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**Integrated Development of the
Petrochemical Industry
in the Arab Countries'**

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INTRODUCTION

1. One of the most potential and challenging enterprises of the 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 improvements, the industry of today has also become vigorously involved in creating new products which not only compete with but also 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 fibres. Synthetic fibres and rubbers have now largely outclassed traditional materials in both performance and economy.

2. In the 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.

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

4. The availability of crude oil, natural gas and other hydrocarbon products as petrochemical raw materials and energy sources also renders it very attractive for Arab countries to enter this field of industry. This, however, is not enough by itself for the Arab countries to start production of petrochemicals. They face a host of problems such as inadequate physical and human resource infrastructure, high construction costs, operation and maintenance difficulties, limited R&D facilities and lack of efficient planning and marketing expertise. In spite of all these problems many Arab countries went ahead and built, alone or as joint-ventures with foreign associates, a host of petrochemical plants, particularly during the late 1970s and early 1980s. A number of these plants have already materialized and some of their products have seen their way to international markets, mainly because of the limited domestic market, but other types of obstacles confront the new producers. The steep drop in the prices of hydrocarbons has eroded many of the inherent advantages of Arab producers; in addition protectionist measures have been adopted by the traditional markets for their products.

5. It has become evident that in order to maintain their viability as producers the Arab countries need 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.

I. THE CURRENT STATUS OF THE GLOBAL PETROCHEMICAL INDUSTRY

6. The revival of the petrochemical industry after the setbacks of the early 1980s was truly global in scope and international in trade, characteristics which caused both problems and opportunities. On the other hand, the supremacy of technological innovation, the obsession of the 1970s, has surrendered to a considerable extent to matters of supply, demand, distribution and international trade.

7. Thus, it appears that the determining factor in the development of the oil refining and petrochemical industries will centre around commercial and business strategies rather than technology in the 1990s. Moreover, many current routes for the 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 feedstock for certain olefin derivatives and aromatics. In many large chemical companies, there are much greater interests in diversification through acquisitions or in entering the production of speciality and performance chemicals with higher profit margins than in producing basic petrochemicals.

8. Moreover, the world petrochemical industry has become highly cyclical besides being aggravated by additional capacity from new producing sources in oil- and gas-rich countries and also from competitors without substantial oil and gas resources, such as Brazil, the Rep. of Korea and Taiwan. Thus, the industry is becoming increasingly competitive, prices remain low and margins in ethylene and most commodity plastics are flat.

9. Traditionally-oriented petrochemical companies will have to take measures similar to those adopted in restructuring processes which took place at the aftermath of the two oil hikes, such as implementing vertical integration moves in order to compete more efficiently during the difficult part of the cycle or going downstream closer to the consumers by making more value-added products.

10. In the field of research and development, efforts seem to be directed from immediate to long-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.

11. This indicates that the petrochemical industry adapts to changing situations on the raw material side and that the efforts in R&D will lead to an array of new products on a higher value level than the traditional commodities. However, commodity thermoplastics, the major bulk of plastic materials, are still holding a firm position worldwide, with their traditional rate

of growth in developed regions led by polypropylene and linear low-density polyethylene, as well as increasing their role in the developing countries.

12. Measures for rationalizing production, particularly in basic chemicals and plastics, a reduction in capital expenditures to prevent further over-capacity and the concentration of efforts in a reduced products line were the measures which mainly contributed to the recovery of the global petrochemical industry.

13. Another key element in the restructuring was that most of the world's chemical companies concentrated on specific products instead of producing a complete end-product array to keep their market share. Companies tried to stick with what they did best and consolidation of efforts became the order of the day. In addition, companies have been joining forces; restructuring has involved mergers and joint-ventures to create more specialized companies and more orderly marketing scenarios.

14. For the long term, however, more drastic measures such as the synthesis of petrochemicals using methanol and the synthesis of gas as feedstocks, the conversion of barrel bottoms - including vacuum residue - to feedstock for olefin plants, increasing the use of refinery by-products, a shift in product portfolios to avoid competition with the products of resource-rich countries and diversification into high technology fields such as electronics and biochemistry have to be considered. Yet such long-term measures would require considerable expense and may also be faced with difficulties of new and strict environmental regulations in the industrialized countries.

15. During the period of the rapid development of the petrochemical industry in the world, the main producing and consuming areas were Japan, the United States and Western Europe. 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.

16. In the 1980s, Canada, Mexico and the Middle East constructed large export-oriented petrochemical plants based on low-priced ethane feedstock. Moreover, the countries in the Asia and Pacific region, which once were net importers of petrochemicals, have lately launched sizable petrochemical complexes enabling them not only to reach self-sufficiency but also to become important exporters.

17. One of the most outstanding features of the present scene of the world petrochemical trade is the advance of Saudi Arabia's products to Western European markets. Low feedstock price is the major advantage of the Saudi Arabian producers diverting their abundant natural gas output to make petrochemicals instead of

flaring. For example, downstream ethylene-fed plants are now making large volumes of products such as ethylene glycol and polyethylene which are largely exported because of little domestic demand. Excluding the nitrogenous fertilizers (ammonia and urea), the total current installed Arab petrochemical production capacity amounts to about 11.62 million tonnes of basic, intermediate and various end-products involving some 30 or more petrochemical materials with further expansion and new complexes underway.

18. Saudi Arabia's petrochemical production capacity as of January 1992 amounted to more than 7.5 million tonnes per year of different petrochemical products and according to future plans, it will be around 11.5 million tonnes in 1995. Of this amount, 3.7 million tonnes will be methyl-tert-butyl ether (MTBE) which, after LLDPE, lately demonstrated the highest growth rate in demand among the world petrochemical products because of its use as an octane booster and in reformulated fuels to meet the requirement of environmental regulations, particularly in the USA and Western European countries. Table 1 shows Saudi Arabia's present petrochemical status and future capacity, 1991-1995.

19. Apart from Saudi Arabia's projected capacity expansion, several other Arab countries in the Gulf region and North Africa are expanding their existing units or installing new plants, especially Algeria, Bahrain, Egypt, the Libyan Arab Jamahiriya and Qatar. These additional expansions, which are mostly scheduled to start-up in 1993-1995, are estimated according to the announced capacities at about 1.86 million tonnes, bringing the total Arab petrochemical capacity in 1995 to 17.4 million tonnes.

Table 1

SAUDI ARABIA'S PRESENT PETROCHEMICAL STATUS AND FUTURE CAPACITY (1991-1995), '000 t/y			
PRODUCT	PRESENT CAPACITY 1991	EXTENSION	FINAL CAPACITY 1995
Ethylene	1,970	500	2,470
Ethylene glycol	650	400	1,050
Ethylene dichloride	560		560
Styrene	360	54	414
Industrial ethonol	300		300
Vinyl chloride monomer	300		300
Propylene		300	300
Butadiene		100	100
Benzene		70	70
Poetylene	1,100	200	1,300
PVC	200	100	300
Polystyrene	100		100
Polypropylene		200	200
Melamine	20		20
Methanol	1,410	630	2,040
MTBE	500	1,400	1,900
TOTAL	7,470	3,954	11,424

Source: Arab Oil and Gas, 16 October 1991

II. PETROCHEMICAL INDUSTRY IN THE ARAB REGION

20. Several Arab countries occupy today prominent 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 are estimated to be over 606,661 million barrels as of 1 January 1992, constituting about 66.21% of the total world crude oil reserves rated at 991,011 million barrels.

21. Arab natural gas reserves are also considered high as illustrated in Table 2, being estimated at about 893,701 billion cubic feet (bcf), or by 20.41% of the world's total natural gas reserves. Arab oil and gas production accounted for approximately 35.79% and 7.2% of world production respectively.

22. Table 2 shows the proven oil and gas reserves, production and installed refining capacity in Arab countries, 1 January 1991.

23. While the world oil reserves are decreasing due to the increasing production of approximately 60 million barrels per day, the undiscovered oil reserves are expected to center around the Gulf, and North America. Moreover, 63.15% of Africa's crude oil reserves are located in Arab countries of Africa: Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia. These phenomena certainly place 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.

24. Arab countries have fully 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, this policy was reiterated on several occasions at the governmental level in most Arab countries and by institutional organizations involved in economic and industrial development process.

25. During the 11th Arab summit meeting held at 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 and Mining Organization (AIDMO), at its Fifth Arab Industrial Development Conference, recommended immediate initiatives for the development of the petrochemical industry in the Arab area and proposed to carry out the required surveys and studies in order to set up practical plans for the development of petrochemical

Table 2

PROVEN OIL AND GAS RESERVES, PRODUCTION AND INSTALLED REFINING CAPACITY IN ARAB COUNTRIES (1 January 1992)					
COUNTRY	a) Est. proven reserves on 1.1.92		Production		c) Refin. capacity on 1.1.92
	Oil	Gas	a) Oil	b) Gas	
	million bbl	bcf	Thousand b/d	bcf	Thousand b/d
Algeria	9.200	116.500	798	1.622	464.7
Bahrain	83.49	6.010	38.2	166	243
Egypt	4.500	12.400	855	260	523.15
Iraq	100.000	95.000	280	18	318.5
Jordan	5	100	0.3		100
*Kuwait	96.250	48.500	191.5	10	819
Libyan Arab Jamahiriya	22.800	43.000	1.500	228	348.4
Morocco	2.13	43	0.9		154.6
Oman	4.250	9.900	705	91	80
Qatar	3.729	162.000	390	253	60
*Saudi Arabia	260.342	184.548	8.222.5	1.578	1,862.5
Syria	1.700	6.400	473	40	237.39
Tunisia	1.700	3.000	104.8	14	34
UAE	98.100	199.300	7.656	1.168	192.5
Yemen	4.000	7.000	200.8		114.5
Arab Countries Total	606,661	893,701	21,445.7	5,448	5,552.55
World Total	991,011	4,378,056	59,919.5	75,380	74,552.55
Arab Countries Share %	66.21	20.41	35.79	7.2	7.4

Sources: a) Oil and Gas Journal, 31 December 1991; b) Oil and Gas Journal, 9 December 1991 (estimated on the basis of 9 months production reports; c) Oil and Gas Journal, 23 December 1991; * - including neutral zone

industries in accordance with the prevailing circumstances and potentials of each individual Arab country. Several other Arab organizations closely interested in the economic 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), the Union of the Arab-Maghreb, and the Gulf Organization for Industrial Consultancy (GOIC) have taken initiatives and progressive steps towards the establishment and enhancement of this sector.

26. At the present time, several Arab oil and gas producing countries already possess quite a well-developed oil refining and petrochemical industry. As mentioned earlier, the total production capacity of the Arab petrochemical industry is estimated at about 11.62 million tonnes per year of basic, intermediate and end-products. Currently, ethylene production capacity amounts to 2.8 million tonnes which constitute about 25% of the total Arab petrochemical production capacity, i.e., 5.75% of the global ethylene production capacity; and methanol production capacity is about 2,566 tonnes which comes to about 15.63% of the global methanol production capacity. Saudi's petrochemical production capacity alone amounts to more than 7.5 million tonnes as of January 1992 and their near future expansions will add about 4 million tonnes, 1,4 million of which will be MTBE. Table 3 illustrates the existing Arab petrochemical capacity.

Table 3

ARAB PETROCHEMICAL PRODUCTION CAPACITY AND ESTIMATED DEMAND (1990 AND 1995), '000 m/t				
PRODUCTS	PRODUCTION CAPACITY		DEMAND 1990	BALANCE 1995
	1990	a) 1995		
<u>Basic olefins:</u>				
Ethylene	2,830	4,393	2,100	730
Propylene	175	531	410	(235)
<u>Aromatics:</u>				
Benzene	385	855	464	(79)
Toluene	26	26	44	(18)
Mix-xylenes	237	247		
Para-xylenes	38	208	208	(170)
<u>Alcohols:</u>				
Methanol	2,566	3,496		
Ethanol	300	300		
<u>Inter-mediate:</u>				
Ethylene glycol	650	1,215	105	545
Styrene	360	1,064		
VCM		594	720	(129)
Ethylene oxide	390	331		
Formaldehyde	62	40		
Ethylene dichloride	62	774		
<u>Final products:</u>				
HDPE	201	1,340	864	180 + 414
LDPE	843	1,183		
PP	68	796	291	(223)
PVC	460	1,060	705	(245)
Polyesterene	100		236	(136)
Melamine	35	52		
<u>Synthetic fibres:</u>				
Polyester	26.5	74	320	(293.5)
Polyamide	4		131	(127)
Acrylic			92	(92)

(Please continue next page)

(Continuation of Table 3)

ARAB PETROCHEMICAL PRODUCTION CAPACITY AND ESTIMATED DEMAND (1990 AND 1995), '000 m/t				
PRODUCTS	PRODUCTION CAPACITY		DEMAND 1990	BALANCE 1995
	1990	a) 1995		
Others:				
MTBE	500	2,548		
Alkyl benzene	90		141	(51)
Unsaturated polyester resin	40		61	(61)
Alkyd resins	38	30	60	22
Polyvinyl acetate resin		60	310	(310)
Terephthalic acid	16			
Formaldehyde resin			23	(23)
Butadiene rubber			88	(88)
Butadiene styrene rubber				

a) Under construction capacity
() deficit

Sources: UNIDO, "The development of integrated petrochemical industry in the Arab region" (ID/WG.522(2)); various issues of Chemical Week, European Chemical News, Chemical Marketing Reporter, Arab Oil and Gas; and UNIDO's draft directory on technological capabilities in developing countries related to the petrochemical industry.

III. CONSUMPTION OF AND DEMAND FOR PETROCHEMICAL PRODUCTS IN THE ARAB COUNTRIES

27. 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 also contribute to the promotion of petrochemical consumption such as the availability of R&D centres and their capability to cope with the fast changing modes of application and trends on petrochemical products and the policies adopted by each individual country for substituting conventional materials with the equivalent petrochemical substances. Therefore, data on the present consumption and the future demand for petrochemical products in the Arab region may not have the same degree of accuracy as that of the production capacity.

28. 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 low compared with the level reached in the industrialized countries.

29. 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 and Mining Organization (AIDMO) and up-dated in 1989, 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 (see Table 3).

IV. THE ISSUE: THE INTEGRATED DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN THE ARAB REGION

30. The Global Preparatory Meeting¹ held in Karachi, Pakistan, from 10-13 December 1991, recommended the following five elements of the issue on *integrated development of the petrochemical industry in the Arab region* to be submitted to the Regional Consultation on the Petrochemical Industry in the Arab Countries:

- Co-operation, co-ordination and integration in the field of petrochemicals
- Marketing of petrochemicals
- Impact of technology on the petrochemical industry
- Infrastructure considerations
- Environmental protection and safety

A. Co-operation, co-ordination and integration in the field of petrochemicals

31. By establishing large petrochemical complexes, Arab countries are making an impact on the global petrochemical industry. This has been possible largely because of the availability of abundant hydrocarbon resources and the advantage of easy access to investment capital. But no domestic market in a single Arab country can support a world-scale sized plant. On the other hand, due to lack of proper integration in the development of the industry, the region as a whole still depends on outside suppliers for its requirements of downstream finished products or some basic and intermediate feedstocks to produce them. Against this backdrop and the prevailing changes through which the global petrochemical industry is passing, the integration of the petrochemical industry in the region through co-operation and co-ordination has become essential for the economic viability of Arab petrochemical producers. In fact, the developed countries, where the petrochemical technology originated and the industry is firmly established, sought co-ordination and co-operation among themselves and with other regions particularly during downward cycles of the petrochemical industry. Because of the complexity, high-investment costs, and the great number and variety of products, and unstable raw materials supplies and prices, the petrochemical industry lends itself well to co-ordination and co-operation.

32. Regional and international co-operation in the petrochemical sector should be based upon clearly defined objectives of mutual benefits to the parties. The basic incentive for co-operation should be mutual benefit, not charity for the less advantageous

¹ UNIDO Report: "Global Preparatory Meeting for the Regional Consultation on the Petrochemical Industry in the Arab Countries, Karachi, Pakistan, 10-13 December 1991". (ID/WG.522/4(SFEC.)).

parties. Co-operation will involve different institutional and legal arrangements to determine the roles, obligations and responsibilities of the parties to obtain desired objectives. Co-operation extended to regional, sub-regional and international levels such as enterprise-to-enterprise co-operation and co-operation between enterprises and R & D centres in different countries have proved to be most useful in improving operational and production economies of petrochemical producing companies.

33. Integration also implies a wider scope of interconnection between several economic sectors of national economies. At the enterprise level, integration may assume vertical integration involving addition and modification, or expansion of an activity to produce alternative raw materials, intermediates or other inputs which have formerly been obtained from other sources or enterprises.

34. As the downstream petrochemical products serve many other sectors of the economy like agriculture, food, textiles, shelter and health-care on a wide scale, a well-integrated downstream petrochemical industry is vital for the economic development of the Arab region. On the other hand, since the petrochemical processing industry exerts a great influence on the type and pattern of demand for polymers, which in turn determine the type of intermediate and basic petrochemicals needed for their production, the downstream processing industry becomes the most vital link in the chain of integrated development of the petrochemical industry. It is therefore essential for the Arab petrochemical producers to develop downstream petrochemical industries and integrate them with basic and intermediate production units.

35. Practical approaches for co-operation in Arab petrochemical industry could involve.

- a) **Setting up of information centres and data banks**
- b) **Co-operation in production plans and the marketing of petrochemical products**
- c) **Co-operation in upgrading technological bases, R & D activities and the transfer of technology**
- d) **Co-operative infrastructure development, both physical and human**
- e) **Co-financing and other forms of joint investments**

Information centre and databank:

36. Accurate and updated information is the pre-requisite for all possible co-operation, co-ordination and integration. There is an urgent need to collect and periodically update the information regarding existing capacity, present and potential demand for products, sources of available technology, equipment

and skilled manpower. An information centre will help to exchange information and experience among the parties to avoid the mistakes incurred by some petrochemical producers, to undertake future investment plans, to pool regional resources etc. Complimentary assistance from UNIDO's database may be sought in this respect.

Co-operation in the production and marketing of petrochemicals:

37. There should be a relationship between installed production facilities and the local demand at the sub-regional or regional levels. As mentioned earlier, Arab countries are currently exporting some basic petrochemicals, which are in excess capacity world-wide. On the other hand, they are importing finished petrochemicals or intermediate feedstock to produce them. If sufficient downstream industries are established through regional co-operation with an equitable allocation of projects among the cooperative parties for the production of various petrochemicals, the region could attain self-sufficiency for its production and marketing of petrochemicals. The co-operating parties would then exchange petrochemical products at various stages of production among themselves.

Upgrading of the technology base:

38. As the petrochemical industry is highly technology driven, it is essential to strengthen the region's technological capabilities for absorption and assimilation of imported technology and to establish technical back-up facilities. Co-operation in this field may include joint engineering and construction companies, equipment manufacture, spare parts manufacture, R & D activities and regional training institutes. More emphasis should be placed on the genuine transfer of technology by concerted and efficient R&D activities to rationalize and develop the various technologies to suit the regional environment.

Infrastructure development and joint financing:

39. Infrastructure development includes the development of common sites, communications, storage, transportation, shipping and port facilities. Furthermore, due to the fact that the infrastructure required for the petrochemical industry is capital-intensive, joint efforts may be considered when individual financing of projects becomes difficult. Moreover, infrastructure is usually utilized by several economic agents, and where co-operation among these different beneficiaries would help in distributing the cost between several parties.

B. Marketing of petrochemicals

40. Marketing of the final product is often the single most important factor for the financial viability of a manufacturing project. It is usually essential to have an assured and

preferably captive market for at least 50 percent of the plant output. Petrochemical products are used either as intermediate inputs in a downstream manufacturing facilities or as end products. At present Arab producers of basic and intermediate petrochemical products are mostly dependant upon export markets. With the changing situations of the industry world-wide, they become vulnerable to external problems like global over-capacity, saturation in export markets, volatility in prices and economic recession in the consumer countries.

41. It has now become crucial for the producers of the Arab region to develop regional markets for their products. This is specially attractive as there exists good potential because the consumption level of downstream petrochemical products is still very low in the Arab Region compared to industrialized countries.

42. Regional markets can be developed, on one hand, by encouraging the establishment of downstream industries and on the other hand, by an effective marketing strategy. The marketing strategy should encompass the following provisions:

Availability	development and/or adaptation of the plant output to suit the market requirements
Prices	local producer's prices that are competitive with the traditional suppliers' prices
Specifications and customer orientation	proper quality and management to satisfy customer preferences

43. In order to develop downstream industries' complementarity and to avoid the creation of a glut or severe undersupply in the region, careful planning and co-ordination are essential. A prerequisite for such planning and co-ordination is accurate market information. Appropriate networks of information on marketing and market-related parameters will provide the basis for development and investment in downstream industries, adaptation of the present plant output to suit the market demand and product specifications, and required quality control of the product.

44. The development of certain infrastructure such as roads, jetties, tank farms and terminals and other communication facilities is an important element for marketing products. These are usually cost-intensive and should not be charged to the project alone, rather they should be perceived as essential facilities by the government for overall industrial development of the country.

45. Until such time as sufficient downstream petrochemical units are constructed in the Arab region to absorb the bulk of the basic and intermediate products, the petrochemical industry of the region has to rely on international markets. Arab countries should make a strategic review of their overall trade policy for the establishment of a firm presence in the world market through various cooperative activities, such as joint sales organizations, long-term sales agreements, price-arrangement policies, joint transportation grids, territorial market allocation etc. Arab countries have, to a lesser extent, practised such co-operation while co-operation among Arab countries still is very limited with the exception of few cases such as the Gulf Petrochemical Industry Company in Bahrain, a joint-venture among Saudi Arabia, Bahrain and Kuwait, and the Arab Company for Detergent Chemicals, a joint Arab Company in Iraq.

C. Impact of technology on the Petrochemical industry

46. Technological changes play a crucial role in determining the level of development of the petrochemical industry because its wide range of products have extremely diversified fields of application. The global industry overcame the critical constraints of feedstock price increases and economic recession in the 1970s and 1980s largely through technological improvement of production processes. Technological innovations in the industry have become involved in creating new materials and products which not only compete with but also are surpassing the quality of traditional materials and products on the basis of cost/performance effectiveness. Because of the deep-rooted technological base of the industry, it is of utmost importance for any producer to keep abreast of the continual technological changes shaping the industry.

47. Like most of the developing regions, the Arab region acquires process technologies from the industrialized countries and is heavily dependent on them. In developed countries, due to the presence of technological capabilities and strong back-up facilities and services, any technological improvement is readily assimilated by the industry. In developing countries, the absence of such support gives rise to many technical problems resulting in a slow assimilation rate and inferior product quality, especially when downstream products are to be manufactured and modified to suit local or regional needs.

48. Thus, in order to develop an efficient and integrated petrochemical industry in the Arab region that is dynamic and flexible enough to accommodate future needs and trends, Arab countries need to establish certain criteria for the development of their indigenous technological base in order to absorb and assimilate imported technologies and their rapid changes according to their own requirements and thus consolidating their petrochemical industry.

49. The development of indigenous technological capabilities could be initiated by promoting the local manufacture of some equipment and machinery, utilizing indigenous and alternative raw materials, developing skills and experience in engineering design and consultancy and establishing effective research and development facilities.

50. Pragmatic approaches to technological development in the Arab countries may include the following:

- **Compilation and exchange of information on available technology, pilot or semi-commercial plant operational experience, technological know-how and availability of technical training facilities**
- **Development of joint programmes on specific petrochemical industries for production, research and development, training trade and others. Such programmes may also involve foreign partners, including encouraging highly qualified scientists into this field**
- **Establishment of programmes for the exchange of experience and personnel, including exchange through regional and international agencies.**
- **Co-ordination and harmonization of laws and regulations in Arab countries dealing with technology import, absorption and use and the implementation of common licensing policies**
- **Establishment of an Arab association of petrochemical producers as a tool for the promotion of closer co-operation between themselves and as a common forum for their relations with the outside world**
- **Seeking assistance where needed to achieve the above-mentioned objectives from organizations like UNIDO, AIDMO, ESCNA, IDB, OAPEC, GOIC**

D. Infrastructure considerations

51. In all developing countries in general, one of the main obstacles for the development of the petrochemical industry is the lack of adequate infrastructure, which directly affects the efficiency of production units, the degree of local and regional co-operation in marketing, research and development and supportive activities. Even on occasion, otherwise viable petrochemical projects are not implemented due to prohibitive costs associated with the development of the required infrastructure.

52. Because of the diversity and strong technological base of the industry, infrastructure requirements for the petrochemical industry include various components as follows:

<u>Physical</u>	well developed transportation and communication systems, distribution networks, special storage facilities, import-export terminals, tank-farms etc
<u>Human</u>	well-educated manpower capable of absorbing specialized technical and management skills in both construction and operation of plants
<u>Organizational</u>	research and development centre, training institute, engineering and consulting bureaus, equipment manufacturing and contracting organization, common waste treatment and disposal agency, financing institute etc

53. The recent surge in the establishment of petrochemical projects in the Arab region clearly needs a parallel development of supportive infrastructure for the transportation and the distribution of raw materials and products, and technical and other organizational back-up services for sustaining the growth and development of the industry.

54. The development of such an infrastructure would require extensive investments and a considerable gestation period, but the benefits are directed not only to the petrochemical sector but also to other economic and social priorities, and as such will contribute to overall national economic development. Therefore, the establishment of the infrastructure should be incorporated in the economic development plan of the country and should not be limited to the petrochemical sector alone. The petrochemical industry should co-ordinate closely with the public sector to ensure fulfilment of those specific needs. Sub-regional or regional co-operation may provide an added impetus for development of such infrastructure.

55. Academic, vocational and technical training institutions' support could play an important role in providing manpower with an adequate technical and management background on which to base required skills and experience. The curricula of the concerned departments in the universities, institutes and training centres should be designed to equip the manpower with the necessary background for absorbing and developing the specific skills needed for the petrochemical industry.

E. Environmental protection and safety

56. The last two decades have seen an increased awareness about environmental conservation, and the petrochemical industry is facing growing pressures to respond to these concerns. Economic

and environmental issues are becoming increasingly intertwined, and present industrial and governmental policies are being reassessed in the light of their environmental impact.

57. On the surface, funds and efforts invested in environmental conservation will not earn extra revenue, but it must be recalled that ultimately the cost for environmental protection must be borne, either now or in the future. Investment related to environmental conservation should be considered as an unavoidable and integral component, like those related to plant safety, accident prevention etc. This calls for greater effort in understanding environmental risk, including the costs and benefits of reducing them and reconciling economic and environmental interests.

58. Pollution prevention can also yield considerable pay-offs. The origins of waste and effluent in the petrochemical industry can normally be traced back to spillage, unreacted raw materials, impurities in the reactants, undesirable by-products, unusable materials generated during upsets, start-ups and shutdowns, fugitive releases, spent auxiliary materials (catalysts, solvents etc.), materials generated during sampling, handling or storage and used maintenance materials. A close examination of these elements will reveal that an attitude to minimize waste generation will bring about considerable operational improvement, resulting in productivity increases and economic gains as well as huge but hard-to-quantify sources of environmental protection.

59. Practical approaches for the conservation of the environment in the Arab Region could include:

- At the government level, the formulation of appropriate policies on environmental protection and adequate mechanisms for their implementation. This should include setting up standards and specifications for air and water emissions and disposable waste to suit the local needs, and the creation of appropriate bodies to detect, monitor and regulate such disposal.

- For any new project, a comprehensive environmental impact assessment should be conducted. Similarly, for existing plants, periodic environmental audit should be performed.

- At the plant level, waste and effluent disposal may follow the strategy of avoiding and minimizing waste at the source, recycling materials or using energy recovery, and as a last resort, disposing the waste after proper treatment to meet the standards set out by the regulatory bodies. This strategy will ensure efficiency and pollution prevention at every step, and thus avoid spending huge sums on clean-up at the discharge end.

- Each petrochemical plant should have its own 'Environmental Conservation Department', independent of the

operation and maintenance department, which should be responsible for overall activities in this area.

- The success in attaining environmental conservation will depend largely upon the attitude and re-orientation of the management. These can be stimulated by proper education, training and the creation of awareness within the industry.

V. THE PROBLEMS AND OBSTACLES TO INTEGRATION
OF THE PETROCHEMICAL INDUSTRY AMONG
ARAB COUNTRIES

60. It is useful to review some of the main obstacles hindering the success of integration of the petrochemical industry 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 the Arab countries' total trade in spite of the recent diversification in both geographical and sectoral terms. In 1989, 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.
- The absence of a common economic policy and the related industrial co-ordination, which would encourage and promote economic integration between the Arab countries.
- The limited role of the main economic actors, whether public or private, in the integration process in trade and industry: instead, government through its bureaucracy assumes a leading role in this context.
- The different stages of economic development reached by Arab countries and their structural imbalances as national economies.
- The limited development of local technological capabilities and the dependence on ready-made foreign technology packages, external consulting organizations and to some degree expatriate skills.
- The lack of adequate physical infrastructure capable of supporting the development of integrated petrochemical industry.
- The lack of technological support in the 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.
- Inadequacies in technical universities, training centres and human resource development institutions etc.

VI. SOME CONSIDERATIONS ON REMEDIAL MEASURES

61. The UNIDO Secretariat's preparations for the Regional Consultation, including both the analytical efforts and the Expert Group Meetings convened on the subject, have identified and recommended a series of measures to counteract the effects of the described constraints, among which are the following:

62. a) To establish a central data bank for chemical and petrochemical industries that will be at the disposal of the decision-makers in the Arab region and which will serve as a medium of co-operation and greater communication between Arab countries and other regions in the sector;

63. b) To establish a form of an Arab union, federation or association of manufacturers specializing in the chemical and petrochemical industries, similar to that of the Arab Federation of Chemical Fertilizer Producers;

64. c) To promote the formation of joint Arab companies (bi-lateral and multi-lateral) as a practical approach for integration;

65. d) To intensify the Arab countries' co-operation and interrelations on all possible levels with experienced international firms in industrialized countries, including joint-ventures, for the purpose of building up the region's marketing experience and of effectively opening routes for technology transfer;

66. e) To develop new process technologies of particular relevance to the Arab petrochemical industry through established R&D centres in the Arab region in co-operation with international process engineering firms;

67. f) To promote Arab downstream industries by introducing and expanding the use of their products in different economic sectors and by developing their markets, which, although still relatively undeveloped, are deemed capable of significantly increasing their absorptive capacity for all types of commodities, e.g., plastics, synthetic fibres and rubbers;

68. g) To examine closely the practical modalities for technology transfer of existing small- and medium-sized enterprises spread throughout the Arab countries for the purpose of accommodating downstream production units, for which machinery and petrochemical end-product manufacturing elements are supplied by industrialized countries and may require some modifications or alterations in their operating conditions for processing Arab petrochemical products;

69. h) To create appropriate incentives, e.g., barter, subsidizing, after-sale services, deferred payments and preferential conditions, that will not only encourage but also

promote and expand intra-Arab trade in petrochemical products and commodities;

70. i) To promote the production of the raw materials and intermediates required by downstream industries, particularly by those facilities already in existence which are the driving force for the expansion of basic and intermediate petrochemicals in the Arab region;

71. j) To carry out detailed and comprehensive market surveys for Arab petrochemical industry covering all marketing aspects at the national, regional, sub-regional and international levels;

72. k) To encourage and facilitate direct co-operation and co-ordination among the Arab petrochemical producers by taking all possible measures to remove the barriers hindering the transfer of goods, spare parts, supplies and other required inputs of co-operation, including exchange of operators and other technical personnel;

73. l) To secure availability and low price of the raw materials and intermediate products by exploring the advantages of free trade or low tariff zones in the exchange of petrochemical products among Arab countries;

74. m) To catch up whenever possible 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 by diversifying from emphasis on the production of traditional materials;

75. n) To harmonize regionally or subregionally the research programmes of Arab R&D establishments, whose activities are essential for a diversified petrochemical industry; this requires adequate funding in addition to qualified and well experienced staff and scientists;

76. o) To exert co-ordinated efforts towards the development of local and regional Arab capabilities in the field of engineering design in order to enhance process improvement, local manufacturing of equipment and product adaptation to suit local conditions.