Phthalic anhydride		12	-	
DOP		49.3		
Alkyd resins	40	108.2	(68.2)	
Polyurethanes	-	21.3		
Unsaturated polyester	29	21.2	7.8	
Nitrotoluene		6.1		
Phenol	1	1.97	(0.97)	
Terephthalic acid				
Linear alkyl benzene	90	141	(51)	
Styrene	360	254	(106)	
Caprolactum	12			

* See reference 3

** Figures in parenthesis mean deficit

The status of methanol production and consumption in the Arab region

Inspite of the fact that methanol is used as raw material for the production of many essential petrochemical products utilized in several industrial sectors; plastics, synthetic fibers, adhesives, solvents, paints and gasoline additives, etc., the production of methanol in Arab countries was not really driven by the demand of such industries, neither to be used as fuel or fuel additives except the Saudi Arabia's MTBE project where methanol is used for the production of methyl-teriary-butylether, a gasoline antiknock additive for local and export purposes. Other industries which utilize methanol as raw material in the Arab region are so small in size and do not really justify the present high tonnage production of methanol. Yet, the methanol making trend in natural gas rich Arab countries could be considered a very practical solution at present for the good utilization of natural gas instead of flaring it since exporting natural gas invovles a very complicated and expensive process.

The current total Arab region's production capacity of methanol is approximately 2,566,000 tons, being 1,410,000 tons in Saudi Arabia, 600,000 tons in Libya, 296,000 tons in Bahrain and 100,000 tons per year in Algeria. United Arab Emirates is also planning to produce 1,325,000 tons methanol by 1995.

Present and future industries based on methanol in Arab countries are indicated in Table 41.

Table 41

Methanol based industries in Arab countries
1000 s tons (see reference 3)

Product	Country	Production capacity 1985	Expected production 1995	2005
Methyl-teriary butyl-ether MTBE	Saudi Arabia	704	704	704
	Libya	-	46	46
TOTAL		704	750	750
Formaldehyde	Algeria	20	20	20
	Egypt	25	25	25
TOTAL		45	45	45
Melamine	Saudi Arabia	20	20	20
	Kuwait*	15	15	15
TOTAL		20*	35	35
Formaldehyde resins	Jordan	1.6	3.1	3.1
	Algeria	14.4	14.0	14.0
	Saudi Arabia	-	9.6	4.6
TOTAL		16	21.7	21.7
Acetic acid	Arab Gulf Area**	-	150	150
Vinyl acetate	Arab Gulf Area**	-	110	110
Polyvinylacetate resins	Jordan	10	10	10
	United Arab Emirates	6	12	21
	Saudi Arabia	8	8	8
	Iraq	3	3	3
	Kuwait	5	5	5
	Libyia	-	4	4
	Morocco	6	6	6
TOTAL		38	57	57

* Kuwait's melamine plant was out of operation for the past three years since 1985-1986, and it is on the process of resuming the operation.

** Projects at study stage

Co-operation and integration in the petrochemical industry in Arab countries

Definitions of various aspects of co-operation and integration

International economic integration has been defined as a process which involves the amalgamation of separate economies into larger ones and it is specifically concerned with the discriminatory removal of all trade impediments between the participating economies and the establishment of certain elements of co-operation and co-ordination among them. These types of co-operation and co-ordination depend on the actual form assumed by the integration, e.g. free trade areas, customs unions, common markets, complete economic unions, and complete political integration. Morevover, within each scheme there may be sectoral or subsectoral integration in particular areas of the economy [38/].

On the level of the much smaller structure of the enterprise, integration may assume two main directions: vertical integration which involves the addition, modification, or expansion of the activity of the enterprise units to produce alternative raw materials, intermediates or other input which have formerly been obtained from other sources or other enterprises, or to further process its products into forms similar to the products of other firms. Horizontal integration is exemplified by the expansion of the activities of an enterprise to produce more of its products within the same plant or in other parts of the region, or to purchase other units producing similar commodities to be joined to their own.

In further analysis of the concept of integration, it is important to point out that international economic integration may be either active or passive in its form but not in its results. The term passive integration has been used to refer to the removal of trade barriers between the participating nations or the elimination of any restrictions on the process of trade liberalization. Active integration relates to the modification of existing instruments and institutions, and, which is more important, to the creation of new ones so as to enable the market of the integrated area to function properly and efficiently and to promote other policy objectives of the union (see reference 38).

38/ El Agraa, Ali M. International economic integration, London, Macmillan, 1982, pp.1-2

B. The motives for international economic integration

In spite of the fact that almost all schemes for economic integration were proposed or formed for political reasons, arguments in their favour generally advertized only the possible economic gains resulting from the various arrangements. However, whatever the motives for economic integration may be, an analysis of the economic implications of the involved geographically discriminatory groupings is still necessary.

First, at the custom union and free trade area level, the possible sources of economic gain can be attributed to:

- enhanced efficiency in production made possible by increased specialization in accordance with the law of comparative advantage;

- increased production levels due to better exploitation of economies of scale made possible by the increased size of the market;

- an improved international position, made possible by the larger size leading to better terms of trade;

- inforced changes in economic efficiency brought about by enhanced competition;

- changes affecting both the amount and quality of the factors of production due to technological advances;

If the level of economic integration is to proceed beyond the custom union level to the economic union level, then further sources of gain become possible due to:

- factor of mobility across the borders of member nations;

- the co-ordination of monetary and fiscal policies;

- goals of near full employment, higher rates of economic growth and better income distribtuion becoming unifying targets (see reference 38).

As was mentioned before, the term integration, in economic development, is also used to express the close relationship or interconnection among different sectors of the economy. Thus, within any individual country, integration implies a wider scope of interconnection between several economic sectors and involves different products. For example, the integration of the agricultural and industrial sectors, the former providing cotton, wood, oil seeds, sugar beets and cane, etc. and the latter the refined foodstuffs, would obviously improve efficiency in all respects. Likewise, and concerning the topic of the present study, there are various ways in which the oil industry might integrate with several other sectors in order to expand its services to more than one economic sector by the efficient production of not only basic fuel and energy but also various petrochemicals.

The concept of integration may be summarized as being an advanced form of co-operation which involves different forms of administrative and legal arrrangements between or among the parties involved to determine their roles, obligations and responsibilities.

The assessment of progress towards economic integration remains to be one of the most confusing aspects of integration studies, perhaps because of the difficulty of identifying a set of criteria which may be sufficiently operational as instruments of measurement. The result has been a tendency for most integration movements to be measured in terms of their approximation to theoretical models which often do not reflect the practical situation. This is particularly true of integration movements among developing countries where far fewer theoretical formulations have been made than for developed countries 39/.

Forms of co-operation among Arab countries in the petrochemical field could be expressed in various ways and serve as formidable tools for the development of the Arab petrochemical industry and the solution of many of its problems. The expediency of co-operative efforts may be realized when we observe that Arab countries have largely been planning their petrochemical industry according to the vision of each individual country, often with little or no consideration to the realistic needs of the country concerned or to that of the Arab Region, a situation resulting invariably in either excess capacity or severe imbalances. Examples of possible fields of co-operation include:

39/ Hare, Kenneth. The Caribbean community, (chap.9, pp.200-201) in El-Agraa, Ali M. ed. International economic integration.

exchange of petrochemical products at different levels of processing, co-operative efforts to supply equipment and engineering services, technology transfer, training, different forms of investment and/or financing, joint ventures, etc. Such co-operation could be extended to regional, sub-regional and international levels. Moreover, co-operation extended to regional, sub-regional and international levels such as enterprise-to-enterprise co-operation and co-operation between enterprises and research and development centers in different countries have proved to be most useful in improving operational and production economies of petrochemical producing companies.

It has been noticed that several regional organizations in the Arab countries such as AIDO, OAPEC, APICORP, GOIC and Arab Economic Council have played a very sincere and active role in promoting Arab co-operation and co-ordination in the petrochemical industry. Several volumes of in-depth studies on the subject conducted during the last two decades by these organizations stand witness to this effort. We notice, on the other hand, that few tangible results have taken root with the few exceptions of APICORP and the Gulf Petrochemical Company.

Co-ordination of various economic activities among the Arab countries has been the subject of continuous discussion at all political (state), professional, industrial and popular levels since the emergence of national statehoods in the Arab world after World War II and the disintegration of the Ottoman Empire. These activities have developed further after World War II and the gaining of independence of several additional Arab countries from colonial rule. The establishment of the League of Arab Nations and the subsequent birth of several off-shoots of pan-Arab organizational structures dealing with legal, social, cultural, financial, commercial, industrial, labour, military and other specialized activities and disciplines bear witness to the intensive effort made in the line of co-ordination of Arab policies on these issues. It should be noticed, however, that the multiplicities of legal and organizational structures did not result in many practical steps of co-ordinations. Many critics suggest that failure to achieve practical results rested with the fact that co-ordination was always commanded from the top political level and was not allowed to permeate at the grass roots level, a situation which resulted in the immobilization of co-ordination whenever political disagreements (or changes) at the top level occurred.

The latest trend of co-ordination which may hopefully lead to integration is taking the form of regional or sub-regional groupings. This has started with the formation of the Gulf Co-operation Council (GCC) between Saudi Arabia, Kuwait, Bahrain, Qatar, United Arab Emirates and Oman in 1981, followed by the foundation of the Union of Arab Maghreb Countries (UMA) between Marocco, Algeria, Tunisia and Libya, and lastly the formation of the Arab Unity Union with the participation of Egypt, Jordan, Iraq and Arab Yemen Republic. The proclaimed objectives of these three groupings are co-operation, co-ordination and integration at all levels of economic, social, cultural, military, commercial and financial and political activites. Most of the legal and organizational infrastructure has been established for these three groupings and in the case of the first one i.e. GCC a number of important measures of macro-economic and political co-ordination and integration measures, which have resulted in an increase in the number of joint economic and commercial enterprise among the countries concerned, have been implemented.

The achievement of economic integration at regional level presupposes two objective conditions, first the availability of political will and the ensuance of measures and incentives therefrom to encourage active integration at sectoral and subsectoral levels. The second precondition is the acceptance of a certain level of division of labour between the countries concerned based on the availability of resources, production factors, markets, investment financing and competitiveness and complementarity of production resources and market outlets. A continuous review of policy measures and inventives would be essential to maintain the process of integration on a healthy and comptetitive course and avoid its decline into a bureaucratic, inefficient and self-defeating process.

The petrochemical industry, due to its technological structure lends itself to integration, particularly vertical integration. The concept of refinery-petrochemical complex is an outstanding embodyment of vertical integration from the raw material (hydrocarbon) to petrochemical feedstock (product of refinery) to basic, intermediate and finished petrochemical products. In such a closed production cycle maximum benefit is made of by-products. As a whole this technologically integrated approach, also inherent to its energy generation and use, is the most economically effective and competitive approach.

Integration on the enterprise level, may assume two main directions:

vertical (integration) involving the addition, modification or expansion of an activity to produce alternative raw materials, intermediates, or other input which has formerly been obtained from other sources, and horizontal (integration) which is exemplified by the expansion of the activities of an enterprise to produce more of its products within the same plant or in other plants in the same country or region.

Even more important than this level of technically and economically motived integration at the enterprise level is integration of the petrochemical industry with other economic sectors and activities. The real contribution of the petrochemical industry to economic development of the Arab countries as a whole lies in its ability to help accelerate the development of such vital economic sectors as agriculture, construction and housing, the heavy and light industries sub-sectors, communication and research and development. The immense diversity of the products and fields of applications of the petrochemical industry renders it an ideal position to play such an integrating role in the national and regional economies of the Arab countries. It is essential that the vision of such a role be realized at the planning stage of establishing the petrochemical industry and conscious efforts be taken towards its realization.

C. The present status of integration in the petrochemical industry among Arab countries

In practice, very limited practical attempts have been made for integration of the petrochemical industry among Arab countries in spite of its remarkable development in some Arab countries, particularly in the production of ethylene, methanol and to some extent ethylene polymers (HDPE, LDPE, LLDPE and polystyrene).

The relatively recent establishment of the petrochemical industry in the Arab region during the mid-seventies to the middle of the eighties has been made with little co-ordination. This industry was established essentially to upgrade the economic benefit of available natural and financial resources. Petrochemical projects in industrialized Arab countries were built in line with each Arab country's individual circumstances, investment climate, and motives. Consequently, Arab oil and gas rich countries have included in their economic development plans the utilization of natural gas, in particular associated gas, for the production of petrochemicals.

Some Arab countries such as Algeria, Iraq and Egypt have established their petrochemical industry at the first stage to satisfy their own domestic market; therefore, production capacities were relatively low (120,000 tons ethylene, 48,000 tons LDPE and 35,000 tons PVC in Algeria; 130,000 tons ethylene, 60,000 tons LDPE, 30,000 tons HDPE and 60,000 tons PVC in Iraq and 80,000 tons PVC in Egypt). Thus little consideration was given to economies of scale in deciding upon the capacities of plants established in these countries. Also little consideration was given to export markets.

The petrochemical production units of other Arab countries such as Saudi Arabia, Qatar and Libya, was mainly targeted to international markets thus making use of economies of scale and the choice of world scale plants operating at low production costs: (Saudi's ethylene production capacity reached 1,970,000 tons, methanol 1,410,000 tons, ethylene glycol 530,000 tons, LLDPE 462,000 tons, and 700,000 tons MTBE in 1989; Qatar's ethylene production capacity was 280,000 tons, LDPE 140,000 tons; and in Libya the ethylene production capacity was 660,000 tons in the same year.

Kuwait is also planning a high capacity production unit for ethylene 350,000 tons, styrene 340,000 tons and benzene and other aromatics 430,000 tons targeted to international markets [40/]*.

The diverse production strategy and the absence of co-ordination among Arab petrochemical producing countries has resulted in a siuation where first the high tonnage volume of Arab petrochemical products in some countries is facing marketing difficulties. Secondly, Arab petrochemical producers center on the production of ethylene and ethylene derivatives in particular by using only ethane base feedstock (with the exception of Libya) in their ethylene crackers. As a result, other olefins, propylene, butadiene and their derivatives, which are required for their domestic needs were not produced locally.

The limited utilization of naphtha as feedstock is another example of the lack of integration between the petrochemical producers and the refinery

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40/ Arab oil and gas: V, XVII, no.410, October 16, 1988, p.40

* Kuwait's plan for petrochemical production is postponed at present except for the production of 80,000 tons/year PP based on the propylene produced in their refineries.

industry on national level as well as on an Arab regional level. Naphtha is produced from Arab oil refining industry in large volume (about 14.4 million tons per year) which gives a high yield of propylene, butadiene and aromatics when it is used as a feedstock for ethylene production.

The use of naphtha as feedstock in Arab countries counted for about only 1% of the total feedstock used for the petrochemical industry while this ratio in the United States reached about 15%, in Western Europe 88% and in Japan about 96%. Although the trend of using natural gas as the main feedstock in Arab countries may be justified, to a certain degree, by its availability and low cost, the comparative utilization of naphtha for the production of the other basic olefins has great significance in the vertical integration of the petrochemical industry, as an alternative to allowing the stagnation and limitation of such a vital industry to mainly ethylene production and ethylene derivatives.

Table 41 shows the pattern of petrochemical production and demand in the Arab region in 1990. The said table also records a complete absence of butadiene, butene-1-, terephthalic acid, vinyl acetate, propylene oxide, acrylic, all types of synthetic rubber and carbon black. The balance of other petrochemical products, apart from ethylene, ethylene glycol and low density polyethylenes, indicates a shortage in the supply for 1990. Thus, main petrochemical raw materials for the manufacture of synthetic fibers and synthetic rubber are not currently produced. Moreover, the supply/demand balance and analysis, shown in Table 41 in fact does not reflect the actual picture of the supply and demand for the petrochemical industry because of lack of co-ordination and integration in the industry has encouraged the exportation of most, if not all, of the excess products to international markets and, as a result, most of the needs of other Arab countries are obtained from international markets. The picture is further distorted by the fact that the balance of supply/demand is estimated on the basis of 100% capacity utilization, which is an unlikely case.

It can be seen that Arab countries which are not producing basic or intermediate petrochemicals for one reason or another (non-availability of raw materials, lack of capital investments, etc.), form a considerable potentiality for downstream industries where they require either intermediate or final products to convert them into different varieties of commodity plastics, synthetic fibers, detergents and rubber tyres.

At present, great numbers of small enterprises (mainly private) for the manufacture of plastic materials and synthetic fibers, rubber tyres, paints and varnishes, synthetic fiber textiles and detergents, are spread out all over the Arab region and not limited to the few petrochemical producing countries. However, most of the materials for these industries are imported from sources other than Arab countries particularly the United States, Western Europe, Japan and other industrialized countries. Even Arab petrochemical producing countries themselves import their needs from international sources because of the limitation in the variety of the products they produce.

Table 41

Current design capacities of Arab petrochemical industries and the demand for 1990
1000s tons

Petrochemical products	Current design capacity	Demand for 1990	The balance excess and (shortage)
Basic petrochemicals			
Ethylene	2,471	2,119	352
Propylene	175	410	(235)
Butadiene	-	-	
Butene-1-	-	-	-
Benzene	370	464	(96)
Toluene	26	44	(28)
p-xylene	38	208	(170)
Mix-xylenes	247		
Intermediate petrochemicals			
Ethylene glycol	530	105	415
Styrene	360	254	106
VCM	591	720	(129)
DMT	25	-	-
Teraphthalic acid	-	310	(310)
Vinyl acetate	-	84	(84)
Propylene oxide	-	93	(93)
Acetic acid	-	-	-
End products			
Polyethylenes	1,044	864	180
Polypropylene	68	291	(223)
PVC	460	705	365
Polystyrene	100	236	(136)
Polyvinylacetate	38	60	(22)
Polyester fibers	26.5	320	(293.5)
Acrylic	-	92	(92)
Nylon	4	131	(127)
SBR (styrenebutadiene rubber)	-	88	(88)
PB (polybutadiene r)	-	23	(23)
BR (Butyl rubber)	-	31	(31)
Polyurethane raw materials	-	164	(164)
LAB (linear alkyl benzene)	90	141	(51)
Polyester (unsaturated)	14	61	(47)
Carbon black	-	100	(100)

(see reference 3, 36, and 35)

It is evident that a close examination of the petrochemical production matrix in the Arab countries reveals great possibility for co-operation, co-ordination and integration in the petrochemical industry of the Arab region on both the national and regional level. However, in order to grasp the full extent of this potentiality it would be necessary to undertake a thorough examination of this industry in each Arab country, to define in concrete forms all co-operation opportunities and to recommend appropriate measures at all levels which would lead to the gradual realization of these potentials.

D. The problems and obstacles to integration of the petrochemical industry among Arab countries

It is useful to review some of the main obstacles hindering the success cf integration of the petrochemical industy in the Arab countries:

- The paucity of economic linkages between the Arab countries. In fact, intra-Arab trade still represents a very limited share of Arab countries total trade in spite of its recent diversification in both geographical and sectoral terms. In 1987, for instance, intra-Arab exports accounted for only 7.1% of the total Arab countries exports, while intra-Arab imports constituted 7.5% of their total imports. This percentage is negligible in the context of the intra-regional trade of other groups of countries such as the EEC or CMEA where it accounts for over half of their total trade (see reference 40).

  While there is very little, if any, information available on petrochemical intra-Arab trade yet, statistics on petrochemical integration among the EC (European Community) as far as trade is concerned indicate that the intra-regional trade among the European Economic Community countries (intra EC imports) is more significant than the external EC imports and exports [41/].

- Absence of a common economic policy and the related infrastructure which would encourage and promote economic integration between the Arab countries;

41/ Shaefer, Walter A. The integration of the EC petrochemical industry in: Oil and Arab Cooperation, V.12,No.2, 1986

- The limited role of the main economic actors, whether public or private, in the integration process in trade and industry. Instead the government through its bureaucracy assumes a leading role.

- The different stages of economic development reached by Arab countries and their structural imbalances as individual countries.

- The limited development of local technological capabilities and the dependence on ready-made foreign technology, foreign consulting organizations and to some degree on foreign skills.

- The lack of adequate physical infrastructure capable of supporting the development of integrated petrochemical industry.

- The lack of technological support in form of R + D, quality control, productivity development centres, engineering designs and local manufacturing capabilities which are required to ensure the healthy development of the petrochemical sector.

Conclusions

Review of the petrochemical industry's status and prospects in the world and Arab region leads to the following conclusions:

A. On the international level

The world petrochemical industry has recently witnessed a state of relative stability, particularly in the United States, Western Europe, Japan and other industrialized countries after the recession of the late 1970's and early 1980's and the accompanying restructuring and rationalization measures.

No drastic event or major changes are expected to occur in the world petrochemical industry in the near future. The difficult lessons learned from the world prolonged economic recession and its impact on petrochemical industries in the industrialized countries have led to greater caution in planning future expansion. Instead, efforts are being concentrated on high capacity utiliziation and capacity creeping rather than on building new production units for basic petrochemicals and traditional polymers. More attention is being given to the production of speciality chemicals and high value-added products.

Moreover, the process of globalization in the petrochemical industry of Western Europe, Japan, the USA and their spheres of influence has been intensified to a very high level in all respects (resulting in a fewer number of companies, greater level of specialization, optimization of joint marketing, R + D and global distribution of new capacities).

Most of the problems connected with the petrochemical industry which were inherited from the world economic recession have been overcome mainly through the process of restructuring on both regional and global levels. However, this process is in no way completed and the future plans for basic petrochemical production in the year 2000 in Europe are still not clear, especially when considering the fact that about 50% of the ethylene crackers in Europe are now about 15 years old.

In the United States, there is no expectation so far of a drastic change in the present prosperity of the petrochemical industry for the near future. Capacity utilization rates are high, product lines are sold out and margins are high. The only problem foreseen is the possible risk of overcapacity due to over-enthusiastic investment, and a possible slowing down in 1991-92 as new capacity comes on line.

Japan, which was most affected by the recession because of its almost complete dependence on petrochemical feedstock imports (96% naphtha) focussed their R + D's efforts on feedstock alternatives such as methanol, synthesis gas, and the conversion of barrel-bottoms including vacuum residue to feedstock for olefin plants.

The future petrochemical industry will be characterized by the entrance of new producers from developing nations including the Middle East, Latin America, Far East and Centrally Planned Economies. New capacity additions in ethylene, propylene, styrene, methanol and main plastic petrochemicals (PE, PP, PS and PVC) by the developing nations mentioned above may be interpreted as a migratory trend of some basic petrochemical capacities, shifting from the traditional producers in industrialized countries to the third world, particularly to the oil and gas-rich countries of Latin America, the Middle and Far East.

The new producers of the developing nations, had put up new capacity for ethylene only about 9,510,000 tons between 1982-1987, methanol 7,635,000 tons, polyethylene 1,110,000 tons and PP and PVC 1,674,000 tons (see reference 12). Saudi Arabia alone contributed 1,970,000 tons of ethylene and 1,410,000 tons of methanol (see reference 13).

In the field of R + D, efforts seem to be directed from immediate to longer range problems, emphasizing future-oriented innovations, because many current routes for the production of key petrochemicals are reaching their limits in catalyst efficiency and reactor design.

B. Conclusions on the Arab region

Within the region of the Arab countries, the petrochemical industry is characterized by the predominant production of ethylene and ethylene derivatives over all other petrochemical products including methanol. Existing, under construction, and planned capacity for ethylene and ethylene derivatives account for about 70% of the total Arab region petrochemical production; and the other 30% represent aromatics, propylene, MTBE and other non ethylene based products. This is mainly due to the use of the abundantly available natural gas which would have been otherwise flared, as the main feedstock. Naphtha which is produced in large quantities in Arab oil refineries (about 14.4 million tons in 1985) was little used because it was internally marketable 43/.

Naphtha is not commonly used in the Arab petrochemical establishments as a feedstock in ethylene production crackers except in Libya. Consequently, the other basic olefins propylene and butadiene, are not produced in the Arab region, nor are their derivatives as well as all intermediate products required for the production of synthetic fibers. However, Arab countries have become increasingly aware of this imbalance and have taken into consideration the use of naphtha as feedstock in their recent and future plans.

Examination of the production pattern of petrochemicals in Arab countries, the capabilities and the estimated demand indicate the weakness of co-ordination in production planning of the petrochemical industry on the level of capacities, feedstocks and types of products required. Moreover, the fact is that integration or co-ordination among establishments concerned with the petrochemical industry in each individual Arab country has not taken its normal course, such as the co-ordination between the refining and the petrochemical industry. This is in complete contrast with the globalization policies followed by the industrialized regions where the big multinational companies attempted to integrate the petrochemical industry from the oil well to the end product in order to optimize profitability.

Considering the total population of the Arab region (5% of the world population) (see reference 36) and their oil supply (about 25%) (see reference 35) of the world total supply, the estimated petrochemical production of Arab countries for 1990 will still not exceed 2.4% of the world total petrochemical production in that year (total world production 348.3 million tons) (see reference 40). This fact indicates a high future potential for Arab petrochemical production for the domestic and export markets.

The Arab domestic market for most commodity plastics and synthetic fibers it still immature. Moreover, in some speciality plastics and certain other

43/ Ferhanq Jalal - Integration requirements of petrochemical industry in Arab region. Oil and Arab co-operation, Vol.12, issue No. 2, 1986 petrochemical products the Arab market is still virgin. Many economic sectors having the potential to use petrochemical commodities such as the agricultural sector, construction, machinery building, capital goods industry and the consumable products sector are far from being mature, a matter which promises a higher growth rate of consumption.

In considering the average per capita consumption of developing countries (Latin America, Africa, and Asia) as resembling Arab per capita consumption for example, LDPE/LLDPE 1.6 kg, HDPE 0.66 kg, PP 0.6 kg, PS 0.43 kg, and PVC 1.27 kg, these rates do not exceed 13% of the average corresponding consumption in Western Europe, USA and Japan.

No specialized Arab organization exists to look after Arab petrochemical interests and affairs, such as in the case of the Arab Federation of Chemical Fertilizer Producers or other similar unions. Considering the existing state of development in the Arab petrochemical industry, its future development, and the immensity of the problems ahead of it, it seems incompatible not to have, or plan to have, such an organization to provide data and fora, and to act on behalf of the common interests of its members.

Arab consulting bureaus in the field of chemical and petrochemical industries are either not involved enough in the study plans, design and supervision of the construction of petrochemical plants, or they are not, themselves, developed enough to be involved. The same case exists with the R + D centers which require more direct and closer relationships between them and petrochemical producers in the Arab region in order to tighten the relationships and examine possibilities for co-operation and integration in the petrochemical industry in the region.

Many attempts were made by Arab countries to promote co-operation and integration, and quite a few agreements were also made in this respect, both bilateral and regional, most of these agreements being decided by high-level inter-Arab meetings and conferences; yet still the economic relationships among Arab countries are weak, intra-Arab trade is very low and economic development planning fails to be co-ordinated.

The petrochemical industry in the Arab region suffers seriously from the lack of information on consumption and demand which for[illegible] an [illegible]ential ground for rational planning. Consequently, production cap [illegible] [illegible]ded by Arab petrochemical producing countries either do not meet the demand or they are far in excess because of the exaggeration in the forecast of demand.

C. Main requirements of economic integration

Whether the issue of integration is concerned with general economic integration or deals with any particular sector, such as the petrochemical industry which is the subject of this study, integration requires that the following important elements be considered:

- First, integration requires a genuine political will, without which no real co-operation or co-ordination could be accomplished.
- The second principle of economic integration is the assurance of an equitable distribution of costs and benefits.
- Each individual country's (company's) interest must be well protected and preserved.
- Provision of adequate infrastructure, both human and physical, as an effective instrument of integration.
- Agreements reached bilaterally or multilaterally should be respected by, and binding to all parties involved.

Recommendations

The recommendations suggested in this paper for the development of integrated petrochemical industry in the Arab region intend to be practical, simple, and gradual, taking into consideration the local circumstances and many other characteristics of the countries concerned.

Thus, the following recommendations are proposed with the belief that they may serve as effective measures towards the integration process in the Arab petrochemical industry.

1. Since accurate data, statistics and other information are the first and most important element in economic planning and development, it is recommended to establish a central data bank for chemical and petrochemical industries to serve the Arab region as well as to facilitate communication between Arab countries and other regions with which co-operation may be possible.

2. To establish a form of an Arab union, federation, or association specialized in the chemical and petrochemical industries, similar to the Arab Federation of Chemical Fertilizer Producers, the main purposes of which would be: to collect required information, such as statistics on Arab and intra-Arab trade and data related to other Arab industrial activities in order to analyze their similarities and potential relationships to the petrochemical sector, to organize efforts for co-operation among Arab countries and between them and other international organizations, to hold technical and trade seminars, and to attend national and international meetings, exhibitions and conferences. (Such a federation could be started as a division within AIDO or OAPEC.)

3. To promote the establishment of joint Arab companies (bilateral and multilateral) as a practical approach for integration.

The recently set up Arab Company for Detergent Chemicals in Baghdad, Iraq, serves as a practical example of a joint Arab petrochemical enterprise and encourages further steps in petrochemical and industrial co-operation. The sodium-tri-polyphosphate (STPP) project is planned to be executed by the same company soon; and the newly established Iraqi/Jordanian Company for industry, has now reached a very advanced stage in the execution of a powder detergent plant based on the main raw materials produced by the Arab Company for detergent chemicals (which is now producing linear alkyl benzene and toluene).

4. To intensify co-operation and interrelations with the experienced international firms of industrialized countries on all possible levels, including joint ventures, in order to build up marketing experience and to open effective routes for the transfer of technology.

5. To make good use of the already concluded agreements among Arab countries on different aspects of economic co-operation and unity: in particular, the Intra-Arab Trade and Transit Agreement (1953), the Arab Economic Unity Council, and the decision to establish an Arab common market (taken in 1964), as well as other similar agreements, to facilitate the intra-Arab trade and joint investments by eliminating the trade barriers, as well as to enhance the flow of capitals.

6. In the R + D fields, the established centers in the Arab region are recommended to develop new process technologies, which are vital to the Arab petrochemical industry, with the co-operation of international process engineering firms in joint names.

7. To promote Arab downstream industries by introducing and expanding their use in different economic sectors. The market in various economic sectors of Arab countries is still very immature and thus has great potential for absorption of great amounts and different types of commodity plastics, synthetic fibers and synthetic rubber.

8. To closely examine the existing small and medium sized enterprises spread out through all Arab countries for the purpose of accommodating these units for processing Arab petrochemical products. Most of such machinery and petrochemical end product manufacturing units, if not all, are supplied by other industrialized countries and may require some modifications or alterations in their operating conditions. The recommended petrochemical federation mentioned above could take such an initiative.

9. In order to promote, expand and encourage intra-Arab trade in petrochemical products and commodities, it is recommended to create an incentive which is attractive enough to encourage the favouring of intra-Arab trade rather than the currently practiced external trend. Such an incentive might assume several forms, examples of which are barter, subsidizing, after sale services, deferred payments for long periods and soft conditions.

10. To promote the production of the raw materials and intermediates required by the downstream industries, particularly for those industries which already exist in the Arab region and are the driving force for the expansion of basic and intermediate petrochemicals besides their role in the development of other economic sectors.

11. To carry out a very detailed and comprehensive market study for Arab petrochemical indu ry covering all marketing aspects on national, regional, sub-regional, and international level.

Special emphasis should be given to the issue of petrochemical consumption and demand, intra-Arab trade status, and promotion of the joint efforts for extra-Arab trade (export to international markets) taking the Saudi Arabia's experience into consideration.

12. To encourage and facilitate the direct co-operation and co-ordination among the Arab petrochemical producers by taking all possible measures to remove the barriers hindering the reciprocates of goods, spare parts, operating supplies and other required aspects of co-operation including exchange of operators and other technical personnel.

13. To carefully study the advantages of free custom duties or low tariff on the exchange of petrochemical products among Arab countries with the gains in the availability and low price of the raw materials and intermediate products.

14. The development of downstream industries should not necessarily be tied up with the availability of all required raw materials in the Arab region, because, first it is not inevitable that the Arab region will economically be able to produce all such raw materials, and secondly, the development of the downstream industries themselves will derive the production of the required inputs.

15. It is recommended, whenever possible, to cope up with the international trends of the petrochemical industry by making a move towards the production of some high value-added petrochemicals such as sophisticated and special use plastics and fine chemicals and not to live with the stagnation state of the production of traditional materials.

Such trends may bring many returns on Arab petrochemical industry especially in enhancing the development of the R + D centers, expanding trade volume in value and encouraging the utilization of some by-products.

16. Since the R + D activities are very important and essential to such vital and diversified industry and they require a great deal of expenses besides their need of qualified and well experienced staff and scientists, it is recommended to sub-regionally centralize the Arab R + D establishments and to be partialy supported in a form of a fund.

17. Efforts should be made towards the development of local and Arab regional capabilities in the field of engineering design to implement process improvement, local manufacturing of equipment and product adaptation to suit local conditions.