



TOGETHER
for a sustainable future

OCCASION

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



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

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

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



19604

Distr.
LIMITED

ID/WG.524/2(SPEC.)
8 April 1992

United Nations Industrial Development Organization

ORIGINAL: ENGLISH

Regional Consultation
on the Petrochemical Industry
in the Arab Countries

Innsbruck, Austria, 22-25 June 1992

*iii, 111p.
tables
graphs*

**A STUDY ON THE STATUS AND
PROSPECTS FOR COOPERATION IN
THE PETROCHEMICAL INDUSTRY IN THE
ARAB COUNTRIES**

Discussion paper

Prepared by
the UNIDO Secretariat

V.92-53104

This report was submitted by Mohammad Al-Shukri, UNIDO Consultant, for the Regional Consultation. The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. Mention of firm names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

CONTENTS

CHAPTERS	Page
I. Introduction and summary	1
II. A brief review of the present status of the petrochemical industry in the Arab countries..	4
III. World petrochemical outlook	16
- Recent trends	25
- Future prospects	35
- Growing environmental awareness and its impact on the industry	39
IV. What makes petrochemical industry unique	43
V. Petrochemical industry and its intrinsic features for cooperation	45
VI. Changing pattern of the Arab petrochemical industry	46
VII. Problems and obstacles	49
VIII. Cooperation : The key to Arab petrochemical development	54
IX. Forms of cooperation	57
- Joint ventures	57
- Exchange of information and establishment of data banks	65
- Cooperation in financing and other forms of investment	66
- Trade relations	69
X. Levels of cooperation	71
- Cooperation at enterprise to enterprise level	71
- Cooperation on the national level	72
- Regional cooperation	74
- Global cooperation	75

CHAPTERS	Page
XI. Areas of cooperation	78
- Marketing	78
- Transfer of technology	82
- Research and development	84
- Engineering and manufacturing.....	88
- Operation, maintenance, environmental control, safety and training	90
XII. Formulae for cooperation	92
XIII. Conclusions	98
XIV. Recommendations for an integrated development of the petrochemical industry in the Arab countries	106

I. INTRODUCTION AND SUMMARY

It is an established fact that, besides the available funds, the main basic elements for developing the petrochemical industry, energy and raw materials, are abundantly available in the Arab oil and gas-producing countries. The total proven crude oil reserves of the Arab countries constitute about 65 % of the total world proven crude oil reserves; and the Arab natural gas reserves are estimated at about 21.3 % of the total world reserves in 1991-92, (tables No.1&2).¹ Moreover, while the estimated world reserves of crude oil are decreasing yearly because of the increasing rates of consumption (20-22 billion barrels per year)², the undiscovered crude oil reserves are, so far, centred around Iran and the Arab countries in the Gulf region, the United States of America and the Union of Soviet Socialist Republics, which obviously implies that the future prospects of the industries based on crude oil and its products will be concentrated in these regions. Nations rich in petroleum resources have historically shifted from export of crude oil to export of finished or semi-finished chemical commodities.

There is virtually no economic sector of our modern age which does not, in one way or another, use petrochemical products in its development. Moreover, the petrochemical industry has lately become involved in creating new products which not only compete with, but surpass, traditional materials such as commodity resins, elastomers, and engineering polymers which serve as excellent substitutes for metals, wood, and other construction materials in many applications. Polymers are also being used as glazing materials, panels, parts for transportation hardware, components of computers and other electronic devices,

¹ Arab Oil and Gas - Vol. XXI No. 488 - January 16, 1992

² Several Oil and Gas Journals, 1990, 1991, 1992

irrigation, and packing materials substituting paper and natural fibres. Synthetic fibres and rubber have now surpassed, in many instances, traditional materials in both performance and economy.

Arab oil and gas producing countries, especially after the increase of crude oil prices in 1973 and 1979-80, have set up ambitious economic plans for the development of their various economic sectors and subsequently the national economy as a whole, and for the resulting improvement in the standards of living of their nations which had, for a long time, been somewhat lagging behind. Thus it is evident that the petrochemical industry in the Arab region has become a vital element in the development of their economic sectors and the industrialization of the region. Moreover, the estimated future demand for petrochemicals in the Arab countries indicates that a number of petrochemical production facilities of varying capacities will be required to meet the expected increase in demand regardless of the currently estimated low per capita consumption rate.

In spite of the fact that the industry's technology originated in the countries of the developed regions, particularly Germany and the rest of Europe, the United States, and later Japan, and besides their possession of large markets, developed infrastructure, mature economy and availability of skilled manpower, etc., these countries have passed, during the development of the petrochemical industry, through a series of national domestic and international crises which exposed their industry to many economic difficulties where serious measures had to be taken to overcome these crises, maintain economical operation levels and protect them from any further collapse. Some of these crises are still very well remembered, particularly the serious economic recession in the early 1980s.

Among the most effective measures taken by these developed countries, besides the restructuring of the industry, was the increased role of coordination and cooperation on all levels and in many areas.

With the absence of national technology in the Arab region coupled with the limited market, lack of experience, scarcity of skilled manpower and inadequate infrastructure, it appears that the issue of coordination and cooperation in the field of petrochemical industry became not only useful but essential.

Moreover, the present world trends along with the rising of petrochemical industry in the Arab countries suggest that the region is highly potential, not only in respect to increasing petrochemical production facilities but also in growing rates of consumption, development of infrastructure, adoption of advanced technology and reinforcement of their marketing activities. The Arab countries have also become more aware of the grounds for their industry's problems, the required solutions and the indispensable need for closer cooperation among their countries and between them and other regions to face the increasing global challenges.

Thus, this paper was especially designed to indicate the competitive position of the Arab countries in the petrochemical industry, relative to the region and to the world from the point of view of raw materials and the potentiality of petrochemical production, and to offer a schematic presentation of the main topics concerning cooperation in the field of petrochemical industry including: forms of cooperation, levels, areas and mechanism.

As the various topics and aspects of the cooperation issue are so interconnected and closely related, it is realized that some repetition unavoidably occurs in various sections because of the nature of the topic. Naturally, when marketing is discussed, trade and experience are mentioned; and when difficulties are analyzed, the same matters may appear again. Accordingly, the author would like, in advance, to ask for your kind understanding of this occurrence.

II. A BRIEF REVIEW OF THE PRESENT STATUS OF THE PETROCHEMICAL INDUSTRY IN THE ARAB COUNTRIES

Many of the oil rich developing countries all over the world are shifting from the export of only crude oil to more value added oil products not only because of the pure commercial value of such products but also to develop their industrial capabilities, enhance the process of technology transfer and to supply their own growing domestic markets with the various petrochemical products which have become essential elements in the development of the different economic sectors.

Arab oil and gas countries have, in due time, realized the importance of this industry to their economic development and the urgency to utilize their natural hydrocarbon resources, particularly natural gas, by converting them to more valuable products.

Consequently, a number of Arab countries launched many significant world-scale petrochemical complexes, mainly in the second half of the 1970s and early 1980s, motivated by the following factors:

- Abundance of natural gas, most of which has been flared to waste;
- *Availability of funds, particularly after the oil price rises in 1973 and 1979-1980;*
- High international demand, especially for basic and intermediate petrochemical products, and the encouraging world prices of these products;
- The desire to produce more value-added products rather than only selling crude oil and oil products with lower profit margin;

- The Arab domestic market was a virgin market for practically all petrochemical products, particularly thermoplastics (the main five commodity plastics: HDPE, LDPE, PP, PS, and PVC) as well as synthetic fibres and synthetic rubber;
- The establishment of a considerable number of oil refining industries in the Arab region and the consequent production of naphtha, LPG and other petrochemical feedstocks;
- The desire to generally industrialize their countries, improve their economies and raise their standards of living.

Owing to these factors which prevailed in almost all Arab oil and gas-rich countries, particularly the Arab Countries in the Gulf region and North African Arab countries (especially Libya and Algeria), quite a few of these countries have as mentioned before, established many sound petrochemical industries in their regions. Excluding the production of nitrogenous fertilizers (ammonia and urea), the total installed Arab petrochemical production capacity amounted to about 11.62 million tons in 1990 (Table no. 3), besides several other ongoing expansions and newly planned future products.

In spite of the very short history of the petrochemical industry in the Arab region, this industry has accomplished an outstanding development in both the magnitude of production capacity of basic, intermediate and end-products involving some 30 or more various petrochemical materials produced in a large number of units spread around several Arab countries namely: Saudi Arabia, Algeria, Iraq, Libya, Qatar, Egypt and Bahrain. The majority of these projects are of world scale and up-to-date process technologies.

Saudi Arabians present capacity alone, is more than 7.5 million tons per year of different petrochemical products; and

with the already committed future plans, the total production capacity will amount to almost 11.5 million tons in 1995/ (Table no. 4)³. In fact, most of these added capacities will be in operation in 1993.

Other Arab countries are, as well, expanding their petrochemical industries. Bahrain planned for the construction of 300,000 tons per year MTBE based on its existing 400,000 tons methanol,⁴ Libya will add 80,000 tons of LDPE and 80,000 tons PP; and Algeria may jointly, with Libya, construct a 130,000 tons per year high-density polyethylene unit.⁵

Iraq, another major industrial country in the region has started the second largest petrochemical complex after Saudi Arabia to produce 420,000 tons ethylene, 160,000 tons polyethylene (different units), 90,000 tons PVC, 15,000-20,000 tons maleic anhydride, 245,000 tons propylene, 100,000 tons polypropylene and other aromatic products. Other Arab countries are also known to have planned the production of various petrochemical products at a lesser magnitude, such as Egypt, Kuwait and other Arab countries in the Gulf region. Besides these large petrochemical complexes, innumerable small-scale and downstream petrochemical industries based on imported or domestic raw-materials and intermediate products are spread around practically all Arab countries.

It is a normal phenomenon to notice that ethylene, ethylene products, methanol and lately methanol's main derivative, MTBE, have dominated Arab petrochemical production; moreover, these products naturally form the major portion of the Arab petrochemical production because Arab petrochemicals are mainly a gas-based industry, having the

³ Arab Oil and Gas Vol. XX No. 482, 16 October 1991

⁴ Chemical Week, 3 July 1991

⁵ Petrochemical industry in Algeria, A. Djellali - Technical Director ENIP, Nov., 1989.

Table No.1
Proven Crude Oil Reserves
(million of tons)

At 1st. January	1990	1991
North America	4,365	4,370
Latin America	17,056	16,596
Africa	8,026	8,204
of which: Algeria	1 255	1 260
Angola	276	284
Egypt	614	616
Gabon	100	100
Libya	3,110	3,123
Nigeria	2,183	2,342
Western Europe	3,111	3,054
Near East	90,142	90,767
of which: Saudi Arabia	34,783	35,618
United Arab Emirates	13,385	12,630
Iraq	13,642	13,699
Iran	12,668	12,719
Kuwait	12,895	13,292
Oman	580	589
Qatar	614	616
Far East / Pacific	3,076	3,594
Centrally Planned Economies	11,473	11,408
World Total	137,249	137,993
of which: OPEC	103,787	104,510
Arab Total		89,659
Arab % of World Total		64,97 %

Table No.2

Proven Natural Gas Reserves
at the Beginning of 1991
(billions of cubic meters)

Far East	7,396
Western Europe	5,174
North America	7,466
Latin America	6,852
Near East	37,468
Abu Dhabi	5,173
Saudi Arabia	5,246
Bahrain	177
Dubai	136
Iran	16,990
Iraq	2,689
Kuwait	1,517
Oman	204
Qatar	4,619
Ras Al-Khaimah	57
Sharjah	306
Syria	156
Yemen (North)	198

Table No.2 continued

Africa	7,860
Algeria	3,246
Angola-Cabinda	51
Cameroon	110
Congo	73
Ivory Coast	99
Egypt	351
Ethiopia	25
Gabon	14
Libya	1,217
Nigeria	2,473
Tunisia	85
Tanzania	116
Centrally Planned Economies	47,082
World Total	119,298
Arab Total	25,377
Arab % of World Total	21,27 %

Table No.3

Existing petrochemical facilities in Arab countries with

their production capacities as of 1990

1000 metric tons

Products	Algeria	Saudi Arabia	Iraq	Qatar	Libya	Egypt	Bahrain	Morocco	Total Arab region
Basic olefine									
Ethylene	120	1,970	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		300							300
Intermediats									
Ethylene glycol		650							650
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	560	105		95	160		40	1024

*) The development integrated petrochemical industry in the Arab region /UNIDO adjusted by the author.

*) Arab oil and gas ,December 26,1990.

Table 1 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</u>									
<u>fibers</u>									
Polyester f.						26.5			26.5
Polyamide f.						4			4
<u>Others</u>									
MIIE		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
									11.621

*) Ethylene dichloride intermediate is not added to the total.

Table No. 4⁶

**Saudi Arabia's Petrochemical Present Status and Future Capacity
SABIC's Present and Forecast Capacities, 1991-1995
('000 T/Year)**

Product	Present Capacity	Extension	Final Capacity
Ethylene	1,970	500	2,470
Ethylene Glycol	650	400	1,050
Ethylene Dichloride	560	-	560
Styrene	360	54	414
Industrial Ethanol	300	-	300
Vinyl Chloride Monomer	300	-	300
Propylene	-	300	300
Butadiene	-	100	100
Benzene	-	70	70
Polyethylene	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

⁶ Source: Arab Oil & Gas. Vol.YY No.482, 16 October 1991

advantages of low-cost feedstock. However, it should also be very normal to develop other areas of petrochemical production such as propylene and aromatics and their down-stream products because most of the Arab countries presently have large and well developed refineries, the source of LPG and naphtha, for the production of both propylene and aromatics, demand of which is continuously increasing. As a matter of fact, naphtha has been introduced in ethylene crackers in Libya, and propylene and polypropylene are being presently produced. Basic aromatics, particularly benzene and xylene are produced in Saudi Arabia and Algeria in relatively large amounts and further capacities are under construction to meet demand, yet still the downstream industries based on aromatic intermediates are not developed. Among the most important aromatic intermediates are terephthalic acid and dimethyl terephthalate, the raw materials for the production of polyester fibres; however, these chemicals are not yet produced in the Arab world in spite of their importance and need. Most of the aromatics-based industry in the Arab region presently depends on imported intermediates. However, the polyester raw materials are not the only important materials missing from the Arab petrochemical production matrix; products for manufacture of polyamide and polyacrylic fibres are as well not presently produced. The same situation also applies to synthetic rubber raw materials and other vital chemicals.

In spite of such an admirable accomplishment of the petrochemical industry in the Arab world, the industry, with no doubt, has faced many difficulties and constraints in different stages and on various levels. Moreover, the industry was basically designed according to each country's individual views and policies involving a very limited extent of coordination and cooperation. Also, the industry was either based mainly on the domestic market of that particular Arab country or was basically oriented for export to international markets. Thus, in most cases, production is either much more than the local market demand or too small to meet Arab domestic markets.

Another obstacle to development of the industry is that the various economic sectors utilizing petrochemical products are not yet developed; and the available market is too small to absorb the production, particularly in the absence of coordination and cooperation, elements which are considered to be vital to this industry. In addition, there are many other technical obstacles such as the lack of adequate marketing experience, availability of trained personnel, organized and functional R&D, adequate infrastructure and required technology.

Nevertheless, petrochemical industry in the Arab region has been progressively growing: product diversity has been expanded, many difficulties have been efficiently treated, a number of problems are being solved and experience has been deepened. And if the future of the petrochemical industry will not always be sparkling, there are many indications that it might at least be very promising.

Table No.5

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

1989-1990 Products	Production Capacity	Consumption 1990	Balance
Benzene	385	464	(79)
Toluene	26	46	(20)
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	-	-

- Figures in parenthesis mean deficit

Source: GOIC/AIDMO: "Production of aromatic compounds from Naphtha in the Arab countries", June 1988

Remark: 112 thousand tons under construction/no shortage

III. WORLD PETROCHEMICAL OUTLOOK

The sluggish United States economy together with European economic depression have certainly left their fingerprints on the chemical and petrochemical industry's growth as well.

The world economy had just started reviving at the end of the 1980s after a long period of recession which followed the two oil crises. Western Europe's average GDP was growing at more than 4.5% per year in 1987; however, by 1990, that growth dropped to 2.8% and is expected to decline further in 1991*. Meanwhile, in Eastern Europe, the economies are even more depressed, and output is expected to continue to fall for the next two years at least. Thus, it appears that a sign of possible repetition of the early 1980s' economic situation might be flickering on the world petrochemical horizon.

It is hard to say much at present amidst these changing events and instabilities. The standing situation carries both opportunities and risks for Western Europe in particular, Eastern European demand may increase, and the production of the developing countries will also increase, especially that of the Middle East region which considers Europe as its potential market. The question which puts Western Europe in a dilemma is whether or not they can compete with the Middle East producers in supplying the Eastern European market; or, in other words, would Eastern European countries be more attracted by Middle Eastern suppliers?

On the other hand, the Asian region, which once represented a large net importer of petrochemicals, is gradually becoming self-sufficient. The Japanese seem that they may be reconsidering their plans for building all the proposed ethylene projects in order to avoid extreme excess capacity. South Korea's underway and proposed projects will have a negative market impact on global petrochemical industry and on Japan in particular because a substantial amount of their products are

likely to be exported and will consequently compete with the Japanese existing market in China and other Far East countries. South Korea's ethylene capacity in 1988 was 500,000 metric tons per year and by 1993 is expected to reach 3.2 million - more than six times that of 1988. In contrast, Western Europe's ethylene capacity in 1993 is expected to be 1.2 times that of 1988; in the United States 1.3 times, and in Japan 1.14 times⁷.

On top of this, some large group companies with almost no experience in the petrochemical industry are also entering the business, constructing both upstream and downstream facilities, such as Samsung and Hyundai, which are each building 350,000 ton-per-year ethylene crackers to be finished by the end of 1991 or early 1992. South Korea's surplus ethylene is most likely to be exported to the United States rather than to Western European markets; and also an attempt to enter the Japanese market will probably be made.

Besides the Korean projects, others have been announced in the Asian region. Among them are two in Taiwan for a total of 850,000 metric tons ethylene per year; one in China at 380,000 metric tons; a second cracker in Thailand at 350,000 metric tons; a cracking capacity in Indonesia of 550,000 metric tons; and a cracker in Malaysia with 320,000 metric tons. This amounts to a total of 2.45 million metric tons per year of announced capacity, most to be operating in 1994-95.

Singapore, as well, is expecting an expansion of their petrochemical complex scheduled for 1995 at an estimated cost of \$ 1.5 billion. Besides more traditional petrochemicals, it will add new derivatives capacity; for example, as they announced, it will include engineering plastics and specialty fibres, aromatics and also specialty chemicals.

⁷ Chemical and Engineering News, 4 November 1991

As the petrochemical industry faces up to the economic depression in the West, a fundamental shift in power towards the Far East is beginning to make itself felt between 1991 and 1994, assuming that world wide production of ethylene will increase by a total of approximately 12.00 million tons between 1992 & 1995. Of this total 6.35 million tons (54%) will be built in and around the Far East region.

The logical assumption is that this extra production of ethylene and its derivatives will replace a great deal of material that is currently imported to Asia from America, Europe, and the Middle East. While in 1980 Europe and the United States accounted for 24% of polyethylene and 35% of polypropylene imports in Asia, today these figures are 17% and 25% respectively, and are set to fall further.

Saudis as well, will be forced to look more to the West, unless they will increase their cooperation with Asian countries to coordinate production and search for a firm market there. Table No.6 shows the present world ethylene capacity and the forecast for 1995.

Table No. 6 shows the world present ethylene capacity and the forecast for 1995.

World Ethylene Capacity 1988-1995 in million metric tonnes ^a					
Region/Countries	1988	1990	1992	1995	remarks
N.-America	19.34	20.60	24.30	26.30	
W.-Europe	15.47	17.40	18.30	20.43	capacity in 1993 is 19.53
E. Europe	7.19	7.55	7.93	8.75	
Japan	5.06	5.06	5.56	6.40	
TOTAL developed regions	47.06	50.61	56.09	61.88	
Asia	4.14	4.90	5.60	9.35	*)***)***)
Middle East and North Africa	2.9	3.39	3.45	4.97	
Latin America	3.0	3.7	4.2	4.4	
Total developing countries	10.04	11.99	13.25	18.75	
WORLD TOTAL	57.1	62.6	69.34	80.63	
Share of developing countries in per cent					
	17.58	19.16	19.11	23.25	

Note:

- *) China and South Korea will add to world capacity about 4 million or more tonnes of ethylene by 1994-1995 respectively (Alessandro Vitelli, Platts's Week/5, Sept, 2, 1991, London)
- ***) Oil and Gas Journal 26, August, 1991, P. 18
- ***) Conservation estimate for Asians ethylene capacity was taken, although forecasters estimate for 1995 exceeds 10.0 million tons.

^a Data compiled from the following sources:

- UNIDO: "Study on trends in technological development in the Petrochemical industry", July 1980
- European Chemical News, 25 November 1991
- Oil and Gas Journal, Oct.28, 1991 and Special Report 10 September 1990

As for the demand, it would be useful to indicate that forecasts by the Royal Dutch/Shell group show that Asia-Pacific oil demand will increase from 13 million b/d in 1990 to 15 million b/d in 1995. Only marginal growth is expected in Europe and North America during the same period.

In 1988, Asia-Pacific oil demand lagged the European Communities consumption of a little less than 12 million b/d. Within two years Asia-Pacific demand had shot up to almost 13 million b/d while EC recorded a little more than 12 million b/d. By 1995, Asia-Pacific demand of 15 million b/d will compare with about 12.5 million b/d in Europe. South Korea alone recorded product demand increases of 20-30%/year during 1988-1990.

Petrochemical growth will be equally dramatic and again leave Europe and the United States standing. Increase in Asia-Pacific demand for ethylene and propylene are forecast by Shell at 6% and 9%/year respectively. South Korean new ethylene plants will put supply-demand balance in the region into surplus up to 1995. The six new ethylene plants in South Korea which are expected to be onstream in 1992 will boost the capacity to 3.2 million tons/year from 1 million tons/year. These plants will turn Korea from a net importer of about 400,000 tons/year of ethylene into a major exporter to the United States and other Asia-Pacific countries. Figure No. 1 shows the comparison of ethylene demand in North America, Western Europe, and Asia-Pacific regions for 1990, 1995, and 2000; and figure No. 2 indicates the average increase of ethylene and propylene demand.*

With the start-up of eight major new crackers worldwide in 1991, the operating rate of ethylene fell, at the first

* Oil and Gas Journal, 26 August 1991

Figure 1: Ethylene Demand: N.America, W.Europe and Asia Pacific.

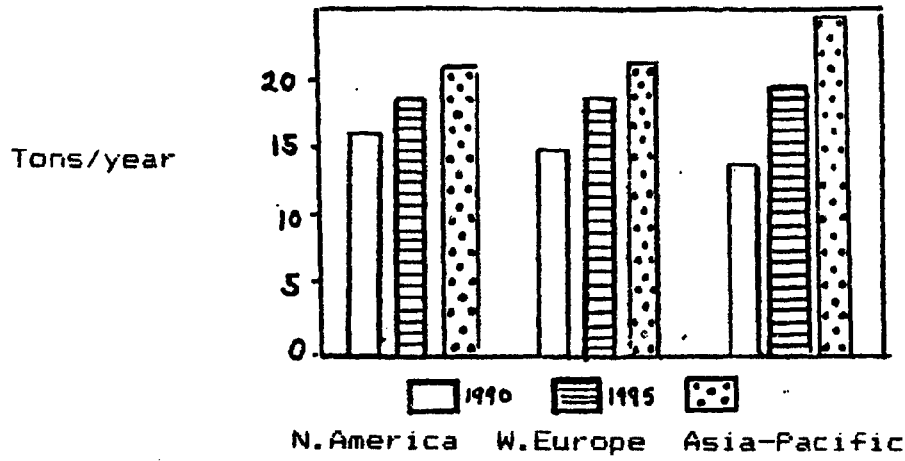
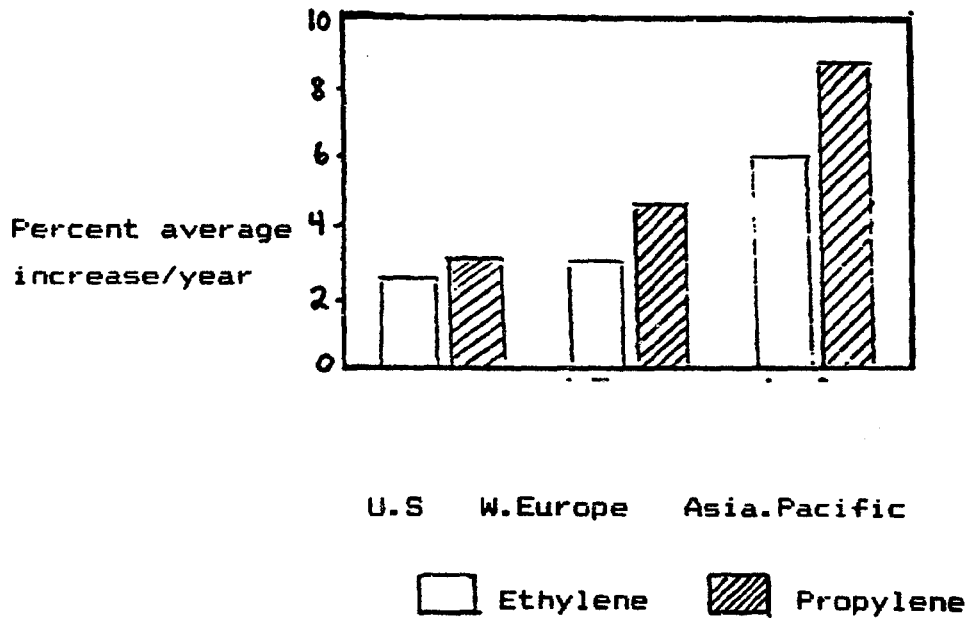


Figure 2: Ethylene and Propylene rate of growth (%) 1990 - 2000



quarter of 1991, in West Europe to the approximate rate of 84%.¹⁰; Figure No.3.

Olefin over supply from capacity expansion in Europe plus poor downstream demand has weakened the ethylene market; and together with the strong prices of naphtha, has brought the ethylene business to a critical level.

Today, Asia is virtually self-sufficient in ethylene as mentioned above and expected also to be self sufficient in ethylene's major plastics derivatives in 1994. Thus, the United States and Western Europe are gradually losing their foothold in the Far Eastern markets.

Saudi Arabia, the major petrochemical producer and exporter in the Middle East, sells a significant portion of their petrochemicals (about 25%) to Asia¹¹; and now they have to find other markets or closely cooperate with Asian countries by coordinating production strategies and arranging long-term supplies. Other Middle East countries such as Qatar, Iran and Iraq, with their expansion plans, will turn the region into a large petrochemical concentration area.

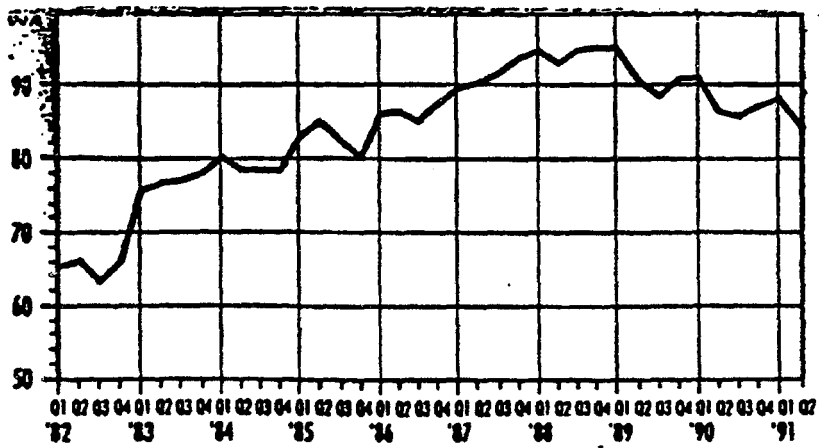
Qatar, with its new large complex scheduled to produce in 1993, will become another large petrochemical producer in the area; and Iran, which has the highest gas reserves in the region, may also occupy a significant position in the petrochemical industry according to their first five year economic plan.

Iraq is a great potential petrochemical producer with a large market and long industrial experience. Besides their first petrochemical complex which produces 120,000 tons

¹⁰ Chemical Week, 24 July 1991.

¹¹ "Changing patterns in global petrochemical trade", Alessandro Vitelly, PLATT's Week/5, 2 Sept.1991, v.4., No.35

Figure No.3

**THE RISE AND FALL OF WEST EUROPEAN
OPERATING RATES****(% of total nameplate capacity)**

ethylene, 90,000 tons polyethylene, and 60,000 tons PVC per year, they have already started the construction of another very large complex in 1989 to produce a wide range of petrochemicals using different feedstock (natural gas, LPG and naphtha).

Thus, the region will be greatly potential for export; moreover, the focus now is on Europe, which is still a net importer of ethylene and at the same time has the highest production costs mainly because most of its petrochemical industry is oil-based, contrary to the case of America and Saudi Arabia where most of their production is gas based. Saudi producers have fewer costs to cover and fewer local environmental concerns with which to deal, besides having virtually not enough domestic demand for their ethylene and derivatives; therefore they must market their out-put aggressively throughout the world. However, with the American and Mexican products, which have already made their way into Europe, they will find the market there somewhat more crowded.

Recent trends

Trends in plastics

Plastics in general did not escape the slip into the down-phase of the business cycle, but were affected with much less severity. Commodity thermoplastics (the major bulk of plastic materials) are within their traditional rate of growth led by polypropylene where growth rates show a higher average.

Linear low-density polyethylene (LLDPE), in most areas of the world, will significantly outpace other competing large-volume plastics such as low-density polyethylene and high-density polyethylene. New capacity is under construction at numerous locations. Often, this is :Swing: capacity that can be used to make either LLDPE or HDPE. ¹²

PVC's global demand is expected to grow at an average of 3.7% to bring the total world production to 26,36 million tons in the year 2000. Over the past several years, global demand for PVC has increased at 4 to 5% annually, bringing it to 18,2 million tons in 1990.

Specialty petrochemicals which were the fashion among chemical manufacturers in 1980 to retain higher earnings and because they are believed to be recession-proof products. These products are not exactly enjoying those days, but they are holding up well. Hereunder is a brief review of the developed regions' main plastics production status.

Western Europe

As for the commodity thermoplastics, there is a sign of improvement in the growing demand over the 1989 rate; however, polypropylene consumption led that of all plastics, with a 1990 growth of 12.5% in Western Europe, mainly due to the substantial

¹² C + EN, June 10 1991

increase in film use and in injection moulded parts for automotive and electric sectors.

Consumption of high-density polyethylene (HDPE), meanwhile rose 9.6%, low-density polyethylene use grew by 3.7%, LDPE homopolymer use was, however, relatively stagnant, while LDPE copolymers and linear low-density polyethylene (LLDPE) posted above average gains. Polystyrene consumption rose 6.6% and polyvinyl chloride (PVC), in spite of the continuing pressure from alternative materials, increased in virtually all markets including packaging, though only by 1.7%, ¹³ (Table No. 7)

Table No. 7

<u>Consumption of the Main Thermoplastics</u> <u>in Western Europe</u> ¹⁴				
Products	1989	1990	1995	Calculated on growth rate/year 1990-1995 ¹⁵
LLDPE	2.68	2.94	3.66	4.5%
LDPE				3.0%
PP				7.5%
PS				3.0%
PVC				2.0%

¹³ Modern Plastics International, January 1991

¹⁴ Modern Plastic International, January 1991

¹⁵ European Chemical News, 28 January 1991

USA

In the United States, the majority of plastics will continue their traditional growth in demand and production. Most sources forecast that this growth rate will be, however, lower than in the 1980's. High density polyethylene (HDPE) is expected to exceed 4.5 million tons in 1995 up from over 3.6 million tons in 1991, which is 30% of global demand which is about construction will allow capacity to grow and keep pace with, or exceed demand. Low-density polyethylene output is growing again in the United States after declining for several years as a result of the partial shift towards linear low-density polyethylene (LLDPE). Limited by capacity restraints, US demand will continue to increase, averaging more than 2% annually over the next five years, as other polyethylene now are seldom substituted for the low-density materials.

Linear low-density polyethylene (LLDPE) growth during the 1990's will be substantial but not similar to that of the last decade where demand jumped from less than 340,000 tons to more than 2 million tons (at an average annual growth rate of about 20%).

Polypropylene witnessed an average rate of growth around 5% in 1990, which is about 2 to 2.5 times the growth of gross national products. In 1990, United States demand for polypropylene was more than 3 million tons and by 1995 is expected to exceed 3.86 million tons; and U.S. export of propylene in 1990 was about 730,000 tons. This brought the total domestic and export demand to 3.73 million tons in 1990. The larger markets are in fibres and filaments, injection-moulded items and films.

In the next five years, more than 5 million tons of polypropylene capacity will be built outside the U.S.; and most of them will be in the Pacific rim region, currently an area of

high imports of polypropylene from the U.S. Thus export is forecast to decline at the rate of 9% annually through 1995.

Polyvinylchloride (PVC) has grown steadily since 1982, but it showed a slippage in 1991 and the output declined by about 3% from the 1990 output; but production is expected to recover. In 1990, U.S. output of PVC was estimated at 4.14 million tons and in 1991 about 4 million, down by 3%. Forecasters still see that North America will continue exporting PVC during the 1990's because of a cost advantage. Capacity is foreseen to be still short in the Asia/Pacific region, causing the region to be a net importer of PVC throughout the decade.

Polystyrene's production is falling slightly in the US for the third year in a row (1989-1991). In 1990 the production declined by 1.6%, but both production and demand are expected to grow in the future but not at the rate experienced earlier in the decade. It is forecast that the average annual growth rate for the 1990's in the US will be less than 2%. (Table No. 8).

Globally, polystyrene demand will grow 3.3% annually, and total demand will hit 12.3 million tons in the year 2000. Areas with rapid growth will be the Pacific rim, Eastern Europe, Africa and the Middle East.¹⁶

¹⁶ Chemical + Engineering News, 10 June 1991, P. 39-62.

Table No. 8

UNITED STATES
Production and consumption of selected petrochemicals

<i>Production in million metric tons</i>				
	1988	1989	1990	1991
Ethylene	16.0	15.88	16.63	15.68
Propylene	9.65	9.12	8.77	9.27
Styrene	4.08	3.69	3.59	3.36
HDPE	3.82	3.68	3.68	3.55
LDPE	4.73	4.91	4.91	4.68
PP	3.31	3.64	3.64	3.45
PS	2.36	2.27	2.27	2.1
PVC	3.8	4.05	4.05	3.88

Consumption (domestic demand) in million metric tons *			
	1989	1990	1995
Ethylene	-	16.63	18.95
HDPE	3.36	3.78	4.6
LDPE	4.41	4.91	5.9
PS	2.26	2.26	2.46
PP	2.80	3.03	3.86
PVC	3.49	3.87	4.2

Japan

Japan is a mature economy country with an anticipated GDP growth of about 3-4% annually. Currently, the Japanese government is influencing domestic economic growth through fiscal policy; and because the Japanese yen is expected to maintain its strength, such a policy is expected to continue through the 1990's. However, production of plastics showed no sign of slow-down. Among the commodity materials, polypropylene posted the most gains in 1990 over that of 1989 due largely to growth in injection moulding applications. The same trend is also seen in the engineering thermoplastics market.

Consumption in LDPE and HDPE are keeping their levels with World Methanol and MTBE (Methyl tert-butyl ether) slight increase in LDPE. (Table No. 8).

Table No. 9

Production and Consumption of Selected Petrochemicals in JAPAN
in million metric tons

Production			
	1988	1989	1990
Ethylene	5.06	5.6	5.8
Propylene	3.68	4.0	4.2
Styrene	1.76	1.99	2.06
HDPE	2.38	2.71	2.86
LDPE			
PP	1.56	1.72	1.89
PS	1.89	2.0	2.01
PVC	1.84	1.97	1.99

Consumption in million metric tons

	1989	1990
HDPE	0.91	0.95
LDPE	1.31	1.47
PP	1.72	1.93
PS	1.00	1.06
PVC	1.91	1.93

World Methanol and MTBE
(Methyl tert-butyl ether)

MTBE is one area of the petrochemical industry which demonstrated an abnormally high demand, particularly in the developed regions, holding a highly esteemed position in the chemical industry. It has been the fastest growing chemical of the 1980s, and it will likely continue to hold that distinction throughout the 1990s. In the United States, while the petrochemical industry continues its down-cycle, methyl-tert butyl ethers' (MTBE) increased demand is expected to average 25% per year by 1995 or further to the end of the decade. MTBE is now entering a new phase of dramatic growth in the US because of its use in reformulated fuels to meet requirements of the Clean Air Act. The current US MTBE capacity is estimated at 5.6 million metric tons and the announced projects will double capacity to over 14 million metric tons by 1995, although numerous other projects under construction could easily boost the total capacity to 22 million metric tons by the end of the decade. But even that may not be enough to meet demand if growth of MTBE continues at the expected rate.

In addition, more MTBE projects are being built and others are under construction elsewhere in the world, many of them export oriented such as Arab Gulf countries that will be looking to supply Europe and future US demands.

In Western Europe, as well, most countries have become near to the deadline for using leaded gasoline; thus MTBE demand will soar. Environmental awareness of air pollution caused by automobiles is growing in many developing regions and the use of MTBE will be eventual.

This boom in building MTBE is beginning to strain the methanol market and prices for methanol look set to rise; and methanol producers who hope to be able to meet their methanol demand (the main raw material for MTBE) from the world

methanol export oriented plants such as those of the Middle East, Southeast Asia and Latin America, met with the fact that many countries of these regions are shifting to produce MTBE or planning to do so. Thus, forecasters expect that the methanol market will soon move away from its current stagnation into a deficit due to rapid building of MTBE capacity. However, on a world-wide basis, methanol should be balanced for the majority of 1992 but tighten thereafter as a potential shortfall of over one million metric tons develops in 1993. ¹⁷

In Saudi Arabia, for example, besides SABIC's underway increase of the MTBE production capacity in its complex from the present 500,000 tons/year to 1.9 million tons/year scheduled for 1993, studies for the construction of three other units with a combined capacity of 1.8 million tons/year are being carried out, aiming for 3.7 million tons of MTBE in 1995.

¹⁷

Chemical Week, Andres Wood and Ronald Begley, 31 July 1991, p. 22-23.

- C + EN, 10 June 1991, p. 13

- Arab Oil and Gas Journal: Vol. XX, No. 482, 16 October 1991.

Benzene Markets

World benzene demand is estimated at 22 million tons in 1990 and will grow 3.8% per year to 26.5 million tons in 1995. No increase in demand is expected in 1991, however, a growth of 2.5% is foreseen for the year 1992; but demand will increase at an average of 5.5%/year during 1993-1995. The Far East/Asia region will demonstrate an increase of benzene demand of about 5.9% per year. Consumption in the US will increase by an average of 3% per year, in Western Europe by 3.2% per year and in Eastern Europe and South America will remain unchanged through 1993.

Global benzene capacity will increase to about 36.7 million tons in 1995, which is a 6 million increase since 1990.¹⁸

¹⁸ Oil and Gas Journal, 23 September 1991, p. 22

Future Prospects

In view of the frequent, numerous and dramatic world events which have happened and overlapped in a very short time and in such a sequence, it would have been quite difficult or almost impossible to have taken effective recovery measures at the right time to regulate the effects of this unavoidable impact.

As the wounds of the Gulf War are still bleeding and the after-shock continues to reverberate around the petrochemical business, Western Europe edges towards greater unity and the Soviet Union is being dissolved. Several new Soviet independent republics were born with their eyes glittering for free market economy; and Eastern European countries have marched their way through democratization. All of these events came at a time when the world is in a relatively serious recession cycle and the industry is suffering from transient overcapacity build-up, decrease in demand and poor returns.

Although it is quite premature to forecast with much accuracy the future of the industry, it seems evident that the steadily rising feedstock prices for European ethylene crackers, and the low prices of ethylene derivatives are forcing European ethylene producers to search for ways of reversing their losses. The cracker operating rates are expected to dip below 80% as ethylene capacity grows by over 20% over the period 1991-1993 and the tune of the early 1980s: cost reduction, plant closures and "mothballing", rationalization, alliance and joint ventures, integration of refinery operations and petrochemical production... etc., will be buzzing around the producers' ears.

Thus whatever the approach, the consensus among producers is that this sector of the industry is unlikely to see a return to happier times before 1993 despite the fact that demand for polymers is running at a reasonably good, but less than expected rate. For polyethylene, for instance, the growth in demand is forecast at 1.2% per year with a feeling that a return to the 3%/year level will not take place until 1993 at the earliest. Moreover, as long as Europe relies on naphtha cracking, a situation which is regarded as a serious weakness, it will continue to have the highest ethylene costs of any developed region. Naphtha supply is also expected to become tighter in coming years, with cost rising faster than other feedstock, which may even worsen the situation among European ethylene producers.

The US industry has the added advantage of flexibility of feedstock supply and at the same time possessing the plants and infrastructure to be able to take advantage of variations in price between ethane, LPG and naphtha. Production in the US is based on ethane (42%), LPG (29%) and naphtha (18%), while naphtha accounts for 70% of all ethylene production in west Europe and flexibility in using other feedstocks at most units is almost nonexistent. In fact, only five crackers in Europe have the capability to switch to LPG. ¹⁹

Japan, which is almost entirely dependent on Gulf sources for its naphtha and other petroleum products seems likely to face the greatest naphtha supply problems as a result of Saudi's plan to cut-down the total exports from 4.3 million tons to 2.7 million tons in 1992. Japan is also asking for lower naphtha premium which complicates their supply problems from both the Saudis and Kuwait which just started shipping their first 50,000 tons to Europe.

¹⁹ European Chemical News, 25 November 1991

Soviet naphtha exports had also deteriorated sharply in 1991; and the situation for 1992 remains quite volatile. Meanwhile, naphtha prices continued to fall, with the current European spot price around \$ 195/ton. ²⁰

Thus, both US producers using propane and ethane, and Middle East producers based on ethane, are able to petrochemical deliver materials to Europe in competition with European domestic producers, even with the lowest cost naphtha.

Cyclicalities in the global petrochemical industry is being aggravated by additional capacity from new producing sources such as Venezuela, Mexico, Thailand and Malaysia, and the new producers will have to consider relating investments to the timing of industry cycles, or face poor returns when start-ups occur just at the beginning of a worldwide downturn, as foreseen by Chem Systems, until mid 1990's. Traditional producers are also preparing for change in their strategies.

It seems also that the world petrochemical industry would be highly cyclical for at least a decade and that newly developing countries with substantial oil and gas reserves would find an important place in the industry, particularly the Arab countries and Iran in the Gulf region.

However, developing countries without substantial oil resources, such as Brazil, Taiwan and South Korea, have also become important petrochemical producers, indicating that possession of hydrocarbon reserves is not the only driving force in building a petrochemical industry.

Thus, the industry is becoming increasingly competitive everywhere and restructuring in the developed areas is eliminating smaller, high-cost producers, which historically have been responsible for propping up prices of many commodity

²⁰ European Chemical News, 9 December 1991

petrochemicals. Shutdown of such producers has flattened the cost curve for such commodities as ethylene and polyvinyl chloride, with corresponding lower margins for the more efficient producers.

Also, with competition now on a global basis, it has become necessary to develop global, not just regional, cost curves to assess pricing and likely future margins for the products. Consequently, traditional petrochemical companies are implementing vertical integration moves in order to compete better during the difficult parts of the cycle or going downstream closer to the consumer by making more value-added products.²¹

²¹ Quoted: Chemical Marketing Reporter, 11 November 1991, by Chem. System Mr. Peter H. Spitz

Growing environmental awareness and its impact on the industry

Mankind has become increasingly more acutely aware that the future is inseparably linked to the protection of the natural environment in which we live, particularly in regard to climatic changes, bio-diversity and the management of toxic chemicals and hazardous wastes.

Chemical industries in particular are greatly responsible for polluting the environment by releasing harmful substances to air, water and land. In developed countries, where the bulk of the industry is concentrated, the issue of environmental protection has been of great concern to all public enterprises and governmental levels. Numerous regulations have been issued in Europe, the US, and Japan for determining the allowable limits of effluent to be emitted to the environment and are continuously being amended with tighter restrictions aiming for a better balance between the environmental nature and the industries' disposal impact.

Among such newly issued environmental legislations are the Clean Air Act and its amendments in the US and Integrated Pollution Control (IPC) as a part of UK's Environmental Protection Act (1990) which introduced a radical concept giving the Industrial Pollution Inspectorate wide powers to control all manufacturing operations which involve release of "prescribed substances" to air, water or land. However, while these and other such legislations would, with no doubt, improve environmental conditions, their impact on the industries' costs, which hinge on the method of implementing the environmental control regulations, could not be easily overlooked. Thus, for some of the smaller chemical companies, the full implementation of these pollution control acts may determine their entire existence.

The unique nature of the petrochemical industry as a large producer of packaging and other disposable materials, particularly plastics which represent nearly 8% of municipal wastes in developed countries, requires the adoption of sound policies not only in the production side of the industry but also in the utilization and end uses of petrochemical products. It is very important to closely control the utilization of the suitable grades of plastics for the right purpose and to safely dispose of such materials. The concept of degradable plastics has been the core of these days' research and development activities where a great deal has been accomplished in the field of producing photo and bio-degradable plastic materials.

In developing countries, there has been a growing awareness of environmental effects of the petrochemical industry aggravated by the large number of processes and technologies imported from industrialized countries. A number of these countries have established sets of regulations for environmental protection from the industry's emissions; yet some of these regulations are either just duplicates of developed nations' rules which require modifications for the local conditions or they are being implemented at ease. However, adequate environmental guidelines on emission and released effluents should be adapted by the Arab countries where the petrochemical industry is rapidly growing with the following goals :

- to avoid the adverse effects on public health and environmental quality of the rapidly growing petrochemical production in the Arab region by the enforcement of adequate pollution control regulations. Such regulations would require the evaluation of possible environmental impact and public health effects of the different process operations of petrochemical production facilities, and the necessary measures to mitigate adverse effects.

- to assess environmental impacts by conducting surveys of the existing environmental conditions at plant sites including characterization of the volume of wastes, rate of flow, and the chemical, physical and biological characteristics of the generated waste, as well as handling and storage of hazardous wastes originating from the industry's different processes. Moreover, lists of the various processes which contain priority pollutants and sound technologies for treatments are available, but the core of the environmental protection process lies in the proper management and cooperative efforts between the governments and petrochemical producers as well as provisions for the high investment incurred.

The issue of pollutant release from the various industries and in particular from chemical and petrochemical process units is very large involving thousands of harmful and hazardous materials handled by various producers and environmental protection agencies, and could not easily be covered in this paper; however, some of the important specific measures to be taken in the Arab petrochemical producing countries as well as in developing countries, are briefly summarized as follows:

- The establishment of local institutional environmental protection agencies in each country.
- The assignment of a special department for pollution control and environmental protection in every petrochemical complex to closely monitor and control emissions as well as to insure the safety of the workers and the security of the plant against accidents.
- Minimization of the amount of waste generated, by selecting more efficient processes or modifying the existing industrial processes involved.

- Investigation of possibilities for the transfer of some of the solid and liquid wastes to other companies where they may be of use.
- Improvement of waste reprocessing techniques for the recovery of useful materials and the elimination of harmful disposals.
- Efficient utilization of the plentiful surveys carried out in other developed countries on the nature, levels and management of waste treatments and allowable disposals.
- Encouragement of cooperation regionally and interregionally to increase awareness of environmental effects and to assist in efficiently utilizing measures adopted by others.

Finally, it may be said that the environmental pollution problem is similar to human health in that prevention is always easier and less expensive than treatment; in other words, one ounce of prevention would be worth a sound investment.²²

²² Engineering and Environment Review Supplement, July 1991
Chemical Week, 2/9 January 1991
European Chemical News, 11 November 1991; July 1988
World Bank Technical Paper, No. 84
Environmental Conservation, Vol. 18, No. 2, Summer, 1991
UNIDO: "Environmental Study of the Petrochemical Industry", IS/568,
11 October 1985

IV. WHAT MAKES PETROCHEMICAL INDUSTRY UNIQUE

There is no industry in the world like the petrochemical industry that demonstrates such extreme changes in all aspects of technology, trade, and economy in such a short period of time. In the 1960's and 1970's, the industry witnessed large domestic markets, increasing strong demand, economies of scale, effective production, direct marketing (with little effort), high fixed costs, abundant organizations, high rate of return, abundant feedstock supply, ramifications in operation and products, and long products' life.

In the 1980's and early 1990's, the petrochemical scene reflected saturated markets, mature products, slightly increasing demand, technology rivalry, integrated production, a customer-tailored product trend, specialized marketing, long-term arrangements in feedstock, insignificant price increase, cost cutting, financial and loan arrangements, high investment, (fixed cost), high variable costs, low or moderate rate of return, concentration in operation, emergence of non-traditional producers, especially from oil and gas rich countries mainly from developing regions, change in locations, increased awareness of environmental pollution and control, rationalization and energy conservation trends, mergers, reduction in capacities, closure and shut-down, and shifting to higher value added petrochemical products (engineering plastics, specialty chemicals and composites).

Moreover, chemical and petrochemical companies in the developed regions (especially in West Europe and the USA) came closer to the oil majors to secure their energy and feedstock supply; and modes of coordination, cooperation and integration became normal trends among those companies which included unified trade policies, R&D activities, and shared infrastructure (such

as natural gas and ethylene pipeline grids), as well as the increasing trend of globalization of the industry in several forms, particularly the joint investment arrangements in both developed and developing regions. It was a common occurrence to observe joint investment in the developing countries with companies from developed regions and joint investments among or between developed countries; but recently, the industry has witnessed a new trend that developing countries are jointly investing in developed regions. Qatar, for example, is investing in France; and the Dalmia group (New Delhi) has become the first Indian enterprise to invest in Germany (former East Germany) with TFS (Thuringische Faser AG, Schwarza-Rudalstadt); in fact, the Indian firm took over TFS in mid-October, 1991.²³

In conclusion, it appears that the future of the petrochemical industry will be characterized by frequent up and down-turn cycles, which may contribute to the industries instability. Moreover, the petrochemical industry perhaps does need a move of new restructuring which is different in nature from the restructuring of the early 1980's.

Companies in the industrial nations are closing older plants and building new ones. They are also debottlenecking and retrofitting existing plants with the latest technology to increase feedstock processing flexibility, use energy more efficiently, increase product thruput, minimize plant and product wastes, and eliminate risks to personnel health and safety. Some companies are shifting their research, development, and marketing emphasis to focus on special niche markets. More producers are implementing quality programs, and some are entering into partnership agreements with customers, vendors and engineering-construction companies.²⁴

²³ Chemical Week, 6 November 1991, p. 7

²⁴ HPI Marketing Data, Special report: "Hydrocarbon Processing Industry", 1992,

V. **PETROCHEMICAL INDUSTRY AND ITS [REDACTED]**
INTRINSIC FEATURES FOR COOPERATION

Due to its complexity, high capital investment, great variety of products, need for high quality and intensive research and development centres and activities, developed infrastructure requirements (physical and human), need of wide experience in marketing, high technology and know-how, expensive royalty fees, experience in marketing, the use of different alternative feedstock and continuous process and product development as well as other aspects of this industry which involve design, engineering, required utilities, adequate capabilities to manufacture and fabricate equipment, and the impact of this industry and its products on the environment and safety from both social and economic aspects, the petrochemical industry lends itself more than any other sector to national, regional and interregional cooperation, particularly with regard to production sharing both on horizontal and vertical levels as well as marketing, besides other conventional areas of cooperation.

VI. CHANGING PATTERN OF THE ARAB PETROCHEMICAL INDUSTRY

As a rule, Arab petrochemical industry is a gas-based industry having both the advantage of low-cost feedstock and the disadvantage of limited product diversification, a phenomenon which enabled many Arab petrochemical products to compete with the international market; however, in the meantime, many important products domestically required for the manufacture of presently imported commodities are missing from the Arab petrochemical production matrix. For instance, in spite of the realized need for the synthetic fibre industry and synthetic rubber because of the increasing demand, there is practically no production of the intermediate petrochemical products required for these industries; and almost the same case applies to many other productions such as propylene and aromatic based petrochemical products (with the exception of Libya's naphtha-based ethylene cracker). However, Arab countries have become aware of this problem and have begun to take into consideration the use of naphtha and other feedstock for the production of propylene, butadiene and aromatics.

Moreover, most of the Arab petrochemical production is oriented for export to international markets more than for the development of the domestic downstream industries.

The petrochemical industry in Arab countries is also characterized by an obvious lack of coordination in production capacities and types of production, resulting in either much over capacity or far less than is required by the demand. Coordination between the different economic sectors and the petrochemical sector or between the petrochemical industry and refineries in any individual Arab country is either very weak or doesn't even exist, a situation which delays the process of

developing the indigenous market and hinders vertical integration respectively.

Among other features of the petrochemical industry in the Arab region are:

- The Arab domestic market for practically all of the petrochemical products is not yet mature; and per/capita consumption is very low in most commodity plastics compared with the developed regions' average consumption) a case which implies a considerable market potentiality.
- In spite of the huge production of petrochemicals in the region, intra-Arab trade in this industry is almost negligible.
- There is a considerable scope of joint-venture arrangements in the field of petrochemical industry between some Arab producers and foreign firms from developed regions in many areas: joint construction, joint marketing, joint management, ..etc., which greatly contribute to mainly the horizontal transfer of technology.
- Arab petrochemical products have remarkably stepped into international markets inspite of all the difficulties and obstacles deliberately created by the developed markets to discourage the flow of Arab products and to protect their producers.
- Like most of the other developing regions, Arab petrochemical industry is entirely based on foreign technology both in process know-how and construction. However, Arab engineers, the technical manpower, and trained operators have been actively involved in the operation and maintenance of their petrochemical plants and the gradual substitution of the foreign personnel as time goes by and experience is increased.

- In spite of several R&D centres in the Arab countries involved in the petrochemical and fertilizer industry, still their activities could not show a noticeable presence in the development of the industry. It may be too soon to see much of a contribution, yet it is so important to continue the efforts, increase the budgets and intensify cooperation with the world developed regions and technical institutions. Without efficient R&D activities, the industry will remain depending on the industrialized countries' technology.

VII. PROBLEMS AND OBSTACLES

Arab petrochemical industry, in general, is encountered with three main problematic issues: one is connected with the marketing and its related intricacies; the second is tied up with the lack of technical capability and the methodology of technology transfer; and the third is the issue of the lack of serious and genuine coordination and cooperation nationally, regionally and internationally. All other secondary problems such as training, lack of adequate infrastructure, limited manufacturing capabilities...etc. which are so often repeated in practically all studies and surveys on the status and development of the industry in developing countries, would gradually be solved during the progress of the industries' development and the overcoming of the main problems. Moreover, these secondary problems are simply related to industrial development as a whole, and would be resolved in parallel with the development of the other economic sectors and the whole status of the economy of each Arab country.

As for the three main issues mentioned above, the focus has been placed on them simply because these problems are not normally solved just by a matter of time or could easily be overcome through a purchase of package technology or licence agreement arrangements. These issues are of an entirely different nature, being greatly dynamic, cost intensive, and requiring long experience and serious attempts.

The first issue, that of marketing, stands as a main problem because it determines the whole economy of any industrial project, involves many aspects and requires lengthy experience and a high degree of skill.

Marketing skill, for instance, is not just a commodity to be purchased or a set of instructions to be learned and followed

Marketing skill, for instance, is not just a commodity to be purchased or a set of instructions to be learned and followed in all cases and at any time. For example, it can not be expected that each different petrochemical product could be marketed, from one Arab country to another Arab or any other country from the region or the world with the same strategy, or be facilitated by the same conditions at every time.

This example, however, simple as it may be, clearly represents the dynamic nature of the marketing process with all of its interrelated variables.

In short, the major issues of marketing difficulties in the petrochemical industry in the Arab countries are centred around the following:

- Limited size of the domestic markets for basic and intermediate products because of the slow development of downstream industries and the very low per-capita consumption.
- Lack of adequate marketing experience and skill.
- Severe competition in the international markets.
- The increasing role of new forms of trade (counter-trade) in the world. This trade constituted about 8% (or \$US 155 billion) of the world trade in 1984 against only 2% in 1976. Moreover, these kinds of trade transactions are very complex; and their real extent, and accurate data concerning them are not very often publicly released. They include many forms, such as classic barter, counter-purchase, offset (similar to counter purchase but mainly used in dealing with the government and usually connected with aircraft and military equipment), and buy back (also a form of counter trade which involves industrial projects

such as steel mill, aluminium smelter, or transport-vehicle projects.²⁵

- Trade barriers, whether among Arab countries themselves or international trade barriers of a tariff and non tariff nature additionally created to discourage the export of Arab petrochemicals to developed markets in particular.
- Lack of cooperation and coordination in the strategic industrial plans of Arab countries as well as the absence of such cooperation inter-regionally.
- Lack of adequate facilities for easy transport of products, storage, and distribution.
- Weak, if not absence of, after-sales services.

The second form which presents another major obstacle for the development of the petrochemical industry in the Arab region is related to technology in general, whether it be the lack of domestic technological capabilities, or the most important side of it which is the method presently practised in the transfer of technology.

In spite of the effectiveness of the means followed by some Arab countries such as Saudi Arabia and Qatar in the process of technology transfer through establishing various joint venture arrangements with the well experienced and specialized companies from different developed regions, such methods, although greatly contributing to horizontal transfer of technology, will have very little effect on the vertical transfer. Other forms followed by some Arab countries, such as process licence agreements, operation and management, and supervision of construction, erection and commissioning of petrochemical plants do, as well.

²⁵ ESCWA-UNIDO-AIDO, "Trade in industrial strategic commodities petrochemicals and fertilizers in the Arab world", 13 December 1987, p.64-66.

contribute to the technology transfer process, but to a relative extent.

The most important aspect of technology transfer, however, is the vertical transfer of technology which forms the spine of real and consolidated technology in any region. Such a technology transfer process could only be performed and nationalized to suit the local conditions and to lead to self-dependence through serious and efficient R&D activities.

Such a process will naturally require a great number of elements; and on the top of the list are highly qualified scientists and well-trained personnel, besides all other related facilities such as sophisticated equipment, laboratories, pilot plants and reliable sources of information with well developed engineering and design organizations and local manufacturing capabilities as well as the existence of the petrochemical industry itself.

Since these technical infrastructures would require a great deal of investment and a relatively long time, particularly the human resources, it goes without saying that cooperation becomes a very important factor by which the burden of costs would be shared and resources could be pooled to accelerate the process of technology transfer both horizontally and vertically.

The third main problematic issue is the cooperation itself, which, in fact, forms the core of this paper and will be analyzed in further detail in the subsequent paras. However, a brief glance at the present status of the Arab petrochemical production and their future plans obviously reflects the absence of any satisfactory level of cooperation, even within the plans of each individual country. Every Arab country possessing the elements for building a petrochemical industry seems to plan its industry based on its own individual vision and on the particular country's strict economic policy. Moreover, it appears that often little regard is given to other Arab countries' markets,

their industrial capabilities, other economic sectors, and above all to the matter of product diversification.

Possible cooperation with the regional countries is as well seemingly not receiving much consideration, particularly the Asian countries which form a potential ground for cooperation in many areas, especially those areas which are causing many Arab petrochemical producing countries some difficulties. In fact, a number of Arab petrochemical problems could be resolved through such cooperation, especially in the long term supply of raw materials and intermediate products as well as different types of technical assistance.

VIII. COOPERATION: THE KEY TO ARAB PETROCHEMICAL
DEVELOPMENT

The issue of cooperation, coordination and integration as applied to the petrochemical industry in the developing countries in general, and lately in the Arab regions as an effective means for the development of this industry, has been one of the important issues of many local and regional organizations involved in industrial promotion and economic development in these countries. Moreover, this issue has become one of the major concerns of some international organizations and in particular the United Nations Industrial Development Organization (UNIDO) which has convened regional meetings, published many papers, and organized fora for experts in this field.

On the national level, the vast number of petrochemical product applications suggests a great potentiality for activation and acceleration of development of the various economic sectors such as agriculture, construction, health, food, clothing, shelter, transportation and in almost every wake of life and human activity, thus contributing to the well-being and elevation of the standard of living.

Cooperation on the Arab regional level as well, is essential for the implementation of world scale plants in the region, making use of the high potential of the integrated Arab sub-regional and regional markets. On the other hand - by its very nature - the petrochemical industry lends itself in a very suitable way to vertical integration - from the source of raw materials through to the end products and right to the downstream processing industry. In addition, cooperation offers numerous advantages technically and economically for the cooperating parties on different levels and in many areas such as, but not limited to, exchange of experience, transfer of technology,

market development, improvement of design and engineering capabilities, etc.

The recent evolving world situation, particularly the unification of the European market in 1992, the unity of the North American market and the rise of ASEAN (The Association of Southeast Asian Nations) as well as the restructuring of the world petrochemical industry in the developed countries in forms of mergers, greater levels of specialization and integration naturally leading to greater market control, creates more need for Arab countries to drive themselves towards further cooperation among themselves as a region and internationally in order to safeguard their industry and secure the future of its development.

In realizing the interest, gains and benefits of the cooperating parties emanating from the process of cooperation in any form or at any level, notable attempts have been made among Arab countries in the line of possible cooperative arrangements in the field of the petrochemical industry; however, very limited cooperative accomplishments have been materialized apart from the formation of the Gulf Petrochemical Industry Company in Bahrain (a joint venture among Saudi Arabia, Kuwait and Bahrain) and the establishment of the Arab Company for Detergent Chemicals to produce alkylbenzene in Iraq, a joint Arab Company in which some eighteen Arab countries have been involved directly and indirectly, and the recent Algeria-Libyan agreement on polyethylene-polypropylene product specialization in addition to other joint venture arrangements which cite promising examples of successful forms of regional cooperation. Moreover, there are also several regional organizations in the Arab countries which have exerted a lot of effort and have played quite an active and important role in promoting Arab cooperation and coordination in the petrochemical industry such as the Arab Industrial Development and Mining Organization (AIDMO), the Organization of Arab Petroleum Exporting Countries (OAPEC), the Gulf Organization

for Industrial Consultation (GOIC), the Gulf Cooperation Council (GCC), The Arab Maghrib Union (UMA) and the Arab Economic Council; however, the reality of only a moderate achievement in this field may be attributed to the fact that too much has been expected too soon.

On the level of international cooperation, the several joint venture agreements and activities between some Arab countries, and certain well known international companies could be indicated as practical and successful means of implementing such international cooperation, especially those involving joint ventures on marketing and plants' equity sharing bases.

However, with the repeated world economic recession, the rise of petrochemical feedstock prices, particularly naphtha; the flat profitability of most of the bulk petrochemical basics and plastic materials and the increasing globalization of the industry, further future cooperative movements between the Arab region, the source of raw materials, and the industrialized countries, the source of technology as well as among Arab countries themselves, are certain to appear in the near future.

IX. FORMS OF COOPERATION

Cooperation among Arab countries in the field of petrochemical industry could be expressed in various ways and forms, the materialization of which would offer effective tools for the development of this industry in the region and for the resolution of long-standing problems obstructing the progress of the industry. Among the possible forms of cooperation are joint ventures, exchange of information and experience, efforts to strengthen inter-Arab trade relations including exchange of petrochemical products at different levels of processing, cooperation in research and development (R&D) and transfer of technology, financing, and other various forms of investment and marketing strategy.

In view of the obvious need for intensive and strategic cooperative activities in the industry, the present paper attempts to analyze some of these various forms of cooperation to serve as a guide line for any possible or feasible means of implementation in the development of the petrochemical industry in the Arab countries.

Joint Ventures

Joint ventures simply are sorts of joint activities which reflect joint interests or complementary interests of two or more different parties and are usually expressed in setting up a commercial organization (s) to carry out an agreed economic activity over a long period of time.²⁶ Through several studies and surveys conducted by a number of specialized organizations, firms and experts including UNIDO studies, joint venture

²⁶ UNIDO: "Survey and Analysis of Joint Venture Arrangements in Petrochemical Industry", 10 October 1985

arrangements were found to be one of the most effective forms of long term cooperation. Because of the joint and complementary interests of such arrangements, financial burden will be shared, capabilities will be gathered and experiences will be exchanged.

Thus, joint ventures have become increasingly important to the petrochemical industry, particularly for the developing countries which seek access to technology, markets and managerial experience. These facilities are normally offered through the joint venture agreements, particularly with the developed countries' partners which can dispose such experience and technology. Joint ventures among developing countries including those arrangements within the Arab region would not reflect less importance than joint ventures with the developed countries ; because this form of cooperation among developing countries including the Arab region in particular, would facilitate, through the nature of this process and mutual interest, the flow of information and exchange of experience, the lack of which was greatly responsible for many mistakes committed by the new producers in the region due to inadequate information on the other developing countries' past experience and the similar problems and mistakes which they have encountered . Moreover, joint ventures among Arab countries from the developing regions would offer many opportunities; such as; access to each others' markets, close examination of available design, engineering, R&D, and manufacturing capabilities to facilitate the exchange of operational and maintenance experience, possible supply of feedstocks, exchange of basic, intermediate and final products as well as conducting joint feasibility studies on petrochemical industry and/or any of its sectors in the region . Also, they could, through the close relations created by the joint venture, formulate a joint policy to deal more efficiently with the developed market whose interest is not always concerned

with the principles of developing the petrochemical industries in other regions. Above all, joint ventures, in general, lessen the risks of the industry and serve to build confidence.

To this effect of joint ventures, some Arab countries have accomplished quite a few successful arrangements among themselves as well as between them and other international corporations from the developed countries. Saudi Arabia has taken the lead of the region in the accomplishment of wide scale joint venture arrangements with a number of well-known international firms and on different levels: joint investments, joint marketing strategies, and managerial and operational agreements, etc., through which Saudi Arabia has successfully built several petrochemical complexes and admirably conquered a great deal of the international market. A few other Arab countries have as well concluded similar arrangements but to a much lesser extent.

Since this paper is not exclusively dealing with the issue of joint venture surveys in the Arab region, detailed information or full coverage of Arab joint venture arrangements will not be extensively presented; nevertheless, some examples of Arab joint venture arrangements will be reviewed, especially those experiences of Saudi Arabia and Qatar which represent joint ventures with multinational companies besides some examples of other Arab-Arab joint relations. Saudi Yanbu Petrochemical Company (YANPET) was the first major Saudi petrochemical company formed between the Saudi Basic Industries Corporation (SABIC) and Mobil Chemical Company (U.S.A.) with 50/50 capital participation. It was signed on April 19, 1980 to produce ethylene, ethylene glycol, linear low density polyethylene (LLDPE) and high density polyethylene (HDPE) and was commissioned in 1984. Saudi methanol Company (ARRAZI) in Al-Jubail Industrial City was established in November, 1979 as a joint venture between SABIC and a Japanese consortium led by the

Mitsubishi Gas Company at an equity ratio of also 50/50 percent each, to produce chemical grade methanol, and was scheduled to produce in 1983. In fact, commissioning was ahead of schedule, and the first shipment of methanol was exported to Japan in April, 1983. Moreover, these were not the only joint venture establishments concluded by SABIC; a few others were implemented as well, namely Al-Jubail Petrochemical Company (KEMYA), a joint venture between SABIC and Exxon Chemical Company (U.S.A.) to produce LLDPE , Saudi Petrochemical Company (SADAF), with Pectin Arabian Ltd., an affiliate of Shell Oil Company (U.S.A.) to produce ethylene, ethylene chloride (EDC), styrene, crude industrial ethanol and caustic soda, National Methanol Company (IBN SINA), a joint company between SABIC and both Celanese and Texas Eastern of the U.S.A. with a production capacity of 2,100 metric tons of chemical grade methanol. Eastern Petrochemical Company (SHARQ) is another joint venture company between SABIC and a Japanese consortium led by Mitsubishi to produce LLDPE and monoethylene glycol; and the other joint venture company which was mainly oriented to produce polyvinylchloride (PVC), a commodity which is consumed on a large scale in the Kingdom by many plastics processing industries such as the National Plastics Company (IBN HAYYAN). This company was established relatively late at the end of 1983, contrary to all others which were founded in 1980-81, and it was concluded between SABIC and the LUCKY GROUP of South Korea. In addition, Saudi Arabia has also formed other joint venture companies to produce methyl tertiary-butyl ether (MTBE), butadiene, and butene -1 with Neste Oy (Finland), AGIP (ITALY), and Al-Khobar (Saudi Arabia) based Arab Petroleum Investments Corporation (APICORP).

Qatar is an other Arab country which was also involved in establishing a joint venture company, Qatar Petrochemical Company (QAPCO) with CdF Chemie (a subsidiary of the French firm Charbonnages in 1974 to produce ethylene and low density polyethylene.

Qatar General Petrochemical Company (QGPC) has also cooperated with CdF Chemie in a joint venture for the establishment of Copenor Petrochemicals Plant at Dunquerque (France) for the production of ethylene and LDPE which started its operation in 1979.

On the level of Arab-Arab joint venture arrangement, what has been done indeed is very little and the joint Arab petrochemical establishments are lagging far behind any ambition compared with the existing opportunities for any type and scale of joint petrochemical plant between or among Arab countries, particularly those countries who belong geographically to one region. The Gulf Petrochemical Industries Company (GPIC), a joint venture owned by (PIC of Kuwait, SABIC of Saudi Arabia, the government of Bahrain " the host party " and the Arab Company for Detergent Chemicals in Iraq in which some eighteen Arab countries have participated directly and indirectly in its establishment), represent practically the only joint Arab petrochemical companies in spite of their relatively small sizes and limited product varieties. GPIC produces 1,000 tons/day ammonia and 1,000 tons/day methanol, both based on Bahrain natural gas as feedstock. SABIC will market the methanol while PIC of Kuwait will take care of the ammonia marketing. The Arab Company for Detergent Chemicals produces 50,000 tons linear alkyl benzene, 8,000 tons toluene and 3,000 tons heavy alkyl benzene per year.

Other serious attempts for Arab joint ventures may be materialized between Arab countries in North Africa's Arab region, particularly the plan of Libya to establish a joint project with Algeria for the production of 130,000 tons of high density polyethylene per year in Algeria; and another joint venture between the two countries is to produce 80,000 tons polypropylene in Libya.

Moreover, several substantial studies have been performed by some Arab organizations concerned in the field of petrochemical industry such as the Arab Industrial Development and Mining Organization (AIDMO) and the Gulf Organization for Industrial Consultation (GOIC) through which significant surveys for the Arab opportunities to cooperate in establishing joint venture plants in the Arab region were clearly displayed and supported with all available information, type of production, raw materials, recommended location and preliminary investment cost, ready for any further steps of detailed feasibility for implementation. Although little has been accomplished so far, still there is a high degree of optimism regarding the benefit and utilization of these studies and the probability that the proposed number of these projects will find their way to realization in the near future.

Problems and obstacles facing joint-ventures among Arab countries:

The problems and obstacles facing the promotion of joint ventures among Arab countries are, in general, similar to those factors hindering cooperation among the developing countries, with some exceptions which are connected with the availability of raw materials and investment funds where Arab oil and gas countries are better off. Thus, the difficulties viewed as obstacles to the development of further cooperation and formation of Arab-Arab joint ventures may, for the most part, be categorized as follows:

- Differences in the Arab economic strategies;
- Lack of sufficient information on the different Arab countries' economic and industrial planning;
- Lack of marketing information;
- Trade barriers and restrictions on the flow of goods and experts (personnel) among the Arab countries;

- Limited loan extension and other financial facilities to the Arab countries which are short of finances but which have a potential market for various petrochemical products.

Joint ventures with foreign partners are mainly hindered by:

- The fear of some Arab countries of foreign partners' conditions of the joint ventures which are likely to imply long term control of products marketing, requirements of low cost raw materials, imposing the use of their materials, chemicals and/or other supplies from their own or their affiliate plants in their countries or elsewhere, and the possibility that they might link their joint ventures to some kind of oil or other natural resources supply on soft terms.

- The second important area of differences between the foreign partners and Arab countries (as well as with any developing country) is the issue of matching these countries' plans for diversification or expansion with foreign partners' interests which may likely either fall beyond their technological field or against their market interests.

- Another problem facing both partners of the joint venture is the extent of managerial involvement, where foreign partners usually lean towards acquiring a larger share because of their intensive experience; on the other hand, developing countries are anxious to be more involved in managerial and marketing activities, perhaps as a status symbol or because of internal regulations of particular Arab or developing countries which do not allow such foreign domination.

In regard to technical matters, such as technical assistance and operation management, it seems, from different actual experiences, that disagreements are likely to be less; and if any, differences could be easily solved in most cases.

- Among the most common points of conflict in joint ventures are situations which are connected with developing countries' government policies, where sudden legislation may be issued that changes the commercial environment, such as new pricing of raw materials, imposing minimum limit of capital share, and altering the percentage of ownership, by which foreign partners would lose their real incentives for cooperation, because these elements were what had formed the main attraction for entering the joint venture.

- There are a few other points of which the developing countries might not be well aware at the time of signing the joint venture agreements, such as the suitability of the foreign technology employed which should be well established (i.e neither obsolete nor unusually sophisticated) and not in any way encourage further dependence on the foreign partner's interests or industry. Moreover, related technical points should be well examined on time in order to eliminate future problems in the interpretation of the agreements, stipulations and intentions.

In spite of the difficulties elucidated above, joint ventures, whether among developing countries or between developing countries and foreign partners, in particular form one of the most effective and practical means for the development of the petrochemical industry; and these arrangements would certainly contribute to:

- Transfer of technology;
- Training of personnel on operation and maintenance;

- Deepening marketing and management experience;
- Enhancing the exchange of information;
- Facilitating utilization of indigenous resources;
- Leading the way to the establishment of advanced R&D centers pending the desire of the developing countries and the extent of willingness of the foreign partners.

Exchange of Information and Establishment of Data Banks

Adequate and reliable information is most essential to all forms of cooperation at any level. In order to make cooperation possible, it is fundamental that a proper information network system be created to serve not only the cooperation process among Arab countries alone but also the promotion of cooperation between Arab countries and other regions.

Such a network should be accessible to all countries, producers, consumers, and other beneficiaries in the region such as financing organizations, design and engineering establishments, equipment manufacturers and centers of excellence (R&D), etc. Such networks or any information center should also be designed to facilitate the flow of information to and from the developed and developing countries' regions to increase the awareness of global opportunities for any possible route to cooperation in the petrochemical industry. Without adequate information concerning the nature and sizes of markets, technologies and trends, planning of petrochemical projects would suffer many difficulties and face more problems, some of which could have been avoided if adequate knowledge of others' experiences had been available.

In fact, many errors have been committed by new producers in developing countries as well as in some Arab countries because of

lack of information on the experiences of the countries which started their petrochemical industries at an earlier date, especially in regard to choice of proper technology, sizes of plant units and required utilities, manpower and training, and the extent of outside expertise needed, etc.

Therefore, it is a prerequisite for the establishment of sound petrochemical industry in the Arab region that an effective system for securing adequate and reliable information be established, and that such information be continuously reinforced and updated. In fact, there exist, within the Arab region, several data collection centers, various substantial studies and surveys and other information sources on industry in general and on the petrochemical industries in particular ; yet they are still not well organized or connected with other centers; and most of them lack up-dating to serve as a satisfactory base for comprehensive information. Thus, closer cooperation is the tool for gathering these efforts and establishing a sound data base for Arab petrochemical industry.

Cooperation in financing and other forms of investment

Petrochemical industry is known to be characterized as a capital intensive industry. The costs of the plants are high, the infrastructures require tremendous expenses and the marketing will not be successful without great investment in establishing distribution centers and performing intensive research. Thus, the financial aspects, with no doubt, are very important parameters in shaping up the industry, not only for investment in new capacities but also in respect to other supporting function areas which differ from one region to another. These principles are not only very essential for Arab countries and other developing countries alone; but they are also as important to the developed region. In fact, financial and technological capabilities were among the most important factors in enabling developed countries to command the

international lead of the petrochemical industry. Recalling the early 1970s oil shake up and the sudden and drastic rise of oil prices in 1979, the whole structure of the international petrochemical industry was changed, the cost of feedstock and energy increased, the demand decreased and the profits declined. Petrochemical corporations in developed countries, in counteracting these changes and in order to safeguard their interests, have taken a number of measures in response to these changes and their impact on the industry by applying the so called "restructuring process"; and new forms of investment (NFI) were adapted.

Petrochemical companies in the developed regions moved to establish closer relations with oil majors and national oil companies to cooperate with them in terms of joint ventures in order to secure their feedstocks supply and to maintain a good level of commodity production. Among other measures taken by these companies were: encouraging new regional gas/crude oil discoveries, gaining access to suppliers other than OPEC's countries, and internationalization of investment. Consequently, the bulk of petrochemicals and thermoplastics capacity in developing countries since 1975 has been built through the new forms of investment (NFI), as a strategy in response to the global changes in profitability which occurred in the 1970s.

This example was cited mainly to reflect the importance of the financing element in shaping the industry's structure and determining its merits even in the most developed countries. Available cash flow and other financial facilities (soft conditional loans and credit) will not only facilitate the good performance of the petrochemical projects' implementation, but also allow freedom of choice of production facilities, suitable and well-established technologies, and promote marketing of products in regional and international markets. It also allows extension of export credit to consumers in the targeted markets whether in the Arab region or other sub-regions to promote the expansion of the

related downstream processing facilities leading to further development of the industry in the region besides the value of marketing the petrochemical products themselves.

As for the issue of cooperation in financing and other forms of investment within the region of Arab countries, it became evident that a wide scale of financial facilities has to be extended for the establishment or the expansion of the petrochemical units in other Arab countries which suffer financial shortage. Such financial facilities could be in the form of investment, cash, or supply of petrochemical products in order that a sizable amount of bulk petrochemicals from the main Arab producers could be absorbed in those countries with a large market and limited financial capabilities, a process by which petrochemical consumption base will be expanded, markets will be developed and the whole industry will be firmly founded in the region.

The national development objectives of the Arab region as a whole should be considered by tolerating the fact that commercial profitability might not always be maintained as a prior prerequisite for financial commitments to petrochemical projects in certain Arab countries. Thus, a minimum level of sacrifice has to be considered in the form of extending credit facilities to Arab countries where such credit would ultimately emphasize the further development of the industry in the region and where long term return is inevitable.

In conclusion, it is of great interest for the Arab region to cooperate financially in any possible means: joint ventures, extension of soft conditions, and long term loans, and/or subsidizing raw materials and intermediate products in order to establish a sound industry in the region and to promote the marketing of their products as well as to enable the region to formulate unified policies that could overcome the difficulties and obstacles normally placed by the traditional international firms

against the development of the industry and the marketing of their products in the international market.

Trade Relations

The issue of trade movement among the Arab countries in general is very well realized; and it has been of great importance to the highest levels of authorities concerned, in the Arab region. Emphasis on its importance has been repeatedly stressed; and several serious decisions have been taken to facilitate, expand and promote trade flow among the Arab countries, including those decisions regarding the removal of trade barriers. Nevertheless, very little has been accomplished in spite of many available opportunities. The reasons for this situation appear to be rather complicated; and the measures to overcome these difficulties, from the practical point of view, would require an extensive effort for coordination and cooperation over a long period of time. It appears that the matter is not connected with the pure commercial interests of the parties involved in the trade movement in the different Arab countries; but that the difficulties are mainly related to the Arab countries' various economic policies. Thus, facilitation of the trade movement among Arab countries would require intensive coordination of their production planning programs to suit the interests and the future plans of all countries involved. This will, of course, require the establishment of specialized organizations through which negotiations, exchange of ideas and discussions aiming to clarify all aspects of the trade issue would be held. Subsequently, satisfactory solutions to this problem would finally be found on the basis of in-depth studies and consultations.

Internationally, petrochemical trade is dominated mainly by developed market economies, which continue to block the routes of other countries' products to their markets by the employment of all

possible difficulties and obstacles such as tariff and non-tariff barriers.

It is noticeable that there are significant import/export activities of petrochemicals in many Arab countries; but regrettably, most of these import/export movements are performed with countries other than Arab countries, a case which may be attributed to the situations mentioned above in addition to other reasons connected with pure commercial motives where a particular Arab country could import intermediate and finished petrochemical products at much lower prices than those imported from countries of Arab origin; while others feel that imports from a developed market are facilitated by extended loans or proximity to the developed region for transportation cost saving.

In conclusion, it is inevitable that creation of a proper environment for promoting the trade movement among the Arab countries, starting simply with the removal of trade barriers and the extension of financial facilities in forms of long term loans or sales on deferred payment terms, including export of petrochemicals to other Arab countries on a subsidy basis would have to be seriously considered in order to elevate the level of the intra-Arab trade movement.

X. LEVELS OF COOPERATION

As it was mentioned before, there are many possible kinds of cooperation at different levels in the petrochemical industry . Cooperation could be performed to different extents at the following levels:

- 1) Enterprise to enterprise;
- 2) Country (national);
- 3) Regional;
- 4) Global (international).

Cooperation at enterprise to enterprise level

This type of cooperation is usually performed directly between different enterprises which are mostly independent from the general economic policies of the relevant countries of these enterprises. Moreover, it is commonly practiced among the companies in the developed regions; and the most important type is cooperation in the production capacities and vertical integration in order to maintain a profitable utilization rate for the petrochemical industry.

Such a level of cooperation could also be of particular importance among the petrochemical organizations in Arab countries in order to increase awareness of the available petrochemical establishments and the related service as well as to examine the possible areas of cooperation which may be performed with the least level of consent from the different governmental authorities, such as training, and exchange of information, chemicals and common spare parts, etc. It also seems, from the available information, that this level of cooperation is not widely practiced among the Arab petrochemical establishments. In order to enhance such cooperation, it would require, at least, some sort of channeling system among the different Arab petrochemical companies that

would facilitate easy contacts in order to examine the feasible areas of cooperation. Perhaps, the creation of even a club-level system where petrochemical producers from different Arab countries could meet and exchange opinions would be a good start.

Cooperation on the (Country) National Level

On the country level, a clear strategy for cooperation and integration of petrochemical industry should be the first step for the development of the industry as well as for further regional and global cooperation. Moreover, institutional organizations in charge of such coordination are found also to be especially effective for the elaboration and application of the countries' policy of cooperation. In spite of the fact that the nature of the petrochemical industry lends itself to coordination and integration with other sectors and scientific institutions on the country level, there is a general trend in most of the Arab and developing countries that this level of cooperation is likely to be given less attention; or, in other words, is not viewed as being sufficiently active for the promotion of the industry within the country itself. Important economic sectors within the country such as agriculture, building, construction, communications, food industry, pharmaceutical and others are all potential areas for different types and qualities of petrochemical products consumption which, through efficient coordination and cooperation with the petrochemical sector would expand the volume of consumption and invite the production of specialized and tailor made products to suit these different sectors and their various application needs.

Close cooperation and coordination among the various scientific and technical institutions, universities, laboratories, design and engineering establishments and R&D centers are as well a prerequisite for the development of the industry; but regrettably,

in most Arab countries such coordination is not demonstrated at promising levels to serve as effective tools. Efforts may have been made for the establishment of these industry-backing foundations and significant investments are spent, yet these efforts are lacking sufficient coordination to be fully utilized for the development of the industry. Some horizontal integration may be noticed within the country, expressed in the expansion of petrochemical capacities by building new similar production units; but vertical integration has been much less practiced, even within the petrochemical establishment itself, and between petrochemical plants and oil refineries in particular.

Finally, government bodies could play a significant role in creating some specialized consultation and institutional organizations to command the coordination, cooperation and integration of the different local activities and continuously demonstrate their progress.

Regional Cooperation

Regional cooperation is a level of cooperation which usually takes place between or among countries from neighboring regions.

Many developing countries have gained quite a long experience in running petrochemical plants and have achieved a relatively high level of skill in operation, maintenance and marketing. Some of these countries have, as well, expanded their own creative research and development projects which could serve as a promising ground for initiating joint cooperation between these countries. Objectives are nearly the same, which mostly center around the utilization of their natural resources, commitment to industrialization and general economic and social development. Also, common problems and difficulties in the development of the petrochemical industry in these countries are mostly of the same

nature apart from some financial differences as mentioned earlier.

Thus, cooperation among countries of a region brings many benefits to their petrochemical industry by many means, including exchange of information and experience, training of personnel, supply of raw materials, intermediate and finished products, and the formulation of a mutual arrangement for more effective R&D activities; and above all, the chance for countries which have recently started their petrochemical industry to avoid most of the mistakes and overcome many of the difficulties which have been faced by the older and more experienced producers. ²⁷

²⁷ UNIDO: "International trade and the marketing of petrochemicals", the third consultation on petrochemical industry, Vienna, 2-6 December 1985

Global Cooperation

Technology, marketing experience and financing form the backbone of any sound petrochemical industry in any region without which the industry could practically not survive. The developing countries, as a rule, depend on foreign technology from the developed regions for the manufacture of petrochemical basic materials as well as their conversion and downstream facilities. This phenomenon also holds true in regard to technical back-up from the licensors or contractors for the efficient, safe, and on-spec-operation of the petrochemical plants.

International trade of the industry is also dominated by developed market economies, and the petrochemical markets are to a great extent controlled by these countries.

In stating such absolute facts, intention was certainly not to underestimate many developing countries' capabilities, but to indicate the importance of international cooperation in the absence of which transfer of technology could not be efficiently performed and marketing experience would not be deepened. Thus, international cooperation is of vital importance to the establishment and development of the industry in the developing countries in particular because of their potential hydrocarbon resources and availability of finances which constitute, with imported technology, the three pillars on which the industry could stand.

International cooperation (which customarily implies cooperation between developing countries and developed countries, (or what is so called South/North cooperation) is usually driven by factors of attraction which developing countries could offer or which the developed partner in the cooperative arrangements could obtain, namely, but not limited to, access to low cost raw materials, utilization of some advantageous rules and facilities through which the developed countries could promote their products

in the developing countries' markets, obtaining soft conditions loans from oil and gas rich countries, and even linking some of the favorable terms of oil supply to the process of cooperation, etc. It is a reciprocal process and involves mutual interests. Through cooperative arrangements, Arab countries will have access to major companies' advanced technology, management techniques, marketing skills, operation and maintenance experience including environmental and operational safety.

In spite of the obvious advantages of cooperation with the developed countries in the petrochemical industry, there exists a series of problems and ambiguities, concerning, in particular, the following issues:

- optimal utilization of indigenous raw materials;
- capital cost structures of different areas of cooperation particularly in technology;
- operation, maintenance, and technical back up characteristics;
- responsiveness to local market potential;
- socio-cultural adaptability;
- series of technological continuity;
- sectorial integration in the overall economy;
- limitations of genuine transfer of competent technology;
- different views on marketing strategies.

Nevertheless, the acquisition and transfer of overseas technology, in spite of its imperfections, has traditionally represented the only mechanism for implementing the industrial aspirations of the developing countries.

In regard to the Arab countries, the region has been the center of attention for industrialized countries' firms, particularly transnational petrochemical companies, since the Arab countries

took control of production and pricing of crude oil in 1973; and a great boom of investments in building many grass root plants and modern infrastructure was started in the region. Following the second rise of oil prices in 1979, many giant and international size petrochemical projects were considered; and steps for implementation of some complexes had already been taken. Moreover, the Arab region presented a completely new and different set of conditions than those in the other regions, a situation which offered a variety of incentives to attract large international petrochemical companies and construction firms for closer cooperation and collaboration with the potential Arab countries for the realization of petrochemical development schemes. Thus, several international firms were involved in different types and extents of cooperation in the Arab region.

The plants built were mostly based on the latest technology, capacity, construction methods and operational technique; however, the greater part of the production consisted of primary and intermediate petrochemicals which were oriented for export, which calls for emphasis on intensive cooperation, particularly in marketing their products. Hence, quite a few sets of joint venture agreements have been concluded between some Arab countries and several international firms in this respect.²⁸

²⁸ UNIDO: "Survey and Analysis of Joint Venture Arrangements in the Petrochemical Industry" (ID/WG 448/4) 10 October 1985, p.9-15

XI. AREAS OF COOPERATION

Many opportunities in several areas of the petrochemical industry are available for all levels and forms of cooperation among Arab countries themselves and between them and other regions. The extent of cooperation and its relevant importance is different from one area to another pending many factors such as genuine willingness, extent of development of these areas in the Arab region and their rank of priorities. However, several of these areas of cooperation will be reviewed hereunder, starting with the most important and vital area which is uncommonly felt to occupy the top of the list: that of the issue of marketing.

Marketing

Arab petrochemical plants, as a rule, were designed basically as export oriented industries; and until sufficient downstream units are constructed in the Arab region to absorb the majority of the basic and intermediate petrochemicals, which will take quite a long period of time, it appears that a sufficient portion of Arab petrochemical output will continue to find its way to the international market, mainly in the developed regions' markets such as Japan, U.S.A. and Western Europe which are still constituting the major consuming markets in spite of being the major producers.

Upon examining the international market in view of the current economic slow-down, particularly in the U.S.A., and with the emergence of new petrochemical producers from countries besides the Arab region such as, Mexico, Brazil, Libya, China, Thailand and South Korea, which are becoming major producers of petrochemicals, it appears that marketing of the Arab petrochemicals is now facing an added burden over the usual difficulties. Practically all new producers are focusing on developed regions' markets for the export of their products. The United States deficits will

naturally be supplied by the neighboring countries (such as Canada) because of the advantageous cost element over those from Arab countries, assuming that the production cost conditions are the same.

The European region, because of its geographic proximity to the Arab world and its very large and accessible market becomes virtually the natural market for Arab petrochemical products assuming that only ethane gas-based Arab petrochemical plants are able to charge less and to produce and deliver to Western Europe on a variable/marginal cost-basis. However, on a full cost basis (assuming favorable conditions of European production cost) such a difference in production cost is narrowed. The cost advantages of Arab petrochemical products over those of European naphtha/LPG based petrochemicals was very true when the crude oil price was exceeding \$U.S. 30/bbl. At present, with the fall of the price of crude oil to, or less than, \$U.S. 20/bbl which is expected to last through the first half or more of the 1990s, the gas based variable/marginal competitive advantages have been minimized if they are not already eroded. This, in addition to the restrictions put by EEC countries (including tariff barriers and export ceilings) to protect their local industries, places a great deal of pressure on the Arab petrochemical producers to seek and establish other markets in which they could dispose their products. Therefore, there is no option left for additional markets other than the potential developing countries where at present only limited cooperation in this field has been achieved because of the many difficulties and obstacles encountered concerning realization of fruitful cooperation with the regional developing countries. These difficulties may be attributed to mainly: financing, lack of technical and marketing experience, different political and economic structure and lack of experience in similar cooperation.²⁹

²⁹ ESCWA, AIDMO, ESCWA: "Trade in industrial strategic commodities", (ID/87/15) 13 December 1987

In addition to this and to the recent vying of the challenging markets for Arab petrochemical producers (W. Europe, Japan and U.S.A) by other relatively non traditional producers from the Far East, South America and Canada, as mentioned before, the set of economic conditions which promoted the establishment of the export-oriented Arab petrochemical industry in the late 1970s and the early eighties are quite different now. This situation calls for not only the expediency of Arab countries making a strategic review of their overall trade policy for the establishment of a firm presence in the world market, but also to thoroughly review the policies of the existing plants and their envisaged plans.

Moreover, the reality of the emergence of one European market in this year (1992) , the effective unification of the North American market, the increasing consolidation of the ASEAN market, and the recent development of CMEA markets make such a policy review on a regional Arab level even more imperative.* However, based on the factual regional and international developments, certainly the prevailing situation brings up the significance of cooperation towards a search for possible formulae that would offer the Arab petrochemicals a right of way to international markets. It may require a combination of all levels of cooperation, regional and international.³⁰

The Arab petrochemical industry appears to be entering a new era; and further production strategies, marketing research and studies, and examination of more effective forms and levels of cooperation will have to be expediently considered. Nevertheless, at present and until the Arab and other regional markets will be developed, joint efforts with international specialized firms from

³⁰ ASEAN - Association of South East Asian Nations.
CMEA - Council for Mutual Economic Assistance.
Discussion paper for the first preparatory meeting on regional consultation on petrochemical industry in the Arab countries, Vienna, 26-29 September 1989

developed regions, whether in the form of joint venture or any other kind of marketing cooperation arrangement, claim priority ; and subsequently other feasible forms of cooperation with the regional developing countries may very possibly be born, even in the shape of triangle cooperation which could synchronize the elements of technology and marketing experience of the industrialized countries, together with the Arab petrochemical production capabilities and their available hydrocarbon resources, and the potential markets of the regional developing countries, particularly those countries with relative advances in technology (engineering, operation and some equipment manufacturing).

Such an attempt would bring us back to the issue of the factors hindering cooperation (mentioned elsewhere in this study), particularly the lack of adequate and reliable information.

In summary, marketing of petrochemicals would simply mean how to profitably export the various products to regional and international markets by a practical and efficient means so that the local market could be expanded and consumption increased. As for the issue of export to the developed market, cooperation should be centered around lowering the trade barriers of both tariff and non-tariff nature coupled with some sort of reasonable incentives for the developed countries' cooperative parties. Removal of trade barriers between Arab countries and other regional developing countries could, first of all, facilitate the process of interregional cooperation and open the door for new opportunities. Developing countries from neighboring regions would welcome interregional cooperation initiatives because they are desperately in need of petrochemical raw materials (basic and intermediates), and often their financial capabilities are limited. However, they do have some advantages over the Arab area in their larger market, relative experience in operation, engineering, and R&D, cheaper labor, and availability of reasonably good physical infrastructure for building a number of downstream industries.

Transfer of Technology

This area of cooperation concerning transfer of technology is, to a great degree, limited to cooperation with the developed regions where the origin of technology has been initiated and developed over a long period of time and tremendous cooperative efforts in research and development, as well as very high investments have been spent. However, there has been an appreciable degree of technology transfer which took place through the process of cooperation among some developing countries which have achieved a relatively advanced level of industrialization.

Technology transfer is not merely an event; it is a process of achievement; and as one examines the various elements of that process, it becomes obvious why effective technology transfer is not so easy. There are a number of essential elements determining the efficiency and degree of technology transfer such as type of technology, the degree to which it is indispensable, effective implementation, positive attitudes, and the sense of investment.³¹

It is, above all, a process which is highly "human oriented" and requires the understanding and cooperation of both the source of technology and the recipient during all phases of the project and at several staff levels within each organization. Cooperation during all phases of project implementation presents opportunities for promoting the technology transfer process: planning, design, project management, procurement, construction, commissioning and operation.

³¹ "The Petrochemical Industry, gateway to acquisition of high technology", Robert F. Raymond-Uop-, 22 September 1982

Also, it must be remembered that the high technological capacity of the industrialized countries has been built through a continuous process over a long period of time and it cannot be transferred overnight or transplanted in other regions; it is rather to be developed in its own cultural and socio-economic environment, once a base is found.

Nevertheless, through different forms of cooperative arrangements, an appreciable amount of technology has been transferred from developed regions to some developing countries and has been well adapted to its environment. Among the different arrangements for technological transactions are: the package licensed technology and the relevant services, detailed engineering design of equipment and hardware, procurement, erection and commissioning of the plant and the supervision of normal operation, maintenance and training during the early years of the plant's operation.

In a few developing countries, some capacity may be found to perform specific functions related to these technical activities, i.e. the design and fabrication of some equipment, civil engineering works, project execution management, etc., which forms, in many cases, a good mode for cooperation among developing countries.³² And last but not least, it is worthy to mention that the joint venture arrangement in the implementation of the different phases of a petrochemical project may offer the best opportunity for technology transfer provided that an active involvement of the recipient should start right from the first steps of the project's implementation. Nevertheless, whatever cooperative form would be taken for technology transfer from the industrialized region, attention has to be given in any relevant agreements to safeguard the interests of the developing countries

³² UNIDO expert group meeting on international cooperation on petrochemicals, Vienna, 19-21 September 1984

and to assure that the relevant cost is to be reasonable.

It is also to be understood that such a type of transaction will mostly involve the horizontal transfer of technology which has only insignificant implication and influence on the vertical transfer of technology processes within the particular developing country. R&D activities are the pioneers for vertical transfer of technology; moreover, they form the backbone for developing licensed technologies and their adaptation to local conditions and requirements.

Research and Development

It is needless to mention the importance of research and development activities in the petrochemical industry, an industrial sector which is scientifically based and technology intensive. It requires both processors and producers to take provisions to keep abreast on a continuous basis with the rapid technological developments involved in this industry.

Today, more than ever, world progress and the well-being of any nation depend on scientific and engineering innovations and

inventions. The pace of scientific development and new inventions is so rapid that the present modes attempted for the transfer of technology from industrialized countries to developing nations will certainly not be sufficient to sustain the durable development of these countries unless they are backed by sufficient research and development of their own.³³

Many European petrochemical producers have been lately involved

³³ OPEC/UNIDO/Opec Fund Seminar - Vienna, March 7-9, 1983: "Opportunities for cooperation among developing countries for the establishment of petrochemical industry", p.33

in advanced new technologies such as genetic engineering or the development of new industrial materials and composites. Also, the European chemical industry out spends most others in its R&D investments. More than U.S.\$ 8 billion a year, amounting to 4% of the sales turnover, is spent on research and development work.³⁴ Europe's future as an economic power will, in fact, depend to a great degree on the scientific advances currently being made in the laboratories of the chemical and petrochemical companies.

Besides the very high costs incurred in the development of R&D activities, they require sophisticated equipment and other hardware, highly qualified scientists, well-trained personnel and a good design and engineering ground supported with other adequate facilities such as reliable sources of information, scientific and educational institutes, and manufacturing capabilities, besides the existence of the chemical and petrochemical industries themselves in order to be able to perform meaningful basic scientific research, long-term development of process technology, new products development, and the search for new applications.

R&D's objectives are also extended to various other activities such as ensuring smooth operation of the production and utility units, saving in energy consumption, investigation of alternative raw materials and feedstocks, monitoring the industry's pollutants emission including both its effect and control, improving and stabilizing the quality of products, and offering solutions to the industry's various technical problems as well as its role in the selection, assimilation and improvement of technologies.

Such requirements would be much beyond any petrochemical company in the developing countries and even beyond the capabilities of most developing countries themselves. Therefore,

³⁴ APPE - Petrochemical: "The key to European high technology", 1987-88

the role of the governments comes more into effect in this regard, where they could actively allocate an appreciable fund and extend facilities in other required infrastructures (physical and human). In fact, a great deal of R&D activities in the developed countries were accomplished through the giant chemical and petrochemical companies' cooperative efforts supported with serious and genuine backing by their various governments.

There do exist within the Arab region an appreciable number of R&D centers and quite reasonable scientific institutions as well as some infrastructure, especially human (intellectuals with advanced degrees in engineering and other scientific fields); but these facilities are poorly organized, not adequately supported with required infrastructure, and their objectives are not clearly defined.

The proper development of R&D in the Arab region urgently calls for closer cooperation, first on the national level and at large among the potential Arab countries and finally with other neighboring developing countries. The pooling of resources of several Arab countries and other regional developing countries would assist in overcoming most of the restrictions mentioned above, and would provide a wider scope of activity and more incentives for the joint R&D establishments. Cooperation in R&D would also lift some of the financial burdens on individual companies, countries, and establishments by spreading the cost over a number of relevant organizations or countries.

In addition, it should be mentioned that in the Arab region as well as in the developing countries, the role of governments in the R&D sector is crucial, since many petrochemical companies simply cannot afford to possess "state of the art" laboratories and analytical and technical services, pilot plants and testing facilities, etc.; in many cases, the organization of back-up facilities and systems can only be state-sponsored or even

state-owned.

Finally, it should also be remembered that R&D activities in the Arab region and the other developing regions are to be as well oriented as to suit the local requirements, environmental conditions and producers' and consumers' needs .

Engineering and Manufacturing

A number of developing countries, notably in Latin America and Asia, have acquired a certain amount of indigenous project-engineering expertise. In some cases, local contractors are able to provide services comparable to those offered by foreign groups and at lower costs because they normally charge much less per engineering hour. The experience of EIL (Engineer India Limited) could be cited as a very close example. Moreover, these countries often have a definite advantage over outsiders because they are familiar with local conditions; and many have enough experience to buy the equipment they need directly. This situation as well holds true in regard to the manufacturing capabilities of a number of developing countries, particularly in the production of non-sophisticated equipment such as low pressure heat exchangers and boilers, water and fuel tanks, general purpose steel structures, small and medium-size service pumps and electric motors, different carbon steel pipes and fittings for water supply, sewage, and process water disposal, etc., thus offering numerous opportunities for cooperation concerning the acquisition of the various needs.

Items such as those mentioned above constitute roughly around 30% of the total cost of the hardware of a chemical or petrochemical plant if they are purchased within the total cost of a turn-key project.³⁵

In some Arab countries, such capabilities are, as well, being considerably developed and could be utilized cooperatively to bring many mutual technical and financial benefits to the Arab

³⁵ Based on actual experience of the author in supervising the implementation of a number of ammonia-urea complexes on a turn-key basis.

engineering and manufacturing firms as well as to the petrochemical producers, and at large contribute to the firm establishment of the industrial capability and well-being of the region.

Cooperation with other developing countries in the region whose engineering design and manufacturing capabilities are relatively far advanced, would certainly contribute to the development of capabilities of the lesser technically advanced countries, open other cooperative opportunities among the countries in both regions, and ultimately narrow the gap between developing regions and the developed countries in this field.

Thus, both regional and interregional cooperation are particularly effective among the developing countries in such areas because the practice of this cooperation would be independent from the ties of multinational companies and could jointly be developed to suit the local environment and purposes, contribute to procurement experience, as well as being safe in cost.

Operation, Maintenance, Environmental Control, Safety and Training

It goes without saying that most of the Arab petrochemical and fertilizer producers are proud of the degree of experience gained in the operation of different high technology process units. They, as well, have accomplished a great deal of knowledgeable practice in the field of maintenance and some normal trouble shootings.

A considerable number of petrochemical and fertilizer plants in the Arab region are even being operated at designed production capacity level and are well maintained; moreover, to a relative extent, certain modifications to suit some local circumstances and regional environmental conditions have been successfully introduced. Normal and emergency shut-down and start-up are also being performed; and sophisticated repair with less effort has been practiced to a certain degree.

Therefore, a considerable number of opportunities for cooperation between Arab countries and between the Arab region and other regional developing countries who have been, for a longer period of time, gaining such experience, are available, particularly in areas of normal operation and maintenance, trouble shootings and emergency shut-downs, training of personnel at different levels, warehouse management and procurement of spare parts, etc.

However, there is much left to learn and more technology to be transferred, particularly in areas of high delicacy and closed know-how, such as computerized control processes, welding of high pressure stainless steel vessels, high speed giant compressors, high pressure boilers, sophisticated instrumentation, etc., which would require further and closer cooperation with the source of technology from developed regions and from other experienced firms from industrially advanced developing countries. The petrochemical

industry, like any other chemical industry, affects the environment; and with the increasing awareness of the environmental effect that chemical and petrochemical industries could cause, the industry has a duty to satisfy itself that its products are manufactured, handled, transported, used, and disposed of safely and without unacceptable risks for the environment. This requires not only strict compliance of producers with the laws and regulations controlling the limitation of disposals to the environment, but also to take independent and responsible action as needed, concerning the matter.

Every company has to draw an environmental policy and establish procedures for its implementation, monitor the effects of current operation and new processes on the local environment, minimize wastes, and foster among employees at all levels an individual sense of responsibility for the environment and the need to be alert for potential sources of pollution associated with plant operation.

Obviously, it is a collective effort and would require long experience. The matter is not only related to processes, machinery or other hardware; it is also a human activity; and as the human cannot be perfect, the control of the environment would not be free from imperfection. Therefore, exchange of experience nationally, regionally, interregionally and globally would constitute a high degree of aid to minimize the effect of the industry on the environment.

XII. FORMULAE FOR COOPERATION

Mechanism of cooperation, from its name, implies the means to be followed, actions to be taken, and area of priority to be selected for initiation of the first step of real implementation of cooperation.

Moreover, above all, is the question of attitude: what are the real attitudes of the cooperating parties towards the principles of cooperation before any kind of policy could be adopted and a practical way, or mechanism of cooperation could be put into action, referring especially to cooperation in Arab countries and between them and other regions.

It is obvious among the industrialized countries that they have evaluated the fact that greater concentration on cooperation for long term effects rather than occupation with petty differences will keep their industry operating profitably, their economies healthy, their problems less, and their future more promising, thus serving the well being of their nations.

Therefore, chemical and petrochemical companies and the related establishments in the developed regions, as well as the countries themselves, consider the issue of cooperation as an indispensable activity based on a need, and not as a sort of welfare organization or charity donation which everyone has to praise or make a minimum contribution to, and forget about it. Hence, cooperation among the Arab countries requires, first of all, a positive attitude towards its process and a sense of need for it and for the benefits of its various forms.

People do not usually do what they are supposed to do; they do what they have to do. Also, people do not usually go to doctors unless they are sick. When developed countries, companies, scientific institutions and commercial organizations have seriously

practiced various forms of cooperation at different levels, they did it because they needed it, they felt the pain without it, and they continued to do it when they realized its worthwhile returns.

Looking at the evolution of cooperation, coordination and integration in the petrochemical industry in EC countries before and after the world oil crises, it may be seen that it reflects the degrees of cooperation performed progressively as the need for it intensifies. Moreover, in a very brief review of the development of the petrochemical industry in Europe regarding their cooperative response to the changes in oil prices and the disruption of the markets, it could be seen that, at the first oil price rise in 1973 to fourfold and the short supply of domestic naphtha and its expensive import, chemical corporations, as separate entities, reacted differently to the emerging situation. In general, they had to shed their highly individualistic postures and develop closer linkages with the oil companies; for example, Bayer joined with British petroleum, BASF linked with Shell in W.Germany, and British ICI joined with BP in order to secure their raw materials and energy. At the second oil prices rise in late 1979 and the world economic recession which followed in the early 1980s, chemical and petrochemical companies in Europe as well as in other developed regions promptly reacted to those drastic changes in a series of measures which was so called "restructuring", where mergers, capacity utilization, shut down of plants, specialization, search for alternative feedstocks, and the adoption of new trends to produce specialty chemicals which have higher value added and lower cost raw materials but with higher technology.

Nevertheless, and in spite of the severity of these conditions, European industry survived; and they overcame the majority of the problems through serious and genuine cooperation and intensive R&D activities. Soon after the mid 1980s, a number of petrochemical producers, especially from the Arab countries in the Gulf region,

in particular Saudi Arabia, and to a lesser degree Qatar, have begun to step into the West European market as potential competitors, threatening their economic interests and exposing their industry to relative disruption. Again, European producers came collectively to unify a policy to counteract this invasion of foreign products to their markets by introducing all types of barriers such as tariff and non-tariff barriers as well as other obstacles and difficulties such as imposing export ceilings, and declining from extending further technology and other hard conditions in order to discourage these new products from invading their market, (assuming that Arab Gulf producers were having the low feedstock advantages). Another example of cooperation among the European petrochemical and oil majors is the ethylene grid which connects the Cologne area (Germany), where the largest capacity of ethylene is concentrated, with the second largest ethylene concentration area in the Rotterdam-Antwerp area (The Netherlands).

Virtually all of the best known names and producers of petrochemicals such as Hoechst, Bayer, BASF and Veba of the "German group", AKZO, Solvay and DSM of the "Netherlands group", and Gulf, Caltex, Exxon, Shell and BP of the "oil-majors group" are located on this grid and both take and supply ethylene into it. In addition, the European natural gas transmission system (from Italy to the North European countries) also represents a good example of close cooperation.³⁶

In conclusion, it is apparent that cooperation is likely to be initiated by a good understanding and positive attitude, and will be encouraged, enlarged and well established by the virtue of need and nourished by its beneficial outcome.

Returning to the main point of this study, the issue of

³⁶ UNIDO: "Emerging Petrochemical Technology", Arni V.R.S, (IS.350), p.69-71

cooperation in the Arab countries, concentration should be on application of the essential parameters for initiating and developing modes of cooperation in line with those indicators which promoted the cooperation among companies and countries of the developed region: the attitude, the incentives, the need, and the whole general sense of gains and benefits. It should be realized that it might soon be almost too late to start cooperation in the Arab region; if it was not started yesterday or today, it should begin tomorrow. Oil prices are not likely, for quite a while, to witness a sharp increase; Arab domestic markets are not growing with the absence of cooperation, coordination and integration at a high enough rate to be able to absorb a major portion of the Arab petrochemical production; the world market, including the developed market is hitting a new cycle of economic slow-down (sluggish economy); there is an increase of new producers from the oil and gas rich countries, mostly from OPEC; there exists a decrease of marginal production cost difference of Arab petrochemicals compared with the European naphtha-based ethylene after oil and oil products' prices became relatively low and stable; and continuous protective measures are being taken by European and other developed countries against the flow of Arab petrochemicals into their markets. All of these factors coupled with the relative expansion of the Arab petrochemical industry and increasing marketing difficulties as well as other technical problems should create a strong incentive and demonstrate an urgent need for genuine cooperation. Arab petrochemical producing countries should, by now, metamorphose from their individualistic postures and develop closer linkages with other Arab petrochemical producing countries or with other non-producing countries who have a potential market and/or adequate infrastructure for R&D development as well as to extend such a linkage with other regional countries with which mutual benefits could be gained through some forms of cooperation in accordance with their prevailing capabilities.

Early in this study, a number of forms of cooperation were

reviewed, some of which were quite elaborated because of their especially important role in the development of good cooperative bases. Also, different levels of cooperation were introduced, and several areas were pointed out.

In summary of the present topic, the mechanism of cooperation or the means by which cooperation could be applied, is schematically listed hereunder:

- Cooperation could begin with the simplest way of exchange of information and collection of data available on the present petrochemical plants through a central organization created by Arab producers in any organizational form: federation, association, union, or club, to be in the future a well -established data bank designed to be interconnected with regional and interregional information centers.
- The promotion of downstream industries in both petrochemical producing countries and in those Arab and other regional developing countries with no basic petrochemical industries, by means of supply of basic and intermediate products supported by different financial facilities, such as credit, long term loans, or deferred payments on soft conditions.
- The removal of all trade barriers standing against the flow of petrochemical products (import) (export) among Arab cooperative countries. As for other regional countries, it appears that there is a great desire and good intention to remove such barriers.
- Starting cooperation on bases of bilateral arrangements primarily between Arab countries of the same geographical region and subsequently extended to include other

cooperative countries with which mutual benefits may be shared.

- Adoption, to the greatest possible extent, of unified norms and standards in order to facilitate the promotion of cooperation in exchange of materials, such as common spare parts and chemicals, etc.

Unification of norms and standards would also help to economize in pooling the slow moving spares such as compressor rotors and large pumps, etc., which are very costly (in millions of U.S.\$) and of which cases of need to change these parts or equipment are rare.

- Examination of the possibility of adapting similar processes in some main process units of different petrochemical plants and sharing royalties.
- Pooling resources for R&D activities to lift financial burdens on a single company or country and to spread the cost over a number of establishments which, in turn, would increase incentive.
- Integration of the petrochemical sectors with other economic sectors in order to widen the consumption base of the industry.
- Promotion of local and regional manufacturing capabilities in order to be able to support the downstream industries and to develop engineering and design experience.

XIII. CONCLUSIONS

From the brief review of trends in world petrochemical industry, its development in the Arab region, the importance and role of various forms of cooperation in the industry in Arab countries as well as in other developed and developing countries, it could be concluded that:

- (1). The petrochemical industry has undergone, in a relatively short period of time, a series of fluctuations and up-and-down cycles, an event which seemingly forms part of the present nature of the industry, and will most likely continue for at least a decade, causing large traditional producers much concern over adjusting themselves to these down-turns to avoid their adverse impacts; while some smaller enterprises face more serious difficulties which may lead to an entire shut-down.

Thus, another spell of restructuring of the industry is expected; merging and acquisition activities will be renewed, globalization will be increased, new technical solutions will have to be initiated in spite of their inherent risks from increasing technology sophistication and potential environmental liability, and other strategies in R&D and marketing are likely to be employed to face the new challenges.

- (2). There is an obviously noticeable geographical shift in petrochemical production to developing regions encouraged by the availability of cheap and abundant feedstocks or by predicted high growth in demand.

Some developing countries without substantial oil resources, such as Brazil, Taiwan and South Korea which once were traditional importing countries have also become important petrochemical producers.

Thus, Latin America, the Middle East, and the Asia-Pacific region are all pressing ahead with plans for building ethylene plants and downstream derivatives, leaving a premonition of world overcapacity.

Nevertheless, forecasters believe that such overcapacity, if it occurs, will not remain for long and will soon be absorbed, and that the newly developing countries with substantial oil and gas reserves have decided advantages and would find an important place in the industry.

- (3). The announced world sizable ethylene capacity additions coupled with the expectation of weak short-term economic growth suggests that low utilization rates are likely for world ethylene and key derivative markets in the early 1990s.

Should all of the announced olefin plants be built, ethylene capacity in the Far East will be increased from 2.7 million tons/year to 8 million tons/year ; the United States will add some 4.6 million tons of capacity; West Europe will add 4 million tons; and the Middle East will add about 1.8 million tons/year of capacity, bringing the total world ethylene capacity to about 80 million tons/year in 1995, a situation which would put considerable pressure on world naphtha supply, particularly in West Europe. Thus, during the 1990s, polyethylene's share

of ethylene markets is expected to increase from 53.3% to 56.3%.

Based on anticipated demand and capacity growth in the Far East, United States exports to China, Japan, and other Asia-Pacific countries are likely to decline, while producers in the Middle East, particularly the Arab countries in the Gulf region, could continue supplying Asian markets with ethylene derivatives if they expand capacity as planned.

- (4). In spite of the world economic depression, the plastics industry was not greatly affected. Commodity thermoplastics (the major bulk of plastic materials) are within their traditional rate of growth, led by polypropylene where rates of growth show a higher average.

Linear low-density polyethylene (LLDPE), in most areas of the world, will significantly out pace other competing large volume plastics such as low-density polyethylene and high-density polyethylene. New capacity is under construction at numerous locations which is often a "swing" capacity that can be used to make either LLDPE or HDPE.

PVC's global demand is expected to grow at an average of 3.7% and specialty petrochemicals are holding fairly well.

- (5). While the petrochemical industry continues its down-cycle, one product, methyl-tert-butyl ether (MTBE) holds a highly esteemed position in the world chemical industry. Moreover, it has been the fastest growing petrochemical, with no other chemical product having experienced such a unique growth profile. MTBE

started basically as an octane booster and later became a clean air component.

Booming MTBE demand draws an increasing number of producers as well as tightened methanol supply. The demand for MTBE was also aggravated by the new Clean Air Act and its latest amendment in the United States and the close deadlines for the use of leaded gasoline in Europe as well as by increasing awareness elsewhere in the world of the environmental pollution caused by automobiles.

Thus, the methanol market will move away from its current long standing position into a deficit due to the rapid build-up of MTBE capacity. On a world-wide basis, methanol supply will fall short by over one million tons in 1993 and 2.7 million tons in 1994, giving the Arab countries with abundant natural gas production and reserves promising opportunities to enter the international market, especially the developed regions.

- (6). The new restructuring of the industry will certainly be different from those measures taken during the 1970s' two world oil crises and the economic recession of the early 1980s simply because most of the potential forms and areas for restructuring have already been exhausted.

The increasing constraints on traditional mergers and acquisition, the scarcity of good candidates (as many have already merged or been taken over), the fear of acquiring potential environmental liability, and tight operational integration of many petrochemical complexes (which makes carving out operations difficult), will lead to more

innovative possibilities and new restructuring. However, the changes apparently point in one direction, that is: increased globalization.

Thus, there will be great potential opportunities for Arab oil and gas rich countries to utilize the present need of the industrialized nations for global cooperation by coordinating their petrochemical production plans, cooperating in marketing performance of the Arab petrochemical products, concluding technical assistance agreements and facilitating transfer of technology both horizontally and vertically.

- (7). In spite of the vast opportunities for cooperation in the petrochemical industry among the Arab countries, very few significant achievements have been noticed on both a bilateral and multilateral basis. Most of the factors hindering modes of cooperation are clearly identified, areas for cooperation are numerous and forms of cooperation and integration of the industry are repeatedly analyzed.

Hence, the various studies and analyses suggest that the hidden cause for non-enhancement of cooperation in the Arab countries lies mainly on the issue of the general Arab attitude towards cooperation, a factor which mainly determines the degree of motivation for genuine and effective moves toward cooperation. Obviously, a favorable and enthusiastic attitude will lead to insight on ways of facilitating the mechanism, or practical steps and means, to be assumed for any level of cooperation and integration in the potential areas

of the industry.

Furthermore, the positive attitude towards cooperation itself is usually driven by either desperate need or by sensing the high returns of cooperation to the parties involved. It also requires that Arab countries metamorphose from their individualistic positions concerning these issues in order to appreciate the benefits of cooperative efforts for the establishment of a sound industry, the development of their economies, and the well being of their nations.

Many western countries have successfully practiced all levels and forms of cooperation with a positive attitude towards mutual benefit and the long lasting returns to all of the participants.

- (8). Although very few joint venture arrangements have been concluded among the Arab countries in the area of the petrochemical industry, it appears that this particular form of cooperation is one of the most practical means of building up positive attitudes towards the process of cooperation. Through such a mechanism, several aims could be achieved which would enhance further cooperation, examples of which are: exchange of information, display of some aspects of economic planning, and awareness of available infrastructure in the countries involved in the joint venture. Moreover, difficulties and obstacles will be closely felt, trade movements will be facilitated by virtue of the implementation of the joint venture agreement stipulations, and the direct financial interests are found to be very much linked to these important factors. Marketing

of the products, for instance, will need an open market in the cooperating countries, raw materials would have to be transferred from the source region to the host country (s), operators and other technical staff are normally secured from the involved countries, and problems would have to be collectively solved through consultations and/or the different R&D and other technical and scientific institutions in the nations of the joint Arab agreements or other technically potential countries.

- (9). It is also realized that several Arab industrial and economic organizations such as AIDMO, GOIC, GCC, UMA, the Arab Economic Unity Council, and others have made numerous efforts for the promotion of cooperation, coordination and integration of the petrochemical industry in the Arab region. In fact, a great deal of effort has been spent by these organizations; and many substantial studies and surveys have been accomplished, particularly by AIDMO and GOIC, to pave the route for closer cooperation and the development of the industry in general. Nevertheless, the argument concerning the extent of achievement as being somewhat less than expectations may point to the latent actuality that "too much was asked too soon". Petrochemical industry in the Arab region is still very young; and what has been accomplished is far better than any normal development in developing regions; and opportunities for future cooperation are promising. Most of the difficulties identified as factors delaying further cooperation in the petrochemical industry are, in fact, not related exclusively to this sector; but they are some of the economic and

political phenomena in the majority of the developing countries. As was mentioned in different sections of this study, these difficulties and obstacles are inherited from the nature of the region, its individuality and the recent engagement in such great industrial activity. Time and desperate need will catalyze cooperation, extend coordination, and achieve integration.

- (10). A number of Arab countries presently possess different levels of information and data-base centers, R&D facilities, some equipment manufacturing capabilities, and to a lesser extent, design and engineering establishments. However, it is true that most of these facilities do require further development in order to be better organized and reinforced. Therefore, the creation of effective forms of cooperation to gather these efforts, pool the resources and integrate activities in order to meaningfully serve the Arab petrochemical industry in particular and the other industrial and economic sectors at large, will be expedient goals for the future of the industry.

XIV. RECOMMENDATIONS FOR INTEGRATED DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN THE ARAB COUNTRIES

- (1). It is recommendable that Arab petrochemical producers should keep their prices competitive, principally by limiting product lines to olefins, polyolefins, glycol etc., and using, whenever possible, light feedstocks: ethane, LPG and refinery gas to maintain being long-term, low-cost producers of basic petrochemicals and competitive manufacturers of downstream products, besides moving towards the production of some high value-added petrochemicals and the intermediate petrochemical products especially required for the production of synthetic fibers and synthetic rubbers, both of which the demand is large and the consumption rates are rapidly increasing.
- (2). to increase integration with the refinery sector by:
- adding more secondary units: reformer, FCC units, hydrocracking, olefins plus aromatic feedstock, and gasoline pool, as well as the:
 - production of:
 - benzene, toluene, xylene (P-xylene),
 - styrenemonomer, cumene and methyl tert-butyl ether (MTBE).
- (3). to utilize the increasing world trend in the petrochemical industry's globalization (the most

foreseeable forms of new restructuring strategies which the industrialized nations will be likely to perform), and to conclude fruitful and mutual arrangements, particularly in the area of long term supply of feedstocks, basic petrochemicals, marketing, and horizontal and vertical technology transfer. The prevailing international trend forms a fertile environment for suitable international cooperation.

- (4). to increase interregional cooperation, particularly with the Asian countries in the form of long-term commitment and/or joint venture with the possibility of combining refinery business: crude oil, gasoline marketing, and petrochemicals, etc.

- (5). It is also recommended that cooperation among Arab petrochemical producing countries could adequately be performed (bilaterally or multilaterally) initially between or among the countries of the same Arab geographical regions where common interests are more likely to be realized and communications are accessible, socio-economic policies are closer in nature, and the factor of proximity is favorable. With such a plan of action, if it finds its way to further implementation. an Arab sub-regional policy will subsequently lead to a wider scope of cooperation

among all Arab countries directly or indirectly and in accordance with each Arab country's conditions, capabilities, and intended degree of cooperation.

- (6). to coordinate the different Arab production plans as far as possible to avoid regional over-capacity and lessen competition in the interregional and international markets.
- (7). In order to facilitate the performance of any level of cooperation, it is expedient to immediately initiate any form of joint Arab petrochemical organization, even the establishment of some form of petrochemical club, through which closer communication and exchange of thoughts could be accomplished. Such an initiative will inevitably lead to a more advanced and well organized Arab petrochemical community which will be able, in the future, to play a more significant role in the cooperation among Arab countries and between them and other regions.
- (8). to increase the domestic consumption of petrochemical products by promoting downstream industries through expanding the uses of petrochemical products in different economic sectors; and to facilitate such expansion through all possible means, including loan

extension and supply of basic and intermediate petrochemicals to the local downstream producers and to other Arab countries (especially to those with a high potential domestic market and a shortage of finance) on the basis of long-term credit and soft conditions.

- (9). to join the scattered Arab petrochemical information and data base centers in a unified network to be accessible to all producers in the Arab countries as well as to other related sectors. Such a data network should also be designed to be connected with the international data base centers and to be continuously updated.
- (10). to promote intra-Arab trade in petrochemicals by eliminating the barriers hindering the flow of trade and the smooth movement of personnel involved in both trade and technical affairs among the Arab countries through implementation of various trade agreements and other arrangements concluded by the Arab countries on this subject. Joint Arab, besides other directly involved organizations such as AIDMO, GOIC, GCC and The Arab Economic Unity Council, could effectively assist such implementations.

(11). to pool R&D resources, both human and physical, a process which is inevitably required to save in costs, gather experiences, and secure highly qualified scientists and technical personnel.

Promotion of R&D activities will be the only route to the development of national process technology and ultimately to vertical technology transfer.

(12). Other fields of cooperation will, with no doubt, be developed concomitantly with the ongoing process of industrial development; and the required infrastructure will gradually be established as the needs arise, particularly when there already exists a certain extent of facilities which represent at least the minimum infrastructural requirements, both human and physical. However, it is not really so indispensable to place much emphasis on the development of sophisticated high-cost infrastructure as an absolute prerequisite for the industry at this stage.

In summary, it should be understood that cooperation is not really an aim by itself to be reached or accomplished; but it, in fact, is a mean for the development of a sound petrochemical industry in the Arab region and a form to facilitate the proper

utilization of their natural resources and ways to collectively face the world economic challenges which became beyond any single Arab Country's capabilities to face the growing of various regional and international alliances.