Distr.
GENERAL
E/ESCWA/ID/85/13
3 February 1986
ORIGINAL: ENGLISH

UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA

A FRAMEWORK FOR A MASTERPLAN FOR THE DEVELOPMENT OF TECHNOLOGICAL CAPABILITIES IN THE OIL REFINING, PETROCHEMICAL AND FERTILIZER INDUSTRY

February 1986

E/ESCWA/ID/85/13

86-0415

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF ABBREVIATIONS

ADNOC	Abu-Dhabi National Oil Company
AIDO	Arab Industrial Development Organization
AIIC	Arab Industrial Investment Company
AL-RAZI	Saudi Methanol Company
ARADET	The Arab Detergents Chemical Company
ARAMCO	Arabian American Oil Company
AREC	Arab Engineering Company
BSCF	Billion Standard Cubic Foot
C.A.N.	Calcium Ammonium Nitrate
Cu. ft/d	Cubic feet/day
DMT	Dimethylterphtalate
EIDDC	The Engineering & Industrial Design Development Centre
ESCWA	The Economic & Social Commission for Western Asia
GAS	National Industrial Gases Company
GDR	German Democratic Republic
GEPC	The General Egyptian Petroleum Company
GFC	General Fertilizer Company
GLP	Gas Liquification Plant
GDP	Gross Domestic Product
GNP	Gross National Product
GOIC	Gulf Organization for Industrial Consultation
HDPE	High Density Polyethylene
IBN-HAYYAN	National Plastic Company
IBN-SINA	National Methanol Company
KEMYA	Al-Jubail Petrochemical Company
IDTC	Industrial Development Technical Centre
INOC	The Iraqi National Oil Company
IPI	Intermediate Petrochemical Industries Company
JOPETROL	Jordan Petroleum Refinery Company
KD	Kuwait Dinars

LIST OF ABBREVIATIONS (Cont'd)

KFAS	Kuwait Foundation for the Advancement of Sciences
KISR	The Kuwait Institute for Scientific Resarch
KNPC	Kuwait National Oil Company
KOC	Kuwait Oil Company
KPC	Kuwait Petroleum Corporation
KREMENCO	The Kuwait Refinery Maintenance and Engineering Company
KSB	The Kuwait Santa-Fe Braun Engineering and Petroleum Enterprises Company
LDPE	Low Density Polyethylene
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
MTBE	Methyl Tertiary Butyl Ether
MT/Y	Million Tons/Year
NODOC	The National Oil Distribution Company
NPK	Nitrogen Phosphate Potash Compound Fertilizer
OAPEC	Organization of Arab Petroleum Exporting Countries
OPEC	Organization of Petroleum Exporting Countries
PETROKEMYA	Arabian Petrochemical Company
PETROMIN	The General Petroleum & Minerals Organization
PDRY	People's Democratic Republic of Yemen
PIC	Petrochemical Industries Company
PRC	Petroleum Research Centre
PTA	Purified Terephtalic Acid
PVC	Polyvinyl Chloride
QAFCO	Qatar Fertilizer Company
QAPCO	Qatar Petrochemical Company
QGPC	Qatar General Petroleum Company
R & D	Research and Development
RSS	The Royal Scientific Society
SABIC	The Saudi Basic Industries Corporation

LIST OF ABBREVIATIONS (Cont'd)

SADAF	Saudi Petrochemical Company
SAFCO	The Saudi Arabian Fertilizer Company
SAMAD	Al-Jubail Fertilizer Company
SANCST	Saudi Arabia National Centre for Science & Technology
SBR	Styrene-Butaine Rubber
SHARQ	Eastern Petrochemical Company
TIC	Technology Investment Company
TPA	Terephtalic Acid
U.A.E.	United Arab Emirates
UNIDO	United Nations Industrial Development Organization
VCM (MVC)	Vinylchroride monomer
YANPET	Saudi Yanbu Petrochemical Company

PART ONE

INTRODUCTION

Introduction

The importance of industrial co-operation among developing countries has been stressed by many conferences and studies. Thus, UNIDO has set-up a system of consultations which has specially recommended a programme of co-operation among developing countries in the field of petrochemicals. Also, UNIDO's Second Consultation on the Petrochemical Industry, held in Instanbul (Turkey) in 1981, urged the need to develop such a programme of co-operation among developing countries, including those with and without petrochemical feedstocks.

As a result, UNIDO convened, jointly with the Organization of Petroleum exporting Countries (OPEC) and the OPEC Fund for International Development a seminar on co-operation among developing countries in petrochemical industries, held in Vienna (Austria) in 1983.

At this Seminar, a joint paper by the OPEC Fund and UNIDO secretariat noted that demand projections for petrochemicals in developing countries show the need for a large number of plants by 1990. Since most of the ESCWA countries have significant resources in this industry, projects could be successfully implemented within a framework of co-operation among these countries for mutual benefit. A number of areas for co-operation have been selected: financing, manpower training, engineering and plant design, construction, operation and maintenance, marketing and R & D.

ESCWA, in its 1984-1985 work programme, undertook to prepare a masterplan for the development of process, plant and product design capabilities in petrochemical (including fertilizer), industries.

Subsequently this study became a joint project between the Arab Industrial Development Organization (AIDO) and ESCWA. As a result the study was expanded in the following manner:

- All technological capabilities and not only process, plant and product design were included in the study;

- Oil refining industry was added to petrochemicals;

- The study had to cover all Arab countries and not only ESCWA countries, as found in this study (to be published as a joint ESCWA/AIDO study).

The refining and petrochemical industries in the region have developed and evolved into a key element in the industrialization policies adopted since the sixties in the region and in the structure of world markets. This rapid development was prompted by the desire of the petroleum producing countries to fully utilize the oil and gas potentials available, capture the high value-added component of advanced oil processing projects, diversify production and exports and exploit the competitive advantages available because of the low price of energy and feedstock in the region. If the processing of raw materials is carried to the manufacturing stages, it will encourage at the same time local production of end products, and in this way the countries do not only diversify their industrial base but also create new jobs and provide training and technical experience and promote backward and forward linkages.

The first generation of projects in the late 1960s, were typified by delays in commissioning and plant start-up difficulties. This fact became less serious during the second and third generation development. Many of the obstacles facing the refining and petrochemical projects established then, have been the result of many infrastructural problems related to the initial preparation of a project site when roads, housing utilities, parts facilities had to be built at the same time as the construction of the plant itself. But the main element was the lack of experience and the technological capabilities required for the identification, implementation and operation of projects of such scale. The mastering of the required expertise and technology is a process that needs a long period of accummulation of knowledge and practical experience. Petroleum processing projects in the region require the continuous development of national technological capabilities, in the form of skilled and experienced manpower and appropriate institutions, to be able to acquire the full advantage of industrial development.

There is no doubt that the countries of the region have established and are continuing the construction of refining and petrochemical plants which depend to a great extent on the procurement of equipment, engineering expertise and technological know-how from foreign sources. How far these countries have developed their indigenous technological capability and what are the potentials for future development, is the question that this study attempts to analyse.

The study attempts to assess the present status and development of indigenous technological capabilities acquired in the process of transfer of technology in the refining and petrochemical industry in the past period (1965-1985). It explores also the ways and means of speeding-up this development and making increasing use of human resources and institutions available within these countries. Finally, it will develop a plan of action comprising policies and measures for implementation by government agencies and private institutions in ESCWA member states for the development of indigenous technological capabilities taking into consideration the prospects of future advanced technologies in this industrial sector.

1.1 Background of the study

1.1.1 The industry

The term petrochemcials is the generic name given to all industries which use hydrocarbons as raw materials to produce a variety of chemical products. These are utilized in, among others, agriculture (fertilizers), textile industry (polyesters, nylons), health care industry (soaps, shampoos) and pharmaceuticals (aspirin, antibiotics).

The oil refining industry in the region of the ESCWA member States started already in 1912 in Egypt, with the establishment of a 2000 b/d topping plant. Iraq followed in 1927 with a 5500 b/d plant at Al-Wand.

Refining for export began in 1937 in Bahrain, with a 25,000 b/d complex, followed in 1949 by the 25,000 b/d Ahmadi plant in Kuwait and by Saudi Arabia's Ras Tanura plant. Currently, there are 42 refineries in the region (established or under-construction), ranging in capacity from 5,000 to 565,000 b/d. (for detailed information about the refining capacity in the region, (see table 2.1).

The petrochemical industry which includes here the fertilizer industry based upon natural gas, started much later, in the 1960's, with the establishment of an ammonia plant in Kuwait (see table 2.2). The reasons at that time for the fact that there were no petrochemical industries despite the abundance of cheap raw material and a potential market in the region were:

First, the price of the crude oil was not significant in the manufacturing cost of most bulk petrochemicals. Second, the commercial plant size was larger that the domestic market. Third, the required huge investment capital was not available in the countries of the region. And finally, the physical and human intrastructure was inadequate.

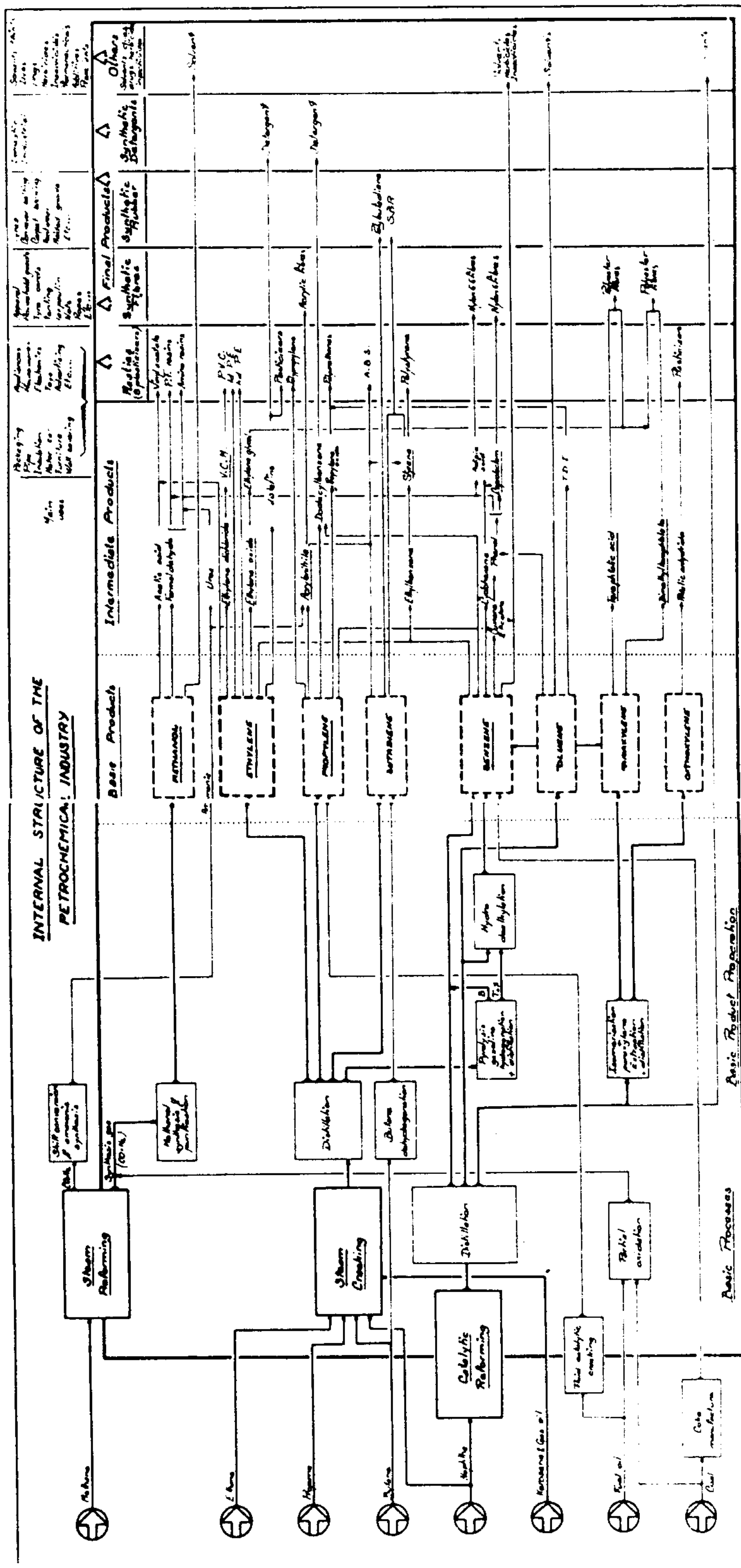
Also, joint venture type agreements were too restrictive because of the condition demanded by the technology and know-how owners and the cost of royalties and licence fees was considered too high to be acceptable. This situation changed dramatically with the two oil price rises of the seventies, and the subsequent higher costs of energy and feedstock.

1.1.2 <u>The technology</u>

The production complexity of the petrochemical industry implies the application of several technologies and many technical alternatives in the field of products, processes and raw materials. However, all large-volume petrochemicals are synthesized from only eight basic petrochemical building blocks, namely the oldefins ethylene, propylene and butadiene; the aromatics benzene, toluene and xylenes; ammonia and methanol. These can be produced from different feedstocks such as naphta, LPG, Ethane and Natural Gas (see figure 1 UNIDO).

There are two primary processes for the production of petrochemical, which are the steamcracking of naphta for olefins and the catalytic reforming for aromatics. A third major process, steam reforming is used to synthesize ammonia and methanol. Furthermore, a distinction is made between intermediate and finished products. The first group comprises products which have received some upgrading but need further processing before they become commodities. This group includes ethylene dichloride, ethylene oxide, vinylchloride monomer (VCM), ethyleneglycol, ethylbenzene, styrene, phenol, caprolactam, dimethylterephtalate (DMT) and terephtalic acid (TPA). The category of finished products encompasses a group of products that requires minimal processing to be transformed into consumer goods. They include: polyvinylchloride (PVC), high and low density polyethylene (HDPE/LDPE), polystyrene, styrenebutadiene rubber (SBR), and various polyester and nylon fibres.

Figure 1



Source: First World-Wide Study on the Petrochemical Industry, 1975 - 2000, UNIDO/ICIS 81, 12 December 1978.

Countries in the region have only recently begun to establish petrochemical plants which can produce the basic petrochemicals, with a view to optimize the value of their crude oil by further processing it into refined products for specific end users. The existence of a refinery industry is an indispensable means for producing the feedstock, and at the same time, a refinery is needed to utilize the by-products of the petrochemical plants. Since both refining and petrochemical processing depend to a great extent on similar technologies, integrated processing (refining and petrochemicals) can benefit from trained manpower and already built-up experience in the longer established refineries.

The investments being undertaken in the new export refineries, are in most cases in conversion refining (essentially catalytic cracking) as opposed to reforming. This is required to produce the high quality products for the OECD markets, which have a continuously increasing demand for motor gasoline and less for fuel oil. Further refineries have to be designed therefore to optimize high-value "white" products (such as motor gasoline). This implies the extensive use of hydrocracking and deep desulphurization. These are all more energy and capital intensive than hydro-skimming, but the oil-producing countries of the region can benefit from advantage, in having the available flared-gas as well as capital finance.

In the petrochemical industry, with few exceptions, it is the big internationally operating manufacturing companies that have the financial and scientific capacity to develop new processes. Furthermore, it took developed countries about 30 years to build-up this industry to its present stage. To repeat that process in the developing countries in less than ten years is not only a too ambitious programme but also not necessary, even with the huge financial resources available, so a carefully planned and implemented programme, especially taking into account the manpower situation in the region, would be needed to develop the required technological capabilities to sustain, operate, and innovate these industries to the needs of the region and their future objectives and prospects.

1.1.3 The capabilities

The above-mentioned paragraphs on industry and technology clearly demonstrate the complexity and wide range activities required by the petroleum industry. The progress of this sector calls therefore for the development of a vast array of activities and capabilities, not only for the acquisition of equipment and process technology know-how, but also for the ability to operate and maintain a complex industrial plant. There is need for advanced technology, which requires less - in number - but at the same time higher skilled manpower, and therefore there is a continuing dependence on the transfer of industrial technology from developed countries.

The manpower to absorb the new technology, to operate and service the plants and to expand or modify them, should possess a wide range of capabilities. These capabilities have been identified as follows:

- Project identification
- Pre-feasibility studies

- Feasibility studies
- Engineering and plant design
- Construction
- Supervision of plant erection
- Process design
- Product design
- Production management
- Marketing services
- Research and development
- Plant technical services
- Customer technical services.

In the following chapters, these will be assessed seperately, in-depth in various countries and for different projects. However, it is to be noted that these capabilities can not easily be generalized, since their scope might differ from one project to another. If a capability to undertake pre-feasibility and feasibility studies exists, this might mean that for certain projects 100 per cent of the activities needed can be performed internally, while for other projects the involvement of affiliate offices or outside consultants in addition to internal capacities becomes necessary. It also depends on the type of project undertaken, whether it is a new plant or an extension of an existing one, a study for a complete new refinery installation or for provision of other equipment, the introduction of a new process or the improvement of an existing one, the installation of a new production line or modifications in the existing line.

However, in the following pages attempts have been made to present an overview of the results received from the questionnaires, specifically regarding the question whether in-house capabilities exist in the respective areas in each country surveyed.

Another observation should be made here regarding the data received through the questionnaires. A question was asked to indicate for each capability the degree of participation of (outside) organization in the implementation of major projects. From the replies given, it could be seen that most of the (new) petrochemical plants gave the name of the foreign organizations involved in the initial design and construction of the plant. It is obvious that these establishments do not yet possess the capabilities to design new processes or products, since they have only recently started this new process. Therefore, all data had to be carefully interpreted with the prevailing context in mind.

1.2 Methodology

To assess the existing technological capabilities in the region, the activities to be undertaken were divided in two phases, namely desk-work and field work. The first phase, the desk-work, covered the collection and analysis of all relevant published information at the local and international level. This includes surveying literature, technical and economic periodicals, specialized reports etc.

A comprehensive list of issues and areas related to the development of technological capabilities in the oil refining and petrochemical industries were suggested for study.

The field work started with the preparation of specific questionnaires for each of the four organizations related to the technological development process in the petroleum-related field:

(a) Manufacturing establishments
(b) Engineering design, consulting companies and contractors
(c) Laboratories and industrial and other research centres
(b) Universities.

The questionnaire for the industrial establishments centred on information regarding the number of employees by nationality and educational background, training programmes available, co-operation with national organizations, technology selection procedures and existing technological capabilities.

The questions asked from the consultants and contractors dealt with the relationship between the local organization and the mother company, sectoral activities they were engaged in, number and categories of employees and specific capabilities possessed.

The universities and research centres were asked to provide information on the number and respective specialization of their graduates and staff, major research programmes, co-operation with industry and possible contract work.

The modified questionnaires were sent to senior officials and technical staff of selected organizations directly or were handed over by the local experts.

For each country, a list of relevant organizations was compiled, and local experts for a selected number of countries were recruited as focal points for this project. The tasks of the experts were to conduct in-depth interviews with senior staff of the organizations selected, to prepare background papers providing information on the existing capabilities, and policies for developing them, etc. and to submit a case-study dealing with the transfer and development of technology process in at least one national organization.

Furthermore, a leading expert in the petrochemical field was recruited as an overall consultant and assigned to assist in the desk-work, as well as to participate in some of the missions, whenever required.

A pilot testing of the initial questionnaires was undertaken in the Arab Gulf region and a number of modifications in its design were made, taking into consideration the views of some leading organizations, and experts.

A limited number of field missions were undertaken by this consultant and/or the team members of the project to gather unpublished data, to identify, recruit and brief the local experts and to fill any information gaps where possible. The workplan and dates of the missions are provided in the annexes.

For practical purposes, the countries in the region visited were: Saudi Arabia, Kuwait, Bahrain, Qatar, U.A.E., Jordan, Syria and Egypt, since these countries possess the bulk of the refining capacity and petrochemical plants (existing plus under construction) in the region. The questionnaires returned, contained useful data and other relevant information in many cases, however the responses from different countries and the quality of the replies, varied greatly, as shown in table 3.

The overall response was approximately 40 per cent, (excluding Iraq).

At the same time, many questionnaires were only partly completed and most of the relevant questions for the study remained unanswered. In several cases the meaning of the question was not properly understood and the answer given therefore, was not relevant. Also, in some countries, the lack of a reply from a complete sector of the industry, made the generalization of the results of the questionnaire difficult. e.g. in Saudi Arabia no replies were received from the petrochemical sector, and in U.A.E. and Qatar the universities and/or research centres did not reply.

The same table also provides information on which local experts prepared a background paper and/or case-study on the technological capabilities in their respective countries.

As soon as the material, collected and prepared by the local experts (questionnaires, background paper and case-study) was received, an analysis was made of this information, together with the documentation gathered through desk-work. Country profiles were subsequently prepared for eight countries, outlining the historical development of the oil refining and petrochemical industry, the technological capabilities developed so far and its degree of independence from foreign technology suppliers.

Finally, an assessment on a regional basis, was made of the technological capabilities present in the various national manufacturing companies, consulting organizations, universities and research centres.

Table 1.1.

	Response %	Questionnaires returned Mtg. Establ.	Conslt.	Univ.	Lab/R&D	Background papers
Iraq	n.a.	n.a.	n.a.	2	1	+
U.A.E.	25%	1	1**	-	-	
Syria	82%	3	2	3	1	+
Kuwiat	47%	2	4	1	2**	+
Bahrian	20%	1	-	-	-	-
Egypt	n.a.	1*	1*	-	1	+
Qatar	40%	1	3**	-	-	-
Jordan	20%	-	2	1	1	+
Saudi Arabia	50%	12	8	2	-	--
Total		21	21	9	6	

* Is combination of several companies/organizations in one question.

** Includes regional organizations OAPEC/Kuwait, GOIC/Qatar, and AREC/Abu Dhabi

This report is divided in the following five parts:

Part 1 Introduction
The introduction gives also the background and methodology of the project.

Part 2 Basic data
In this part basic country data on the oil refineries and petrochemical industries are presented. They include information on capacity, technology and manpower of the plants as well as on the organizational set-up and managerial responsibilities for production and expansion, if available it also provides a short historical overview of the industry.

Part 3 Assessment of present technological capabilities
This part gives a detailed overview of the capabilities in a selected number of countries in the region.

Part 4 Advanced future technologies
This part will assess the impact of future and more advanced technologies on the development of the petroleum-based industry in the region.

Part 5 Conclusions and proposals
This part will propose policies and recommendations for actions to be taken by government authorities and private instituitons in the ESCWA region to develop their indigenous capabilities.

PART TWO

STATUS OF THE INDUSTRY

2.1 Egypt

The Egyptian General Petroleum Corporation (GEPC), fully owns and manages serveral companies in the refining and petrochemical sector. In the refining sector there are seven plants, six of them installed and working (see table 2.1) and one is under construction in Assiout. There is the petrochemical plant which is also under construction near Alexandria, and the Natural gases company. The total capital invested in these nine companies is over 1200 million Egyptian pounds and the annual sales is worth over EP 5000 million. The working force in the refining and petrochemical plants reached 13,500 workers in 1983. While in the whole petroleum industry the total workers are 42 thousand. The total future investment for the Petroleum industry within the 1983/1987 five year development plan is 1093 million Egyptian pounds.

2.1.1 Oil Refining

The refining sector was established in early 1954, and completely nationalized in 1966, when it started to export some of its production. Petroleum consumption grew at a rapid pace during the decade 1970-1980 Egypt's petroleum policy for the coming two decades is to rationalize energy consumption and improve the effeciency of petroleum production and utilization. Many steps have been taken towards that goal, including (a) encouraging new and old foreign oil companies to explore for oil and gas reserves; (b) trying to achieve self-sufficiency in petroleum products and to bring specifications up to international standards; (c) increasing oil exports to maintain a sufficient surplus in the oil sector's balance of payments; (d) enhancing the oil and gas transport and distribution systems; (e) supporting the scientific institutes and engineering companies in research and developing local technical capabilities. The refining capacity increased in Egypt from 2.3 million tons in 1952 to 8.5 million tons in 1966 realizing a surplus of about 2 million tons available for export. But after the 1967 war, the oil industry had serious problems. The Suez refineries, which accounted for about 80 per cent of refining capacity at that time, were damaged during the war.

The installed crude oil refining capacity in 1983 totalled 15 million tons as compared to the 12 million tons in 1980 and as compared to the 7 million tons in 1973, which means refining grew 10.2 per cent per year after the 1973 war. The total petroleum products amounted to 13.1 million tons in 1980, as compared to 6.6 million tons in 1973, with an average annual growth rate for 1973-1980 of 10.3 per cent.

Utilized capacity in 1980 was 92 per cent compared to 58 per cent in 1973. The main yields were gasoline and naphtha (15.4 per cent), Kerosene (12.8 per cent), gas and diesel oil (19.2 per cent) and fuel oil (48.9 per cent).

The refining capacity increased after 1980, adding about 2.65 million tons to the total.

The output of petroleum products increased over the 1970-1980 decade at an average annual rate of 15 per cent from 3,251 thousand tons in 1970 to 13,132 thousand tons in 1980, while crude throughout rose at 15.2 per cent.

The refined oil in 1983 reached 18.1 million tons, out of which 560 thousand tons are from the Ras Tanura terminal in Saudi Arabia with an increase of 7.9 per cent over 1982.

The total output of petroleum products in 1983, in thousand metric tons are:

1.	Benzene/Naphtha	2323
2.	Kerosene/Turbine (Jet oil)	2135
3.	Gas oil/Diesel oil	2862
4.	Mazout (fuel oil)	8879
5.	Asphalt	508
6.	Base lubricants	122
7.	Others	121
Total		16,950

Production Distribution by Refinery in (thousand metrications) are as follows:

Year/Plant	Ameriyah	Suez 1	Suez 2	Tanta	Monstards	Alex	Total
1983	2913	3282	1142	1005	4895	4907	18144
1980	3040	2137	1092	969	4489	5040	16767

Refining capacity expansion is under construction at the Alexandria refinery as well as an expansion and construction of reforming unit in Suez refinery, the capacity will reach about 22 million tons in 1985. Further refining capacity increase is also planned, reaching 38.7 million tons in 1990. There are also plans for fuel oil conversion of 2 million tons capacity (50 per cent by Hydrocracking and 50 per cent by thermal process). Current expansion programme, includes construction of a new refinery at Assiout and recommisioning of the Suez refinery, Assiout is scheduled to start production at an initial rate of 40,000 b/d by 1987. The revamped Suez refinery is to come on stream at 112,000 b/d in late 1987. There are also plans to increase ouput and expand the range of products at the Cairo, Alexandria, Tanta and Sinai refineries.

Domestic consumption has been rising by 12 to 14 per cent year against and annual rise in output of no more than 7 per cent domestic use accounted for 46.5 per cent in 1982/1983. Oil exports account for a third of Egypt's foreign currency earnings. The government's task over the next few years is to increase and expand production of crude, gas and refined products and at the same time make domestic use of energy more efficient.

2.1.2 Petrochemicals as Fertilizers

The petrochemical plant is currently under construction, the first stage includes the erection of 3 plants: for MVC, at a capacity of 100,000 ton/year for PUC at a capacity of 80,000 tons/year, and a chlorine plant at a capacity of 160,000 tons/year. The contracts for these plants have been awarded to international companies. This stage is due for completion in 1985/1986. A second stage is planned for the production of ethylene at 200,000 tons/year and low density polyethylene.

The fertilizers sector is under the authority of the Ministry of Industry. The four plants using natural gas resources are all operating at present, the Dekheila plant at a capacity of 500,000 tons of urea/year and 100,000 tons/year of ammonium nitrate, the Talkha 1 plant opened in 1976, has a capacity of 380,000 tons/year of nitrogeneous fertilizers and Talkha 11, in operation since 1979, produces 396,000 tons/year of ammonia, which is used to produce 570,000 tons/year of urea. The Suez plant has a 250,000 tons/year capacity of nitrogeneous fertilizers.

Future expansion plans in fertilizers includes a new plant to be established in the Suez area, with a capacity of 1350 tons/day of ammonium. Part of the production, 350 tons/day, will be used in the Al Naser plant in Suez, the rest of the capacity, 1000 tons/day, will be used to produce 2550 tons/day (= 765 thousand tons/year) of ammonium nitrate. Construction of the plant was supposed to start in 1984-1985. Production was planned to start in 1987-1988 at 70 per cent capacity and to reach full capacity in 1990-1991.

2.2 Iraq

Iraq is a major oil producer with a population of approximately 15 million (1984 estimates). The first oil field was discovered in Kirkuk in 1927, other fields were discovered in the north, centre and south of Iraq. Iraq is known to possess about 6 per cent of the world's proven oil reserves, its reserves are estimated (1982) at 41 billion barrels, including the new discoveries over the past few years. The 1982 estimates for proven gas reserves are 815 billion cu.m. Both associated gas and dry (non associate) gas are available in Iraq.

The Iraqi National Oil Company (INOC) established in 1964, is responsible for all phases of oil exploration and field production. The State organization for Oil Refining and Gas processing is responsible for the oil refining sector and which includes the LPG plants. It operates eight oil refineries and two plants for gas production (LPG). The State Organization for Petrochemical Industries has the responsibility for the petrochemical complex in Basrah. The fertilizer industry is the responsibility of the General Organization for Fertilizer Industry. The production of crude oil reached over 2.5 million b/d while natural gas production reached over 11 million cubic meters.

2.2.1 Oil Refining

- Al wand Refinery: established in 1927, at a nominal capacity of 250 thousand tons/y, its capacity was later increased to 500 thousand tons/y.

- Haditha Refinery: established in 1949, at a capacity of 250 thousand tons/y.

Table 2.1. <u>1980 Refining Production Capacity in Egypt</u>

(000 tons)

Products Refinery	Ameriyah	Suez 1*	Suez 2*	Tanta	Mustard	Alexandria	Total	%
L.P.G	22	17	19	6	40	30	134	0.8
Naphtha	485	318	–	152	107	800	1862	11.1
Gasoline	–	–	148	–	550	–	698	4.2
Kero/jet	362	322	130	114	529	600	2057	12.3
Gasoil	604	430	220	190	882	1000	3326	19.8
Fuel oil	1342	1050	515	507	2381	2400	8195	48.9
Lube	60	–	60	–	–	100	220	1.3
Wax	–	–	–	–	–	10	10	
Asphalt	165	–	–	–	–	100	265	1.6
Total Products	3040	2137	1092	969	4489	5040	16767	100
Fuel and losses	160	113	58	51	236	260	878	
Total	3200	2250	1150	1020	4725	5300	17645	

* Suez-1: El-Nasr Petroleum Company, Suez 2: Suez Petroleum Processing Company.

<u>Source</u>: Based on published information.

- The Al-Multiya Refinery: established in 1953, at a capacity of 200 thousand tons/y. the operation of this refinery was terminated in 1973.

- Dorah Refinery: established in 1953, started production in 1955, at a capacity of 1.2 million ton/y. Its capacity was expanded in 1960 to reach the current capacity of 4 million tons/y.

- Basrah Refinery: established in 1974 at a capacity of 3.4 million tons/y, later expanded in 1979 to 6.8 million tons/y.

- Kirkuk Refinery: at a capacity of 1.5 million tons/y.

- Samawa Refinery: at a capacity of 1 million tons/y.

- Baiji Refinery: at a capacity of 1 million tons/y.

- Qayyarah Refinery: at a capacity of 0.3 million tons/y.

Iraq's total refining capacity in (1980) reached approximately 15.5 million tons/y.

The main refined products and total production in 1979

Product	Thousand tons
L.P.G.	364
Gasoline	1258
Kerosene	975
Jet	443
Gasoil/Diesel/Oil	2214
Fuel oil	5404
Asphalt	1000
Total	11658

There are two established and operating LPG plants, with total designed capacity of 150 million cu.ft/d, currently producing 450 thousand metric tons/year of mixed LPG products. A third plant is planned, at a designed capacity of 1200 thousand MT/Y.

LGP plants location and designed capacity

Location	Designed capacity million cu.ft/d	Mixed LPG products (000) MT/Y
Tahji	80	250
Zubair	70	200
South Iraq (planned)		(1200)
Total	150	1650

The French company Technic, in association with its Italian subsidiary Technipetrol, have been awarded a contract by the State Organization for Oil Projects, for the turnkey construction of a lubricant plant at Baiji worth $395 million (this contract ended a lengthy negotiation period which was started in 1981). Its designed capacity is 250,000 tons/year of motor oil, asphalt and bitumen. It is scheduled to start in 1987, and will be the third of its kind in Iraq.

2.2.2 Petrochemicals as Fertilzers

The State Organization for Petrochemical Industries, was established in late 70's to sponsor the execution of a petrochemical complex in the Zubair area and to expand into downstream petroleum activities. The complex is designed to produce ethylene at a designed capacity of 130 thousand tons/year, feedstock will be 90 million cu.ft/day of natural gas.

Ethylene is to be used to produce the following final products (1) 60 thousand tons/year of PVC; (2) 60 thousand tons/year of LDPE and 30 thousand tons/year of HDPE making up a total designed capacity of 150 thousand tons/year. The complex was planned to start production in 1984, yet the commissioning and production were delayed because of compelling circumstances in the area.

The manpower requirements of the complex are 2046, including 100 engineers and 13 administrators, the majority will be locally provided. The main contractors for the complex are West German - US group. Thyssen Rheinstahl Technik and C.E. Lummus.

Technipetrol has been contracted by ARADET (the Arab Detergents Chemical Company)* in 1984 to build a 50,000 tons/year, linear benzene alkyle plant at Baiji. The plant's construction cost is $95 million. Some of the engineering and equipment will be supplied by the company Techno-export, which previously collaborated with Technipetrol on the expansion of the Salahaddin refinery at Baiji. The new plant will use the process developed by the American firm UOP.

The general organization for fertilizers industry was established in 1970 to undertake the operation of the first nitrogen fertilizers project, the second project was constructed in 1976, the third project in 1979. The organization is owned completely by the Iraqi Government, and its activities are limited to production operations of fertilizers, while internal sales and exports, are undertaken by other local, specialized organizations.

The three plants are designed to produce nitrogen fertilizers (ammonia and urea). The three plants' total capacity for ammonia is 787 thousand tons nitrogen its actual production nearly 461 thousand ton nitrogen in 1980.

---

* ARADET was established in 1981 and based in Iraq as a joint venture between the Iraqi Government (32 per cent) APICORP (32 per cent), Saudi Arabia's Petromin (10 per cent), Kuwait's petrochemical industries company (10 per cent), Jordan's Arab Mining Company (10 per cent) and AIIC (6 per cent).

A plan for a fourth plant which is included in the expansion programme of the organization was lately (1983/84) reformulated, and the location has to be changed to Baiji at the Salahaddin refinery complex. The new designed capacity is 1,000 tons/day of ammonia and about 1,800 tons a day of Urea. The State organization for industrial design and construction was responsible for formulating and announcing the tenders for the construction of the plant.

The total estimated manpower in the fertilizers industry for the period 1970-1980 are found below:

Year	Total employees
1970	700
1975	900
1980	3,262

2.3 Jordan

Jordan is not an oil producing country, it has no hydrocarbon resources, nor gas reserves, it depends on oil imports to solve its energy needs (the energy bill amounted to 11 per cent of GNP in 1980). Jordan's recent search for oil, and its decision to exploit shale oil could reduce its energy imports. The exploitation of known phosphate reserves, which are estimated at 2 billion tons, and the related fertilizers and chemical sectors constitute the major part of Jordan's industry.

The lack of basic raw materials other than phosphates and dead sea brines, the absence of indigenous hydrocarbons and natural gas reserves, and the relatively small scale of domestic oil refining capacity limits the scope for the development of chemical industries. However, the planned development in the petrochemicals production (ammonia, ethylene, etc.) in the neighbouring oil-producing countries should enable Jordan to import these basic products at competitive prices to develop Jordan's (petro) chemical industries.

The country's only refinery, located in Zarqa 20 km north west of the capital, was established and operated by the Jordan Petroleum Refinery Company (JOPETROL). The refinery was commissioned in 1961 with nominal capacity of 330,000 tons/y. Several extensions were subsequently accomplished, bringing nominal capacity to its present 5 million tons/y. Zarqa refinery has also been modernized through the construction of two conversion units: a hydrocracking unit of 198,000 tons/y and a F.C.C. unit of 211,000 tons/y. It has 26,000 employees, all of whom are nationals. The refinery's actual production in 1980 was as follows:

Products	1000/tons
L.P.G.	40.9
Gasoline	286.2
Jet fuel	200.0
Kerosene	169.5
Base oil/diesel oil	470.3
Fuel oil	497.2
Asphalt	95.9
Total	1,760.0

Thus actual production in 1980 was approximately half of the designed capacity and exactly enough to satisfy domestic demand. In view of its capacity, it will be able to fulfill the national requirements in the near future.

2.4 Kuwait

Kuwait's proven oil reserves will last for another 150 years at present rates and techniques of extraction. In recent years there has been a major shift in Kuwait's oil policy. Instead of totally relying on the sale of crude oil, Kuwait is turning to refining, the marketing of refined products and prospecting and producing abroad. It has embarked on oil exploration projects in a number of countries and has acquired several refineries and marketing outlets in (mainly) Western European countries.

The oil industry in Kuwait is the responsibility of the Kuwait Petroleum Corporation (KPC), set up in 1980. It reorganized the functions of the operating oil companies as follows. Kuwait Oil Company (KOC) became specialized in exploration, drilling and production in all areas of Kuwait. The Kuwait National Petroleum Company (KNPC) is responsible for refining, local marketing and gas liquification operations, and Kuwait Oil Tankers (KOTC) is in charge of transporting crude oil, liquified gas, and oil products to various world markets. The Petrochemical Industries Comapny (PIC) was set up to develop the use of the country's hydrocarbon resources in setting up petrochemical industries. Finally, the marketing and selling of gas and oil world-wide is the job of the International Marketing Department in KPC.

Crude oil and natural gas production in Kuwait during the period 1980-1983 was:

	mln b/d	mln cu.ft/day
1980	1,659	847
1981	1,126	611
1982	823	466
1983	1,052	526

The three oil refineries in Kuwait are located in Mina Abdullah, Shuaiba and Ahmadi. They have a total of 614,000 b/d refining capacity. Present modernization schemes will bring this to 700,000 b/d, with more emphasis on low sulphur oil products.

2.4.1 Oil Refining

KNPC, which is the focus of this study, was established in 1960 with a capital of KD. 15 millions of which 60 per cent was initially held by the State and the rest by private Kuwaiti interests. KNPC first took over in 1961 all local distribution of petroleum products, which it acquired from KOC. With a view to exploring and developing relinquished areas from KOC, KNPC created in 1968 the Kuwait Spanish Petroleum Company to act as operator for KNPC. In 1975, the Kuwaiti Government acquired the 40 per cent share of the private interests in KNPC, at a cost of KD. 70 million. Shuaiba refinery was the first refinery fully owned by Kuwait Government, established in 1965 and put on stream in 1968. Shuaiba refinery has been considered as one of the world refineries which largely uses hydrogen in its operating units to produce export-oriented high quality fuels. At its inception, the refinery had a designed capacity of 95 thousand b/d. The current capacity was brought up to 195 thousand b/d after carrying out some debottlenecking and revamping of the vacuum distillation unit. Shuaiba refinery comprises now the following principal operating units:

- Atmospheric and vacuum distillation unit, capcity 195 thousand b/d.
- Hydrogen production unit, capacity 220 million cubic foot/d.
- Naptha fractionator unit, capacity 41 thousand b/d.
- Naphtha, kerosene, light diesel and heavy diesel hydrotreatment units capacity 36, 45, 18 and 14 thousand b/d, respectively.
- Heavy gas oil hydrocracking unit, capcity 23 thousand b/d.
- Heavy residue hydrocracking unit, known to be the first of its kind to be commercially introduced, capacity 50 thousand b/d.
- Naphtha platinum reforming, capacity 16 thousand b/d.
- Sulphur recovery, capcity 570 t/d.
- Lube oil blending unit, annual capcity 32 thousand tons.

Before the establishment of KNPC Shuaiba refinery, two refineries, namely Ahmadi (established in 1949 by KOC) and Mina Abdulla (established in 1958 by American Independent Oil Comapny, Aminoil) represented the refining activities undertaken in Kuwait.

Ahmadi refinery started with a crude distillation unit (25 thousand b/d) to produce fuels for bunkering and local marketing, gasoline, kerosene and gas oil. The refinery later added two distillation units 110 thousand b/d each, whose capacities were increased by revamping to reach a total capacity of 270 thousand b/d. Other units, acquired by Ahmadi refinery through its development, include propane and liquified gas recovery, 90 thousand b/d, gasoline, kerosene and atmospheric residue desulphurization, and naphtha platinum.

Mina Abudulla (MAB) refinery started with a distillation unit of 30 thousand b/d which was destined to process the high sulphur crude oil from (Walfa oil fields), which represents Kuwait's share of the Neutral Zone. The capacity of MAB refinery was increased to reach 47 and 110 thousand b/d in 1960 and 1962, successively. Some modifications of the distillations units were later introduced and a vacuum unit was added, culminating in a capacity increase to 144 thousand b/d. In 1968, a hydrogen unit, of a (38 million cubic foot/d), heavy gas oil desulphurization unit (35 thousand b/d) and sulphur recovery unit (325 tons/d) were added. A modernization upgrading plan for MAB refinery envisions the commissioning in 1986 of two atmospheric residue desulphurization units (33 thousand b/d each), two delayed coker units (30 thousand b/d each), in addition to a kerosene desulphurizer (16 thousand b/d) and a gas oil desulphurizer (55 thousand b/d). In 1978, Aminoil was fully taken over by the Government. For the fiscal year 1982-1983, Shuaiba, Ahmadi and MAB refineries were reported to have processed 70.8, 80, and 22.7 million barrels, respectively.

KNPC undertakes to ensure that the three refineries operate as a fully integrated refining system whereby its operations are optimized. This is achieved through an inter-refinery transfer of intermediate and finished products. High quality fuel oil blending stocks are optimally produced by upgrading low quality crude bottoms.

In addition to the above-mentioned three refineries, the refining scheme includes a gas liquefaction plant whereby gases associated with recovered crude oil are compressed, liquefied and fractionated. In this regard, it is worthwhile pointing out that the recovery and liquefaction process of the associated natural gases has passed through two main stages. In the first stage (1960-1971); a unit for recovery of propane and butane gases (200 b/d) was established at Ahmadi refinery to meet domestic consumption of these gases. This was followed later by establishing two units (65 thousand b/d) which process the condensate collected from oilfields. The capacity of these two units was thereafter increased to 80 thousand b/d. A propane recovery unit was added in 1971, thus increasing the total output of propane-butane gases to 90 thousand b/d.

In the second stage, the associated natural gas resource was considered the property of the State of Kuwait. In 1979, a gas liquefaction plant (1725 million cubic foot/d) comprising three trains (575 million cubic foot/d each) was established. The liquefaction plant is fed with the associated gases in addition to the condensate separated at the crude gathering centres at the principal crude oil production zones. The plant is designed to produce 100, 55 and 40 thousand b/d of propane, butane and natural gasoline, respectively, in addition to 1150 million cubic foot/d of other gases.

For the fiscal year 1982-1983, it was reported that only two trains of the gas liquefaction plant (GLP) were operated. This is due to the sharp cutback in oil production. GLP is expected to remain underutilized until additional gas feed is supplied or other alternative uses are developed. Feedstock to the two trains of the GLP during the year totalled 147.3 billion standard cubic foot (BSCF) of gases and condensates. The plant produced 773, 653, 59 and 457 thousand tons of propane,butane, pentanes and natural gasoline, respectively, in addition to 115 BSCF of lean gas. The respective export and domestic consumption of liquefied petroleum gases (LPG) were 967 and 54 thousand tons, for 1982/83. Domestic power stations consumed 482 thousand tons of LPG and pentanes which were injected into the fuel gas.

According to the fourth annual report issued by KPC for the fiscal year 1983-1984, KNPC is fully owned by the State of Kuwait and has an authorized capital of KD. 260 million and a paid-up capital of KD. 260 million. Its fixed assets approximate KD. 714 million, indicating added assets due to underway expansion for the same fiscal year (1983-1984). The total crude throughput to the three refineries was 170 million barrel (an average of 464 thousand b/d). The refined products amounted to 24.2 million metric ton, distributed refinerywise, Shuaiba 46 per cent, Ahmadi 30 per cent and MAB 24 per cent, and productwise, Naphtha 16 per cent, automotive gasoline 0.8 per cent, kerosene-aviation turbine 8 per cent, diesel 24 per cent, furnace fuel 50.5 per cent, and other products (bitumen and sulphur) 0.7 per cent.

The approximate feedstock to the gas liquefaction plant was 180 BSCF and the propane-butane output amounted to 1.8 million metric ton. The distribution of sales of refined products, according to destination (1983-1984) was 26.3 million barrels for the domestic market (18 per cent) and 20 million metric tons for the export market (82 per cent). The exported quantities of LPG were estimated at 1.41 million metric ton.

A breakdown of the distribution of sales for 1980 was issued by Ministry of Oil and indicated 180 thousand b/d for domestic market (37 per cent), 22 thousand b/d for Arab market (4.5 per cent) and 286 thousand b/d for other markets (58.5 per cent).

Liquefied gas export was estimated for 1980 at 2.27 million metric tons whose distribution according to destination is about 66 thousand tons for the domestic market (3 per cent), about 11 thousand tons for the Arab market (0.5 per cent), and about 2.2 million tons for the other markets (96.5 per cent).

Hydrocarbon export in 1983 totalled approximately 366 million barrels, which is distributed as follows 200 mln.b/d crude oil (54.6 per cent). 150 mln.b/d refined products (41 per cent) and 16 million barrel of LPG (4.4 per cent). The total value of the overall hydrocarbon export was estimated at about 11 billion dollars. The approximate values of the exported refined products (except for sulphur) are as follows: naphtha US $850 mln. aviation fuel US $40 mln. kerosene US$ 400 mln. diesel oil US $ 1,000 mln. marine diesel US $20 mln. furnace fuel US $ 1,700 mln. and LPG US $380 mln. The approximate percentage distribution of exported refined products is as follows: naphtha 21 per cent, aviation fuel 0.8 per cent, kerosene 8 per cent diesel oil 21.2 per cent marine diesel oil 0.4 per cent and furnace fuel 48.6 per cent.

It is worth highlighting that the implementation of the KNPC refining programme is made through a processing agreement, held between KPC and the three refineries whereby KNPC acts as a profit centre. The integration of the three refineries enable KNPC to minimize operating costs and yield losses, maximize process unit utilization, increase energy conservation, optimize operations and secure maximum utilization of manpower resoruces for planning and managing its projects.

2.4.2 Petrochemical and Fertilizer

Kuwait has a petrochemical industrialization plan with regard to establishing ammonia and nitrogen based fertilizer plants. The objectives of this plan are to maximize the utilization of natural gas associated with recovered crude oil, diversify sources for national income, and insure self-sufficiency of fertilizers which play a crucial role in augmenting agricultural output for the Arab and developing countries.

To put this plan into action, the Petrochemical Industries Company (PIC) was created in 1963 with the aim to use natural gas, considered to be Kuwait's second natural resource, as a feedstock for production of nitrogenous fertilizers. In 1964, a joint venture between PIC and foreign partners was established. A chemical fertilizer complex was commissioned, which embraces a liquid ammonia plant, sulphuric acid plant, ammonium sulphate plant, and an urea plant. The first three plants were put on stream in 1966. The urea plant started production in 1967.

PIC undertook later, unilaterally, to establish two plants for ammonia production and two plants for urea, all were commisioned during the period 1971-1972. In 1973, PIC acquired the foreign share and the full ownership of all assets of the chemical fertilizer establishments in Shuaiba area, while having retained a separate legal entity for the fertilizer company. Later, the fertilizer company was completely merged into the parent company (PIC) which is completely owned by the State of Kuwait. In 1974, the ownership of the plants for production of sodium chloride and chlorine was transferred from the Ministry of Electricity and Water to PIC. These plants were established in 1963 with the objective to produce chlorine required for water treatment, in addition to hydrochloric acid and sodium hypochlorite.

PIC has an authorized capital of KD. 130 million, a paid-up capital of KD. 100 million, and total fixed assets of KD. 105 million.

(a) Design versus actual capacity

The breakdown of actual and designed production capacity for PIC during 1983/84 is as shown in the following table:

(in 000 MT)

	Designed capacity	Actual capacity	Percentage underutilization
Ammonia	990	357	38%
Urea	792	549	61%
Sulphuric acid	132	4.65	3.5%
Sodium chloride, chlorine and sodium hydroxide	60	38	66%

Source: Based on published information.

The substantially reduced capacity in production of ammonia and urea is attributed to the sharp cutback in crude oil production as set by the ceiling imposed by OPEC. This curtailed the supply of associated natural gas which is the source for hydrogen production required for ammonia and urea manufacturing.

The production capacity of chlorine and sodium hydroxide was 66 per cent of their design capacity.

(b) <u>Destination and Sales Value</u>

A breakdown of the distribution of sale of products manufactured by PIC during the period 1983-1984 indicates 70,000 MT for domestic market (11 per cent), 5,000 MT for Arab market (1 per cent), and 566,000 MT for foreign markets (88 per cent).

The total value of the manufactured products destined for local and export markets was KD. 27.5 million which was distributed according to destination in the following order: KD. 4 million for the local market (15 per cent), KD. 0.6 million for the Arab market (2 per cent) and KD. 23 million for foreign markets (83 per cent). The products that are consumed locally are either used as feedstocks for established industries such as melamine which uses annually 55,000 tons urea, or as chemical agent for water treatment in refineries and power generation stations which consume annually 8,000 ton chlorine, 2,000 ton hydrochloric acid and 10,000 ton sodium hydroxide. About 100 ton of liquid ammonia is consumed annually by the Kuwait Industrial Gases Company. The consumption of the above chemical products is expected to increase to reach 20,000, 40,000 and 10,000 ton for chlorine, hydrochloric acid and sodium hydroxide, respectively.

(c) <u>New and envisaged projects</u>

A new ammonia plant having an annual capacity of 330 thousand tons was commissioned in the third quarter of 1984. Also, the detailed engineering and civil construction were completed for a new plant for production of chlorine and sodium chloride, having a daily capacity of 75 and 150 tons, respectively. The plant is due for completion in the first quarter of 1986.

Expansion projected for the next five years includes a unit for production of polypropylene (60 thousand ton annual capacity). Propylene produced from catalytic cracking of gas oil and delayed coking of low sulphur heavy residues constitutes the feedstock to the polymerization unit.

Also, a unit for the production of ammonium diphosphate is planned, (330 thousand ton annual capacity), which consumes annually 70 thousand ton ammonia. By doing so, PIC is implementing a policy of forward integration whereby ammonia that is produced by upstream units is consumed for the manufacture of urea and ammonium diphosphate in downstream operations. The backward integration is implemented through PIC utilization of natural gas and propylene produced from upstream refining operations for the manufacture of ammonia and polypropylene, respectively.

2.5 Qatar

Qatar's natural resources are oil and natural gas and construction materials. The proven oil reserves are 3.3 billion barrels and the proven gas reserves of the newly discovered North field are around 150 trillion cubic feet, its probable gas reserves estimated at over 300 trillion cubic feet. The development of the North field was initiated in June 1984 and is expected to be producing in 1988. The total population is 200,000 (1984) with 46 per cent below 15 years, and the active population 37 per cent. The Qatari work force has increased from 8,168 in 1970 to 16,267 in 1980. The foreign work force constitutes more than 80 per cent of the total active population. The petroleum and manufacturing industry sectors combined have 2,387 employees which is not more than 15 per cent of the Qatari working force in 1980.

Qatar's oil comes from the onshore Dukhan field, and offshore (3 fields) and the Bundug field which is shared equally with Abu Dhabi. At Qatar's monthly OPEC production rate of 300,000 b/d the oil reserves would last 40 years. In 1981 the production of natural gas increased by 91 per cent because of the decrease in crude oil production set in 1981 and its effects on the production of associated gas. In the last four years, the Qatari domestic demand has been short of gas which is used as (1) feedstock for its petrochemical, fertilizer and iron and steel plants, (2) as fuel for industries such as iron and steel, cement plants and for power generation and desalination of water.

Total crude oil production in 1983 was 107 million barrels, and exports were 102 million barrels, equivalent to 280,000 barrels a day slightly below the OPEC-set limit of 300,000 b/d, 377,000 metric tons of petroleum products and 194 billion cubic feet of natural gas were produced in the same year.

The petroleum sector is the main contributor to GDP. It alone generates 66 to 80 per cent of GDP in the period 1980-1983. Oil revenues represent 89 per cent of the government income.

Qatar's policy since 1971 has been to stabilize and conserve crude oil production a depleting source of income, take over, expand and control all operations of its oil resource production base and marketing services, diversify the sources of national income, create a balanced economy which is not totally dependent on oil production and sales, invest oil revenues for expanding the country's productive industries, build the needed infrastructure in transport, communication, housing, water, energy, electricity, education and health facilities, increase agriculture production and better direct the trade, finance and services sectors in Qatar.

To accomplish this, Qatar's Government was faced with the problem of shortage in local managerial and especially skilled manpower, limited local markets and deficient infrastructure. Thus export oriented and import substitution, capital intensive and low labour requirements, made up the criteria by which Qatar sought to promote its industrialization process, since it enjoyed comparative investment advantage, cheap energy and raw materials mainly petroleum and gas.

Industrial development started in Qatar on a limited scale during the sixties, and on the basis of individual projects, both for economic and technical infrastructural reasons, during this stage few basic industries were developed such as oil refining and chemical fertilizers.

With the increase of oil prices in 1973 and the availability of funds to finance macro-projects, a more advanced stage of industrial development started. The pattern of development by individual projects was considered unsatisfactory if quicker and higher rates of industrial development are to be achieved. Therefore, the pattern of industrial development according to strategic plans was adopted, and a more integrated relationship between industrial projects was planned taking into consideration the establishment of the required infrastructure needed for construction, and maintenance of industrial projects, and the development of Qatari manpower which is needed to achieve effective national control.

The coastal Umm Said site an industrial complex, some 35 miles (56 kilometres) from Doha, has been developed as the first focal point for diversification, particularly in the case of heavy industry. The necessary infrastructure is under continuing development, a deep water industrial port is in full operation, also power and desalination plants, other facilities are provided, such as housing, roads, social and cultural facilities for workers, laboratories and maintenance workshops for the industrial projects.

The petroleum based projects (Refineries, QAFCO, LNG, QAPCO) and other heavy industries such as the iron and steel complex and the cement plant established at Umm Said, are all highly capital intensive that is why the Qatari Government had to take a direct role in the establishment of these projects (The cost of the above-mentioned projects and infrastructure have taken the bulk of the State investment of Q.R. 8,875 to date (1984)).

The Industrial Development Technical Centre: the State's technical and advisory authority in industrial diversification affairs and on major industrial projects is the Industrial Development Centre which was created in 1973 with the task of laying down development plans for the State of Qatar and to supervise the implementation of the major industrial projects.

IDTC has been involved in the following activities: (a) planning and executing the nationalization of the petroleum based industries; (b) strengthening the Qatari inclination to take greater part in the industrialization process of the refining and the petrochemical industries; (c) creating and supervising the oil refining and petrochemical companies in the form of joint ventures with foreign partners, who own the process licences, but have a minority interest in the operations of the projects plus management and in some cases marketing agreements; (d) implementing industrial integration between the different oil refining/petrochemical fertilizer plants already existing and proposed expansion or downstream industries, and exchange of information and experience between local companies and co-ordinating training of local manpower and exchange of experience.

It has built up a team of local and Arab professionals, comprising 80 full-time staff all are experts in related specialization, experienced engineering and scientists and economists, of whom 80 per cent work on the technical side, plus supporting services (data bank, laboratories and maintenance units) at Umm Said. This is complemented by a team of experts from UNIDO whose composition changes with the requirements, it also has a standing consultancy agreement with a leading international firm in engineering consultants, plus drawing as required, on the world-wide sources of information and expertise on an assignment basis.

Organizationally the Centre is composed of activity sections, general management, experts and consultants, working groups, administration and finance. The experts and consultants section is divided into four subsections: research and other studies, geology and natural resources, laboratories, surveys and design. The working group section is composed of three subgroups - industrial safety and security, industrial marketing, industrial contracts, their work interlocks with six other groups for monitoring industrial production, and maintenance, for solar and renewable sources of energy, for documentation and information, protection of environment from industrial polution and for studying light and medium sized industries. Through these units the Centre monitors production, operation and processing performance of all major State owned industries including QAFCO, QAPCO, and the LNG plants.

Two main committees were formed one for maintenance the other for productivity control - the maintenance committee studies the possibilities of preventive maintenance in all major industrial sites at Umm Said. It is to secure successful long-term operations of plants and to insure the availability of spare parts and skilled personnel to solve problems that cause frequent stoppages. The productivity committee monitors the production data from the major projects, and a laboratory set by this committee tests samples of products as a quality control and it operates a mobile laboratory to serve the different companies, studies their problems and its experts participate in co-operation with the companies technical staff in finding solutions and puts efforts to develop productivity measures.

An example of the IDIC role is seen in the development of the fertilizer (QAFCO 2) expansion programme, where it undertook detailed studies and reviewed the preparatory stage of the project's expansion programme thus contributing to key decisions; it also acted as a "technical support system" for the ongoing operation of plants once built. IDIC has been actively involved in dealing with the technical problems and in implementing various improvements. In effect, the centre has made great efforts to link the imported technology with the possibilities for promoting local technological capacities and abilities, one effect of the interaction has been seen in the recent rapidly rising trend of production efficiency in the plants involved.

At present IDIC is keen to encourage and promote the manufacture of finished products using the outputs from the Umm Said heavy industries, such as the plastics plant. Therefore we can summarize by saying that IDIC has in the past 12 years acquired experience and knowledge in 11 project identification and on that basis undertakes feasibility and pre feasibility studies, participates in the negotiation of technical and financial analysis of bids, and contract agreements, plus process identification and selection, (review of engineering construction quality, commissioning) monitoring ongoing operations in certain cases, all these abilities go under management services: All other technological capabilities such as basic plant design, detailed engineering designs, procurement and erection of equipment, preparation of plant operation and start up is mainly under the auspices of the foreign partner. The experience of QAFCO and QAPCO indicates the role of IDTC and the foreign companies role in the execution process.

Qatar General Petroleum Company (QGPC)

QGPC was established in 1974, in accordance with national policy adopted in Qatar in the 1970's, to undertake the new responsibilities and become the holder of the Government of Qatar shares in the various petroleum companies, of exercising national control over crude oil operations, production and refining, undertaking direct responsibility for marketing crude oil, natural gas and petroleum products and keeping a close watch on developments in the regional and international oil and natural gas markets. The Qatari party in all aspects of the oil industry in Qatar and abroad, including production, refining processing, transport and storage of these products and their derivatives, undertakes the training and development of Qatari manpower in the oil and gas sector in order to ensure effective national control in the long term.

In 1983 the paid up capital of QGPC was QR. 3,557 m (1.1 billion US dollars). Up to 1984, QGPC has implemented jointly with foreign partners a number of petroleum related projects in Qatar itself and participated actively on behalf of the state of Qatar, in Arab and foreign ventures.

QGPC employees and its subsidiaries (NODOC, QAPGO, QAFCO) numbered in 1983, 5,553 employees in QGPC many Qatari's occupy the decision-making positions and most management personnel are Arabs. In 1982, 27 Qatari university graduates were employed by the corporation and its subsidiary industries. In the area of training, 29 trainees had training courses in 1982. Another seven of the Qatari employed continued their higher education abroad in the same year. A number of Qatari's have been trained as computer programmers and operators through courses in England and Bahrain, preparing them to work in the computer centre. QGPC has an engineering section which acts as a project development department, the company uses technical research facilities of other countries on the basis of joint or co-operative research programmes as needs develop. The company has adequate means of maintenance in terms of trained personnel.

QGPC has an in-house training centre, which it expanded recently. The centre was established in 1963 by Shell Qatar Company. The training centre is organized to train both high school graduates applying for employment with the corporation, and in-house Qatari and other workers, periodically for upgrading their skills and developing new capabilities. For new employees the centre organizes technical training for three years divided into four scientific studies and one period of on site training. Training is in the mechanics of production, electricity, drilling and maintenance. Following graduation, the development of their capabilities is controlled by the development section in the organization and they have the possibility to go abroad for further training in similar companies.

2.5.1. Oil refining

The National Oil Distribution Company was established in October 1968 to perform crude oil refining operations and local distribution of oil products in Qatar. The paid up capital of the company is 40 million QR. NODOC is a wholly owned subsidiary of QGPC. It owns the original refinery plant which was established in 1953 by the Qatar Petroleum Company, with a daily production of 600 barrels of kerosene, petroleum and diesel. In January 1972, NODOC signed an agreement with J. Ray McDermott, a United State Company, to build a refinery at Umm Sai, with a name plate capacity of 6,700 barrels per day. It was commissioned in 1975, the refinery has subsequently in 1977 been expanded to a capacity of 11,500 b/d because of the continuous increase in national consumption. This enlargement brought the total refined products to 12,000 b/d. Which was still below the local demand by about 6000 b/d.

In response to the persistent deficit in national output in relation to national demand, studies were launched in 1974 for an export oriented refinery with a designed capacity of 50,000 b/d. This refinery was built by Technip of France, the agreement signed in 1980, on a fixed cost basis (turnkey) cost US$ 137 million, the consultation work for the plant was done by Kellogg International and the structural engineering done by India's Dodsal, the factory was inaugurated in February 1984, the total present designed capacity became 62,000 b/d. The design of the new factory allows for further expansion without major modification.

In 1983 the total output of refined crude products reached 377,014 tons, including butagas kerosene, jet fuel and diesel oil. The local consumption exceeded production, an additional quantity of 191,425 tons was imported that year, but in 1984 Qatar stopped all imports of jet fuel, liquefied petroleum, gas, kerosene, diesel and fuel oil due to surplus production.

Both refineries are at Umm Said, the second refinery was built close to the older refinery, to which it is now linked and operated jointly as a single unit. This has decreased the cost of operations and maintenance. The products of the new refinery include LPG, gas oil, regular and octane gasolines, jet fuel and kerosene.

QGPC has previously prepared with the co-operation of the refinery management and the executing contractors Technip, a detailed training programme for the Qatari enineers working for the project, on site and abroad to give them the necessary skills and experience in the operation and maintenance aspects. The first refinery had a body of staff of 292 in 1979. At present the two refineries are run 100 per cent by Qatari and an Arab work-force.

In March 1971 Qatar started a large project QGPC, for the processing and export of natural gas liquids NGL based on the associated gas produced at the onshore Dukhan oil field. The project was commissioned in early 1975, NGL.1 and its products were mostly exported. A fire in early 1977 destroyed most of the fractionation and storage facilities. Re-construction on the same site at Umm Said was decided and the re-constructed plant was commissioned in 1980. This unit has a daily production capacity of 1,290 tons of propane, 850 tons of butane and 850 tons of condensate as natural gasoline. In addition the plant has a production capacity of 350 tons/per day of ethane rich gas and 4 million cubic meters of methane rich gas. The ethane rich gas is used in the petrochemical complex of QAPCO. Production started in NGL.1 in 1981 NGL.1 was constructed by Shell International Petroleum Maatschappij (SIPM).

In the same period (1980), Qatar's second LNG plant was commissioned based on the associated gas, recovered in the offshore oil fields and piped to Umm Said on the mainland. It has a daily production capacity of 1,080 tons of propane, 900 tons of butane, 900 tons of natural gasoline and 1,145 tons of ethane rich gas. The second unit was built by Mitsubishi Corporation and Chiyoda Chemical Engineering and Construction Company. The NGL.1 plant is operated by the onshore Dukhan Service Company (DSC), and NGL.2 by Qatar Shell Company. In 1981, only 1.1 million barrels of NGL were produced. The total production of the NGL complex, in both units of ethane rich gas, butane, propane, natural gasoline condensates was 0.8 million tons in 1982, 1.1 million tons in 1983, and 1.43 million tons in 1984, the local consumption in 1984 reached 638.742 tons and the sales were 745.160 tons, the main market being Japan.

To develop the enormous reserves of natural gas in Northfield, Qatar QGPC signed in June 1984 a joint venture tripartite agreement with British Petroleum and Companies Francaise des Petroles (CEF Total) QGPC has 85 per cent shares) the two companies will participate in the development of the field and in the marketing of LNG, the proven reserves of 150 trillion and probable of 300,400 trillion cubic feet, are estimated to be some 10 per cent of the world's total gas reserves. The cost of the development plan is estimated at 6 billion (Q.R) to be spent over a period of eight years.

Initially it was intended to set up offshore platforms, drilling facilities and pipelines for transporting raw gas from the field to shore. The plan includes the construction of a liquefaction plant and a shipping terminal south of Umm Said. In the first phase of development the plant will produce 2,400 million cubic feet of petroleum products, the second will produce 6 million tons annually of LPG products for export. The first phase is expected to be completed in 1988, and the second in 1990. BASF chemicals and its subsidiary Winter Shell (a Germany company) has completed a feasibility study for developing the project, and United State company Fluor Inc. has been chosen to provide consultancy work, such as detailed facility definitions, planning and design of the NGLS stripping facilities for phase I to be completed in 1985. It will also provide staff to work on the job.

2.5.3. Fertilizers

Established in Qatar in 1969, QAFCO is the first petroleum project as a Qatari limited liability company with the objective of building and operating a nitrogenous (ammonia/urea) fertilizer plant, using the associated gas from the onshore Dukhan oil field, which was previously flared and wasted.

QAFCO is a joint venture (direct investment) project, between QGPC (75 per cent share) and Norsk Hydro of Norway (25 per cent). Its present autorized capital is 100 million QR, as well as its paid up capital, while its total assets are 1,016 million QR.

QAFCO's first nitrogenous (ammonia/urea) plant began production in 1973 and was built at the cost of 360 million QR. The second plant, which has the same capacity started production in 1979. The total designed capacity of the fertilizer complex (QAFCO, 1 and 2) is 594,000 metric tons for ammonia, and 660.000 metric tons for urea. The fertilizer complex total investment reached QR 1,360 million ($373.6 million). It is an export oriented project, since the local consumption is satisfied by only 10 minutes production time (in 1983 it was 1,377 tons).

In 1980 and 1981 actual production of both plants (QAFCO 1 and 2) accounted for 77 per cent of designed capacity in the case of ammonia and 89 per cent in the case of urea. In 1982 QAFCO 1 achieved 85 and 91 per cent of the designed capacity in the ammonia and urea lines respectively. The same units of QAFCO 2 achieved 93 and 110 per cent respectively. In 1983 the production in ammonia went up by 110 per cent and 3.5 per cent in urea. The production in 1984 was 734,022 tons of urea and 631,759 tons ammonia, which shows a great improvement in 1983 production of 683,000 urea and 586,000 of ammonia, this is attributed to operating efficiency and appropriate supplies of gas.

In 1984 it exported 201,589 tons of ammonia and 717,146 tons of urea (2/3 of the ammonia produced is used in urea production). Destination of exports are in the Arab world (Jordan, Morocco, Oman), U.S.A, China, India etc. Though its operation efficiency is high and all products are sold to world markets, yet the profits went down from QR 174 million ($47.8 million) in 1981 to QR 138 million ($37.9 million) in 1982 and QR 120 million ($33 million) in 1983 reflecting world-wide depressed fertilizer prices.

Technical development in the complex was planned in 1982, to build a $2.1 million computerized control system for the first ammonia and urea plant, to be installed in 1985, and the QR 20 million ($5.5 million) gas sweetening plant to remove the sulphur content from the offshore gas supplies, in order to make associated gas more suitable for processing at the fertilizer plant.

2.5.4. Petrochemicals

The Qatar Petrochemical Company QAPCO was established in 1974, with the objective of building an export oriented plant to manufacture ethylene and LD polyethylene from ethane rich gas, (produced by the Qatari NGL plant). Sulphur is produced as a by product. In 1984 QAPCO'S capital was $119 million.

For the establishment of QAPCO. The Qatari Government entered in June 1974 into a protocol of association with two french companies CDF Chimie and Gasocean. QGPC in 1975 took over the Qatar Government shares (80 per cent) and in 1976 took over the Gasocean shares. In 1977 QAPCO entered into commercial contracts with four prime contractors and specialized engineering firms for the construction of the complex.

1. Teching (France) the ethylene plant.
2. Coppee Rust (Belgium) low density polyethylene plant.
3. Turbo Tecnia (Italy) the steam and power plant.
4. Japan Gasoline Corporation (Japan) the general off site facilities.

Actual construction started in 1977 and the complex went on stream in January 1981, QAPCO's cost was QR 2,500 million ($687 million). The designed capacity of the plant is 280,000 tons/y ethylene and 140,000 tons/year low density polyethylene, and 50,000 t/y sulphur.

Actual production in the period (1981-1984) was as follows:

	E (t/y)	LDPE (t/y)	S (t/y)
1981		112,300	
1982	126,000	120,000	
1983	164,000	144,000	19,000
1984	204,000	159,000	33,264

The sales in (1983, 1984) were:

	E/(t/y)	LDPE (t/y)	S(t/y)
1983	7,000	132,000	25,000
1984	64,130 T	151,921	23,000

The main destination of sales (1983) were to Saudi Arabia and China for LD polyethylene, Italy for ethylene and Greece for sulphur.

Since operations began in 1981, QAPCO has lost money, partly because of falling oil production in Qatar which had reduced the amounts of gas feedstock available and partly because of technical problems with the gas lines linking the plant with the two natural gas liquids LNG plants at Umm Said.

QAPCO has been producing at one half designed capacity in ethylene, which is used for the production of LD polyethylene and therefore there was no surplus ethylene for export. Because of shortage in feedstock and therefore decreased output, QAPCO cancelled bids for a 70,000 t/y high density polyethylene plant.

To partially solve the problem of feedstock QAPCO awarded in February 1984 CdF Chimie of France a QR 200 million ($55 million) contract to design, supply and install an ethane recovery plant (a turbo expander) at QAPCO's petrochemical complex. The new unit will increase QAPCO's ethane feedstock by 500 tons/day to 1,100 tons/day upon its completion in 1985. (The plant in 1984 was running at 60 to 70 per cent of its designed capacity).

2.6 Saudi Arabia

2.6.1 General

Saudi Arabia is the world's largest oil exporter and was a founder member of OPEC. Oil was discoverd in the country in 1938, but large-scale development of oilfields began only after World War II. The country has the largest proven oil reserves, in the world, estimated at 168.03 billion barrels (1980).

As can be seen from the table, Saudi Arabia is gradually decreasing its oil production, even below its sustainable capacity, which is estimated at between 10 and 12 million b/d.

Oil production in 1980:	10.0 million b/d
1981:	10.0 million b/d
1982:	8.5 million b/d
1983:	5.0 million b/d
1984:	4.2 million b/d

Besides political and economic reasons there are also technical factors in favour of reducing oil output. First, Saudi Arabia's proven reserves of light oil are being depleted more rapidly than those of the medium and heavy variaties. The country is trying to change their 65/35 export mix to a 50/50 ratio. Such a ratio would mean a production of about 6 to 6.5 mln b/d unless plans to increase the heavy oil production were implemented. Second, Saudi Arabia's Master Gas System - a $ 20 billion project for the gathering of natural gas - cannot absorb associated gas output beyond approx. 7.3 mln b/d of oil output. Additional output of associated gas would have to be flared and wasted.

The Arabian American Oil Company (ARAMCO) produces about 96 per cent of the country's total production from its five areas of operation totalling 220,000 sq kms in the eastern area of the Kingdom. The remainder is produced by Getty Oil and the Arabian Oil Company (offshore). Crude oil production in 1980 was divided as follows over the three existing companies:

ARAMCO	3,525.1 million barrels
Getty Oil	28.5 " "
Arabian Oil	69.9 " "
Total	3,623.5 million barrels

This constituted 16.6 per cent of the world production.

ARAMCO's, principal oilfields are at Abqaiq, Ain Dar, Dammam and Ghawar. Offshore fields are Safaniya, Aba Sa'fah and Berri.

Natural gas reserves were estimated at 3,433 billion cu metres in 1983, Net production in 1981 totalled 52,382 million cu metres. There is a natural gas liquids (NGL) plant at Abqaiq and a liquefied natural gas LNG plant at Ras Tanura.

The Master Gas System (MGS) is designed to provide fuel gas for industry, power generation and water desalination. It will also provide ethane as feedstock for petrochemical complexes at Al-Jubail and Yanbu and propane, butane and natural gasoline for export. The project, which is implemented by ARAMCO, comprises the following gas processing and fractionating plants:

a) NGL centers:	Berri	NGL	54,000 bl
		methane	400 mln cu.f
	Shadqum	Feed	1,500 mln cu.f
		NGL	160,000 bl
		ethane	780 mln cu.f
	Othmaniyah	Feed	1,400 mln cu.f
		methane	525 mln cu.f
		NGL	305,000 bl

b) Fractionating plants:

Juaymah (Jubail)	ethane/NGL	300,000 bl
Yanbu	ethane/NGL	270,000 bl

The development of the petroleum-based sector of the Saudi industry is the responsibility of four organizations:

The Royal Commission for Jubail and Yanbu
The Saudi Basic Industries Corporation (SABIC)
The General Petroleum and Minerals Organization (PETROMIN)
Arabian American Oil Company (ARAMCO)

The Royal Commission is responsible for building the intrastructural facilities in Jubail and Yanbu, the two sites selected on the east and west coast, respectively, to locate basic industrial projects. PETROMIN will set up a number of new oil refineries and a cross-country pipeline to supply the Yanbu projects with crude. SABIC is preparing and implementing a number of petrochemical and iron and steel projects in co-operation with several foreign firms specializing in these areas. The activities of these organizations are briefly described in the following.

Royal Commission for Jubail and Yanbu

Its objective is to develop the two industrial cities, Jubail and Yanbu, and to provide all the intrastructural facilities required by the industrial projects undertaken by SABIC and PETROMIN. The infrastructure programme for each city includes the construction of an airport, seaports, utilities, telecommunications, water desalination plants, a sea-water cooling system, bulk material handling and storage facilities, site preparation for industries, a comprehensive network for commercial facilities and permanent community facilities such as schools and hospitals. The industrial plan foresees in the setting up of 17 primary industries, 136 secondary and over 100 tertiary industries by the year 2000. Upon full operation, these industries will create 140.000 new jobs.

The total population of Jubail is planned to be 300,000 by the year 2000 while the total population of Yanbu is expected to be 150,000 in 2006.

The two huge development projects are being managed by two different companies, with involvement of national companies.

The Jubail programme is being managed by the Saudi Arabian Bechtel Company, a joint venture between the United States Bechtel Corporation and the local Olayan Group.

The Yanbu programme is managed by Saudi Arabian Parsons, the local affiliate of the United States Ralph M Parsons Company. It includes an NGL fractionation plant, domestic refinery, export refinery and a petrochemical complex. A 400-hectare site is being prepared for secondary industries. The feedstock for primary industries at Yanbu, 350 km north of Jeddah, is piped across the Kingdom. For this purpose, a 1,270 km pipeline, the East-West Crude Oil Pipeline (Petroline) links the Ghawar oil field in Eastern Province with the port of Yanbu. Its throughput is 1.6 million b/d, which can be upgraded to 2.3 mln b/d. It was completed in 1981 by the United States Mobil Overseas Pipe Line Co. (cost $1,600 mln). Aramco has also completed the construction of a high pressure pipeline for transporting natural gas liquids NGL from Shedgum to Yanbu. The capacity of this 1,170 km long pipeline is 270,000 b/d of NGL and ethane.

Jubail's 1,150 hectare site for secondary industries receives its natural gas from Eastern Province oilfields.

Another 240 km pipeline links the Khurais field with the Riyadh refinery. Its capacity is approx. 300.000 b/d.

The development of the two complexes is facilitated by very advantageous electricity, water and land prices. For instance:

Electricity	SR	0.07	or	$	0.52/kWh (1/4th of generating cost)
Land	SR	0.08	or	$	0.03/sq.m.
Water rate	SR	0.25	or	$	0.10/cu. m.

PETROMIN

PETROMIN was set up in 1962 and is responsible for implementing and administering public projects for petroleum and minerals; import raw materials needed, conduct studies; conduct petroleum and mineral operations such as exploration, production, refining, transportation and distribution, and co-operate with private companies in the same field. The distribution of oil products domestically is also controlled by Petromin.

It has also undertaken a huge project for gas gathering, treatment and transportation (GTT) with ARAMCO being responsible for the construction. This scheme will produce the following:

Sulphur	4,000 t/d
Methane	2 bln m^3/yr
Ethane	0.37 bln m^3/yr
LPG	375,000 b/d

SABIC

SABIC was established by Royal Decree in 1975 to set up, operate and market the products of basic industries, based upon local hydrocarbon and mineral resources, as well as other downstream and supporting industries. As an initial step it invested SR 38,000 million (1983 prices) in a first group of industrial projects and will require a total of about 7,000 employees of all categories.

The oldest SABIC industry is the Saudi Arabian Fertiliser Company (SAFCO), established in Dammam in 1964. Since 1981 it has been producing 300,000 t/y of urea. SAFCO also markets Samaa's output.

The first three new joint ventures coming into operation and their investment costs were as follows:

Saudi Iron and Steel Company	(Hadeed)	SR	3,196 mln
Saudi Methanol Company	(Ar-Razi)	SR	900 mln
Al-Jubail Fertilizer Company	(SAMAD)	SR	977 mln

Under construction and/or near completion are:

National Methanol Company	(Ibn-Sina)	SR	1,468 mln
Saudi Petrochemical Company	(SADAF)	SR	9,963 mln
Saudi Yanbu Petrochemical Co.	(Yanpet)	SR	7,876 mln
Arabian Petrochemical Company	(Petrokemya)	SR	3,055 mln
Al-Jubail Petrochemical Co.	(Kemya)	SR	4,480 mln
Eastern Petrochemical Co.	(Sharq)	SR	4,936 mln
National Industrial Gases Co.	(GAS)	SR	415 mln
National Plastic Co.	(Ibn Hayyan)	SR	1,333 mln
Total investments....................		SR	38,599 mln

SABIC has started preparing for a second group of industries, which are downstream and supportive to its basic industries. They are meant to provide feedstocks for existing national industries, or to encourage new ones to be set up. As it is formulated in the Five Year Plan these industries are "to provide horizontal integration in production, which will consequently serve Saudi consumers and foreign markets with goods in high demand".

These industries include the industrial gas plant project referred to above (GAS) and a VCM/PVC project. The latter joint venture company (Ibn Hayyan) will start production in 1986. The feedstocks for this plant will be ethylene dichloride and ethylene, produced by SADAF and PETROKEMYA.

SABIC has also undertaken the final economic feasiblity study for a MTBE, butene-1 and butadiene plant at Al-Jubail, to be built in conjunction with Aqip (I) and Neste Oy (Finland).

The plant was established in 1985 as the Saudi European Petrochemicals Company (Ibn Zahr). It has a 10 per cent Finnish share and its production will be:

MTBE	500,000 tpa
Butadiene	124,000 tpa
Butene-1	80,000 tpa

Note: MTBE = methyl tertiary butyl ether. Is an agent used to upgrade the octane level of petrol.

Furthermore there are plans for fertilizer, metals, plastics and other petrochemical industries, requiring an estimated capital investment of SR 16,000 million, as follows:

Petrochemical	SR	8,415 million
Metals	SR	3,000 million
Plastics	SR	2,546 million
Fertilizers	SR	1,093 million
Other products	SR	695 million
Research & development	SR	453 million
Administrative buildings	SR	200 million
Total investment	SR	16,400 million

The products of the first generation of SABIC;s industries are:

Ethylene	1,600,000 mtpa
Chemical grade methanol	1,250,000 mtpa
Ethylene glycol	520,000 mtpa
Ethylene dichloride	454,000 mtpa
Styrene	295,000 mtpa
Ethanol	281,000 mtpa
LLDPE/HDPE	700,000 mtpa
Caustic soda	377,000 mtpa
Urea	830,000 mtpa
Rods and bars	940,000 mtpa
Oxygen	438,000 mtpa
Nitrogen	146,000 mtpa
Vinyl chloride monomer	300,000 mtpa
Polyvinylchloride	200,000 mtpa

The following tables give the name(s) of the partners of SABIC in the joint venture:

	Joint venture partner of SABIC:	partner share
Hadeed (Jubail)	Deutsche Entwicklungsgesellschatt (DEG) Kort Stabl (FRG)	5.5 %
Ar-Razi (Jubail)	Mitsubishi Consortium (Japan)	50 %
Ibn-Sina (Jubail)	Celanese/Texas Eastern (USA)	50 %
SAMAD (Jubail)	Taiwan Fertiliser Co. (Nat. China)	50 %
YANPET (Yanbu)	Mobil Oil Corporation (USA)	50 %
Kemya (Jubail)	Exxon Corporation (USA)	50 %
SADAF (Jubail)	Pecten Arabia Ltd. (Shell Oil Co.) (USA)	50
PETROKEMYA (Jubail)	none	
SHARQ (Jubail)	Mitsubishi Consortium (Japan)	50 %
SAFCO (Dammam)	none, Saudi employees 10 per cent other shareholders 49 per cent	
GAS (Jubail)	Seven Saudi gas companies	30 %
Ibn Hayyan (Jubail)	Lucky Group (South Korea)	15 %

2.6.2 Oil refining industry

Saudi Arabia's oil refining capacity in 1984 was put at 2,045,000 b/d with majority at ARAMCO's Ras Tanura Refinery (cap. 738,000 b/d). Other refining centres are Jeddah, Mina Saudi, Khafji, Riyadh and the PETROMIN-Shell Facility at Al-Jubail.

Plans for four major new refineries are under consideration and these will add a total of 800,000 b/d to refining capacity.

Also a number of refineries have been expanded and modernized. The first one was Riyadh Refinery, which is now able to run at 6.0 mln tpa. Since this capacity is not enough to satisfy local demand, a new refinery at Suraidah will be built, with a cap. of 7.5 mln tpa. this refinery serves Central Province, start up was scheduled for 1986-87, but latest information indicates that this project has been rescheduled.

In the Western Region a refinery was built at Yanbu (cap. 7.7 mln tpa). This one will be of the hydroskimmning type in order to produce fuel oil for bunkering services and desalination plants in the area. This project also seems to have been postponed.

The following gives an overview of Saudi Arabia's refineries, with information on its capacity and labour force.

All refineries have the following basic product-mix with slight variations depending on the crude oil used: LPG, naphta, gasoline, kero/jet, diesel oil, fuel oil and asphalt:

Name	Location	employees	Capacity (000 b/d)
PETROMIN-Shell Refinery Company	Jubail	645	250
PETROMIN-Mobil Company	Yanbou	706	150
PETROMIN Refinery Company	Rabigh	515	325
Yanbu Refinery	Yanbu	509	170
Riyadh Oil Refinery	Riyadh	400	120
Mina Saud	Neutral zone		55
Al Khafji	Neutral zone		33
	Buraydah		160
	Shakaikh		160
Jeddah Oil Refinery	Jeddah	556	100
Ras Tanara			745

Furthermore, there are a number of lubricating oil refineries in Riyadh, Jeddah, Al-Jubail.

The Saudi Arabian Fertilizer Company (SAFCO), established in 1965, is 41 per cent owned by SABIC. It produces urea (330,000 tpa) and sulphuric acid (100,000 tpa) and this plant had many technical problems after its establishment, resulting in poor performance in production output. Actual output was far below designed output. But after a thorough review of the bottlenecks in the equipment, new investments led to a substantial increase in output and SAFCO is now producing at over 100 per cent capacity utilization. SAFCO is also responsible for marketing the output of SAMAD.

A new ammonia plant at Al-Jubail is planned by SABIC and SAFCO (cost $200 to 250 mln.), with a capacity of 1,500 t/d. This plant will come on-stream in 1987 and engineerig and feasiblity studies were supposed to be completed before the end of 1984.

Future expansions are foreseen for nitrogen phosphate potash (NPK) and purified terephtalic acid (PTA), used in polyester manufacture.

At the end of 1984 a 20,000 tpa melamine plant began operation at the Dammam complex. Its output is mainly for export.

The Saudi Methanol Company (Al-Razi), located in Jubail, is one of the first SABIC plants to start operation. It has a designed capacity of 600,000 tpa of chemical grade methanol.

SAMAD, the Al-Jubail based Fertilizer Company, was established in 1979 and produces 500,000 tpa of urea and 330,000 tpa of ammonia. The production of this plant goes partly to meet the needs of the local agriculture. SAFCO is marketing the output of SAMAD.

Plans already exist for a new 500,000 tpa ammonia plant, which will mainly produce for the export market.

The Saudi Yanbu Petrochemical Company (YANPET) started production at the end of 1985, and the complex comprises production units for 455,000 tpa ethylene, 220,000 tpa ethylene glycol, 205,000 tpa LLDPE and 91,000 tpa HDPE.

The Al-Jubail Petrochemical Company (Kemya) was established in 1980, with a designed capacity of 260,000 tpa of LLDPE. Most of its production is intended for export, but a portion will be directed to the domestic market.

Another petrochemical company at Jubail is the Saudi Petrochemical Company (SADAF). This is the largest of SABICs projects, and this complex includes the production of:

Ethylene	656,000 tpa
Ethylene dichloride	454,000 tpa
Styrene	295,000 tpa
Ethanol	281,000 tpa
Caustic soda	377,000 tpa

Part of the ethylene production (38 per cent) will be directed to the Kemya plant.

A 650,000 tpa methanol plant is under construction as the National Methanol Company (Ibn-Sina).

The Arabian Petrochemical Company (PETROKEMYA), is another ethylene plant under construction. Its output will be 500,000 tpa of ethylene and 260,000 tpa of LLDPE. This will feed the SHARQ petrochemical complex. SHARQ owns 46 per cent of the ethylene to be produced here. The remaining part is owned by PETROKEMYA.

Part of the production will also be used by the nearby Ibn Hayyan plastic plant, presently under construction. PETROKEMYA owns 50 per cent of the ethylene glycol plant under constrcution at the site of the SHARQ project.

The Eastern Petrochemical Company (SHARQ) has a designed production capacity of 300,000 tpa ethylene glycol and 130,000 tpa LLDPE.

The National Industrial Gas Company (GAS) was established between SABIC (70 per cent) and a number of Saudi companies (30 per cent), engaged in the field of industrial gases. The plant will produce 1,200 MT of oxygen and 400 MT of nitrogen daily to meet the needs of SABIC, PETROMIN and other industries in the Al-Jubail area.

The National Plastic Company (Ibn Hayyan) was established in 1983, and its output will be 300,000 tpa VCM and 200,000 tpa PVC. Production is scheduled for 1986.

The feedstock ethylene comes from the PETROKEMYA plant and the ethylene dichloride from SADAF. The output of this plant will be used as a primary material in the manufacture of plastic, cables, artificial leather etc. VCM will mostly be used to produce PVC, however surplus VCM will be sold in export markets.

2.7. Syria

The Syrian Arab Republic has formulated Five-year Development Plans since 1960. The industrial sector has always been given a high priority in its allocations, as can be seen from the following table presenting the allocations to the manufacturing industry sector during the three consecutive plans.

Table 2.2 Allocations for the Third, Fourth and Fifth Development Plans in Syria

Industrial branch	Third Plan 1970-1975 allocations (LS.MILLION)	Fourth Plan 1975-1980 allocations (LS.MILLION)	Fifth Plan 1981-1985 allocations (LS.MILLION) a*	b**
- Vocational training	4.4	71.0	141.7	
- Industrial testing and research	12.6	10.1	25.6	
- Management development and productivity	8.1	3.0	13.6	
- Textiles	204.4	1228.0	890.7]	
- Engineering	115.1	673.3	177.4]	
- Chemical	207.0	3402.4	748.5]	
- Food processing	70.4	163.5	79.8]	
- Sugar	10.1	617.4	244.8]	
- Portland cement and building materials	150.0	2570.6	951.2]	4050.2
- Tractors & agricultural implements	97.3	1500.0	34.5]	
- Flour mills and Bakeries***	66.0	361.0	1817.3]	
- Tobacco***	37.0	136.0	79.7]	
- Oil refining***	-	1429.2	1290.0]	
			6794.8	4050.2
			a+b	
TOTAL	982.4	9386.3	10845.0	

* Allocations corresponding to the basic stage (for existing establishments and projects under execution).

** Lump sum allocation, to be distributed to new projects.
*** Not under the Ministry of Industry.
Source: based on published information

As can be seen, nearly 20 per cent will be spent on the further development of the oil refining industry, besides additional investments in new projects out of the lump sum allocation. Also the development of the chemical industry sector has been allocated a relatively important share of 11 per cent.

2.7.1. Oil Refining:

There are three main petroleum-based industries in Syria, they are as follows:

(a) Homs Oil Refinery Company
(b) Banias Oil Refinery Company
(c) General Company for Fertilizers (Homs)

Each of these organizations are described below:

(a) <u>Homs Oil Refinery Company</u>

This refinery was established in Homs in the late fifties and started production in 1959. Its production capacity was 1 million tons of crude oil per year. It was designed and built by the Czechoslovak Company; Technoexport.

At first the crude oil was imported, but after the discovery of oil in the country and its exploitation on a commercial basis, a mixture of the locally produced heavy crude oil and the lighter imported crude was fed to the refinery.

Under the various economic and social development plans that were implemented in the early sixties, the refinery underwent six expansion schemes, whereby its capacity was increased five-fold to reach, under the present Five-Year Development Plan 1981-1985, 5.2 million tons of crude oil per year.

Forward linkage exists between the Homs Refinery and the Fertilizers Company, in that the former supplies the main raw material for nitrogen fertilizer production, namely, naphta. However, this linkage is expected to be interrupted in 1986, when the natural gas and associated gas exploitation project will be completed. Thus the fertilizer company will then switch from naphta to natural and associated gas.

(b) <u>The Banias Oil Refinery Company</u>

The Banias Oil Refinery was established as one of the main projects of the Fourth Five-Year Plan for Economic and Social Development, 1976-1980. The Refinery was designed and constructed on a turn-key basis by the Rumanian Company; Industrial Export. Construction work began in 1975 and trial runs were started in 1979. The refinery entered the actual sphere of production in 1982. Its capacity is 6 million tons/year of crude oil. Location of the refinery in Banias, on the Mediterranean Sea, between the ports of Tartus and Lattakia, constitutes an asset in connection with importation of crude oil and exportation of some final products, like benzine and fuel oil, by maritime transport. The sources of technology applied in the refinery are: Rumaniah, West German and American.

2.7.2. <u>Fertilizers</u>

The General Fertilizer Company is located in Homs and includes the following three plants:

(a) The Calcium Ammonia Nitrate Plant
(b) The Ammonia-Urea Plant
(c) The Triple Superphosphate Plant

A brief review of each one of them will be given below:

(a) The Calcium Ammonia Nitrate Plant

Originally this plant was to be built by the Soviet Organization; Nephtechim Promexport in the early sixties. After long negotiations with the said organization, during which other suppliers were contacted, an agreement was reached whereby the main units of the plant were to be furnished by the following supplies:

- The Nitric Acid Unit, having a design capacity of 8,700 tons/year of 100 per cent nitric acid: supplied by the Soviet Organization; Nephtechim Promexport.

- The Ammonia Unit, having a design capacity of 150 tons/day or 50,000 tons/year: supplied by the Italian Firm; Snamprogetti, following the Casale System.

- The Calcium Ammonium Nitrate Unit (CAN): having a design capacity of 148,000 tons/year: supplied by the Czechoslovak Establishment; Technoexport. This nitrate had a 26 per cent nitrogen concentration; in early 1984 the nitrogen content of the nitrate was raised to 30 per cent.

Civil construction was undertaken by the General Establishment for Execution of Industrial Projects, a Syrian public sector enterprise, with the assistance of foreign consultants.

The project was started in 1965 and production commenced in 1972. Plant production never reached the design capacity, and has been in the range of 115 to 120 thousand tons per year.

(b) The Ammonia-Urea Plant

The Ammonia-Urea Plant was established as one of the main industrial projects of the Fourth Five-Year Development Plan 1976-1980. The project was contracted as a turnkey job to the French firm: Creusot-Loire Enterprise. The contract entered into force on 30 November 1975. The production of the plant is as follows:

- 1,000 tons/day of ammonia by the Kellogg process, of which 60 per cent would be consumed in urea production, thus leaving 400 tons/day of ammonia.

- 1,050 tons/day of urea, by the Stamicarbon process.

Naphtha, one of the main raw materials needed by this plant, as well as by the Calcium Ammonia Nitrate Plant, is supplied by the Homs Oil Refinery.

As mentioned earlier, once the natural associated gas exploitation project, at present under execution, is completed, nitrogen fertilizer production will be switched from naphtha to natural and associated gas. This is envisaged to take place in 1986. The project was completed in late 1979 and production started in late 1980.

(c) The Triple Superphosphate Plant

This plant was also established as one of the main projects of the Fourth Five-Year Plan 1976-1980. The project was contracted on a turnkey basis to the Romanian Firm; Industrial Export. The contract entered into force on 4 June 1975.

The production capacity of the plant is 450,000 tons/year of triple superphosphate. Actual production started in late 1981, in 1984 triple superphosphate production was 191,000 tons.

2.8. United Arab Emirates

In view of the importance of oil derivatives in industry and in generating electric power as well as in various transportation means, thinking was focused in the early seventies on the establishment of refineries to cope with the needs of local consumption of oil derivatives. The Abu Dhabi National Oil Company (ADNOC) was established in November 1971 to work for the petroleum industry in Abu Dhabi and abroad including exploration of natural gas, petrol and other hydrocarbons. It is also expected to produce, refine and transport these products and other by-products, market them, export them and distribute them domestically.

To extend its full control over management of the products of onshore and offshore fields in the emirate, ADNOC established a number of local companies to manage oil fields.

It also established specialized service companies for drilling, construction, administration of ports and marine transportation and laying of pipelines.

In a short time it expanded its activities to cover all stages of the petroleum industry including studies, exploration and drilling and the execution of many development programmes in oil fields and reservoirs, establishment of oil refineries and gas manufacturing installations. Its activities also covered transportation and marketing of crude oil, gas and petroleum products in local and international markets.

ADNOC has in fact addressed itself to this task, and by 1983 it owned and managed two refineries for crude oil with a gross capacity of 195,000 b/d. This is in addition to the extension currently under construction to increase the refining capacity of Ruwais Refinery. This extension is a hydrogen fractioning unit with a capacity of 27,000 b/d.

2.8.1. Oil Refining

The first Umm-Al Nar refinery was established to meet the needs of Abu Dhabi for oil derivatives. Construction of the refinery started in 1973. It was commissioned in 1976, and was designed to a capacity of 15,000 b/d of crude oil. The refinery comprises four main production units: distillation unit, unit of treatment with hydrogen, improvement of benzine unit (platform) and unit for recovery of gas. This is in addition to the units of supporting services for production.

The designed productive capacity of the first Umm-Al Nar Refinery is 700,000 ton/year of final oil derivatives distributed as follows:

Liquefied petroleum gas	10,000 tons
Super gasoline	63,000 tons
Premium gasoline	100,000 tons
Jet fuel/kerosene	65,000 tons
Diesel (gas oil)	247,000 tons
Fuel oil	213,000 tons

During the construction of the Umm-Al Nar Refinery, local demand for oil derivatives developed at an unexpected rate. When commissioned, it was found to be unable to meet local demand for the Emirate of Abu Dhabi. Therefore ADNOC started preparing the necessary studies to establish a larger refinery in order to meet the present needs of the UAE, and to export the surplus of derivatives to outside markets. Construction of the refinery started in 1978. The refinery was commissioned by mid-1981. The refining capacity of Ruwais Refinery is 120,000 b/d or 5.2 m. tons/yr. of crude oil produced from the main onshore and offshore fields. It comprises six units: Crude distillation unit, naphtha desulphurizer unit, platforming unit, kerosene hydroheater unit, heavy gas oil desulphuric unit and sulphur recovery unit. It also has the necessary installations to produce electric power, steam, pumping seawater and desalinating it, and also compressed air and nitrogen. Adjacent to the refinery, there is a farm of storage tanks for crude oil and refined products, with a gross storage capacity of 1.2. cu. m.

The designed annual producing capacity of final oil products by the Ruwais Refinery is about 5.2 m. tons/yr. distributed as follows:

Liquefied petroleum gas	88,000 tons
Super gasoline	420,000 tons
Premium gasoline	487,000 tons
Jet fuel/kerosene	794,000 tons
Diesel (gas oil)	1595,000 tons
Fuel oil	1785,000 tons
Sulphur	9,000 tons

<u>Umm-Al Nar second Refinery</u>

The second Umm-Al Nar Refinery was established for the purpose of expansion in the petroleum industry and maximization of benefits from oil revenues and the increase of its contribution to the national income as well as to meet the increasing demand for some oil derivatives and exporting the surplus to outside markets.

Construction of the refinery started in April 1981 adjacent to the first refinery. It was designed to refine 60,000 b/d of crude oil. The refinery comprises the following main producing units: distillation and desalination unit, unit of improving products by chemical catalyst, unit for treating kerosene with hydrogen, unit of desalination and fractionating of gas, unit for extraction of sulphuric water, in addition to supporting and general services.

The designed producing capacity of the refinery to produce final oil products is 2.8 million tons per year distributed as follows:

Liquefied petroleum gas	150,000 tons
Super gasoline	177,000 tons
Premium gasoline	333,000 tons
Jet fuel/kerosene	210,000 tons
Diesel (gas oil)	990,000 tons
Fuel gas	810,000 tons

The refinery was commissioned on 6 August 1983.

Unit for fractionating by hydrogen

This unit is for treating low value heavy crudes left over by ADNOC refineries and cannot be marketed and converted into light and medium products. Work in the hydrogen fractionating unit started in 1982. It complements the Ruwais Refinery, and comprises three main subunits: vacuum distillation unit with a capacity of 46,000 b/d, hydrogen fractionating unit with a capacity of 27,000 b/d and a hydrogen production unit in addition to general services supporting production. When designing this project a high degree of flexibility in production was taken into consideration to meet the needs of the market, whereby it can produce naphtha and medium oil products. The following figures show the annual capacity of petroleum products by this project:

Liquefied petroleum	87,000 tons
Naphtha	382,000 tons
Jet fuel/kerosene	307,000 tons
Diesel/gas oil	518,000 tons
Fuel/oil	731,000 tons
Sulphur	20,000 tons

The project is expected to be completed by mid-1985. In order to achieve further integration in the refining industry, techno-economic feasibility studies were prepared for exploiting heavy oil produced by refining processes in the existing refineries for the purpose of producing basic oils and asphalt. The studies allowed for establishing a unit for producing basic oils with a capacity of 200,000 tons per year in order to meet the UAE's needs and export the surplus; in addition to establishing an asphalt production unit with a capacity of producing 100,000 tons/year to meet the needs of local demand.

Studies for the establishment of a petroleum coke plant were also completed to recycle materials left over after refining oil. It will have a capacity of 140,000 tons/year which mainly will meet the needs of aluminium plants in the region.

FERTIL was established by Emiri decree in October 1980 as a joint venture between the Abu Dhabi National Oil Company (ADNOC) holding 66.6 per cent of shares, and the Compagnie Francaise Des Petroles (CFP) holding 33.3 per cent.

With FERTIL Abu Dhabi entered a new era of industrialization whereby its natural resources are converted into commercially viable products. The project ushered Abu Dhabi into the complex technology and operations involved in the petrochemical industry.

FERTIL opted for the best in modern fertilizer processes:

- The Haldor Topsoe process for ammonia synthesis.

- The Benfield process for CO_2 removal.

- The Stamicarbon process for production of urea.

By the end of 1980 a turn-key contract was signed with Chiyoda Engineering and Construction Company of Japan for the desgin, detailed engineering and erection of the plant, based on the licences and know-how of the above process owners.

Chiyoda has a long and successful record in the construction of petrochemical plants especially fertilizers. They have already built many similar plants, based on the same processes, both in the Gulf region and throughout the world.

During construction both partners in the joint venture took an active role in supervising implementation of the contract and preparation for the operational and marketing phase of the project.

Construction ended in July 1983. It consists of the following process plants and related facilities:

- One 1,000 MTPD Ammonia Plant

- One 1,500 MTPD Urea Plant

- Bulk Cargo Terminal for export of refrigerated ammonia and prilled urea in bulk or bags.

FERTIL's management recognized the fact that highly qualified personnel were necessary for operating the sophisticated process and control technology used in the fertilizer plant. Recruitment has started well in advance of the operating phase and has resulted in a multinational organization in which every individual has a long and successful record in operating and maintaining nitrogen fertilizer plants. The result of this policy became apparent when the newly recruited personnel took to their posts smoothly and started the commissioning operations with ease and professionalism.

Almost all the urea output is destined for the export market with a potential of 495,000 MT/year supplemented by an export market capacity of 30,000 MT/year of ammonia.

Table 2.4 Capacities of petrochemical and fertilizers plants in the ESCWA Region (000 t/y)
Existing and under-construction

Country/company	Location	Start-up Year	Products	Designed capacity (ooo t/y)	Technology supplier
Bahrain					
Gulf Petrochemical Corporation	Strata	1985	Methanol	330	
			Ammonia	330	
Egypt					
	Talkha I	1976	Ammonia	380	
	Suez	1983	"	250	
	Talkha II	1979	"	396	
	Dekheila	1985	"	500	
Egyptian Petrochemical Company	Amiriya	-	PVC	80	
			MVC	100	
			Chlorine	160	
			LDPE	160	BF. Goodrich
			HDPE	160	
Iraq					
General Fertilizer industry	Abu Flus I (Basrah)	1971	Ammonia	55	Chemico
			Urea	23	
			Ammonia sulphate	29	
General organization for fertilizer industry	Abu Flus II (Basrah)	1977	Ammonia	217	Holder Topsoe
			Urea	198	Snamprogetti
General fertilizers Co.	Khor El-Zubair	1979	Ammonia	515	Holder Topsoe
			Urea	460	Snamprogetti
General Petrochemical Company	Khor El-Zubair	1983	TSP	600	Fisons
			MAP	250	Fisons
			NPK	272	Fisons
			Ethylene	130	C.E.Lummus
			PVC	60	Staufer
			LDPE	60	Distillers
			HDPE	30	Phillips
Jordan					
Intermediate Petrochemical Industries Co. (IPI)		1984	D.O.P	8	Rio Tinto
			PVC	6	Rhone Poulene
			Polyster	3	
			Solvents	3	
			F.G. Reinforced PE sheets	500(M^2)	
			Urea formaldehyde	6	

Country/company	Location	Start-up Year	Products	Designed capacity (ooo t/y)	Technology supplier
<u>Kuwait</u>					
PIC	Shuaiba	1966	Ammonia	660	Holdor Topsoe
	"	1971	Urea	824	
		1971	Ammonium sulphate	165	
<u>Qatar</u>					
QAFCO	Umm Said	1973	Ammonia	297	Norsk Hydro
			Urea	330	
	Umm Said	1979	Ammonia	297	
			Urea	330	
QAPCO	Umm Said	1981	Ethylene	280	CDF-CHIMIE
			(LDPE)	140	
<u>Saudi Arabia</u>					
SAFCO	Dammam	1970	Ammonia	200	CHEMICO
"	"	1972	Urea	330	
SAMAD	Jubail	1983	Ammonia	330	Kellogg
			Urea	500	Stamicarbon
SADAF	Jubail	1985	Ethylene	656	Pecten Shell
			Ethylene dichloride	454	
			Styrene	295	
			Ethanol	281	
			Caustic soda	377	
YANPET	Yanbu	1985	Ethylene	455	Mobil Oil
			Ethylene glycol	220	
			LLDPE	205	
			HDPE	91	
KEMYA	Jubail		LLDPE	260	EXXON
AL RAZI	"	1984	Methanol	600	I.C.I
IBN SINA	"		Methanol	650	Celanese/Texas Eastern
PETROKEMYA	"		Ethylene	500	
SHARQ	"		LDPE	130	Mitsubishi
		1985	Ethylene glycol	300	
IBN HAYyAN	"	1986	VCM	300	
			PVC	200	B.F. Goodrich

-52-

Country/company	Location	Start-up Year	Products	Designed capacity(ooo t/y)	Technology supplier
Syria	Homs	1972	Nitric acid	8.7	Nephtechim Promexport
		1972	Ammonia	50	Snamprogetti (Casale)
		1972	Calcium-ammonium nitrate	148	Technoexport
		1980	Ammonia	300	Kellogg
			Urea	330	Stamicarbon
		1981	TSP	450	Industrial Export
U.A.E					
ADNOC	Al Ruwais	1984	Ammonia	330	
			Urea	500	

Source: ESCWA's complilation.

Table 2.3 Capacities of existing (+under-construction) refineries in the ESCWA region mln t/y - 1985

Country	Location	Start-up	Designed capacity (mln t/y)	Remarks
Egypt	Alexandria	1954	5.3	
	Al-Ameriyah		3.2	
	Mustarad		5.2	
	Tanta		1.02	
	Suez I	1961	3.5	
	Suez II	1962	3.77	
	Asyut	1987	2.0	Under construction
	Total		24.0	
Iraq	Al-Wand	1927	0.5	
	Daura	1955	4.0	
	Baiji I	1978	1.0	
	Baiji II	1985	7.0	Under construction
	Basrah	1974	6.8	
	Haditha	1949	0.25	
	Kirkuk	1973	1.5	
	Samawa	1978	1.0	
	Qayyarah	1956	1.25	
	Salah Al-Din	1985	6.8	Under construction
	Total		30.1	
Jordan	Zarqa	1956	4.4	
	Total		4.4	
Kuwait	Ahmadi	1949	11.41	
	Mina Abdullah	1958	5.28	
	Shuaiba	1968	8.96	
	Total		25.65	
Lebanon	Sidon	1953	0.78	
	Tripoli	1943	1.6	
	Total		2.38	
Oman	Muscat	1982	2.2	
	Total		2.2	
Qatar	Umm Said I	1974	0.56	
	Umm Said II	1983	2.15	
	Total		2.71	
Bahrain	Bahrain (Al-Awali)	1936	12.6	
	Total		12.6	
Saudi Arabia	Jeddah	1968	4.5	
	Khafji	1966	1.54	Located in neutral zone, owned by Arabian Oil

Country	Location	Start-up	designed capacity (mln t/y)	Remarks
	Mina Saud	1958	2.56	Located in neutral zone, owned by Getty Oil
	Ras Tanura	1945	20.7	
	Riyadh	1974	5.4	(PETROMIN)-(RORC)
	Yanbu I	1983	7.67	Domestic refinery
	Jubail	1985	12.38	
	Rabigh	1986	14.65	Under construction
	Yanbu II	1985	12.48	
	Burayadah		7.5	Postponed
	Shukaikh		7.5	Postponed
	Total		96.6	
Syria	Banias	1980	6.0	
	Homs	1957	5.2	
	Total		11.2	
U.A.E.	Ruwais	1981	5.25	
	Umm Al-Nar I	1976	0.65	
	Umm Al-Nar II	1985	2.65	
	Total		8.55	
PDRY	Aden	1954	8.6	
	Total		8.6	

Source: ESCWA's compilation

Table 2.5 Selected Training Centres in the Petroleum Industries in ESCWA

Country/centre	Responsible Org.	Year Est.	Trainee Cap.	Training Staff T	N	F	Training Period	No.Labs/ Workshops	Specializations (selected)	Number of Graduates 1980	1981	1982	1983
Bahrain													
Bahrain Petroleum Company Training centre			304	10	2	8(1983)	2 months -3 years	11	Supervision unit operation Electric, Mechanic, Welding	n.a	n.a	n.a	n.a
Iraq													
a. Kirkuk Training Centre	SEDT	1968	600	36			2 Years	13	Engineering drawing, Chemical Analysis,	n.a	180	67	n.a
b. Baghdad Training Centre	SEDT	1971	2500	191 (1983)			2 years	36	Construction, Unit operation, electric, Mechanic, Electronic Technology Production	620	584	933	n.a
Kuwait													
a. PIC Training Centre	PIC		100	6 (1983)			6-12 months	-	Maintenance, Unit operation, Lab. analysis, production	n.a	n.a	n.a	n.a
b. Academic Training Centre	KPC		350	43	33	10	1 year	4	Unit operation, lab. analysis, Supervision, (N.D.T)	38	72	170	21
c. Training and development Centre	KPC	1975	190	30	13	17	9 months -5 years	7	Unit operation, production, Mechanic, electric welding, engineering (precision instruments, engineering design).	88	n.a	n.a	n.a
Qatar													
QGPC Training Centre	QGPC	1979	120	17	9	8	3 years	12	Mechanic, production electric, precision instruments	64	98	54	47
Saudi Arabia													
a. Riyadh Refinery Training Centre	PETROMIN	1982	192	30	12	18	6 months -3 years	7	Maintenance unit operation	n.a	n.a	n.a	n.a
b. Training Development Centre (Jeddah Refinery)	PETROMIN	1975	800	24	17	7	2 years	8	Operation, maintenance, welding, electric mechanic	280	238	434	496
Syria													
Training Institute for Petroleum Mineral Industry		1972	400	139	139	-	2 years	18	Electric, refining, precision instruments production	246	213	188	n.a
U.A.E													
ADNOC Training Centre	ADNOC	1982	400	40	28	12	2 years	20	Unit operation, maintenances precision instruments administrators, accountants	n.a	n.a	121	n.a
Total			5956	566	486	80							

Source: Arab Petroleum Training Institute.

PART THREE

STATUS OF TECHNOLOGICAL CAPABILITIES

3.1. Egypt

3.1.1. Historical development

The main capabilities discussed here are in the refining sector, since the petrochemical plant is currently underconstruction, and no information is provided in the survey on the capabilities of the fertilizer sector. The Ministry of Petroleum and GEPC are responsible for the development of the refining and petrochemical sector capabilities.

Egypt has developed in the past two decades, considerable experience in the petroleum industry, which is apparent in the refineries capabilities and in the contracting and engineering companies, in addition to the capabilities of the petroleum research centres. There are at least 14,000 employees in these organizations with high qualifications and long experience in refinery operation, management, construction and quality control of products.

The survey indicates that the Egyptian refining industry is still in a state of limited technological development, the interrelations between companies and R & D are not well organized, and future development of capabilities is dependent on availability of international expertise and technology know-how. The research and development activities are marginal, specially in refinery products, plant and process design.

At present there is a high percentage of international involvement compared with the national capabilities. This has had an adverse effect on the co-operation and promotion of capabilities within the production and engineering companies.

In the past two decades, project implementation, has depended in most cases on foreign sources of technology, and decision making authorities have applied the process of "technology transfer" through the procurement of plant and equipment, in addition to the reliance on foreign expertise and know-how. Turnkey agreements were signed for the execution of new projects such as the petrochemical plant and the expansion in the refining sector, contracts have been awarded to international specialized organizations for process and product design, procurement of equipment, project construction and management. Some projects have been executed by dividing the work load, which is then distributed among the interested international bidders and the local companies. The criteria that affect the decision to award contracts to either local or foreign companies, is the time required for execution, investment and capital control and the availability of local engineering consultancy and contracting companies.

This policy of project execution, has been very flexible in Egypt. For example, after the 1967 war, the petroleum sector was completely dependent on internal technical capabilities within the refining companies, the research centres and among the university staff. The refinery workshops undertook assignments for refinery repairs, renovations and expansions and the refinery accomplished the relocation of old refinery equipment to a new location, when the Suez plant was moved to the Cairo area.

This experience, gave the refining sector a chance to gain applied experience and to promote new skills, in engineering and construction of plants, and to depend on internal capabilities for plant operation, management, maintenance and manufacture of needed spare parts. This period's experience brought about the establishment of local engineering and construction companies.

Since the late 1970's. and with the adoption of the "open door" policy, which incourages rapid industrialization and international investment, there has been a tendency to boost production and increase exports. International investment and foreign producer companies have been attracted to the Egyptian market. Currently these companies are executing new advanced petroleum projects, such as the petrochemical complex. The refining sector is also expanding in production capacity, renovating and rehabilitating existing plants, adding new units and installing advanced processes. (See list of projects under construction).

Engineering and consultancy companies, were established in the period 1976-1978, to execute some of the engineering and construction assignments required in the petroleum sector and provisions have been made to provide them with adequate manpower and resources, and guarantee a percentage of engineering workload. A clause has been inserted in awarded contracts, to use local capabilities in consultancy, engineering design and construction for at least 50 per cent of the workload, to insure that local companies have an opportunity to participate fully or partially in the process of project implementation. Local companies are also assigned parts of projects directly and not through subcontracting. Engineering companies can freely use foreign expertise and assistance especially for training national personnel. They have the ability to directly contact and sign agreements with international organizations, and buy the relevant technological information and knowledge. They also can go into joint ventures with pioneering international companies, who can provide the technical standards and classifications, systems and methods of project management.

3.1.2. Assessment of capabilities

The following paragraphs analyse and evaluate the capabilities in the oil refining sector:

(a) Project Identification, pre-feasibility and feasibility studies

The specialized personnel in GEPC and the concerned refining company, usually undertake with the help of experts and consultants in the universities, the process of project identification and evaluation. This preliminary stage is followed by consultations with international experts, through contracts, to exchange views and information, then proposals and recommendations are finalized and special committees or working groups are formulated from GEPC and the concerned producer company to follow up the execution and implementation procedures.

Training courses have been organized within GEPC to develop abilities in project identification and evaluation, negotiation procedures, and contracting conditions.

(b) Engineering, plant design, construction and supervision of erection

Refining (and petrochemical) projects are executed at present through contracts with foreign companies and partial involvement from local capabilities found in both the concerned producing companies and the petroleum engineering companies. The participation of the producing companies (through the engineering divisions) consists of the following:

1. Preparation of technical descriptions for equipment and machines required for the operating plant, or for the planned units.

2. Preparation of detailed engineering designs for plant layout.

3. Preparation of detailed designs for tools, spare parts and equipment to be manufactured by company workshops.

4. Technical evaluation of proposals for purchasing equipment for the plants units.

5. Performing engineering changes when needed in the plants original drawings. Successful examples of activities by these local engineering capabilities are:

- In the period after the 1967 war, they established refining units in Cairo and Tanta, and relocated the Naphta benefication plant from Suez to Cairo.

- They renovated the production units in Suez, which were hit by air raids and restarted them.

- Provided facilities for the Amiriya plant.

- Some companies undertook independently the erection of distillation units, asphalt production units and petroleum lubricant units, while some also managed to expand the production capacity of certain units.

ENPPI accomplished the following projects, among others:

- Basic engineering design for four gas projects

- Detailed engineering design, as a subcontractor, for 11 projects, including PVC and VCM plants, benefication projects, distillation units and butagas recapturing projects.

For some of the latter projects it was also responsible for international procurement of equipment. It is also the main contractor of the new Asyut refinery and together with Petroject of the petrochemical plant at Suez, presently under construction.

(c) Plant start-up and production management

Plant start-up is usually left to the supplier of the technology and equipment, to ensure effective performance of plant units, and guarantee the quality of products.

The survey indicates that the refining companies have usually required that training of local personnel on start-up operation methods and management, is done on-the-job. After the initial stages of plant commissioning, the foreign contractor, leaves the job of operation and management of the plant to the local personnel. At least two projects exist where local engineering and contracting companies have successfully implemented and completed such a project, and which is now producing satisfactorily. As for the ongoing refineries, operation and production management is totally controlled from within the company.

The operation divisions in the refineries usually prepare production flow-sheets to follow up on production levels and productivity, they also propose measures for increasing production and requests for unit expansions based on the workload of the installed units. They diagnose bottlenecks and propose solutions, or request foreign expertise to help solve difficulties, they request spare parts to be manufauctured by works in the company or request them from foreign sources, they regulate maintenance of equipment and train workers and continually upgrade the capabilities of the operation personnel. Yet the survey does indicate some difficulties in operation management and stresses the need for training in this field to produce awareness of the long preparations needed before a product emerges on the production lines and to know the correct sequence of operations, process lines and product control.

(d) Process and product design

This activity is one of the most important technical capabilities that should be developed within each sector in the petroleum industry. Such capabilities are limited in Egypt, and the role of the research and development centres in this activity is marginal, and needs to be developed to complement the role of the other technological capabilities. No mention is made of any development on product or process design in the petroleum sector, though there are two petroleum research centres and engineering companies. The survey does indicate that 87 patents in the refining and petrochemicals sector have been acquired, in the period 1975-1985 yet it is not clear in what activity or scope of work they have accomplished. Also the research centers do state that they have activities in process and product design yet no particular examples or details are given.

Co-ordination with other petroleum producing neighbouring states, in this field, to exchange information on know-how and related technological developments, might open possibilities for future developments.

(e) Quality control

Product quality control is controlled by the laboratories in the refineries and through two central research centres which operate specialized laboratory experiments and tests on locally produced products.

The main experiments and tests are done on refined products, their quality and adaptations to the local environment.

The following functions and activities are accomplished by the central laboratory in the refining industry:

- Undertaking research to improve the characteristics of refined products.

- Analysing the composition of different products.

- Preparing laboratory measurements and procedures for performance tests and suitability, using international and locally developed standardizations.

- Following up performance of refined products with customers and agents.

- Periodical tests are done, to guarantee the products quality using international and locally developed standardizations.

- Training laboratory technicians for the refinery, petrochemical and chemical industries.

- Exchange information and experience with similar local and international centres and industries.

- Provide performance certificates and licences to approved refined products. Also, it was stated that some 50 per cent of the centres financial financial resources are generated by contract work for industry.

The Egyptian Organization for standardization has formulated Egyptian standards which are available for a wide range of refined products and fertilizers, all tests in the laboratories conform to these standards.

(f) <u>Research and development</u>

Basic research in the fields of refining and petrochemicals, including fertilizers, is performed by the specialized departments in the producing companies. The scientific departments in the universities and the specialized centres, such as the Petroleum Research Centre (PRC) of the Egyptian Petroleum Company, the institute for Petroleum Research, the Plastic Development Centre and the Engineering and Industrial Design Development Centre (EIDDC). The survey indicates that numerous research projects related to the petroleum sector have been undertaken by these centres in the past two decades, they cover:

- Studies related to identifying products suitable to the needs of local markets,

- Market studies, indicating factors to develop production capacities,

- Prepare product design according to local needs,

- Study suitable raw materials available locally,

- Study suitable levels of production automation to employ larger numbers of employees,

- Study technical capabilities of local labour force and abilities to master new technologies,

- Propose ways to make better use of available equipment and training programmes to upgrade labour force capabilities.

Research undertaken by R & D departments in the petroleum companies include: Studies on bottlenecks in production units, solutions are found internally or through the help of specialized consultancy offices in the case of more difficult problems. Follow up, on production performances, possibilities for energy conservation, pollution problems and safety measures.

The proposals for research on products come mainly from within the centre while requests for quality control comes from producing companies, customers and agents. The main problem facing these centres is the limited co-operation with producing companies and other similar centres. There is need for developing better co-operation systems between local laboratories and the producing industry.

The Petroleum Research Centre is specialized in research on performance effectivity of produce through experiments in the laboratory. For this purpose the centre has standardized test motors to test the performance of diesel oils, produced locally, on their suitability for local conditions. The second important area of research is in the field performance tests, in co-operation with international manufacturers of equipment and machines and specialized companies in diesel oil and additives.

Other achievements are:- modified chemical compositions of locally produced diesel oils, so that its performance becomes comparable with imported oils.

- Increased production of middle distillates, - studies on increasing the economic value of petroleum products, and fabricating polymers from local products. Eighty-seven patents have been acquired within the period, 1975-1985, in petroleum and petrochemicals. Also industrial contracts for research projects contributes some 50 per cent of their finances, though there is mention of limited collaboration.

The above information does not eliminate the fact that research and development centres face problems such as:

- The marginal role played by R & D centres in technology development

- Poor linkages between the R & D centres and the producing companies. They also lack linkages with university research centres.

- A science and technology policy at the country level concerning the refining and petrochemical industry seems also to be lacking.

The Institute for Petroleum Research, has a wider range of applied research work including petroleum exploration and production of wells, assessment and analysis, refining, petroleum uses, petrochemicals and operation development. The total number of employees in this institute is currently over 480, out of which 125 are involved in research and development. The range of relevant specializations of the employees covers engineering, science, economic agriculture and business. Some 108 employees have post-graduate qualifications, 40 are graduates of industrial vocational institutes and 116 are secondary graduates mostly from technical schools, while 114 are labourers.

(g) Plant technical services

At present GEPC and the refineries are undertaking a study to combine the technical capabilities in the different company workshops and engineering sections to establish a central maintenance company to serve the different refineries.

They are also increasing the capabilities in manufacturing of equipment (spare parts) by establishing independently or through co-operation and joint ventures with international companies for manufacturing compressor gears, exchangers, vessels, furances and towers.

At the same time they encourage the present equipment manufacturing workshops to attain international standards in manufacturing and develop their abilities to produce all the equipment needed for new projects or for replacements and renovations. This is realized through measures such as contracting all work to these local workshops.

(h) Customer technical services

With research centres the survey indicates that since all products are consumed locally there is a continuous feedback from customers.

They regularly inquire and collect the comments and requests of customers on performance of their products and change product qualifications according to customer needs.

They have regular follow up on performance of products in their different fields of use with the main consuming agents,and provide direct solutions for difficulties.

They also provide energy conservation instructions for diesel oils and fuels, in order to decrease levels of consumption.

Finally, they study and propose effective safety measures for storing and distribution of their products with the local agents concerned.

The following table summarizes the above listed capabilities for a number of projects presently under execution. Also an overview is given of linkages which exist between the GEPC and the local research centres, universities or national consultancy/ engineering centres (table 3.2).

Table 3.1 Technological capabilities in project under execution

	1	2	3	4	5	6	7	8	9
Prefeasibility		______	______	FC	______	______			
Feasibility		______	______	FC	______	______			
Plant design	F	F	F	N	FN	F	F	F	F
Engineering design	N	N	N	N	N	N	N	N	N
Construction	N	F	F	N	N	F	F	F	F
Supervision of	N	F	F	N	N	F	F	F	F
Process design	F	F	F	n.a	F	F	F	F	F
Production management									
Marketing services									
Plant technical services									
Customer services		(All are expected to be performed by C)							
Maintenance									

Source: ESCWA UNIDO Industry Division compilation

(1-9) see list of projects under construction

C: Company possess capability
N: National organization(s) possess capability
F: Foreign capability

<u>List of projects established and under execution</u>

1. Asyut Refinery
Capacity 2 million tons/years to be increased to 5 million tons/year to start in 1987;

2. Butagas Recapturing Unit (Alexandria Petroleum Company)
Capacity 2 million tons/year;

3. Benefication complex (Al Suez Petroleum Processing Company)
Capacity 15 thousand b/d;

4. Capacity Expansion Suez Refinery (Al-Naser Petroleum Company)
Capacity 5 million tons/year;

5. Distillation plant (Al Suez Petroleum Processing Company);

6. Aromatic Complex (Al Naser Petroleum Company);

7. Butagas Recapturing Unit (Cairo Petroleum Company)
Capacity 65 thousand tons/year;

8. Hydroskimming Unit (Al Suez Petroleum Processing Company);

9. Benefication of Oils Unit (Hydrocracking) (Al Suez Petroleum Processing Company);

10. Benzen Complex
40 thousand tons/year (Al-Naser Petroleum Company);

11. Petrochemical/PVC Plant, capacity 80 thousand tons/year;

12. Petrochemical/MUC Plant, capacity 100 thousand tons/year;

13. Chlorine Project, capacity 160 thousand tons/year.

1. Training

The petroleum related industry requires highly qualified and skilled workers and at the same time it creates many new skills and opens opportunities for employment. Egypt does have an extensive education and training system, e.g. in 1983-1984, some 6,000 students graduated from the colleges and universities, in the fields of science, engineering, business administration and economics. It is also estimated that in the past five years the total number of graduates in the above fields, are some 180,000. However, it is reported that, there is not sufficient correlation between what is provided in the education systems and what is required by the industry.

The petroleum industry employs some 42,000 out of which 13,500 are in the refining sector.

The refineries research centres and the engineering companies all have local training programmes, with on-the-job training as well as through lectures, symposiums and workshops, especially for new graduates.

All contracts with international companies include the training of local employees on all stages of implementation in new projects. This is usually accomplished by forming working groups with relevant qualifications, which are required to work at the contracted international companies offices and on the construction sites, At the stages of engineering design, procurement of equipment and erection, these work groups are provided with foreign experts and consultants with rare qualifications and these groups have authority to attend the meetings related to project implementation and review the designs and background papers. Thus these trained personnel usually make up the main block of the engineering and development sections of the company under establishment. Training of employees is also provided at start-up, and at the commissioning stages of operation, so that there are qualified and trained personnel who continue the operation of the plant and accomplish all services, repairs and maintenance.

Continuous training is provided within the production companies, to develop qualifications in new skills and upgrade existing ones in addition to training in project management and high level operational systems, industrial security, energy conservation and pollution simulator facilities are used for on-the-job training.

All the refineries' research centres and the two national engineering and contracting companies have training programmes for their employees. One centre indicates that 30 per cent of its employees get annual training for periods between 4 to 8 months, in addition to training abroad in production plants and in other specialized international training centres.

An engineering company reported to have an extensive training programme, especially for training employees in engineering design. A good number of piping designers have finished training with the help of local and foreign trainers. Another internal programme is currently organized with the help of international trainers, to develop the capabilities in project management and supervision.

Table (3.2)

Technical co-ordination between GEPC and local research centres, universities and consultancy centres

	Research Centres	Universities	National Consultancy/ Engineering Centres
Prefeasibility		X	X
Feasibility		X	X
Engineering			X
Plant Design			
Construction			X
Supervision			X
Product Design			
Process Design			
Production Management			X
Marketing			
R & D	X	X	
Customer Services	X		
Maintenance			X

Source: ESCWA Compilation

3.2. Iraq

3.2.1 Historical development

In the period 1927-1949, small scale refineries were established. They were planned and executed by foreign companies, working in the petroleum sector in Iraq. At that time participation was limited to some activities in the operation and maintenance with foreign supervision.

More advanced technology was used in the establishment of Dawra Refinery in 1953. The construction and execution of the project was accomplished by a foreign company, local participation was evident in the expansion programme of this project in 1960. The Iraqi partner (the State Organization concerned) undertook the following:

1. Prepared the study for alterations and expansion.

2. Participated with the engineering company (Kellogg) in the engineering design of the proposed alterations.

3. Executing alterations with supervision of local and foreign engineers.

Other projects were also undertaken, such as constructing refining units, and petroleum products, upgrading units, with similar local participation. At the same time two Lube oil refineries were established, the first project was executed completely by a foreign company and local participation was limited to involvement in production operation and maintenance under foreign supervision; the other was executed using a different process technology, with substantial involvement of local capabilities in: preparing the specifics and capacity of the project, participation in engineering design with the contracted company, selecting the process technology, supervising erection, onsite and abroad, training of nationals, and active involvement of nationals in the operation of the plant. This participation was marked as a step forward towards promoting local capabilities. Since then the local personnel and the concerned organizations undertook execution of projects and supervision of construction with limited assistance from foreign consultancy companies or through equal participation with foreign companies in all execution stages, and up to signing long-term collaboration agreements with patent owners.

In the case of chemical fertilizers, three projects were executed starting in 1971. The first project produces ammonium sulphates and urea, using Harder Topsoe and Chemico technology, the second produces urea, using Topsoe technology for ammonium production and Snamprogetti know-how for urea production. In this case the local participation started with the selection of process design, engineering design and review and checking of drawings, they intervened also in the selection of equipment and sources of procurement and actively participated in construction and erection, and managed the training of nationals for production operation. The third project that was executed, used the same previous technology as the latter; the Iraqi role started with the technical preparations of specifications for the project, negotiations with bidding companies, preparing contract documents, participation in engineering designs, on site supervision, committing contracted companies to training locals and supervising start-up preparations and production operations, plus signing collaboration agreements with patent owners to exchange information on any future developments in the technology used.

A petrochemical plant was also established for the production of ethylene, LDPE, HDPE and PVC, with a total capacity of 150 thousand tons/year depending on natural gas as feedstock. Inspite of the collaboration with a foreign consultancy company, who determined the specifications and capacities of the project, the final decision on the capacities and on the selection of raw materials was with the Iraqi partner; and the terms agreed upon in the contract which was signed after long and exhaustive negotiations included the following terms:

- Train locals abroad, and expose them to patents and plant processes;

- Local active participation in engineering designs, selection of equipment and sources of procurement in addition to reviewing plans and specifications and authorizing them;

- Locals supervising erection with no foreign assistance.

From the above it can be seen that Iraq, at an early date, attempted to have an effective transfer of technology and to gain expertise and experience in the foreign technology from trained and qualified nations.

3.2.2. <u>Assessment of capabilities</u>

An overview of the capabilities involved at each stage of the execution of these projects and the obstacles faced are described below:

(a) <u>Pre-feasibility/feasibility (techno-economic studies) stage</u>

Attempts to enter into this field started in the 1950s, but produced only general or sectoral studies, undertaken mainly by foreign consultancy organizations. More scientific and specialized studies undertaken later by certain local institutes and departments produced some work. The main characteristics of this are:

- Lack of basic statistics and data, plus the long-term span required to accomplish market studies;

- Lack of specialized centres to undertake such studies, this was overcome later when consultancy centres were established;

- Lack of awareness of the benefits of such studies, by the local industrialist;

- Although many authoritative Iraqi departments still contract foreign consultants to undertake such studies, the local capabilities have greatly developed in this field and participation has increased. Iraq has prepared with the help of a foreign company a feasibility study for the promotion of a consultancy centre;

- Preparation of documents and tenders stage.

Previously all projects in Iraq were executed by foreign partners on the basis of a turnkey project, however currently the refining and petrochemical sector in Iraq is adopting the following steps to participate actively with the assistance of foreign engineering houses in certain areas in preparing the basic designs, selecting production methods, plant and product design, selecting patents, or directly signing agreements with patent owners, preparing project machinery and equipment.

(b) Detailed engineering design stage

The experience gained in this stage usually leads in developing countries to the establishment and promotion of engineering design consultancy organizations and later engineering contracting companies. There is a lack of appreciation locally for developing such capabilities, great efforts need to be made for future development of such organizations.

(c) Equipment and machinery procurement

Iraq lacks capital goods industries, specialized in equipment and machinery for the manufacturing petroleum industries. Therefore the majority of project equipment and machinery are imported, this fact imposes difficulties and problems in project execution. In turnkey projects usually the foreign contractors undertake the procurement of machinery, without local interference. Currently the national partners participate with the contractor in the selection of sources of equipment after participating in preparing technical specifications. Still, this national role is limited in scope and in benefits. In the directly executed projects, the nationals prepare the technical and engineering specifics, offer tenders for equipment procurement from international sources, review the bids and proposals and negotiate with selected bidders and finalize procurement arrangements.

(d) Direct execution of projects/plant operation and maintenance

Direct execution of projects through government organizations and national engineering and contracting companies, either with assistance from foreign companies in the form of joint venture agreements which require a high degree of compatability in inputs between foreign and local partners or secondly through direct employment of foreign engineers and technical experts under local authority.

Experience has shown that the latter method of operation in project execution, has limited effects in the technology transfer process, because of difficulties arising from the different non-compatible foreign scientific and technical backgrounds and methods of work.

Another method in direct execution is by contracting local specialized companies under the authority of a qualified foreign major contractor, on the condition that local companies have the prerequisites and potential to carry out the required activities and applied methods of work.

The method applied in Iraq, involves distributing the work load for a certain project between the international contractor and the local sides when available. Usually international partners undertake engineering designs for plant processes and provide equipment and machinery, train locals on operation management and maintenance and supervision of on site erection, start-up and production operations for an agreed period of time.

Table 3.3 summarizes the degree of Iraqi involvement in various projects.

Table 3.3 Iraqi executed petroleum projects local and foreign participation

Capabilities	Small early refineries	Dawra Refinery	Expansion of Dawra Refinery	1960s refinery	Fertilizer plant	Petrochemical complex
1. Pre-feasibility and feasibility	F	F	F + C	C C	C	C + F
2. Plant design and engineering	F	F	F + C	F + C	C	C + F
3. Supervision of erection	F	F	F + C	C	C	C
4. Process and product design	F	F	F + C	F	F	F
5. Production management	C + F	C + F	F	C	C	C + F
6. Marketing services	C + F	C + F	F	C	n.a.	n.a.
7. Plant and customer technical services	C + F	C + F	F	C	C	n.a.
8. R & D	C + F	C + F	F + C	C	C	n.a.

Source: ESCWA compilation.

C: Company possess capability

F: Capability provided by foreign company

N: National organization possess capability

(e) Research and development

R & D capabilities in the past two years, especially in the petroleum and petrochemical industries have been one of the important fields promoted in Iraq. R & D centres have been established within petroleum organizations. Major research projects are related to production bottlenecks, increase of production, equality control and developing technical specifications of products, also they study corrosion problems.

The petrochemical industry in Iraq has not entered yet into the full production stage. The fertilizer industry on the other hand, has entered into the marketing stage, the three plants started in the seventies have developed the R & D capabilities in the fertilizer industry and the technical personnel managed to gain experience in production operations and absorbed the technologies used in this industry.

A specialized petroleum research centre has also been established but its activities have not been detailed (see also Scientific Research Council).

There is a trend in Iraq to encourage the ministries and the manufacturing establishments to have their own research and development centres, and in-house quality control sections.

(f) Training

The technical training of national staff is one of the basic steps in industrial development especially, within the refining and petrochemical sectors. After the establishment of investment intensive industrial projects, using advanced technology, there is a need to operate and maintain the plants, and to master the advanced technology in order to reach and increase their production capacities. For that reason, two specialized training centres were established:

- The Petroleum Training Centre (under the Ministry of Petroleum).
- The Chemical, Petrochemical and Mining Training Centre (under the Ministry of Industry and Mining).

Both train graduates of secondary schools requiring specializations such as: mechanics, electricity, plant operations and industrial chemistry, etc. The period of training is two years. In addition, industrial firms have annual and long-term training programmes in-house and abroad.

They usually consist of some or all of the following:

- In-house training is done usually on site, applied and theoretical, under the supervision of local personnel.
- In-house training supervised by foreign experts provided by the contracted international company, as part of the contractual conditions.

- Central training programmes provided by other organizations such as the National Consulting Centre.

- Training abroad in similar plants in developed countries, under the supervision of the contracted international company.

- Advanced training programmes, for qualified personnel as part of the participation in the basic engineering design of the projects and with the contracted engineering company and the patents company.

- Training agreements with international organizations with relevant programmes, such as UNIDO, or through bilateral, technical and economic agreements with other countries.

Besides these, there exists also an Arab Petroleum Training Institute in Baghdad, established in 1978 by the OAPEC. The institute specializes in the training of trainers (teachers). The institute employs some 50 staff members, distributed between the two main divisions: the training and studies section and the administration and documentation section. The institute has annual training and seminar programmes, based on the member countries needs in training for the petroleum industry. It covers the field of exploration up to production and maintenance of petroleum plants with the aim of promoting technical capabilities in the petroleum industry. The participants attending these training programmes are assigned through consultation with the OAPEC member States, national training centres and producing companies (see table 2.5).

The institute surveys regularly the manpower capabilities available in the regional oil producing countries and the capabilities of national centres in providing needed training, upon such surveys the institute bases its annual programmes for training sessions in the institute in Baghdad or in the member States training centres.

3.2.3 National institutions

(a) Universities, technical and vocational centres

There are six universities in Iraq, established in the period between 1957-1974 and distributed among the governorates, three are located in Baghdad and one in each of the following regions: Mosul, Arbil and Basra. All of them have science and engineering divisions, one University located in Baghdad is a specialized technology university and it has chemical, electrical and mechanical engineering facility control systems.

The universities have a number of research centres, but their main efforts are said to be in academic research.

Vocational education in the country is under the General Organization for Technical Institutes, which is an independent organization, established in 1974. It has 22 technical institutes in all fields of vocational training. Thus there is an annual high supply of scientists, engineers and technicians in Iraq. The table below provides detailed information about the number of students enrolled, number of graduates and staff in Baghdad University for the year 1983-1984.

Baghdad university students, graduates and staff members (1983-1984)

	Number of registered students		Number of graduates			staff		
	Under graduates	Post graduates	Under graduates	Masters	Ph.D	Locals	Arabs	Foreign
Administration	1833	17	201	14	–	40	–	–
Economics	958	40	165	9	–	40	–	–
Science	2557	253	486	54	–	206	1	–
Engineering	3695	129	524	42	–	149	7	2
Civil engineering	397	59	–	–	–	20	–	–
Total	9440	456	1435	99	–	455	9	2

Source: Provided by the University.

(b) Consulting and engineering design companies

Two state organizations undertake most of the consulting and engineering design for the petroleum projects in Iraq with the help of foreign companies:

1. The state organization for industrial design and construction;

2. The State Organization for petroleum projects.

They are responsible for the construction of projects, by direct execution, or for planning and supervision of projects that are contracted to foreign companies. In 1983-1984 the State Organization for Petroleum Projects, prepared the documents for the tenders of a turnkey contract, to build a lubricant plant at Baiji, the contract was signed with Technip and Technipetrol.

(c) The Scientific Research Council

Established in 1963, it is a public sector organization and has a specialized petroleum research centre. Its main activities are in the following: quality control, process design and standardizations. These activities originate from within the centre or are proposed by industrial and government organizations. The council's role in the process of technology transfer is manifested in its activities as local consultant and in its efforts to plan the policy of technology transfer in Iraq. It aims at co-ordinating between existing research centres and evaluates research activities within manufacturing centres and universities.

It collaborates with the University of Baghdad to undertake research. The Council has formulated a five year scientific research plan (1980-1985), in collaboration with the concerned government departments and other institutes in the country. The main objectives of the plan are: (1) to upgrade scientific research in the production sector, especially in the fields of exploitation of natural resources; (2) to adapt technology transfer to better suit local conditions; (3) to develop scientific infrastructure; (4) to strengthen the links between the academic research done by the universities and the applied research programme of the council or other specialized R & D centres in the manufacturing organizations. Another technology policy was also formulated in 1984, with the establishment of a national committee for technology transfer, which is directly linked to the research council.

The Council concentrates on applied research while the university research centres limit themselves to more theoretical research.

3.3 Jordan

3.3.1 Historical development

Jordan has accumulated in the past two decades substantial technological experience, the local capabilities found in the refining, petrochemical and fertilizer plants are solid and mature though limited in future prospects. It is also indicative that the three manufacturing units are based on foreign technologies that require a highly skilled labour force. In general Jordan is relatively well endowed with highly qualified and experienced chemists and engineers plus other technical staff compared to its small population size.

The fact still remains that most of the technologies installed in Jordan are transferred from abroad in the form of imports, including the technologies used in the petroleum based industry and fertilizer plant. They are purchased through licensing and turnkey arrangements with the help of consulting services. Yet there is some evidence to show that the longer established organizations (e.g. refinery) have with time and effort, matured in experience and their technical and managerial expertise became sufficiently well developed to enable them to exercise greater autonomy in the identification of future technological imports.

The difficulties experienced, sometimes, in operating and maintaining production equipment is partly due to their complexity in relation to available operating skills and the lack of independent R & D capacity. The main problem arising due to these reasons is under-utilization of machinery.

Jordan itself generates very little of the technologies used in its industry, because of lack of adequate facilities, finance and technical expertise. A very limited amount of resources and personnel are devoted to in-house R & D activity in Jordanian firms. And even this activity is primarily concerned with fairly minor adaptation of existing products and processes.

According to a survey made in 1982, the total expenditure on R & D proper and associated scientific and technological activities in Jordan amounts to about 0.5 per cent of the country's GNP and of this expenditure only about 10 to 15 per cent is spent in the production sector. The current development plan does encourage the major industrial establishments to set up their own R & D and planning units with the objective of enhancing the capabilities of these establishments to improve and develop their own methods of production and quality of their products.

3.3.2 Assessment of capabilities

The technological capabilities in the two major companies, JOPETROL and IPI, are analyzed and assessed below:

(a) The Jordan Petroleum Refinery Company (JOPETROL)

In the field of construction and consultation (engineering) there are many organizations in Jordan, yet none are specialized in these fields because of limited scope of work in this field.

JOPETROL was assisted largely by foreign skills (United States, British, Italian and Romanian) during the feasibility (UOP), plant design (Procon), construction (Romanian) and process design (UOP) stages. Product design, management, marketing, R & D and technical service activities were, on the other hand, always undertaken by the company itself. Imported know-how is now almost phased out and national skills are taking over. The number of engineers currently working at the company are 120, in addition to 1,400 technicians.

The company has a laboratory and a research centre of its own. In its workshops at Zarqa, JOPETROL performs its maintenance work of equipment in addition to the manufacture of some parts and spare parts.

According to the experience of the company and as a result of its former reliance on foreign sources at the preliminary stages of work, the company found that the spare parts from foreign sources are rather expensive (although not compulsory in the contract) and large inventories of these, therefore, are to be stocked always to avoid interruption or delay.

From the training programmes and technical services and consultations given by foreign companies from time to time on the spot.

The company is considering the possibility of integrating forward by establishing downstream industries like producing new oil products, recovering sulphur from gases, refining used oils, etc. Its products are widely used domestically for power generation, firing, heating, transport purposes, road paving and for chemical and petrochemical industries.

(b) Intermediate Petrochemical Industries Company (IPI)

Many alternative production technologies were considered for each product during the project identification phase, a technical committee from the company staff and the consulting firm was convened to carry out the evaluation process of these alternative technologies and to select the best ones on the basis of the following criteria:

The technical requirements of the local and regional markets.

The diversity of process schemes.

The local availability of skills.

Finance and financial conditions.

Market constraints.

The feasibility study of the project was conducted by the Industrial Development Bank of Jordan, who is also a partner in the project, while the plant design, the engineering and the process design were carried out by the licenser. The IPI staff assisted by the licenser supervised the erection work and product design, and the company on its own is undertaking the management, the market services, the R & D and the plant and customer services.

The existing complex comprises seven process units and one plant for steel drum re-conditioning, complete with utilities, off site facilities and mechanical process test runs.

The technology owners of the process (the licensers) are the foreign partners of the project: "Rio Tinto" of Spain and "Rohne Poulenc" of France.

These licensers are also responsible for the training and the engineering activities of the project in addition to being the "patentees". They are together with the equipment suppliers, consulted by telex or telephone whenever major problems arise.

The company has a team which was trained at the licenser's plants to handle maintenance and troubleshooting works in addition to the assembling of some of the spare parts needed for the work, such as; glands, shafts etc. Of the total IPI staff of 46, there are five engineers, four scientists, one economist and 25 technicians. Only two of its staff are non-Jordanian.

Training abroad was found to be more useful and efficient than the in-house training using the internal facilities.

Co-operation with consultants and suppliers of equipment was found helpful and constructive. The contract with the foreign partners extends till 1985 and products of IPI will stay under quality control of patentees until then.

The IPI keeps close contacts with its user industries and customers by surveying continuously their needs, testing their products and raw materials, examining their relevant data sheets, discussing problems and instructing them as per the results obtained, and conducts pilot test runs for them in their own premises. Such relations between IPI and its customers were found useful in modifying formulations at IPI to suit users, processes and products.

There are many downstream industries that use the IPI products locally to produce new products including; PVC compound products, reinforced fibre glass pipes, plastic sheets, vessels, resinous marble industry, plywood and chipboard industries, plastic extrusion and blow-moulding industries, bottles, cables, hoses, paints, greenhouses, glues, etc.

Meanwhile, the company is considering the possibility of integrating forward by producing fibre glass reinforced poles for lighting and telecommunication purposes. As for the backward integration plans of IPI, the Formalin now being produced in Saudi Arabia from Methanol, will feed the production of urea and melamine formaldehyde resins at the IPI.

3.3.3 National Institutions

(a) The Science and Technology department at the Ministry of Planning was established in 1980, to co-ordinate and promote scientific and technological activities on the national level and to assist in the formulation of national science and technology policies and plans. It is also assumed to revise the existing laws and measures pertaining to science and technology activities in order to ensure adequate support for such activities and to regulate matters related to transfer of technology.

(b) The Royal Scientific Society

Established in 1970, to carry out original R & D work and to provide scientific and technical consultancy services. It conducts work on the quality control, product development and feasibility studies. The Society indicates that their main activities are in basic research, making up 65 per cent of its total efforts, while testing takes up 15 per cent and applied research 20 per cent. The number of scientists and engineers in the centre in 1983 were 197 out of 397 employees, distributed between four substantive divisions. They undertake contract work for the industry, including refining, petrochemical and fertilizer industry, mainly in quality control trouble shooting, testing and economical studies, but no specific details were provided. Its main divisions of work and distribution of major jobs is seen in tables (3.5 and 3.6).

3. Jordan and Yarmouk Universities

Contributions to development of technological capabilities, is restricted to the educational process. No information of research in the fields of petroleum-based or fertilizer industries is reported. The following table shows total enrolment (1983) and distribution:

	Total enrolment	Engineering	Science
Jordan University	11731	1024	1441
Yarmouk University	10322	1223	1024

The technical and vocational schools in Jordan, number 46 schools, and the enrolment of students is over 27,000 students. Besides that, a sizeable number of students are studying abroad. (see table 3.7).

Table 3.4

Technological capabilities in Jordan refinery and petrochemical plants

Capabilities	Refinery	Intermediate petrochemical industries
Project identification	C	C
Pre-feasibility	C & F	F & C
Feasibility	F	C
Engineering and construction	F	F
Supervision of erection	F	F & F
Process of product design	F	F
Production management	C	C
Marketing services	C	C
Plant technical services	C	C
Manpower	C	C
Quality control	C	F & C
Customer technical services	C	F & C

Source: ECWA UNIDO Industry Division compilation.

C: Company possess capability
N: National organization possess capability
F: Foreign capability.

Table 3.5

RSS distribution of staff according to divisions and professions

Departments/division	Senior manager 1983	Administrators	Scientists	Engineers	Economists	Technicians
Information and budget department	7	27	5	-	-	7
Administrative affairs department	5	22	-	1	-	7
Mechanical engineering department	4	5	2	18	-	39
Industrial chemistry department	5	6	16	6	-	7
Building research centre	7	5	2	33	1	38
Electronic services and training centre	5	4	-	9	-	27
Computer systems department	6	2	7	2	-	25
Economics department	5	3	-	-	25	2
Total	44	74	32	69	26	152

Source: Provided by RSS.

-83-

Table 3.6

RSS number of scientists and engineers by specialization and degree for 1983

Specializations/degree			Bachelors	Masters	Doctors
Scientists:	a. Chemicals	12	-	10	22
	b. Physicists	2	1	2	5
	c. Mathematicians	2	-	1	3
	d. Others	42	24	8	74
Engineers :	a. Electrical	9	-	-	9
	b. Electronic	9	3	2	14
	c. Mechanical	12	3	6	21
	d. Civil	24	10	7	41
	e. Chemical	3	1	2	6
	f. Industrial	-	-	-	0
	g. Others	-	1	1	2
	Total	115	43	39	197

Source: Provided by RSS.

Table 3.7

Yarmouk University distribution of students and staff by faculty and field of specialization for 1984-1985

	Students		Professional staff		
	Undergraduate	Graduate	National	Arab	Foreign
Business administration	1581	-	24	1	10
Economics	1075	-	10	1	4
Science	3227	218	95	4	23
Engineering	1411	93	43	10	32
Architecture	190	-	5	1	5
Others	6269	361	190	20	26
Total enrolment	13753	672	367	38	100

Source: ESCWA/UNIDO Industry Division.

Field of specialization	Number of degrees granted in 1983 Bachelors	Masters	Ph.D.
Arts	601	125	-
Science	406	3	-
Engineering	131	12	-
Architecture	11	-	-
Management	290	-	-
Total	1439	140	-

3.4 Kuwait

3.4.1 Historical development

Kuwait has capitalized on a maximum utilization of its primary natural resource and embarked on an ambitious programme of refining its crude oil and gradually expanding its petrochemical manufacturing. The period between 1965 and 1985 witnessed a major shift in Kuwait's policy from an almost oil-production-based industry to an export-oriented industry based on a large share of oil refining in the domestic economy.

By doing so, Kuwait has created a climate that induces gradual development of expertise needed by the developing refining industry to compensate for the lack of skilled manpower, engineering and management capabilities.

Given the complexity of the processing technologies in refining, Kuwait has had a number of constraints in attempting to meet the technological requirements of investments with its own capabilities. These constraints include:

- The lack of skilled manpower.
- The scarcity of engineering and managerial skills.
- The requirement of highly specialized supporting engineering and capital goods firms.
- And most important the limited size and growth of its domestic market.

3.4.2 Assessments of capabilities

(a) Oil refining (KNPC)

To assess the technological capabilities acquired by KNPC and developed within its refineries, it is necessary to analyse their capabilities in some detail.

Project identification and technology selection

KNPC has developed a domestic expertise in operating processing units which utilize sophisticated technologies such as high pressure hydrocracking of heavy distillates and residues. The experience gained by the all-hydrogen Shuaiba Refinery in solving problems relating to cracking of high sulphur heavy residues has qualified its operating and processing engineers to cope with the challenges of the first H-oil unit.

Assessment of technological capabilities in Kuwait

To assess the present technological capabilities in Kuwait, information has been collected on the capacities in the oil refining industry (mainly KNPC), the fertilizer industry (PIC), the Kuwait University, the Kuwait Institute for Scientific Research (KISR), and the Kuwait Refinery Maintenance and Engineering Company (KREMENCO). These organizations provide a good view of the status of the national capabilities at the moment, and the activities they have undertaken to strengthen their own capacities in this respect. Kuwait has capitalized on a maximum utilization of its primary natural resource and embarked on an ambitious programme of refining its crude oil and gradually expanding its petrochemical manufacturing. The allocation of this resource is currently undertaken and fully controlled by the State organization KPC. In the refining sector during the early 1960s, the Government of Kuwait decided to promote the idigenization of operations related to petroleum production, transportation, refining and marketing, which is facilitated by its oil revenues. This policy insures Kuwait's self-reliance in the long run, even at the risk of reduced profitability in the short run when these operations are performed by experienced expatriates. By doing so, Kuwait has created a climate that induces gradual development of expertise needed by the developing refining industry to compensate for the lack of skilled manpower, engineering and management capabilities. The period between 1965 and 1985 witnessed a major shift in Kuwait's policy from an almost oil-production-based industry to an export-oriented industry based on a large share of oil refining in the domestic economy. The refining capacity has expanded from 350 thousand barrels per day in the 1950s to 650 thousand barrels per day in the 1980s (about 65 per cent of crude oil production). Another feature that characterizes the refining industry is that no place has been given to the transnational companies to participate in oil refining. This facilitates the control of KPC, over the different aspects of the refining business. KNPC is impowered by KPC to oversee operation and maintenance of the three refineries at Shuaiba, Ahmadi and MAB and to undertake contemplated expansion, modernization and integration of their operations. Given the complexity of the processing technologies in refining, Kuwait has had a number of constraints in attempting to meet the technological requirements of investments with its own capabilities. These constraints include first the lack of skilled manpower, second the scarcity of engineering and managerial skills, third the requirement of highly specialized supporting engineering and capital goods firms, fourth and most important the limited size and growth of its domestic market.

To assess the technological capabilities acquired by KNPC and developed within its refineries, it is worthwhile analyzing the various basic elements which form the facets of these capabilities.

For project identification and process technology selection, KNPC has developed a domestic expertise in operating processing units which utilize sophisticated technologies such as high pressure hydrocracking of heavy distillates and residues. The experience gained by the all-hydrogen Shuaiba Refinery in solving problems relating to cracking of high sulphur heavy residues has qualified its operating and processing engineers to cope with the challenges of the first H-oil unit.

This experience has enabled KNPC engineers to undertake refinery modelling and process configuration studies in a self-supporting manner, when they opted on the ambitious plan of expanding, modernizing and integrating the three operating refineries in Kuwait. The refinery scheme envisions the upgrading of heavy residues to maximize distillates while producing high quality fuels. Satisfying world demand for low sulphur fuels has been the prime concern of the export-oriented refineries. H-oil process, commercialized in the early 1960s, helped KNPC to learn by first hand experience. The planned expansion has taken advantage of this experience by placing more emphasis on the process of technology selection so as to better suit Kuwait and be compatible with current and future trends in petroleum refining.

Careful evaluation of alternative possible technologies was undertaken, a technology where competing licensers are available is a better choice than a monopolised technology. It can be stated that, KNPC as a domestic investor and entrepreneur, has sufficient technical capacity to handle the business of foreign process technology acquisition in an efficient and profitable manner.

Refineries expansion programme KNPC engineers and economists have accomplished completely and independently the pre-feasibility and feasibility studies of the plan. KNPC has also undertaken the responsibility of in-house preparation of projects specifications, invitation of tenders and examination and negotiation of bids.

Such practices strengthen KNPC's bargaining position, since the whole project(s) can be unpacked and a second series of tenders can be invited for the different items which make up the package. Also substantial part of construction and civil engineering work has been domestically accomplished by national contractors.

Process design and engineering

KNPC's technological capabilities in these areas has been limited. The building of a grass root refinery involved a broad spectrum of process technologies such as naphtha, platinium reforming, gas oil catalytic cracking, desulphurization of heavy residue and hydrocracking of residual oils, that usually require highly secialized engineering designs.

To build projects of such a magnitude and complexity it has been the conventional practice by KNPC to rely on turnkey projects as a vehicle for obtaining technology and know-how. There is a high concentration of oil refining technology suppliers, the choice of the turnkey option limits the degree of freedom to Kuwait, in few companies, e.g. Lummus and Kellogg who are able to offer the whole package. KNPC has taken some modest but accelerated steps towards the strengthening of its capabilities in the areas of design and detailed engineering. The steps include developing the career of technical staff assigned to process engineering departments within the refineries, borrowing technical manpower from Kuwait Santa Fe Braun (KSB) to assist KNPC engineers, and sending engineers to attend career development programmes organized by C.F. Braun's Engineering at their headquarters where training on all facets of projects is provided. In this respect, Kuwait is taking advantage of the acquisition by KPC of Santa Fe International whose engineering subsidiary C.F. Braun has a world-wide longstanding experience in design and detailed project engineering. C.F. Braun also undertakes activities related to process design and product design, which are not yet well developed at KNPC.

The contemplated expansion by KNPC refineries has been accorded for execution and commissioning to foreign contractors, namely Chiyoda and J.G.C. Corporation of Japan. In doing so, the technical assistance and know-how of technology licensers such as Universal Oil Products (UOP), Chevron, Union Oil Company of California, Institute Francais du petrol (IFP) and Foster Wheeler are made accessible to KNPC technical staff through the intermediary of these contractors. As for production management, KNPC assumes full control of the manufacturing of products and of operation of processing units and utilities in the refineries.

<u>Marketing</u>

KNPC undertakes also the responsibility of the local marketing and selling of the refined products. Natural gases and fuel gases are transported by KNPC to their destinations through pipelines or trucking. The refineries transport refined products destined for export through an extensive pipe network. The domestic gasoline service stations are fully owned, operated and managed by KNPC.

<u>Research and development</u>

Activities related to R & D are undertaken by KNPC technical staff and jointly with the Kuwait Institute for Scientific Research (KISR). Research studies have been conducted on reforming and hydrodesulphurization catalysts, regeneration and disposal of spent hydrocracking catalysts, and on disposal of arsenic contaminated refinery sludge.

Maintenance

This activity is fully undertaken by the technical personnel engaged in this activity within each refinery. This is valid for the maintenance and repairs pertaining to the existing operational units in Shuaiba, Ahmadi and MAB refineries. Shuaiba Refinery enjoys an autonomy in its maintenance capabilities, which have been established since its inception and developed through in-house training and recruitment of skilled and experienced manpower. Ahmadi Refinery has an agreement with a British Company to supervise maintenance of the recently commissioned processing units and utilities. MAB Refinery is expected to follow suit after executing its underway expansion and modernization plans. Also some alternatives are envisioned by KPC, which includes a pooling of maintenance crews, or entering into a joint venture with a foreign firm which has a world-wide experience in refinery maintenance. Local companies such as Conco and KREMENCO are often contracted to provide additional services, particularly at peak load time. KNPC indicated that spare parts are mostly imported from their foreign suppliers as recommended by the equipment manufacturers. A lack of domestic capacity in this area, and a compelling need to adhere to the standardized specifications of the spare parts justify the adoption of this practice.

Technical services

These are rendered to customers by the laboratory facilities available at KNPC refineries. The laboratories are well equipped with modern analytical instruments to carry out performance tests and assure quality of products in compliance with specifications set by government committees for standardization.

(b) Petrochemicals

Project identification and selection of technology: the criteria for PIC's selection of technology were given in the following order of priority: (a) minimum restrictions imposed on the transfer of technology; (b) marketing; (c) rate of return; (d) skilled manpower requirement; (e) compatibility with indigenous raw materials. In this regard, PIC staff were able to select the technology needed without having to seek the assistance of any domestic or foreign consultancy firm. The final decision for technology selection was given to KPC as a mother corporation, who ultimately supervises the arrangements of technology transfer of Kuwait.

PIC reported that the source of the selected technology was foreign. Stamicarbon of Holland, Tokuyama Soda of Japan and Haldor Topsoe of Denmark were the technology suppliers for urea, chlorine and sodium chloride, and ammonia plants, respectively. PIC relied on turnkey projects and signed contract agreements with the licensers to acquire the selected technologies.

This implies that a foreign contractor is generally in charge of the whole project. All the technological decisions are in his hands, including the participation of foreign and local sources for the provision of equipment, material and technical services. In other words, Kuwait receives an ammonia plant rather than the technology. Turnkey projects do not contribute to the strengthening of the recipient capacity, and render the importer of technology dependent on foreign sources.

It is whorthwhile mentioning that PIC in processing the technology transfer did not prefer the splitting of contracts between suppliers, designers, constructors, as this practice entails long delays due to the necessity of co-operation between the relevant parties. Turnkey projects generally insure speedy and expedious arrangements. They are preferred by Kuwait, where capabilities in fabrication of equipment, manufacture of capital goods and in design engineering are lacking.

After carrying out the process of evaluation and screening of alternative possible technologies, PIC selects the technology that optimally meets a prior criteria set by KPC. However, any finalization of the selection process is contingent upon the approval of KPC. Kuwait has not established a central registry bureau, whose functions include supervision of procedures for filling an application for foreign technology transfer. In this regard, the director of the industrial development and consulting bureau at the Ministry pointed out that only general guidelines are set by the Government of Kuwait, which local importers of foreign technologies have to abide with. This implies that KPC as an importer of technology, is an independent party who has full autonomy to select and transfer the technology it finds suitable in Kuwait.

PIC has to file its application to obtain foreign technologies with KPC's legal office who supervises registration arrangements and ratifies the documents of the contractual agreement with the technology supplier. PIC attributed difficulties encountered in acquiring the selected technology to the long time which elapses before a project is ratified by government authorities.

PIC was able to adapt some modifications to its acquired technology with the purpose to maximize the utilization of resources (waste water, tail gas, natural gas, steam, ammonia, hydrogen), control pollution of air by urea dust and of water by nitrogenous liquid wastes, minimize maintenance costs, and to conserve energy in the fertilizer complex. Projects adopted to maximize utilization of resources, include treating polluted water for reuse for irrigation purposes, recovering ammonia from gas vented by purging ammonia units, recovering hydrogen from purge gas for recycling, diverting natural gas from the dual-firing system for use in ammonia synthesis, and using tail gas as fuel after recovery of ammonia from purge gas.

Projects under implementation to control air and water pollution comprises an establishment of a urea de-dusting system downstream of the cyclones, installing cyclones to protect personnel involved in urea bagging against polluting hazards and treating waste water contaminated with urea and other nitrogenous materials. Projects considered for minimizing maintenance costs embrace installing tube plates in heat exchangers and coolers, that can serve efficiently in fresh water or seawater medium, using titanium tubes in surface condensers to extend their service life.

Energy saving projects include adoption of a computer system to control boiler operation, replacement of unworkable steam traps to reduce wastage of heat, installing oxygen analyzer in gas reforming units and boilers to reduce excess fuel utilization, recovery of heat from convection section of reformers and boilers, and applying insulation material. Other improvements and modifications that are currently studied by PIC staff include optimizing operating conditions of carbon dioxide removal system, providing emergency power supply to critical equipment, and debottlenecking urea plant to double its production capacity.

Plant Technical Services

Recognizing the vulnerability of the petroleum-based industry to foreign dependence, particularly in the domain of repair and maintenance, has led the government of Kuwait to encourage the private sector to enter into this business first relying on foreign technical assistance, and eventually creating a technical capacity in the region. Kuwait Industrial Refinery Maintenance and Engineering Company (KREMENCO) is and exemplary illustration of such a developing activity. KREMENCO was established in 1969, and is owned by private sector shareholders, (89 per cent national and 11 per cent foreign). Its activities centre on: (a) design and fabrication of steel structures and pipeworks; (b) design, manufacture and assemblage of pressure vessels, heat exchangers and condensers; (c) non-destructive testing of equipment; (d) chemical cleaning, painting and sandblasting; (e) insulation and lining of tanks and pipes; and (f) maintenance and repair of refinery and power station equipment.

The company has a labour force (skilled and unskilled) of 1,300 employees, including 18 engineers. It has rendered services to different industrial customers in the Gulf region (Saudi Arabia, Bahrain, Qatar and Kuwait).

Consultancy and engineering design

Given the complexity of the operating technologies in the oil refining and petrochemical and fertilizer manufacturing, Kuwait has a number of constraints in attempting to meet the technological requirements of investments with its own capabilities. The contraints include the lack of national skilled manpower, scarcity of national engineering and managerial skills, and the requirement of highly specialized engineering and manufactured capital goods.

The heavy reliance on turnkey projects to obtain technology suggests that Kuwait has many difficulties in overcoming engineering as well as other constraints. Apparently, the export-oriented production targets are so ambitious that strengthening of indigenous technological capabilities in the areas of consulting and engineering design has not been given a primary attention. However, the Kuwait Petroleum Company has recently acquired the Santa Fe Corporation which can provide KPC companies like KNPC, PIC, etc., a supporting capability in areas where these companies are handicapped. Thus, Kuwait Sante Fe Braun for engineering and petroleum enterprises (KSB) company was established in 1982, owned fully by Kuwait Petroleum Corporation (KPC). KSB has 82 employees domiciled in Kuwait and distributed according to professional engineering into 8 electrical, 16 mechanical, 15 civil and 23 other specialties. Twenty administrators (5 Arabs and 15 foreign) make up for the balance of personnel associated with KSB in Kuwait. However, Santa Fe does not have an operations office in Kuwait. It has two major areas of activity, providing agency or sponsorship services for all Santa Fe International Corporation projects in Kuwait and seconding or loaning skilled technical personnel to Kuwait companies. The skilled employees augment the local capabilities and expertise in KNPC and are provided to KSB by C.F. Braun, the engineering subsidiary of Santa Fe International Corporation.

C.F. Braun capabilities in design, detailed engineering and in product and process design should help the engineering staff at KNPC refineries and PIC to identify projects, and select the technology that suits Kuwait's needs.

The services provided by these professional engineers are highly technical and require specialized skills which are not available in the local employment market in Kuwait. These specialists are at present indispensable and may be replaced in the future by nationals who gain experience in these specialized areas. In this regard, KSB has been contributing since its inception in the process of technology transfer to Kuwait, by seconding employees with technical skills to KNPC and other governmental bodies.

To meet its specialized needs, KSB has to rely on the expertise of its professional employees who are borrowed on temporary basis from its headquarters. Skills and specializations needed are not available nationally or regionally.

As to training of manpower, KSB does not conduct programmes, but may be involved in arranging and co-ordinating training sessions for national employees in the Centre for Career Development which is sponsored by C.F. Braun.

KSB is envisioning the expansion of its activities outside Kuwait, offering engineering and construction services, continuing to second skilled employees to local industries, and probably establishing an engineering office in Kuwait. Recruitment of additional skills will be needed, if an engineering office is established in Kuwait, to offer a full range of engineering services. In summary, KSB is not a local company in Kuwait, but has an office which acts as an agency for Santa Fe International and provides technical skills and assistance to compensate for the current shortage of indigenous staff at KNPC. The office is staffed by skilled personnel who are on loan from C.F. Braun for a temporary period and assigned for an identified project. Upon completion of the project, the employees are repatriated to other projects.

KSB is reported to have been undertaking the acceleration of replacing foreign employees by Kuwait nationals and Arabs by establishing the transfer of their specialized and advanced technology on both an individual and national level.

Research and Development

The capability to perform R & D can be found in all the refineries and petrochemical industries, although the function is often more concerned with quality control analysis than with research. Thus the Government established in 1973 the Kuwait Institute of Scientific Research (KISR) with an aim to undertake such applied research.

The allotments for R & D represent approximately 0.50 per cent of Kuwait's oil revenues and 0.25 per cent of gross domestic product.

Emerging as a reliable consultant for several national and Gulf industries, KISR is earning nearly KD 1.5 million a year from consultancy services, which is about 10 per cent of the subsidy it gets from the Kuwaiti Government.

From the annual budget of KISR it is evident that engineering and petroleum, petrochemicals and materials receive only a minor share, 4 per cent and 10 per cent respectively of the annual buget.

The petroleum, petrochemicals and materials division consists of three departments, petroleum technology, products and materials application. The petroleum technology department undertakes activities related to catalysis and crude oil analysis. The products department focuses on evaluation of characteristics and behaviour of polyers and on petrochemical products particularly those that are manufactured locally. The materials department engages in programmes on corrosion, seawater desalination by reverse osmosis, in addition to conducting studies on the application of inorganic materials. KISR has not so far obtained any patents or licensing income from technology transferred or generated locally. However, it has been indicated that applications for three inventions have been submitted for consideration to the patent and trademark office.

Also, the role played by Kuwait Foundation for the Advancement of Sciences (KFAS) by providing finanical support to scientific institutions in general, and KISR in particular, should be mentioned here.

KISR has not served as a partner in technology transfer agreements between foreign sources and local industry.

A company was founded in 1981, namely the Technology Investment Company (TIC) with the objectives to apply the inventions and invest commercially, patents and trademarks that are generated by the scientific organizations in Kuwait. In this respect, the establishment of the TIC is aimed at consolidating the role of KISR and other scientific institutions in the transfer and adaptation of imported technology and adoption of domestically generated or modified technology.

The obstacles that hinder KISR role in the generation, modification and transferring of technology lie mainly in the weak working relationship that prevails among the scientific communities, industrial sector and government departments. A lack of interaction impresses negatively on this role and slows down the contribution of KISR to the welfare of the society. To enhance KISR's role, it is advisable to have closer and healthier relations between the government, industrial and scientific organizations.

<u>Manpower and Training</u>

KNPC had 5,252 employees as of end June 1983 including a 10 per cent increase during 1983 which was necessitated by the current modernization and expansion programmes which are scheduled to be completed by the end of 1986.

	Kuwaiti/Percentage		Arab/Percentage		Foreign/Percentage		Total
KNPC	1,362	26%	3,171	60%	719	14%	5,252
PIC	353	20%	1,237	69%	196	11%	1,786

Source: Provided by the Company.

In this regard, the Kuwaitization programme has been continuing successfully. Nearly one third of the total new employees hired during 1983 were Kuwaiti. As to manpower breakdown by nationality, the number of employees, as of June 1983, were as follows: 1,362 Kuwaitis (26 per cent); 3,171 Arabs (60 per cent); 45 Westerners (1 per cent) and 674 Asians (13 per cent).

In manpower training, KNPC has been continuing its long-term policy in this direction, by offering courses in the areas of refinery operations, maintenance, laboratory techniques, management, computer modelling, fire fighting and environmental hazards combating. A training centre established at the refinery site ensures the implementation of this policy. The distribution percentage of manpower according to specialization and profession was reported by Kuwait Ministry of Oil, as of end 1981, no updated statistics have been available.

KNPC	Number of employees	Kuwaiti percentage
Engineers	209	17%
Administrators	360	38%
Technicians	1524	27%
Clerks	767	24%
Skilled labourers	311	17%
Unskilled labourers	1048	5%
Trainees	327	100%
Total*	4546	

Source: Provided by the Company.

* Breakdown of number of employees is given as of end 1981.

Generally, KNPC suffers from a shortage of technically qualified national personnel. Specific problems pertain to: (a) lack of motivation by high school graduates to enroll in natural science and engineering disciplines;

(b) many graduates of natural science and engineering prefer to work for the government and carry out traditional professions; (c) lack of curricula for undergraduate and graduate levels that are needed for specialized training; (d) scarcity of University teachers with industrial experience.

For PIC, the total manpower employed in 1983 was 1,786. Their distribution is given in the following table:

PIC		of which Kuwaitis
Senior managers	35	85%
Administrators	127	42%
Scientists	249	27%
Chemists (35)		
Engineers	81	16%
Technicians	731	12%
Skilled labourers	204	13%
Half-skilled labourers	104	8%
Unskilled labourers	39	5%
Clerks	161	6%
Trainees	55	100%
Total	1786	20%

These statistics indicate that Kuwaitis are largely concentrated in the managerial and administrative jobs and are thinly represented in the technical professional and skilled jobs. Apparently, there is a prevailing negative attitude towards vocational and technical schools, which is probably due to inherent traditions and cultural heritage. Students favour art, literature and commerce, curricula and shy away from science and engineering studies. Financial incentives and career development programmes should be instituted by the human resource planning and educational governmental departments to change this attitude and encourage enrolment in academic and vocational institutions which provide natural science, engineering and technical curricula. Manpower of Arab nationality, who undertake technical activities, outnumber both Kuwaiti and foreigners and reaches 59 to 79 per cent of total manpower, excluding administrators, clerks and trainees. The enhanced Kuwaitization policy implemented by PIC is well illustrated by the increase in Kuwaiti manpower from 8.7 per cent in 1976 to 20 per cent in 1983.

According to the level of education, the manpower distribution indicates 1956 from technical, high or intermediate school, 369 University graduates, 3 holders of Master Degree and one Ph.D. The percentage of concentration of Kuwaiti in the above respective levels of education is 16 per cent, 35 per cent, 33 per cent and 100 per cent.

As to manpower training, PIC emphasized its concern in developing the career of its new and senior employees through offering courses and participation in seminars instructed and organized by local training centres by Kuwait Institute for Scientific Research (KISR) and by KPC oil companies. Areas of training include operation, maintenance, quality control, computer application, accounting and marketing. Satisfaction is reported on the courses offered by KISR and KPC. The lack of technical facilities and of programmes tailored for the development of specialized expertise, is a factor contributing to the low rating given to other local training centres and institutes.

The implementation of a well designed national policy for manpower employment and training in the oil industry, did not take effect until the late 1960s. Before 1960, the employment was controlled by oil companies who practiced a policy of hiring a larger number of foreigners, particularly Asians. To face this situation, the governmental liaison bureau, which co-ordinated with the oil companies and undertook the issuance of residence permits, had to institute a policy calling for arabization and eventually Kuwaitization of manpower.

Since then, a gradual reduction was mutually agreed upon in the number of foreign labourers and employees. This was augmented in 1970 by formal training programmes for nationals with the aim to form a Kuwaiti cadre which is able to replace retired non-Kuwaitis and assume leading posts in the oil companies. Academic scholarships were granted, and employees were sent abroad for this purpose on two-year training missions.

In summary, except for the preliminary and feasibility studies, production management, customer technical services, marketing and maintenance which were undertaken entirely by PIC, the other activities given below, each with its corresponding contributor, were performed completely by foreign companies:

Plant design	Tokuyama Soda (Japan), Hitachi Zosen (Japan) and Haldor Topsoe (Denmark);
Engineering	Tokuyama Soda (Japan) and Haldor Topsoe (Denmark);
Construction and Civil Work	Hitachi Zosen (Japan), Daelem Engineering (Korea); and Technipetrol (Italy);
Process design	Tokuyama Soda (Japan) and Haldor Topsoe (Denmark);
Product design	Tokuyama Soda (Japan) jointly with PIC.

As for the execution of the chlorine-sodium chloride plant, the percentage participation of PIC and/or the foreign companies in each relevant activity is as follows:

Construction and civil work	Hitachi Zosen Company and Daelem Company (100%);
Process design	PIC (25%), Tokuyama Soda (75%);
Product design	PIC (50%), Tokuyama Soda (50%);
Production management	PIC (100%);
Marketing services	PIC (100%);
Maintenance	PIC (1%);
Customer technical services	PIC (100%) a contract agreement is signed with Tokuyama Soda to provide technical assistance.

As for the execution of the planned projects (polypropylene, ammonia disulphate), the percentage contribution of PIC and potential suppliers of technology in each relevant activity is as follows:

Preliminary studies	PIC (100%);
Detailed feasibility studies	PIC (100%);
Engineering	PIC (25%), others (75%);
Plant design	CF Braun and others;
Construction	CF Braun and others;
Product design	CF Braun and others;
Production management	PIC (100%);
Marketing	PIC (100%);
Maintenance	PIC (100%);
Research and development	PIC (50%), KISR (50%);
Customer technical services	PIC and others (suppliers of technical assistance and technology).

Capitalizing on the optimum utilization of domestic resources, PIC pointed out the need to develop its local capabilities through intense training programmes under the sponsorship of C.F. Braun and Hoechst Company of which 24.9 per cent shares are owned by Kuwait,and in co-operation with KISR and KU.

3.4.3 National Institutions

(a) KISR

The Kuwaiti Institute for Scientific Research (KISR) had as of June 1983 a manpower of 951, distributed as follows: (a) personnel engaged in R & D 548; (b) auxilliary personnel 247 and (c) supportive staff 156.

The breakdown of employees according to their categories is as follows: (table 3.8) senior managers 20 (5 per cent); scientists 110 (29 per cent); engineers 82 (22 per cent); economists 9 (2 per cent); technicians 103 (27 per cent) and administrators 57 (15 per cent). The breakdown of research scientists and specialists, according to specialization, is as follows: (table 2 chemists 32 (30 per cent); physicists 4 (3 per cent); agricultural scientists 31 (29 per cent); engineering scientists 22 (20.5 per cent) and others 18 (17 per cent).

Professionals categorized as research assistants and research associates are distributed according to specialization as follows (table 3), electrical engineers 28 (9.5 per cent); electronics 10 (3.4 per cent); mechanical 11 (3.7 per cent); civil 16 (5.4 per cent); chemical 46 (15.6 per cent); industrial 5 (1.7 per cent); agricultural engineers 48 (16.3 per cent); physical sciences 25 (8.5 per cent); mathematical sciences 24 (8.2 per cent); social sciences 69 (23.5 per cent) and others 12 (4.1 per cent).

Table 3.8

KISR: Number of employees per division (for 1984)

	Petroleum materials div.			Division of engineering			Techno-economics div.			Technical support div.			Env. & Earth science div.			Food resource division		
	Na	Ar	Fo	Na	Ar	Fo	Na	Ar	Fo	Na	Ar	Fo	Na	Ar	Fo	Na	Ar	Fo
Senior Managers	1	3	–	1	3	–	–	3	–	–	2	–	–	3	–	2	2	–
Administrators	–	3	8	–	2	6	–	2	5	–	2	5	–	2	6	–	5	11
Scientists	3	18	5	2	6	3	4	6	1	–	3	3	6	5	5	10	13	17
Engineers	22	4	1	20	2	–	11	3	–	6	2	1	5	1	–	–	3	1
Economists	–	–	–	–	–	–	6	2	1	–	–	–	–	–	–	–	–	–
Technicians	9	24	–	2	4	5	–	–	–	5	7	3	1	8	2	1	26	6
Sub total	35	52	13	25	17	14	21	16	7	11	16	12	12	19	13	13	49	35
Total		100			56			44			39			44			97	

Source: ESCWA compilation.

Na - National (Kuwaitis)

Ar - Arab

Fo - Foreign.

Table 3.9

KISR: Scientists* by specialization and degree as of December 1984

Specialization/degree	Bachelors	Masters	Doctors	Total
Chemists	2	7	23	32
Physicists	-	3	1	4
Mathematicians	-	-	-	-
Others:				
Agricultural Sciences	4	9	18	31
Engineering Sciences	2	5	15	22
Others	1	3	14	18
				307

Source: ESCWA compilation.

* Scientists category; all staff members categorized as research scientists and research specialists.

Table 3.10

KISR: Engineers[a/] by specialization and degree as of December 1984

Specialization/Degree	Bachelors	per cent	Masters	per cent	Doctors	per cent	Total
Electrical[a/]	19	68	9	32	-	0.0	28
Electronics[a/]	1	10	7	70	2	10	10
Mechanical[a/]	7	64	1	36	-	0.0	11
Civil[a/]	14	87	2	13	-	0.0	16
Chemical[a/]	38	65	8	35	-	0.0	46
Industrial[a/]	4	80	1	20	-	0.0	5
Others:							
Agricultural[b/]	31	64	17	35	-	0.0	48
Physical Sciences[c/]	18	72	7	28	-	0.0	25
Mathematical Sciences[d/]	16	67	6	25	2	8	24
Social Sciences[e/]	51	74	16	23	2	3	69
Others	7	58	5	42	-		12
							294

Source: ESCWA compilation.

a/ Engineering Category - all professionals categorized as research assistants and research associates.

b/ Agricultural Sciences - include staff members majoring in agronomy, food science, zoology, agriculture, botany, etc.

c/ Physical Sciences - include staff members majoring in physics, chemistry, geology, etc.

d/ Mathematical Sciences - include staff members majoring in mathematics, computer sciences, information system, statistics, etc.

e/ Social Sciences - include staff members majoring in economics, library science, accounting, etc.

(b) University of Kuwait

The Kuwait University (KU) has presently nine faculties, approximately 13,000 students and a teaching staff of 670.

There is a College of Sciences with 836 undergraduate students (1984-1985) academic year) and a College of Engineering and Petroleum with 296 undergraduate students, all in chemical engineering. Eleven students are enrolled for graduate studies in the College of Sciences and eight students were granted M.Sc. degrees from this College in 1983. The master of science programme encompasses both theoritical and applied research studies, courses are complemented by experimental work. Students, may carry out their research at industrial sites. The College of Engineering has no formal graduate programme.

The number of graduates obtaining B.Sc. degree from College of Sciences and College of Engineering and Petroleum was 210 and 43 respectively. As to the number of faculty and professional staff, College of Science reported a total of 182, distriubted as 53 Kuwaitis (29 per cent), 66 Arabs (36 per cent) and 63 foreigners (35 per cent).

Chemistry, mathematics, physics, geology and computer science make up for the major programmes offered by the college of science. Engineering programme in chemical, civil, electrical and mechanical specializations are offered by the college of engineering and petroleum. R & D projects carried out by college of engineering during the last five years centred on two major areas, desalination of seawater and petroleum refining, no R & D projects were reported by the college of science.

KU does not provide consultancy on contractual basis to local industries or government, nor does it carry out contract research. Nor has it participated as a party or as a consultant in technology transfer agreements between foreign sources and local industry.

KU indicated that its relationship with industries is very limited. There is an earnest need for linkage and policy integration between academic and scientific research institutions on the one side and the industrial and governmental sectors on the other side, so the exchange of information and joint co-operation are enhanced. This can be accomplished through close contacts via seminars and conventions.

3.5 Qatar

3.5.1 Historical development

The first major step achieved in Qatar to develop local technological capabilities in the oil refining and petrochemical sectors, was the establishment in the seventies, of local organizations and bodies entrusted with: (a) defining the Qatari Government national strategy for industrializing the petroleum sector; (b) planning the smooth take-over and national control of petroleum sector; (c) expanding production of petroleum products and control of all aspects of petroleum operations including processing and marketing.

Qatar's technical and advisory authority in industrial diversification affairs and on major industrial projects is the Industrial Development Technical Centre (IDTC) which was created in 1973 with the task of laying out industrial development plans for the state of Qatar and to supervise the implementation of the major industrial projects.

The Qatar General Petroleum Corporation (QGPC) became the executive body through which Qatar carried its petroleum policy, established in 1974, when the country started to regain complete control over its petroleum resources from the foreign companies.

In the establishment of petroleum projects and because of shortages in technical capabilities and know-how and skilled local manpower needed to operate these technologically advanced enterprises, there has been and still is a strong reliance on foreign inputs. Projects were executed on the basis of joint ventures and turnkey agreements including special management and marketing agreements.

Qatar like most Gulf States has relied completely upon assigning foreign partners minority interests in the established projects and depended upon using foreign process licensers and foreign engineering consultants for most of the existing projects. The services required from foreign partners include: (a) product and process designs; (b) the selection procurement and inspection of equipment; (c) supervision of the construction, installation and assembly; (d) supervision of operation of all industrial units of the projects; (e) the detailed engineering comprising civil, structural, mechanical and electrical engineering, implementation planning and other services; (f) training of local manpower; (g) management, maintenance and (h) marketing of final products abroad.

IDTC's main contribution to development of technological capabilities, lies in its early participation in identification of projects, and expansion programmes of existing plants. It also undertakes feasibility and pre-feasibility studies in-house and with help from foreign experts, as well as marketing studies and it has been charged with the responsibility of the negotiating process with foreign parties for most of the large projects. It also participates in draft statements for bids and tenders, in finalizing contracts of the joint venture projects and in arranging financing for the bigger projects. IDTC has started in 1983 an industrial information base which serves the Qatari Governments needs for industrial development data and all industrial companies.

Qatar, like other Gulf States, wishes to develop local capabilities in the engineering sector for the implementation and maintenance of the petroleum processing industries. This has not yet materialized because these capabilities are difficult to accomplish in such a short period taking into consideration the poor initial infrastructural base available. Yet project implementation has not been hindered by this fact. The following engineering capabilities have been contracted to foreign partners: plant design, detailed engineering, construction, process design, product design and control, even start-up, production operation and management, marketing services, plant technical services and manufacture of spare parts.

The experience acquired within IDTC and QGPC management and services departments, have limitations and there is still a great dependence on foreign expertise, especially in the technologically advanced petrochemical and fertilizer industries. Only in the refining sector is there a strong participation on the side of local capabilities.

(a) The experience of QAFCO

The foreign partner Norsk Hydro, has supplied the technology and has under an agreement with QGPC signed in 1979, provided management and supervisory staff for the operation of the company and plants and is also undertaking marketing of the products.

Norsk Hydro, ICI of United Kingdom, Mitsui Toatsy of Japan and DSM/Stamicarbon of Holland, C&F Chimie of France and K.I.I. all have participated in establishing QAPCO 1. QAPCO 2 was built in co-operation between Norsk Hydro, Dauy Power Gas Limited and Costain Process Engineering and Construction Limited, United Kingdom and Chiyoda Chemical Engineering and Construction Company Limited of Japan.

The scope of work for the project development was as follows:

Scope of work	Company
1. Project identification and planning	Norsk Hydro, I.C.I (U.K. and IDTC
2. Technical and economical services	Norsk-Hydro, I.C.I. C&F Chimie, (France)Mitsui Toatsy (Japan) and K.I.I.
3. Engineering Services	Norsk-Hydro, I.C.I., Sir Alexander Gibb and Partners.
4. Managerial and Marketing Services.	Norsk-Hydro.

QAFCO's personnel in 1976 were estimated at 625 employees, this number increased to 1000 in 1982-1983, at the end of 1983, QAFCO management decreased the number of employees by 10 per cent. As of end 1983 the number of employees are 905, out of which 350 are Qatari and Arab employees. The Norwegian staff decreased from 63 employees in 1978 (at the end of plant 2 construction) to 42 in 1983. In the same period, the Qataris increased from 157 to 161, while the Arabs increased from 123 to 154. The following distribution in posts and professions in 1983 has been shown.

	National	Arab	Foreign
Senior managers	1	-	5
Scientists, engineers and economists	11	46	21

The foreigners are distributed in professions as follows:

10 Scientists and 11 Engineers.

At present (1985) the company has no programme for increasing personnel in the company. The productivity of QAFCO's manpower in the period 1974-1983, has increased in both the urea and ammonia lines. For the ammonia it increased from 207 T/man-year to 576T/man-year. For urea from 126 to 676. This is almost three times the increase in productivity of manpower in ammonia and five times the increase in urea.

3.5.2. <u>Assessment of capabilities</u>

(a) For QGPC, the foreign partner Norsk Hydro supplied the technology and had under an agreement with QGCP signed in 1979, provided management and supervisory staff for the operation of the company and plants and is also undertaking marketing of the products.

Norsk Hydro, ICI of UK, Mitsui Toatsy of Japan and DSM/Stamicarbon of Holland, C&F Chimie of France and KII all have participated in establishing QAPCO1. QAPCO2 was built in co-operation between Norsk Hydro, Dauy Power Gas Limited and Costain Process Engineering and Construction Co. Limited in Japan.

The scope of work for the project development was as follows:

	Scope of work	Company
1.	Project identification and planning	Norsk Hydro, ICI (UK and IDTC)
2.	Technical and economical services	Norsk Hydro, ICI C&F Chimie Mitsui Toatsy (Japan) and KII.
3.	Engineering services	Norsk Hydro, ICI, Sir Alexander Gibb and Partners.
4.	Managerial and marketing services	Norsk-Hydro.

(b) QAFCO, like other companies in the country, suffers from shortage of national experienced personnel. Staffing at QAFCO was as follows in 1983:

	National	Arab	Foreign
Senior managers	1	-	5
Scientists, engineers and economists	11	46	21

The foreigners are distributed in professions as follows:

10 Scientists and 11 Engineers.

In 1985 the company had no programme for increasing personnel. The productivity of QAFCO's manpower in the period 1974-1983, has increased from 207 tons/man-year to 576 tons/man-year for ammonia, and from 126 to 676 tons/man-year for urea. This is a three-fold increase in productivity of ammonia and a five-fold increase in urea.

This increase has been effected favourably by the doubling designed capacity of the plant which took effect in 1979, but also indicates the effects of accumulation of experiences and improvement of technological capabilities.

QAFCO has an in-house laboratory and an established training section for on-job training, and for upgrading the educational level of Qatari and other manpower, the section arranges workshops continuously. It also supervises the training of Arab workers for planned similar plants such as the Saudi Arabia plant.

Plant operation and technological improvements have been achieved in the fertilizer plant, especially since the first plant which started production in 1973, never reached its designed capacity. A detailed study of the first plant was carried out in late 1977, to develop its technology for the purpose of incorporating the results in the design of the new plant for which preliminary preparations started in 1975.

QAPCO

The idea of QAPCO appeared in early 1973 through IDTC from available published data concerning processing technology and economical and market studies. IDTC made a deep investigation which led to select ethylene production as the most feasible project for the use of the ethane rich gas to be produced by the LNG plants under consideration at that same period. IDTC repared project specifics and entered the contract negotiations.

CdF Chimie made the best bid, it offered Qatar the benefit of its technical know-how and experience to design and supervise the construction of the complex and its start up, to assist in its operation and management and to bear the responsibility of marketing the main product LDPE.

The following main draft contracts were annexed to the protocols:

LDPE licence contract;

Project management contract;

Marketing contract;

Contract of assistance for operation and management of complex.

Special standards have been added to take into account the local condition:

- Special protection of foundation from under ground water;

- Special protection of equipment and buildings from sand storms;

- Special cooling systems;

- Use of special materials for equipment.

And for the benefit of the complex the following services have been provided:

Laboratory: For analysis and control of fluids, raw materials and products it is largely involved in quality control of the products (polyethylene);

Maintenance workshop: Very well equipped for all professional activities (mechenical, electrical, electronics), and spare parts are available on stock the maintenance taskforce is more than 35 per cent of the whole staff of QAPCO. Safety measures are taken very carefully.

CdF Chimie has a subcontract to manage the project. It made available for the operation of QAPCO the following number of employees:

- 1 General manager
- 6 Senior executives
- 10 Junior executives
- 13 Upper medium staff
- 16 Medium staff
- 12 Highly skilled workers.

Total 58

The intention was to reduce the number from 58 to 25 after 2 years from start up. The total staff required for QAPCO was 626. Recruitment policy in the Company was to recruit first from Qatar and Gulf States then from other Arab States, last from the Far East. After contacts with the Doha Training Centre, it was found that the existing training was not suitable for work in the petrochemical plant. Fifteen Qataris were chosen and sent to France to follow preparatory basic training courses then pre industrial training.

Distribution of staff (1981)

	Qatar percentage	Egypt percentage	Palestine percentage	India percentage	France percentage	Other percentage
Senior staff	11	20	7	2	46	13
Intermediate	7	39	11	14	9	20
Operative staff	23	23	8	29	0	17
Total	14	30	10	19	9	18

In addition a total of 171 trainees were sent to France for a long-term training programme, concentrated on the technical field. Also in-house training was used. Over 20 per cent of trainees were lost through the training period due to drop outs or to transfer to other jobs.

In 1983 the number of workers were 642, (distributed as 91 Qataris, 350 Arabs, and 201 from other countries). Up to 1984 QAPCO was still dependent on technical support from outside the country and the top technical personnel are still foreign mainly French. However the ratio of Qatari and Arab staff are increasing, the management contract with CdF Chimie will end in 2 to 3 years, and it is expected that most of the key positions there would be held by Qatari and Arab employees, except 2 to 3 French personnel who may be retained.

3.5.3. National Institutions

(a) Engineering Companies

No local companies have been established in this field. Furthermore, there is no organization which can train engineers beside the university which provides only basic academic studies, and the Applied Research Centre which is concentrating on the few new industries in the medium and light downstream industries in the private sector.

IDTC has in addition to its in-house technical expertise an agreement with an international engineering firm, for making the basic engineering design for its projects. QGPC has within its management structure an engineering department with authority over small operations ad expansion plans and some modifications, mainly in the refining sector, while QAPCO, QAFCO and the LNG plants all have foreign companies (involved in the joint ventures) controlling the technical services and production management of these companies.

Recently the Qatari Government has been set to subcontract most of the construction to local companies, but the large technology oriented projects of the petroleum sector are put to international tenders. This reflects a tendency towards incouraging local contracting and engineering companies, it also reflects an improvement in the quality of operations and experiences gained by local contracting companies, though these companies have in many cases heavily depended on foreign partners so that they can guarantee a certain level of expertise, and to acquire the required machinery and materials.

Therefore in Qatar, the high-technology projects are expected to remain for the foreseable future, the province of well experienced international companies.

The few local contracting companies which ventured recently in the petroleum field in Qatar are:

- Qatar National Navigation and Transport Company which is planning with the collaboration of a foreign company (United States company MC Dermott) to go into oil offshore fabrication of equipment for a number of oil companies.

- The Mannai Corporation, which established a joint venture with a foreign engineering company (Italy's MICOPERI), and is at present working for QGPC offshore operations. It is also bidding for work in the region. (Saudi Arabia), mainly in maintenance services.

- The largest of Mannai Corporation divisions is the Mid-East constructors (MECON) which is the leading mechanical and electrical contractor in Qatar. It built a fuel-gas supply system in Halul Island for QGPC in 1982, and was the first Qatari comany to get such a contract. It also secured work in the Bahrain Petroleum Company in 1981. It carried out, in 1984, the shut-down maintenance of QGPC's NGL-2 (Natural gas liquids plant), and in August 1984 it won the mechanical erection contract of QAPCO ethane-rich recovery unit, and handled the site mobilization earlier in 1984.

(b) The Scientific and Applied Research Centre was established in 1980, as part of Qatar University, to undertake scientific and applied research in industry and natural resources development, to promote new applied and advanced technologies in the different manufacturing sectors, and to engage students and professional technical and scientific staff in research, which is related to the existing industries. It also aims to provide technical consultancy services.

The centre has been awarded agreements to do pre-feasibility and feasibility studies and research on projects in the private sector for medium and light industries, but it is indicated that it was never approached by the larger petroleum or petrochemical industries.

(c) The Qatar Regional Training Centre Was established in 1971 as a joint project with UNDP. It provided vocational training for more than 1600 trainees. Most of the (technical) staff of the centre are Arab nationals. The training provided includes: mechanics, engineering, electricity and building, plus all basic science courses such as physics, chemistry and mathematics. It regularly organizes workshop in management and drafting. The centre was established to accommodate 900 students, yet it never had more than 600 students, therefore the centre utilizes 70 per cent of its capacity. Most students after leaving the centre, are employed in the industrial sector where they have practical training (in-house). The Centre does not specialize in petroleum related skills, and the number of students attending and graduating every year is not comparable to the needs of the country. Also the students need to develop their capabilities after work to be able to compete with the level of experience of employed expatriates.

Table 3.11

Examples of technological capabilities in Qatar

	QAFCO	QAPCO	Refinery	LNG
Pre feasibility and feasibility	F + N	F + N	C	C + F
Plant design and engineering	F	F	F	F
Construction	F	F	F	F
Supervision of eretion	F + N	F + N	F + C	F + C
Process and product design	F + N	F + N	F	F
Production management	C	C	C	
Marketing services	C	C	C	
R & D	F	F	F	F
Plant technical services	C	C	C	C
Customer technical services	C	C	C	C

Source: ESCWA/UNIDO Industry Division.

3.6. Saudi Arabia

3.6.1. Historical Development

From the 1960s onwards, the development of the industrial sector in Saudi Arabia's economy, has mostly been achieved through the establishment of private enterprises, setting up joint ventures with foreign manufacturers of intermediate or finished products. The production plants and know-how were acquired through importation of machinery and through licences or other forms of contracts for the technology.

In recent years, with the establishment of the large refineries and petrochemical industries, the situation has changed in the sense that the Saudi. Government is taking a much more active role in the development and establishment of industrial enterprises, by investing directly in them.

The process was started with the introduction of the 5-year development plans, which were implemented from 1970 onwards. High economic growth rates were achieved during this period, and many construction and infrastructure projects were implemented. Also many plans for the downstream development of the petroleum-based industry were drawn up. These include plans for massive investment in world-scale size petrochemical plants, producing a variety of products to be used as raw material for many industrial establishments. The size and complexity of these new establishments required a different and more advanced level of managerial and technical capacities, until then only available at a limited scale. Therefore, together with and as part of the 5-year Economic Development Plans, programmes were developed to build-up indigenous capacities to be able to operate, maintain and possibly modify and expand these installations. Until now, the development of the petroleum-based sector was largely achieved through the recruitment of foreign manpower and licensing advanced technology. The impact of the importation of this foreign technology on the development of national technological capabilities, is the objective of part of this study. Like most of the countries of the region, Saudi Arabia has acknowledged the fact that industrial development is necessary to expand its economic base,and it is now slowly emerging from its primary specialization which is export of crude oil.

A country, like Saudi Arabia, which wishes to diversify its industrial sector, will have to develop downstream industries, which will produce the raw materials needed for its petrochemical industries. These industries, in turn, will provide the essential raw materials and intermediate products for a large number of other industries, such as solvents, detergents, paints, coatings, adhesives, etc.

This strategy was clearly spelled out with the establishment in 1976 of the Saudi Basic Industries Corporation (SABIC), which became responsible for setting up, operating and marketing the products of basic petrochemical industries (see Part 2, pp. ...). It has already established several world-scale petrochemical plants, producing both for the domestic and export market.

Once all these industries become fully operational, the task of SABIC will be to operate these plants to the maximum possible extent with Saudi manpower. This can only be achieved if there is a clear policy to develop and enhance local technological capabilities in a wide variety of specializatons.

3.6.2. Assessment of capabilities

Project identification

In the early 1970s it became clear for Saudi Arabia, as well as for other OPEC countries, that there was a need to develop their petroleum-based industry. Therefore, studies were conducted for indentifying petrochemical projects for implementation, and organizations such as SABIC were created to co-ordinate the investment projects indentified by these studies.

SABIC, in consultation with foreign consultancy organizations, identified thus a number of projects to be implemented as a first group of basic industries,later followed by the so called second generation of petrochemical industries.

Specific information on the extent of the involvement of foreign organizations in the identification of projects is not available, but there is scope to believe that at present SABIC has acquired substantial capabilities in this field.

At the same time, PETROMIN was entrusted with the task of implementing and administering public projects in petroleum refining. It conducted the necessary studies for the new oil refineries mostly in connection with the large oil companies, such as Mobil, Dow, Shell and Exxon, which were to become the partners in these joint ventures.

Under this activity also the ability to negotiate a contract can be considered, although this is not necessarily a technological capability. The skills needed for the evaluation and selection of alternative technologies depend on the ability for "unpacking" the technology, and evaluating each aspect according to a set of pre-established criteria.

As a result of the survey, it was found that PETROMIN selected a number of technology suppliers, based upon their reputation in a particular technology and their proven ability to provide the required assistance. Also an important consideration was the company's ability to provide markets for their future products. Since the latter consideration is beyond the scope of the present study, it will not be further elaborated upon here.

For the new, large refinery and petrochemical projects, the technology evaluation was carried out by (foreign) consultants. Criteria applied, in addition to the above-mentioned, were the required manpower needs and the skills available, the technology's degree of flexibility, its cost effectiveness, proven performance and ease of maintenance and also the "age" of the technology (whether it was up-to-date). The final selection decision was always made by PETROMIN, or SABIC respectively.

Pre feasibility/feasibility studies

Technological capabilities needed for carrying out pre feasibility or feasibility studies are among the first to be found in the petroleum based industry. Almost all establishments replying in the survey, indicated that they or their mother company (e.g. PETROMIN) were conducting these studies independently.

In the case of the world scale export refineries being constructed, PETROMIN and SABIC worked in co operation with their partners, but there has been a substantial build-up in capabilities in this area. However, only in one instance it was cited that a local consultancy organization was involved in undertaking the pre feasibility and feasibility studies. In addition, it was reported by most of the foreign consultancy organizations working in the country, that only a very limited part of their activities was in this field.

The studies carried out by PETROMIN were for the 250,000 b/d Yanbu export refinery (in co-operation with Mobil); for the Riyadh domestic refinery (120,000 b/d); for the Yanbu domestic refinery (170,000 b/d), in co-operation with the local consultancy firm Salah Abu AL Khail; for the 250,000 b/d, PETROMIN-Shell Refinery (in co-operation with Shell); and for the 325,000 b/d Rabigh Refinery, (in co-operation with two foreign consultants Foster Wheeler and Snamprogetti). This refinery is still under construction. Besides that, PETROMIN did the studies for a number of new lube oil refineries, e.g. in Jeddah and Riyadh.

A local consulting firm also active in this field is the Saudi Consulting House, established in 1967 as the Industrial Studies and Development Centre. It carries out feasibility studies, planning and project implementation and provides engineering, electrical economic, management, legal and technical consulting services. For engineering and technical services, it has established two joint ventures with Leo A. Daly and the Irish Electricity Supply Board and an association agreement with Arthur D. Little, to co-operate in the areas of economic, industrial and management consulting services.

Plant design and engineering

These activities include a wide range of specialized skills. One can distinguish between basic and detailed engineering. Basic engineering is based upon research and development carried out by highly specialized scientists and engineers, working in R & D centres or universities, in industrialized countries. Detailed engineering and design work, need skilled and experienced chemical or process engineers, and therefore this is a capability which can be built-up.

It is not surprising that practically all activities in this field in the petroleum based industry in Saudi Arabia, are carried out by a small number of specialized companies from Europe, the United States of America or Japan, as reported by both the various companies as well as the consultancy establishments. The contracts thus awarded were carried out mostly in the headquarters of major consultancy offices and the transfer of technology, did not take place to the fullest extent, and although Saudization efforts are underway, still the lack of skilled and experienced nationals limits the development of this capability to a great degree.

The universities have only recently begun to graduate advanced level (M.Sc. or Ph.D.) graduates and although there is no information available on the number of students receiving degrees from abroad, the required number of qualified staff is clearly not available in the local market at present. In addition no clear information was given by the major refineries on the number of qualified scientists working in their organizations in this field.

Construction and supervision of erection

The manpower required to construct the large refineries petrochemical plants and other infrastructural projects in Saudi Arabia during the last decade, was not available in the Kingdom itself. Not only the huge numbers of unskilled workers could not be found in the Kingdom, but equally important, the required skilled manpower and supervisory staff were not available. This situation necessitated the large influx of expatriate workers and supervisory staff.

Although a number of Saudi or Arab companies in the building and construction sector, have been established, (like CCC), their involvement in the construction of refineries and petrochemcial plants was rarely cited in the survey. For example, the recently constructed refineries in Yanbu and Al-Jubail were constructed by Far Eastern companies working under the supervision of Japanese and the United States contractors. Also ARAMCO reported that they were only involved in supervisory activities. In these supervisory activities a limited Saudi involvement could be found, mainly through the local affiliate of the foreign contractor company. However, these partnerships provide the first step on the way to technological independence through the direct transfer of technolgoy so Saudi nationals.

Process and product design

Through the survey, there was no indication found that national capabilities were used or even existed. This is not surprising given the nature of process technology in petroleum-based industries with its generally proprietory know-how. In all cases given, the foreign partners of the joint ventures, and often in co-operation with established and specialized technology suppliers, provided the technology and design under a licence contract, both in oil refining and petrochemical industries.

This is the single most important characteristic of this industry, in which the process know-how is owned by only a small group of companies from highly industrialized countries. Thus, there are generally, a number of process design alternatives, differing in product quality or process paths. The process design includes all aspects related to process conditions, catalyst specifications, etc. and determines therefore to a great extent already the plant design and engineering phase.

Although there is no alternative for the importation of this technology, since developing it independently is a long process which would require enormous investments in human and financial resources, some development of technological capabilities could be achieved. Different ways for obtaining the specialized know-how could be explored, such as the acquisition of a leading consultant company as,for example, the Kuwait Petroleum Company (KPC) has done with the takeover of Santa Fe/C.F. Braun Company (see Kuwait). Another way could be the more traditional approach of learning on-the-job and through special training programmes offered by the technology supplier. This system assumes that a full transfer of technology could be demanded and assured during the contract negotiations stage and that well qualified staff to receive this training are available. Even then it will be a long way before all aspects of the technology are mastered and modifications, adaptations, expansions or complete new designs could be made. Also, the complete range of skills required for the design of any process, could only be mastered by an equally wide range of specialists, each mastering an aspect of the technology package.

Production management

This function includes all the activities required to operate the plants on a day-to-day basis. Usually the foreign contractor provides the managerial staff at the beginning to run the plant, while trained staff are gradually replacing the foreign managers. The technology transfer and training form part of the decisions during the negotiation of the contract. Detailed plans for training, including areas and duration of training programmes are prepared, and started well before the actual plant comes into operation.

These training programmes for operators and managerial staff are provided abroad at the joint venture partner or specialized training centres and sometimes at similar plants elsewhere in the world. This leads to the availability of a number of qualified staff at the start of the production process. Naturally the production management function is the one which is performed by nationals to the highest degree. Through constantly providing courses and upgrading the skills of the employees, most of the older refineries have achieved a high degree of independence from foreign sevices. This applies particularly for ARAMCO and the domestic refineries in Riyadh and Jeddah, and the lubricating oil blending plants.

The survey shows that all refineries and petrochemical industries rely for the operation and maintenance of their plants to a certain extent on a mixture of national, Arab and foreign nationalities.

As for management and administrative functions, the percentage of senior management jobs occupied by Saudis fluctuates from 25 to 100 per cent for the refineries, depending on the age and size of the plant. In other administrative functions, the Saudi share was found to be much less, varying from 10 per cent to almost 60 per cent.

Marketing

Although this is an important activity for any company and thus also for a petrochemical plant, it is not considered a technological capability as such. Most of the refinereies in the survey, reported that the marketing of their products was done either by themselves or by the mother company PETROMIN.

For instance, the world-scale export refineries are coming on-stream only in 1985, and their production is marketed through the network of the foreign partners' company. SABIC's share of their petrochemical plants production output is marketed through bilateral arrangements, but SABIC is just in the process of establishing their own marketing organizations through strategic acquisitions of distribution and storage facilities around the world.

As for PETROMINs products, (gasoline, lube oil, diesel oil, bunker fuel), they are domestically marketed by Petrochem through its own organization or exported to other countries of the region.

Research and development

This technological capability is found to exist in all oil refining and petrochemical plants, but closer examination of the information provided, reveals that in many cases the activities consist mainly of quality control, standardization and other research in areas of less immediate impact for the petroleum industry, such as environmental control measures, desalination and corrosion problems.

Each refinery equipped with up-to-date technology and installations, has a need for scientists to perform R & D functions, as well as managerial functions. This category of highly qualified scientists, will normally include chemists, physicists, and mathematicians. It was found that the percentage of these functions occupied by national staff, was only a fraction of the total number of employees, and this was typically an area, together with engineering functions, in which the expatriate workforce was heavily represented. A reason for this situation can be found in the fact that only a limited number of Saudi Ph. D. or master degree holders were found among the refinery's Ph.D/master holders.

This situation is somewhat better among other categories of staff, e.g. skilled technicians. Especially in some of the older domestic refineries, the Saudi involvement in that category is much higher.

According to information provided by SANCST the number of institutions with facilities to conduct scientific and technological research, outside the universities is estimated as 5 to 10 institutions. In the same report, (E/ECWA/NR/85/WG.3/WP.3), SANCST states that in order to strenthen existing research facilities the following measures are needed: development of management capability, training of scientist and manpower development. The availability of scientific equipment or journals and other publications is less felt to be an obstacle for the present functioning of research institutions.

Three priority areas for research can be considered as (i) natural environment and resources, (ii) industrialization process and (iii) production process. In general the ministries and their departments are responsible for the choice of foreign technologies, facilitated by a registry of technological alternatives as well as consultations with national experts. There exists a programme to train personnel at government level.

The Saudi needs for strengthening the role of regional centres of technology are (i) exchange information on new and traditional technologies, (ii) promotion of pilot and demonstration activities, (iii) participation in data banks on technological alternatives and (iv) advisory services and technological consulting.

According to estimates by SANCST the percentage of scientific personnel engaged in R & D in Saudi Arabia was 15 to 25 per cent, while the rest was involved teaching (50 to 75 per cent) or in production (5 to 15 per cent). At the same time the Saudi targets for expenditure on R & D are 1 to 2 per cent of GNP. Internally generated contributions for R & D are very limited. Almost all resources for R & D are from government budget. A number of policies and directives have been issued to provide incentives to indigenous enterprises to strengthen their in-house research and to contractor otherwise use the services of local R & D universities.

Still more effort is needed to strengthen the linkages between national R & D institutions and the production system. These can be summarized as follows: (i) national policies to encourage or protect the development and use of local technology; (ii) generation of interest on the part of researchers to develop technologies for the local market; (iii) generation of interest by enterprises to make use of locally developed technologies and (iv) creation of a mechanism for communication between researchers and industrialists regarding their respective capabilities and needs.

Plant and customer technical services

These essential functions in all the petroleum based industries, require the availability of graduate engineers and technical diploma holders with varying degrees of experience, to carry out maintenance and problem-soving activities, both at the plant as well as the customers industrial establishment. The replies received through the questionaires, indicate that the day-to-day maintenance activities are carried out by personnel from the establishment, whether nationals or resident expatriates. They stated that only major annual overhaul tasks were carried out by foreign contractors or highly specialized jobs.

On the other hand, foreign contractor companies reported that their areas of activity include with varying degrees the provision of technical services to the oil refining and petrochemical industry. Thus internal capabilities do exist, but it is impossible to quantify and separate the precise skills involved in this area.

3.7. Syria

3.7.1. Historical developments

Technological capabilities in the petroleum based industry have been acquired and built-up over a number of years, since the first refinery was established in 1959.

The industrial sector differs from the oil rich Arab States, in that the country has a much wider industrial base and far less crude oil resources, than most of the other countries.

The per capita income is also much lower than in other countries of the region (US $ 1,100 in 1984), and this has necessitated Syria to rely more on indigenous capabilities, outside consultants and contractors widely used on the Gulf countries, were too costly.

3.7.2. Assessment of capabilities

The capabilities of the oil refineries and fertilizers projects can be summarized as follows:

(a) The Homs Oil Refinery Company which was built by a foreign company and started production in 1959 has been able to accumulate over a period of twenty five years very good skills, through training schemes designed for its personnel, whether new employees or old ones, in the various production and technical sections of the refinery, in the various specialized institutes and in similar enterprises.

The Company does not suffer from the problems of lack of experienced engineers or skilled technicians and workers. Repair and maintenance work is all undertaken by the Company's personnel without the need of foreign assistance. The Company's achievement has been remarkable in creating, expanding and improving its own technological capabilities and skills in the field of pre-feasibility and detailed feasibility studies, process engineering, process design and research and development in the technological field. Nevertheless, in certain cases, the services of foreign experts or consultants are needed to undertake specific tasks.

The company employs approximately 1,000 staff distributed over the specialized categories. All staff in both the Homs and the Banias Refineries are Syrian as shown in the table below:

	Homs	Banias
Senior managers	1	
Administrators	7	
Scientists	20	22
Engineers		
Electrical	10	11
Mechanical	23	38
Electronic	6	17
Civil	7	5
Chemical	91	33
Production		43
Others		10
Economist	24	27
Technical staff	854	897
Total	10943	1103

The educational background of the employees is given in the table below. The quality of the educational level was reported to be good.

	Nationals	Arab	Foreign	Total
Vocational training	337			377
Bachelor	93	1	19	113
Masters			21	21
Ph.D			3	3
Total				474

The refinery organizes, in-plant training programmes for its staff in technical and production departments and training in specialized centres and similar companies abroad.

The Homs refinery underwent, since its establishment six expansions and upgradings. However no information was provided on the extent to which the company was able to implement these expansion projects itself and to what extent it had to rely on foreign contractors.

Since the technology used was provided by UOP, it follows that a foreign share in the implementation was necessary. The survey indicates that the pre-feasibility and feasibility studies were carried out by the government planning organizations, and that plant design, detailed engineering and the construction were carried out by the Czechoslavak Company Technoexport, using UOP process technology.

The refinery claims to have acquired new technological capabilties in engineering and process design, although for plant and product design they have relied on foreign expertise. It has over the years developed its skills to operate and maintain the plant. No engagement in R & D activities are mentioned.

At present the Homs Refinery is adding three more HDS-units with a total capacity of 25,000 b/d to the refinery, which will enable it to change its product mix to 12 per cent gasoline, 12.5 per cent kero/jet, 30 per cent gas oil and 30 per cent fuel oil.

The technology for the H.D.S. and the sulphur units is provided by the French I.F.P. and Hurtey companies.

(b) However the Banias Refinery was established relatively recently, it has succeeded in organizing regular training schemes intended to improve and upgrade the skills of the technical personnel. Such training takes place mainly locally and to a lesser extent, abroad. The Company is at present implementing the establishment of a specialized training centre designed for practical training of its technical personnel.

The refinery has approximately 1,100 personnel, as shown in table (3). The educational background distribution of technical staff is given as follows:

Vocational training	243
Bachelor	213
Masters	8
Ph.D	8
Total:	472

The level of graduates was considered good for each category. Similar to the Homs Refinery, various capabilities are considered to exist,without further specification. For instance, pre-feasibility and feasibility studies are undertaken by the company and the Government planning organization. Plant and engineering design involves usually a foreign contractor besides their own capabilities.

Construction work has been carried out by local companies,but the product and/or process design function is carried out jointly by national and foreign consultants. However, day-to-day operation and maintenance are under taken by the company itself.

(c) The General Fertilizer Company (GFC) is one of the largest industrial complexes in the country, the civil construction of the plant was undertaken by the Syrian public sector enterprise General Establishment for Execution of Industrial Projects, with the assistance of Foreign Consultants. GFC has provided the break-down according to professional level for the following categories of staff.

Scientists	Number
Chemists	58
Others	11
Engineers	
Electrical	23
Mechanical	13
Civil	45
Chemical	25
Production	6
Economists	16
Technical Staff	819

The educational background of the company's qualified employees is given in the table below:

	Local	Arab	Foreign	Total
Vocational training	1360	-	-	1360
Bachelor	340	7	15	362
Masters	2	-	12	14
Ph.D.	-	-	5	5
Total	1702	7	32	1741

The company depends mainly on the national manpower for the operation management and production work.

In-plant condensed training courses on industrial technology are run by the Company in the production sections of the various plants, with a view to improving the skills of existing workers and technicians and acquaint new employees with the nature of the jobs they will undertake.

Other training courses are also organized for the company's personnel in various fields, such as: repair, maintenance,laboratory work, supervisory work, electric mechanics, welding technology, etc. Some of the courses are run outside the Company's premises in specalized training institutions or centres. Such training courses have proved to be most useful in upgrading the skills of the trainees.

During plant construction, engineers and technicians were sent abroad for training in the facilities of the technology suppliers. Although in the case of the calcium ammonium nitrate plant, trainees completed their training abroad and returned to the country well before any work was done on the project. This implied employment of these trainees in jobs other than those they were expected to undertake, thus leading to an eventual loss of their experience. Later on, when the project entered the sphere of implementation, another group of engineers and tehnicians had to be sent abroad for training.

In-plant trainig of engineers and technicians was also carried out under the supervision of specialized experts engaged by the Company. These training schemes helped the company in securing a reasonable number of qualified and experienced personnel, capable of providing a sound basis for technology transfer, adaptation and development.

The company reports to possess itself or at the State Organization, the following engineering capabilities as well as specialized help provided by outside contractors, see table below. It is presently engaged in two major engineering projects, which are the change in feedstock from naphtha to natural and associated gas the establishment of a production line for di-ammonia-phosphate (DAP).

	Company	National organization	Foreign
Pre-feasibility studies	X	X	
Feasibility studies	X	X	
Plant design			X
Engineering design			X
Constructin		X	
Supervision of installation		X	
Product design	X		
Process design			X
Production management	X		
Marketing	X		
R & D	X	X	
Plant technical services	X		
Customer technical services	X		

The company further reports that it has acquired the capacity to manufacture and assemble a number of spare parts without specifying their nature though further development of the mechanical workshops is needed.

The GFC acknowledge that they still depend on foreign expertise in a number of activities, although these are not listed. Their capabilities have already enabled them to solve some technical problems. One expample: due to the high chlorine content of the Syrian phosphates, a corrosion problem developed, which was remedied by applying a suitable lining in the installations.

The Company thus does not resort to engage foreign experts or advisors except in special cases and where problems to be solved are usually quite complicated or of a specific nature. For example, foreign expert services are required to deal with the problem of the pollution of water needed for the production processes, due to the complexity of the problem. Expert services will also be needed to introduce a computerized scheme for organizing the company's storage facilities. Since such services may not be available locally, foreign experts would have to be contracted.

A few foreign experts are at present engaged in process design and in research and development in relevant technological areas. The Company's engineers and technologists are assigned as counter-parts to them. The Company avails itself as well, of the services in the qualified local technical institutions, such as the Faculty of Engineering Damascus University in the engineering and design work.

In fact, the technological capabilities of the Company have enable it to undertake a wide range of jobs, such as pre-feasibility and detailed feasibility studies, product design, maintenance and repair operations, construction work etc. To illustrate this fact we know that the TSP and ammonium/urea plant were constructed on a turnkey basis, while the CAN-plant was a project executed under the overall responsibility of GFC.

3.7.3. National Institutions

(a) The General Organization for Studies and Engineering Design: this organization was established in 1969 and in 1980 became the General Company for Technical Consultancy and Studies. It provides consultancy services in number of economic areas. It carries out techno-economic studies and undertakes detailed engineering design, it supervises the construction of plants and other construction projects it formulates criteria for the procurement of equipment and it provides training for their own and newly graduated engineers to upgrade their skills.

Besides its head office in Damascus, it has established branch offices in Aleppo, Homs and Lattakia/Tartous.

At present it has a staff of 1500 employees, divided as follows:

	Engineers	Technicians	Administrators	Total
Damascus	592	363	215	1170
Aleppo	125	52	21	198
Homs	19	14	6	39
Lattakia/Tartous	45	36	17	98
Total	781	465	259	1505

It has undertaken pre-feasibility studies in various sectors, including oil refining, petrochemicals, fertilizers, manufacture of transport equipment, construction machinery, iron and steel. The company indicated that it possessed the capabilities for undertaking feasibility studies, plant and engineering design, and the supervision of construction projects. The survey provides no further details on these activities.

Although it employs about 100 non-Arab employees, all engineers and scientists, the 100 per cent owned company is carrying out its studies independently. Only in a few cases have they relied on foreign expertise to augment their skills.

This company is registered by the Saudi and Kuwaiti Development Funds as one of the regional Arab consultancy houses.

(b) Universities: The role of the universities in developing qualified personnel is important, since they supply almost all the engineers for the industry. The four main engineering training institutes are at the universities of Damscus, Aleppo, Baath university (Homs) and an engineering institute in Lattakia. Information was supplied only by the Aleppo university and the Baath university in Homs, and therefore the situation cannot be generalized, but is reproduced here only for illustration.

At the Aleppo university there is a faculty of enginnering and a faculty of science. The engineering faculty has four departments: civil, architecture, electrical and mechanical and the science faculty consists of three departments: mathematics, physics and biology. The annual enrolment and the number of graduates is given below.

	1982-83		1983-84	
	Students	Graduates	Students	Graduates
Engineering				
Civil	3080	353	3194	336
Architecture	1337	202	1162	138
Electrical	2731	211	2677	247
Mechanical	2952	248	2812	214

	1982-83 Students	1982-83 Graduates	1983-84 Students	1983-84 Graduates
Science:				
Mathematics	1464	79	1244	71
Physics	1558	195	1405	145
Biology	869	72	826	77

The total number of post graduate degrees for the academic year 1983-84 was 50 diploma engineers in the faculty of engineering and 51 students receiving a diploma in the science faculty. In addition to nine obtaining a masters degree.

The teaching staff, divided by nationality is also given herewith:

	National	Foreign
Engineering:		
Civil	24	-
Architecture	12	3
Electrical	17	2
Mechanical	24	2
Science	64	4

The university has possibilities for undertaking applied research programmes outside the university laboratories. This is part of the masters and doctorate study programmes. However it has not been involved in contract research for industry.

The university has several co-operation agreements with other universities, e.g. in GDR, PDRY, U.K., France, India and China, but it did not specify in which areas.

The Baath University in Homs, which was established in 1979, reported to have 3,114 students enrolled during the year 1983-1984, of which 2,054 were in the engineering, 811 in science and 249 in civil engineering. During that year, 266 graduates were registered of which 153 were in engineering and 113 in the science faculty.

The total teaching staff was 46, most of them engaged in the engineering field (36). Basically, the university is an institute specialized in higher technical education, and it offers therefore programmes only in chemical engineering, civil engineering, chemistry and mathematics.

The university is not involved in any contract research for industry, nor did it undertake consultancy activities. Co-operation with industry is very limited, and no co-operation agreements with foreign universities were reported.

From the above, it can be concluded that the role of the universities is limited in the advancement of engineering technology, there is limited applied research and it does not play an active role in the development of the industry. It is concentrating more on the education and development of the human resources in the country.

3.8. United Arab Emirates

3.8.1. Assessment of capabilities

The United Arab Emirates is one of the major exporters of oil and gas, but its petroleum industry is still heavily dependent on non-national labour force, e.g. the manpower in its refinery and fertilizer plants are divided as follows:

	Nationals	Arab	Foreign	Total
FERTIL	13	141	179	333
Umm Al-Nar	117	798	149	1064

Most of the UAE nationals in ADNOC are working in Administrative positions. However, nationals have slowly been taking up non-administrative positions in technical and operational departments as more and more national graduates enters the labour market.

This dependence on foreign human resources as skilled labourers, technical and managerial staff is a general characteristic of the UAE economy. In 1980, nationals consituted only 24 per cent of the total population and about 16 per cent of the total active population.

ADNOC has its own career development centre providing a training programme for new recruits of ADNOC and its affiliates. The programme is designed mainly for high school graduates. However, it offers a special training programme for nationals that have a level below high school. The training programme develops the employees skills, and prepares them to become operators and maintenance technicians. The duration of the programme is two years followed by one year on-the-job training.

ADNOC also has a short programme of familiarization for new recruits - technical and non-technical - with process equipment, and other facilities.

Besides this in-house training programme, ADNOC's career development also deals with developing the skills of nationals and which is oriented towards fulfilment of a pre-planned career responsibility. These employees are generally sent abroad at professional training centres as well as at companies in similar businesses.

Graduates from national institutions (secondary schools, Al-Ain University) are reported to have a satisfactory level. The Al-Ain University is offering courses for students in the oil and petrochemical industry.

There is not yet any petrochemical industries apart from the urea plant which is part of the FERTIL complex. Both refining and fertilizer industries use locally produced raw materials (crude oil, and natural gas). Almost 100 per cent of the necessary equipment is imported, and an important stock of spare parts - enough to maintain operation for 2 years - is kept available inorder to avoid possible operational disruptions. Only small items are (or can be) manufactured in local workshops - simple castings, piping and tower internals. A plastic packaging factory providing polypropylene sacks to FERTIL has been recently built and is using imported raw materials.

The absence of supporting industries is a general charateristic of UAE's young industrial sector.

More information related to the present capabilities in the UAE can be found in the case-study on AREC in the Annex.

PART FOUR

FUTURE TECHNOLOGIES

4.1. The technological environment

Since the Industrial Revolution, technology has evolved according to an expanding and accelerating pattern. Various major developments like:

Synthtic polymers, plastics and textiles, etc., have come in stages and caused quantum leaps in technology. However, in recent decades, there has been a technological explosion associated with enhanced capabilities due to computer, communication and information technologies and new frontiers in energy, materials and biotechnology. The new situation has been accompanied by an information explosion and the evolution of new efficient global communication techniques for the diffusion of this information. Computer and information technologies have accelerated the pace at which new products and processes are developed and commercialized. Moreover, the rate at which products and processes become obsolete has accelerated, as a result of the new capabilities to upgrade or replace these products and processes.

The emerging frontiers have enhanced, in many ways, the accessibility of technology (even in its most advanced forms) to developing countries, the rate at which this technology may be transferred, and the ability of these countries to implement and adapt to such technology. However, as in many other aspects, the new situation has in it the seeds for widening the gap between the technological levels of advanced and developing countries... unless special precauions are taken. The rate of technological growth in advanced countries is explosive, and, while the rate in the less developed countries is growing, it is growing at a much slower pace than in advanced countries, for obvious reasons. Moreover, in many instances, the developing countries do not possess all the basic ingredients required for a balanced, rapidly advanced technological growth. In many countries technical development might involve only specific aspects of technology and might be lacking in the appropriate infrastructrual and environmental conditions required for balanced growth. Thus, in many instances, the technological gap is expected to widen.

The above must be viewed seriously, and efforts should be made to assure that developing countries build a sound foundation based on the fundamental building blocks for technological development. Technology planners must aim for permanance of technological structures and insitutions and a sustained, balanced technological advancement.

4.2. Gas and petrochemical technologies

Prior to the Second World War, solid fossil fuels, particularly coal, accounted for a significant proportion of the energy supply in the world. Moreover, the petrochemical industry was based mainly on routes employing coal and biomass as raw materials. After the war, oil and gas became the primary sources of energy and feedstocks for the primary petrochemical products. Along with this shift, there was a great explosion of the use of energy in the form of petroleum products for transportation, domestic, commercial and industrial purposes. Furthermore, the number and quantity of downstream petrochemical products based on oil and gas increased dramatically. Synthetic textiles, resins, plastics and rubber, insecticides, pesticides, fertilizers, solvents and coatings are only some examples of these petrochemical derivatives.

A new era associated with oil and gas and petrochemical technologies started emerging in the early 1970s, especially in conjunction with the 1973 oil embargo and subsequent developments involving the price rises and supply instabilities. The net effect of these developments has been to create within the advanced petroleum importing countries political pressures for reducing their dependence on petroleum as a source of both energy and petrochemicals, and particularly to reduce or remove their dependence on OPEC petroleum. Consequently, there have been renewed and extensive technical efforts directed towards the development and reduction of relative costs of alternative sources of energy (e.g. nuclear, hydroelectric, coal, geothermal, wind, biomass, etc..) and the development of new, economically attractive technologies for the use of alternative feedstocks (e.g. peat, coal and biomass) for the production of petrochemical products. Moreover, there have been shifts towards the use and development of non-OPEC based fossil hydrocarbon resources like North Sea, Mexico, and Canadian oil and gas, tar sands, shale oil, coal, peat and biomass.

Another impetus for the shift towards planning of energy and petrochemical technologies different from the conventional oil and gas tehnologies has been due to the growing awareness of the limits on oil and gas resources and the expected depletion of these resources, unless substantial new resources are discovered, in many regions of the world during the first quarter of the 21st century.

Whether or not the petroleum importing advanced countries succeed in achieving independence from the petroleum exporting countries, the latter should be alert to the changing demand patterns in the advanced countries. Furthermore, they should establish the necessary framework that would allow them to respond to these changes without major upheaval. Ideally, the petroleum exporting countries should simultaneously attempt to reduce their dependence on the present markets in the advanced countries. Broadening the production base, which has become an established orientation in the petroleum exporting countries should be continued and expanded. The expansion of production of refinery products and petrochemicals and fertilizers represents a concrete step in this direction. Further downstream expansion into plastics, synthetic fibres and textiles, synthetic rubber and products and other chemical products is a natural extension of these orientations. It should be born in mind, however, that competition in these fields is very strong. For countries in the ESCWA region to compete, they must be able to supply quality products with dependable supply and they must be able to respond to market demands and changing patterns of customer requirements. A sound technological infrastructure with good marketing back-up is crucial for the successful implementation of these industries.

4.3. Restructuring of the oil refining and petrochemical industries

Along with the above developments, new patterns have emerged in the early 1960s and accelerated during the 1970s and 1980s. These patterns, which involved the development of substantial production capacities in the petroleum, petrochemical and fertilizer fields in oil producing countries,also involve the more recent restructuring of the petroleum and petrochemical industries globally, but particularly within the advanced regions: North America, Western Europe and Japan.

Globally, the trend has been to construct world-scale, large refineries and petrochemical or fertilizer factories. As a result, many of the old smaller units, which were built earlier in advanced countries, have become either obsolete or uneconomical. Therefore, these units were closed down. In Europe, North America and in Japan, this restructuring was accompanied with rationalization, consolidation and concentration of production and facilities. Particular emphasis has been placed on operating new large units or upgrading and retrofitting old units which were located close to the sources of feedstocks. This has been the response to competition from new units in oil producing regions (e.g. Mexico, Saudi Arabia and Canada), where the availability of cheap feedstocks (particularly those based on natural gas) offers a significant advantage. Thus, great emphasis in the restructuring has been oriented towards achievement of economies resulting from scale, lowering the contribution of feedstocks to overall cost and advancement of technology to achieve higher yields and better qualities. Furthermore, industrial organizations in advanced countries have concluded that the profitability of commodity oil products and petrochemicals is on the decline (atleast for them due to distance of the feedstock supply). Therefore, they have shifted their emphasis onto specialty and high technology products and materials, where their comparative advantage is clearer, especially due to their technological capabilities. One of the effects of the above restructuring of the petrochemical industry would be that ESCWA region petrochemical products will find markets mainly in Europe, Japan and South East Asian countries. In these regions, they will compete with exports from Canada and possibly from some Latin American countries, in addition to locally manufactured products.

Although ESCWA region petroleum and petrochemical products will have the advantage of proximity to the source of feedstocks (the oil and gas fields), they will compete with products obtained from a restructured industry in the advanced countries of Europe, Japan and North America. The productivity and technological back-up for these competing establishments are the highest that can be expected, and they enjoy the advantage of proximity and knowledge of the markets. Therefore, it would be critical for ESCWA region producers of petroleum and petrochemical products to establish solid technological infrastructure and marketing networks in order to assure themselves of a fair share of the market.

4.4. Future technological trends and implications

4.4.1. Oil, gas, petrochemicals and fertilizers

The oil, gas, petrochemical and fertilizer industries are relatively mature industries. Therefore, it is not anticipated that there will be major technological break-throughs or technical restructuring of these industries. Oil and gas exploration will continue to extend into offshore and frontier areas. The pressure in production technology will be on development of enhanced recovery by a variety of already considered techniques. One interesting new approach might involve the use of microbiological species for enhanced recovery of oil. As oil resources begin to deplete during the next decade, more natural gas will be obtained from non-associated gas fields, in contrast with the current emphasis on associated gas. Since non-associated gas tends to be much richer in methane than associated gas, there will be a significant change in the mix of the petrochemical products that would be produced from natural gas. More emphasis will be placed on development of petrochemical processes involving "single carbon chemistry". Already, processes exist for the manufacture of products like ethylene, enthanol, and gasoline directly from methane or methane derivatives. This pressure will continue, especially since some of the synthesis gas produced from future coal technologies could be used in conjunction with the "single carbon chemistry" processes.

In refineries, the emphasis will continue to be on the conventional refinery products: gasoline, kerosene, fuel oils, lube oils, etc. However, automotive fuel will continue the trend towards the use of more diesel, methanol and Methyl Tertiary Butyle Ether (MTBE) for octane enhancement as lead is removed from gasoline. Improved car engine efficiencies and the possible development of high temperature ceramic or super-metal automotive engines will further reduce demand for oil products (gasoline). This will be reinforced by the continuing decline in the weight of the automobile and aircraft as more conventional metal parts are replaced by plastics, thin metals and composites. To meet the changing product mix requirements and to achieve optimization of production and profitability, the refineries will be designed with more flexibility and will incorporate modern computer control facilities.

Countries in the ESCWA region will maintain a leading position among the petroleum producers of the world. Also, refinery capacity in the ESCWA region will represent an important proportion of overall world refining capacity. In view of this, the competative position of the ESCWA region can be protected by insuring access to up-to-date dvelopments in enhanced oil recovery and the most recent innovations in refinery and gas processing technologies. As market demands for gasoline and other refinery products change, it would be necessary to respond at a reasonable rate and to compensate for the reduced demand. Moreover, as demand for methanol and MTBE grows, countries in the ESCWA region should be ready to supply the market with these products. To achieve this, capabilities in market analysis and forecasting are of the utmost importance. Also, capabilities in the management and optimization of refinery and petrochemical plant operations are critical. In order to establish independence in this field, it would be important to establish training and research and development activities in the relevant fields. These should include the area of "single carbon chemistry".

Some of the most significant developments relating to downstream petrochemical products will be associated with the expanded growth of plastics and composites in the packaging and transportation fields. In packaging, the thrust will be to practically replace all existing metal cans and glass bottles with plastics products. Most of the materials involved would be based on commodity plastics like polyethylene, polypropylene, polyvinyl chloride and blends of such materials. Some products will be based on other polymers like polyethylene terephthalate, polybutylene terephthalate and nylon.

In transportation, the major thrust for use of plastics and composites will be for the manufacture of body panels to replace metal panels currently in use. The main materials under development for these applications are sheet molding compounds (SMC) based on unsaturated polyesters and reinforced reaction injection molding (RRIM) panels based on polyurethane or nylon. It is expected that in the medium term, some of these products will be based on fibre reinforced thermoplastic materials like polypropylene, polyester, polyamede, etc. Under the hood of the car, there will be significant growth in the use of composites, high temperature and high performance engineering plastics. Similar trends will be observed in the aircraft industry but with more sophisticated products.

The expansion of plastics into packaging and transportation applications will involve materials that could be manufactured in the ESCWA region. However, in order to realize a significant portion of these new markets, it would be necessary to develop substantial research and development and technical service capabilities in the relevant fields and to possibly establish industrial activity in the assembly of automobiles and other types of vehicles. Most of the growth in packaging would be associated with applications in the food and beverage industries, and it is not clear whether this expansion would be reflected in the ESCWA region in the form of packaging manufacturing. However, many of the resins involved in this area would be amenable to production in the ESCWA region.

Obviously, for successful penetration of the above very important markets and in order to insure a long-term competitive position, it would be important for the relevent countries in the ESCWA region to develop the appropriate technological capabilities and market knowledge in the associated fields of polymer science, plastics technology, packaging, food processing and automotive applications. Expertise required would involve market studies, product and process research and development, plant and customer technical service and marketing.

Another important area for growth of consumption of plastics materials will be in the high performance and engineering plastics fields. These products are currently under intensive development by establishments in the advanced countries, as they shift their emphasis away from the less profitable commodity resins.

Superficially, it would appear that the ESCWA region would not have the opportunity to participate in these developments in the short-to-medium term. However, involvement in high performance plastics represents a natural extension of the involvement in the commodity plastics field, especially when appropriate research and development institutions are established. The high profitability of these materials provides an attractive incentive for planning to enter the high performance materials field and allows relevant countries from the ESCWA region to enter a high technology field on the foundation of the plastics industry, where the ESCWA region should be able to establish a comparative advantage.

The key to establishing a beach-head in the field of high performance materials would be in supporting research and development at universities and research and development instituions in materials science and engineering, with emphasis on chemistry, physics, chemical engineering and mechanical engineering.

4.4.2. Alternative sources of energy

Over the last decade, there have been great amounts of effort directed towards the conservation of energy in all aspects where energy is used and towards the development of alternative sources of energy, different from oil and gas. The impetus for these developments has been partly due to the upheavels in the petroleum market that led to large rises in prices and disruptions in supply. However, the main reason for the search for alternative sources of energy has been due to the recognition that oil and gas resources are limited, and that towards the middle of the next century, they could be depleted. More recently there have been theories that suggest natural gas resources are far larger than ever thought, since, according to these theories, gas is biogenic in origin and great sources lie deep in the earth. In any case, this theory has to be proven and the prevailing attitude accepts the limitations on oil and gas resources.

One of the main characteristics of oil and gas is that they can be used both for energy and for the production of petrochemicals based on hydrocarbons. In this context, they represent the most economical and readily accessible sources of hydrocarbons for these two purposes. Other sources of hydrocarbons exist, but they require more intensive processing in order to generate energy and petrochemical products. These include tar sands, shale oil, peat and coal. World resources of these materials are great and they contain substantially more hydrocarbons than the proven remaining reserves of oil and gas. Technologies are currently being developed for the economic use of these resources for the production of energy and petrochemicals. Thus, it is anticipated that hydrocarbon-based energy and petrochemicals will continue to be a major factor well into the next century.

Regions with oil and gas resources will continue to have a comparative advantage in the energy and petrochemicals field, due to the relative case of extracting the raw materials. Therefore, countries in the region will continue to play a major role in world energy and petrochemicals. However, it should be pointed out that substantial quantities of tar sands, shale, peat and coal are found in North America and Europe, which are important markets for ESCWA petroleum and products. This factor will maintain pressure on the ESCWA region to attain a high level of productivity and efficiency in the processing of their resources and the marketing of products. Furthermore, in the long term, it might prove most advantageous for the ESCWA region to shift oil and gas consumption in favour of petrochemicals rather than energy products. Besides the clear advantages in value added, this strategy would extend the life of the hydrocarbon resources in the ESCWA region and assure dominance in the petrochemical field, unless major breakthroughs are realized in the "single carbon chemistry" field. The above considerations suggest that serious efforts should be made by ESCWA petroleum producers to establish leadership capabilities in the petrochemical technology field, at all levels ranging from research and development to plant design and engineering.

Other developments in the energy field suggest that the relative use of hydrocarbons in petrochemicals in comparison to energy would increase. All efforts in the energy field, especially in advanced countries, are aimed at reducing the proportion of oil and gas energy in the total energy pool. Thus, in the European Economic Community, imported oil consumption represented 62 per cent of total energy requirements ten years ago, while it represents only 32 per cent at the present. This ratio will be maintained for the balance of this decade. By 1995, the proportion of electricity generated with hydrocarbons should be reduced from 22 to 10 per cent. Solid fuels and nuclear energy should be given priority to reach 40 per cent of electricity production in 1995. By the end of the century, the replacement of conventional fuels by new sources of energy could triple. In the United States, oil and gas will supply nearly 60 per cent of energy requirements in the year 2000, compared to two-thirds currently. Demand for coal for electricity generation will grow at 3 per cent annually, while nuclear energy will grow at 9 per cent until 1990. Subsequently, coal will probably grow at a higher rate and nuclear energy growth rates will decrease.

Beside coal and nuclear energy, renewable sources like solar energy, geothermal energy and biomass will play a role in the energy balance of the future. However, it is not anticipated that they will play a significant role before the end of the century.

Coal and biomass have the potential, as in the case of oil and gas, of being sources of both energy and petrochemicals. Both can be converted by thermal means to liquid or gas products that are similar to those obtained from oil and gas processing, though not with similar ease. In the case of biomass, it is possible to use chemical methods for the production of petrochemicals. New reasearch attempts to employ the principles of biotechnology using micro-organisms to transform biomass into useful energy and petrochemical products. However, much work is needed before biotechnology can be used to reproduce some of the important common gas and oil petrochemicals.

In order to evaluate the potential impacts of new energy technologies, ESCWA countries should maintain a significant and appropriate level of technological involvement in the fields of coal and biomass transformation to energy and petrochemical products. Such involvement might also lead to adaptations of new discoveries in "single carbon chemistry" and biotechnology into the oil and gas and petrochemical technology fields.

4.4.3. Computers and assoicated technologies

In recent years, computers have come to play a major role, not only in the technological domain, but also in the everyday life of society and individuals. The impact of computers in technology has been immense, and it promises to be more profound in the years to come. The computer can be used as a computational and design tool, but it also can be used as an information data bank and a communication centre for the exchange of information and knowledge. New technologies have emerged and grown very rapidly: computer aided design/manufacturing/engineering (CAD/CAM/CAE), computer vision, computer process control, intelligent machines, artificial intelligence, etc. All of these developments have come to be critical aspects of the industrial and technological structure, and it is difficult to imagine a dependable industrial operation which does not incorporate these aspects.

Beside enhancing production and associated activities, the new computer technologies have a great influence on both the technological infrastructure and the technology transfer process itself. They have penetrated all stages of the technological infrastructure: project identification, feasibility studies, engineering and construction, plant design, marketing, sales, research and development. With the new hardware and software available, it is possible to carry out more complex tasks more efficiently and systematically, while reducing the time required and the manpower costs. These systems (hardware and software) are readily available and it is possible to learn to use them without major effort. Thus, many aspects of technology are becoming more accessible to developing countries, leading to a significant increase in technological capacity. This has been coupled with enhanced accessibility to the sources of information via the multitude of data banks and databases and the large number of international software houses.

On the other hand, it should be recognized that computer-based technologies represent very sophisticated and restricted technologies. Most systems are "black box", "turnkey" systems which cannot be easily or legally depackaged. Futhermore, although they enhance the ability of the user to deal with more complex situations, they also contribute to increasing his reliance on the sources of technology. By being basically coded products of digital character, they cannot be easily related to the physical processes that they describe or control. Therefore, they might reduce some aspects of the necessary interaction between the process and the user. Thus, unless appropriate precautions and arrangements are made, the technology receiver would probably increase his dependence on the technology sources.

Obviously, ideally it would be desirable to acquire only those computer systems (hardware or software) which can be depackaged, as by having an open source code of the software package. However, this is not normally possible.

Developing countries need to use the new computer-based technologies in order to benefit from their contributions to productivity, efficiency and overall technological capacity. However, in order to minimize the potential of increasing dependence on technology sources, they need to build up their own capabilities in computer technology at both the hardware and software levels, especially the latter. It is recommended that, while the various levels of technological activity in the ESCWA region acquire and use computer technologies, efforts should be made at universities, research institutions and industrial establishments in order to develop the necessary competence in the computer field. The ultimate objective should be to develop indigenous software capabilities, and, to the extent possible, some aspects of hardware systems capabilities.

PART FIVE

CONCLUSIONS AND RECOMMENDATIONS

5. Conclusions and Recommendations

5.1 General

Technology transfer, refers to the total transfer of technological capabilities from a technology source (country, company, individual, etc.) to a receiving user (country, company, individual, etc.). It should not be confused with production transfer or transplantation, which deals with the installation of certain technological activity, usually a plant or a production or service facility, in a receiving country or establishment. True technological development must be associated with real technology transfer that leads to the creation of a balanced, indigenous combination of technological capabilities, which permit the developing country to ultimately grow independently and evolve technologically according to the same sustained and balanced technological growth patterns experienced by technologically advanced countries. In general, technological development cannot be assosiated with the establishment of technological capabilities in a narrow field of technological activity, but it must involve a broad range of capabilities both in technology and in technology infrastructure.

In order to achieve the desired goals of technology transfer, it is necessary to depackage technology that is imported consequently, it is important to import packages that can be depackaged and analyzed to facilitate understanding and future modification or adaptation. However, preoccupation with depackaging or analysis of technology seems to have diminished the critical and necessary emphasis on developing the technology "synthesis" capabilities of the receiving country or group. In the final analysis, the real test of technological capacity lies in the ability of the technology receiver to ultimately develop his own technology in view of prevailing needs and resources.

A key element in the establishment of viable technological capabilities depends on the development and linking, or networks between various centres of activity at the source end and corresponding centres at the receiver end. Furthermore, internal linkages need to be established amongst the centres at the receiving end. It is difficult, if at all possible, to achieve successful technology transfer by interaction between a single source and a single receiver. Also, the technology transfer process normally extends over a long period of time, and the players on either end might change with time. Thus, in the technology network shown in Table 5.1, each of the organizations interacts with some of the other organizations. Also, there is overlap between the roles and activities of the different organizations. This overlap sometimes leads to co-operation and complimentarity, while in other cases it leads to competition. Each organization would keep lines of communication with counterparts (not necessarily only the same kinds of organizations) in other countries (source countries). In some cases, organizations specialize in one line of activity (e.g. consultants, laboratories, industrial establishments). While in other cases, organizations cover a broad range of disciplines and industrial activities (e.g. consulting groups, laboratories, universities, etc.) (Table 5.1).

Table 5.1

The technology network:
organizations and activities

Universities	Public & private laboratories	Consulting groups	Engineering/ construction	Industrial establishment
Teaching				
Training	Training	Training		Training
R & D	R & D			R & D
Lab. Scale	Lab. Scale			Lab. Scale
Pilot Scale	Pilot Scale			Pilot Scale
Product Testing	Product Testing			Product Testing
Special Consulting	Special Consulting	Consulting		
Identification	Identification	Identification		Identification
Feasibility	Feasibility	Feasibility		Feasibility
Market Studies		Market Studies		Market Studies
		Specifications	Specifications	Specifications
		Request for Bids	Request for Bids	Request for Bids
		Evaluation of Bids	Evaluation of Bids	Evaluation of Bids
		Project Management	Project Management	Project Management
			Process Design	Process Design
			Plant Design	Plant Design
			Engineering	Engineering
			Construction	Construction
			Start-up	Start-up
				Operation
				Plant Tech. Services
				Plant Maintenance Sales
				Customer Technical Service
				Licensing

5.2 Conclusions

The study was based on the information collected from and presented by the various countries, and thus its analysis depends completely on the quality and quantity of the information supplied.

It has been found that two separate groups of countries with similar characteristics exist, namely the countries with a relatively long history of industrial development, and thus a fairly broad industrial sector and technical infrastructure, such as can be found in Egypt, Iraq, Syria and Jordan. The second group includes the Gulf countries - Saudi Arabia, Kuwait, Qatar, and United Arab Emirates, who have an industry solely based on oil production and refining, and have only recently embarked on developing downstream petrochemical complexes and widening their industrial base.

In all countries the various government departments and enterprises involved recognize the important role of human resources development to meet the technological challenge. As a result, each one of these countries has established structures and mechanisms to meet the requirements. The also have put into motion various schemes to develop their long term technological infrastructure and technical human resources. Thus, the above-mentioned first group of countries, have strengthened the science and engineering faculties in the universities, encouraged the establishment of vocational schools, established some research and development laboratories and industrial development institutes. Governments and establishments have in-house training programmes and spend substantial effort and money on training their personnel abroad. Access to technological information is enhanced by the many on-line hook-ups to international database and information services, and some effort is underway to establish indigenous databases. As a result of all the above, the technological infrastructure and capacity to deal with technological growth have expanded substantially in these countries in recent years.

Since the petroleum processing and petrochemical industries are relatively young in the countries of the region and due to the phenomenal rates of growth or these industries in the region, gaps exist in the organizational build-up and linkages between various infrastructure activities. There is overlap and misunderstandings regarding the roles of universities and government research laboratories. Moreover, both universities and research laboratories have yet to gain the confidence of industrial establishments. Governments and enterprises have recognized these problems and, in some cases, they are initiating dialogue and plans to improve co-ordination and communications and, to devise procedures for enhancing the utility of research carried out at national laboratories. Another aspect relates to the rapid growth of some of the national laboratories, leading to overstaffing and poor definition of projects and responsibilities. As a reaction, some laboratories have consciously allowed the size of staff to drop by attrition.

One of the main factors influencing shortages in technological infrastructure and technical human resources in the region relates to the small population of the countries involved. In fact, the Gulf region is rather unique in this regard. An approach that has been employed, to some extent, in order to alleviate the effects of the small populations is to deal with infrastructure and manpower problems on a sub-regional basis (e.g the Gulf region). This has led to the establishment of joint petrochemical industries (e.g Gulf Petrochemical Company, GPC) and infrastructure establishment (e.g Gulf Organization for Industrial Consulting, GOIC). However, the total population of the Gulf region is rather small, and this approach alone could not solve the problem. The regional approach to dealing with the problems of infrastructure and manpower resources should not be isolated from the regional market size, since many of the technological requirements are market-base.

It has been indicated in our survey that qualified nationals from the various countries in the region do not receive sufficiently attractive incentives, especially in terms of income, to choose technological jobs. Nationals with comparable education are able to realize much higher incomes in other aspects of economic activity. Also, it has been indicated that many of the qualified nationals expect to obtain managerial responsibility very early, before they have accumulated appropriate experience. These aspects suggest the need to develop suitable personnel and incentive practices.

More specific conclusions can be drawn from part eight, and these amount to the following. For all of the assessed technological capabilities, it can be said that these are not yet fully developed in the region, although some of these are further developed than others and some countries are more advanced than others. In particular the capabilities in production management and plant technical service are relatively well developed in a number of countries such as Egypt, Iraq and Syria. These countries benefit clearly from their longer established and wider industrial base as well as their better developed educational facilities. A third capability which is more readily found in almost all countries of the region, is the capacity to undertake techno-economic pre-feasibility and feasibility studies. This is largely due to the fact that these experiences have already been built-up in a variety of different economic sectors, and can be applied to a large extent similarly in the petroleum-based industry.

Consequently, a second group of capabilities is less well represented in the countries of the region. These include the technological capabilities in process and product design, engineering and plant design and research and development. These capabilities are closely related, and are based on the availability of technological capabilities from the first group above. In the absence of production management or maintenance capabilities, it will be difficult to undertake basic or applied research, or to undertake process design or engage in product development in petrochemical industries.

As for the capabilitiy to construct and supervise the installation of petrochemical plants, it is believed that after a period of unprecedented growth in the number and size of refineries and petrochemical complexes in the region, this rate will eventually decrease to a much lower level, also in view of the reduced growth in demand in the coming decade for the products of these plants. Therefore, it is a question for further investigation whether there is a need to acquire the specific skills related to this activity. With the present almost complete lack of these capabilities in the region, as evidenced in the survey, priorities should be given to other capabilities.

As is shown in part four, future petrochemical technologies are being developed that have an impact on the demand for certain type of products, and consequently the countries of the region should be ready to adapt to the changes in demand patterns this brought along.

5.3 Recommendations

Finally, a number of specific recommendation can be given for each or a group of the capabilities discussed in this report.

The development of these technological capabilities can be undertaken in two phases. The first phase will encompass the development of the following as a first priority:

- Production management
- Plant technical services
- Pre-feasibility and feasibility studies

Production management

This capacity is one of the most developed of the technological capabilities in the region, and can be found to exist in almost all plants and projects covered by the survey projects with a few exceptions. Despite this considerable degree or independence, a further strengthening of this capability is needed. This can be achieved through the training of nationals at all levels of plant operations, and securing that training on-the-job is a mandatory obligation in the contracts awarded to the foreign technology or equipment supplier.

It is recommended that training programmes are developed in the establishments for training of new employees as well as for upgrading the skills of existing staff, which can thus be given additional responsibilities. At the same time this will support and accelerate the indiginization process which is being implemented by several countries in the region.

Also training and upgrading programmes should be developed for the management development institutes which exist already in countries like Egypt, Iraq and Syria.

Plant technical services

This essential function in each production process has to be developed further, since together with production management they form the basis on which technological capabilities can be built up.

For this, vocational training centres and engineering faculties in universities should be strengthened by attracting more students as well as staff, and better adapting their curricula to the needs of the national industry. For example, in some countries it was found that enrolment in these training institutes actually decreased after a few years of initial growth, for reasons not yet known.

It is also recommended that maintenance resources are combined (pooled) wherever feasible, as some countries in the region have already attempted, e.g. Kuwait. This would enhance the building-up of experience.

Pre-feasibility studies

In most countries, capabilities to undertake the above activities sufficiently exist. They have been built-up through long experience in other sectors of the economy, not necessarily petroleum-related, and can be applied in the petrochemical industry in a similar way.

However, since many projects still relied on foreign consultants to undertake these studies, there is a need to strengthen the organizations or divisions undertaking these capabilities.

The establishment of more local engineering consultancy companies specialized in this field and strenthening existing ones by providing them with part of the work undertaken, to enable them to build up experience and to penetrate the local and regional markets. Although some countries have laws and decrees stipulating the degree of involvement of national organization in each project, others have not yet extended this practice to all levels of this activity.

After the above three priority areas for technological development are achieved a reasonable degree of independence from foreign sources can be expected and a second group of priority areas can be specified. These are:

- Engineering and plant design
- Supervision of erection
- Process and product design
- Marketing
- Customer technical services
- Research and development

These capabilities can only be succesfully developed if an established petrochemical industry is functioning and also managed to large degree by nationals.

Engineering and plant design

This capability is hardly found in the region at present, and it may be difficult to develop these capabilities at a national level. Therefore a regional approach is recommended. Strengthening an organization such as AREC can be considered a good approach. As with many other capabilities the building up of experience is an important requisite and therefore the role of AREC in implementing projects should be actively encouraged.

Process and product design

AREC as a regional organization can play an important role in developing the process and product design capabilities, since the national market is too small in most countries, to warrant the establishment of national organizations. The tasks and the manpower required are of such a nature that a regional approach, where manpower and financial resources can be pooled, is advisable.

Supervision of erection

This capability is not restricted to only the petrochemical industry and therefore national organizations specialized in construction and supervision of civil engineering should be further developed to acquire these capabilities.

Marketing

Marketing capabilities for the petrochemical industries are being built-up in the region by a process of acquiring established marketing firms, storage and distribution channels.

The capability to conduct market studies however, has to be developed. This can be done by building-up a regional data information system whose function is to collect and disseminate trade and other relevant data. This facility could be connected to a required agency such as GOIC for collecting information on patents, trademarks, historical records of licensers and contractors. A further step could be to augment this by a patent bank to advise relevant organizations in the region on all matters connected with the acquisition of a patented technology.

Customer technical services

The capability to be able to advise and support the clients of petrochemical industries, will have to be developed in connection with the production operation capabilities, so as to enable the industry to implement necessary modifications in the specifications of their products. This capability is thus also closely connected to the following.

Research and development

Research and development centres exist in all countries of the region. However their linkage with the petroleum-based industry is weak in many instances. To develop this capability, links should be established between industry and these centres, research programmes should be adapted to the needs of petroleum-related industries and particularly programmes should be initiated in relation with future developments in petrochemical technology, such as research on "single carbon chemistry" and high-peformance composites. By devoting resources to future developments, research centres can play an important role in the future needs of the petrochemical industry in the region.

Bibliography

Technology Transfer

Domestic Technology Generation in LDC's: a review of Research Findings-Jorge Katz, ECLA/IDB/IDRC/UNDP (W.P. 35).

International Technology Transfer: Issues and Policy Options (a background study for World Development Report, 1979), World Bank, (Staff Working Paper No. 334).

Executive Summary of the Study for the Establishment of an Arab Engineering Company in the Oil Sector-prepared by OAPEC. E/ECWA/ID/WG.4/26.

Handbook on the acquisition of technology by developing countries-prepared by UNCTAD. UNCTAD/TT/AS/5.

Problems of Technology Acquisition for Industrial Development: a Perspective from Iraq-prepared by Ferhang Jalal. Workshop on Strategies for Importing Industrial Technology in the Arab World, 20 to 24 October 1983, Baghdad, Iraq.

Development and Transfer of Technology Series, 14 (vol.I & II), 15, 17.

Strategic Assessment of the Petrochemical joint ventures under implementation by SABIC and TNC's (J.M. Wakim).

UNIDO Model Form of Agreement for the Licensing of Patents and know-how in the Petrochemical Industry (incl. annexes). UNIDO/PC.50/Rev.1.

Opportunities for Co-operation among the developing countries for the establishment of the petrochemical industry. UNIDO/IS.876 (Sec. Work Paper Series 1).

Basis for the Formulation of Strategies Pertaining to Development of the Petrochemical Industry in ECWA region. (E/ECWA/ID/WG.5/3).

Manpower needs in Oil and Gas Industry (Arabic). E/ECWA/NR/83/6.

Experts Group Meeting on the Petrochemical Industry in ECWA region, 9 to 12 June 1981, Vienna - Report of the meeting,
- Working papers (3 and 4).
E/ECWA/ID/WG.5/5; E/ECWA/ID/WG.5/4; E/ECWA/ID/WG.5/3.

Oil Downstream: Opportunities, limitations, policies by Abdelaziz Alwattari (OAPEC).

Future possibilities of Development in Petrochemical Industries, No. 13, 6 Volumes by AIDO/SCH. In Arabic only (covering: plastics, fibres, detergents, paints, rubber). Data Arthur. D. Little.

OPEC/UNIDO/OPEC Fund Seminar on Co-operation among Developing Countries in Petrochemical Industries, Vienna, 7 to 9 March 1983.

Fertilizer

Draft Directory of Technological Capabilities in Developing Countries related to the Fertilizer Industry. UNIDO/PC.89, ID/314 and ID/WG.406/10.

General magazines, journals and other periodicals

Arab Oil and Gas Directory
Arab Oil and Gas
MEED
Petroleum Intelligence Weekly
Oil & Gas
OPEC Bulletin
MEES
OAPEC Monthly Bulletin
OAPEC Annual Report
OPDP Annual Statistical Yearbook
UNIDO Statistical Yearbook

ANNEX I

CASE STUDIES

1.1 The fertilizer industry in Kuwait: A case study

Historical Background

Kuwait established a nitrogen-based fertilizer industry by founding the Petrochemical Industries Company (PIC) with the aim to maximize the utilization of natural gas associated with recovered crude oil and to diversify sources of national income. A cheap natural resource augmented by the tremendously growing need of this commodity by developing countries, particularly those in close proximity of Kuwait, was a good reason to encourage the launching of an ambitious plan for production of ammonia, urea and other fertilizer chemicals. A joint venture between PIC and foreign partners was established in 1964, culminating in the commissioning of a chemical fertilizer complex in 1966-1967. The complex comprises an ammonia plant, a urea plant, a sulphuric acid plant and an ammonium sulphate plant having annual design capacities (in thousand ton), 396, 330, 132 and 132 respectively. In 1971-1972, PIC decided unilaterally to undertake the establishment of two more ammonia plants (330 thousand tons per annum, each) and two more urea plants, which brought the total installed capacity for ammonia and urea up to 990 and 792 thousand tons per annum, respectively. Later in 1973, PIC acquired foreign share and thus, wholly owned the assets of the chemical fertilizer plants in Shuaiba area. The fertilizer company merged completely in 1975 into the parent company (PIC). In 1980, the State Organization, Kuwait Petroleum Corporation (KPC), was established and the ownership and activities of PIC in the domain of fertilizer production and marketing were transferred and controlled by the said corporation.

Highlights relevant to the fertilizer industry in Kuwait

The general features that characterize the fertilizer industry in Kuwait are summarized in light of the information collected from the fertilizer Division of PIC, and are as follows:

The Kuwaiti fertilizer industry is wholly owned by the State of Kuwait as represented by KPC, and operated by PIC who undertakes the responsibilities of technology evaluation and selection, feasibility studies, production management, technology adaptation and development, maintenance, marketing and customer technical services.

- The installed plants by PIC are designed to produce ammonia, urea, sulphuric acid and ammonium sulphate. To produce ammonia used as an intermediate for nitrogenous based fertilizers, natural gas associated with crude oil recovered from Kuwaiti oil fields is transported from neighbouring refineries. The ammonia plant is dependent upon the sufficient and sustained supply of natural gas which is steam reformed to produce hydrogen.

- PIC increased lately the annual capacity of its ammonia production to reach 990 thousand tons up from 660 thousand tons.

- PIC plans to install a plant for production of ammonia diphosphate (annual capacity 330 thousand tons) which will consume 70 thousand tons per annum (tpa) of ammonia, an illustration of forward integration.

- Other illustrative examples of forward integration are set first by the utilization of about 300 thousand tpa of ammonia for the manufacture of urea, and second by the production of melamine which consumes about 55 thousand tpa of urea;

- PIC employs a total manpower of 1,786, distributed as follows: 353 Kuwaitis (20 per cent), 1,237 Arabs (69 per cent) and 196 others (11 per cent);

- The total manpower effectively engaged in direct technical activities (operation, maintenance, quality control, and other engineering services) is 1,408; the break down of the manpower into Kuwaitis, Arabs and foreigners is 15 per cent, 74 per cent and 11 per cent, respectively. The percentage distribution of Kuwaitis, Arabs and foreigners classified as university graduates, specialists and engineers, engaged in technical activities is 24, 59 and 17, respectively. The percentage distribution of Kuwaitis, Arab and foreigners performing activities requiring skilled and half-skilled capabilities is 12, 79 and 9, respectively;

- Total Kuwaiti manpower undertaking in-house and abroad training is 55;

- The respective (1983-1984) current capacities (in thousand tpa) for production of ammonia, urea, sulphuric acid, and amonium sulphate are 381, 486, 4.6 and 0.0, which represent, percentage-wise, 38, 61, 3.5 and 0.0, of the design capacities of the respective plants;

- The respective amounts (in thousand ton) of ammonia and urea destined for export market are 505 and 58 (1983-1984 period);

- The amount of urea and ammonia consumed domestically for the same period (1983-1984) totalled 36 thousand ton and 564 ton, respectively;

- PIC imports technology on a lump-sum turnkey basis, reimbursable cost plus and as licensed patents. The foreign contractors, Haldor Topsoe for ammonia plant and Stamicarbon for urea plant are generally in charge of the whole respective project;

- PIC has developed domestic capabilities which enable it to identify its project(s), undertake independently feasibility studies, prepare job specifications and carry out responsibilities relevant to production, maintenance, debottlenecking, in-house technical studies, corrosion combating, marketing and customer technical services. To compensate for the lack of expertise in production management, maintenance and related engineering serivces, PIC recruits Arab and foreign engineers, specialists and skilled labourers who augment the national personnel;

- PIC is handicapped as to developing its domestic expertise in plant design, engineering, plant construction, product design, process design, and research and development. In this regard, Kuwait Santa Fe C. F. Braun (KSB) office which is domiciled in Kuwait is envisioned to provide technical assistance to PIC, particularly in areas which require special expertise, such as plant design and engineering. PIC is collaborating with Kuwait Institute for Scientific Research (KISR) by conducting joint research programs in areas such as combating corrosion in carbon dioxide removal system, developing coatings for slow nitrogen release and improving urea yield;

- PIC collaborates with downstream industries (melamine) to insure that scheduling and programming for production and distribution are closely co-ordinated;

- As for the evaluation and selection of technology, PIC performs autonomously this job. However, the final approval is contingent upon the endorsement by KPC;

- PIC awarded contracts to Tokuyama Soda, Hitachi Zosen (Japan) and Haldor Topsoe (Denmark) to undertake ammonia plant design engineering, product and process design. Also, was accorded to Daelem engineering (S. Korea), Hitachi Zosen and Tecnipetrol (Italy) the civil engineering and construction of the ammonia plant;

- Career development of the manpower is given a prime attention by the management of PIC to qualify Kuwaitis and Arabs to perform their duties efficiently;

- An accelerated Kuwaitization policy is adopted by PIC to help nationals assume their responsibilities in all facets of the fertilizer industry.

<u>Major technical problems encountered by fertilizer industry and measures taken to overcome them</u>

Several technical problems have been cited by the fertilizer industry in Kuwait, which are related to: (a) variability of composition of natural gas delivered from the oil refineries; (b) obsolescence of equipment and machinery entailing non-availability of proprietory spare parts; (c) shortage of skilled manpower to carry out maintenance and repair services; (d) frequent occurrence of dust storms, particularly during hot summers.

To overcome the above-mentioned problems, the following respective measures were taken by the fertilizer division of PIC staff: (a) adjusting continuously the operating parameters so as to insure compatibility with gas composition; (b) replacing old and obsolete equipment and machinery; (c) hiring skilled personnel through local contractors and foreign manufacturers; (d) using sophisticated filters and acquisition of expensive coolers and heat exchangers having a wide design range to accommodate drastic climatic conditions.

Minor problems such as quality control, spare parts inventory control and stocking and shipment control were also cited. However, these were easily tackled by the company through: (a) applying standard procedures and testing facilities and conforming to standardized specifications; (b) proper planning and setting a minimum stock of spare parts that prompts reordering; (c) maintaining close co-ordination between production and marketing departments with the melamine industry.

PIC seems to have no difficulty in absorbing new technologies relevant to the fertilizer industry. They have acquired enough expertise that enables its staff to follow-up new conceptions and keep up with advanced development in materials, equipment and process. Seminars, technical literature and contacts with companies specialized in manufacturing of equipment help boost the capabilities of PIC personnel.

Domestic attempts to adapt, assimilate, modify and develop imported technology

The accumulated capacities and acquired expertise at PIC's fertilizer division have been enabling its staff who are engaged in operational and engineering activities to cope with the challenges of the transferred technology. In response to the management directives, some good efforts have been spared to conserve energy, increase production, improve productivity, reduce maintenance costs, and eliminate safety hazards of polluting contaminants.

Several projects have been undertaken to accomplish the above objectives. These projects include: (a) installing a hydrolyzer to control pollution caused by liquid wastes, and utilize treated water for irrigation purpose; (b) recovery of ammonia from gas vented by purging ammonia units; (c) debottlenecking of urea plant to double its production capacity; (d) recovery of urea dust from air to limit air pollution; (e) using titanium tubes in surface condensers to extend their service life; (f) recovery of hydrogen from purge gas to save natural gas for additional ammonia synthesis; (g) improving carbon dioxide removal system to save energy; (h) using fuel gas for steam generation to save natural gas; (i) installing cyclones in bagging sections to avoid environmental pollution and protect personnel against hazards; (j) replacing malfunctioning steam traps to avoid steam wastage; (k) applying a computerized system and excess oxygen analyzers to control boiler operation and avoid wastage of fuel; and (l) providing an emergency power supply to critical equipment to avoid disruption of operation until main power is resumed.

Analysis of the technological capabilities relevant to fertilizer industry in Kuwait

According to the information collected from PIC and to the assessment of the technological capabilities of the fertilizer industry in Kuwait the following analysis can be reached:

State ownership and regulatory power in technology transfer

The ownership of the fertilizer industry by the public sector (State of Kuwait) entitles KPC as a central government authority to exert great leverage in evaluating and selecting the technology and in negotiating for better terms with the technology supplier. The strong economy of Kuwait, thanks to its oil revenues, enabled Kuwait to finance its fertilizer industry with a larger degree of freedom than many developing countries who have to seek financing through credits from the plant constructor or international agencies.

Design versus actual production capacity

The unfavourable high design capacity to actual capacity ratio for the ammonia and urea plants suggests either a lack of planning and assessment of trends in market demand supply balance or to a needlessly oversized unit capacity. In either case the initial investment was high for such sizable units and entails high costs of production and reduced rates of return if the units are underutilized. The share of the domestic consumption of nitrogen fertilizers and other allied downstream industries is very modest (10 per cent for urea), which makes the export-based economics very vulnerable in case of demand-supply imbalance.

The substantially reduced capacity in production of ammonia and urea is attributed to the sharp cutback in crude oil recovered from oil fields to comply with the ceiling limit imposed by OPEC. The existence of a cheap guaranteed supply of natural gas is not a sufficient reason to set-up a fertilizer industry of that sort of magnitude and complexity. It is unfortunate that Kuwait relies solely on the associated natural gas as a feedstock for steam reformers designed to synthesize hydrogen for ammonia production. To circumvent this difficulty, Kuwait has to explore some alternatives, including replacing natural gas by naphtha or augmenting it by natural gas imported from neighbouring Gulf countries, e.g. Qatar.

Manpower statistics

The percentage of Kuwaitis involved in technical activities in the fertilizer industry ranges from a low of 12 per cent for skilled and half-skilled labour to a high of 24 per cent for professional engineers and specialists. This implies that Kuwaitis are more concentrated in professional jobs than in skill-requiring jobs. Apparently, there is a prevailing negative attitude towards vocational and technical schools, which is probably due to inherent traditions and cultural heritage. Students favour art, literature and commerce curricula and shy away from science and engineering studies. Financial incentives and career development programmes should be instituted by the human resources planning and educational governmental departments to change this attitude and encourage enrolment in academic and vocational institutions which provide natural science, engineering and technical curricula. Statistics also indicate that the percentage of foreigners assuming technical jobs range from a low of 9 per cent for skilled and half-skilled labour to a high of 19 per cent for jobs requiring high level of education and specialization. Manpower of Arab nationality, who undertakes technical activities, outnumber both Kuwaitis and foreigners and reaches 59 to 79 per cent of total manpower, excluding administrators, clerks and trainees.

Effect of obsolescence of equipment

Rapid technological breakthrough in ammonia production may be a factor in rendering much of early plant equipment obsolete. This led PIC to resort to replacement of aged or obsolete equipment and avoid being idle due to non-availability of spare parts and due to enormous expenses incurred by buying proprietory materials.

Turnkey contracts and transfer of technology

Being an importer of technology on a turnkey basis, PIC relies heavily on licensed patents and know-how of the technology supplier. This implies that a foreign contractor is generally in charge of the whole project. All the technological decisions are in his hands, including the participation of foreign and local sources for the provision of equipment, material and technical services. In other words, Kuwait receives an ammonia plant rather than the technology. Turnkey projects do not contribute to the strengthening of the recipient capacity, and render the importer of technology dependent on foreign sources. In this respect, Stamicarbon and Haldor Topsoe were the technology exporters of urea and ammonia plants, respectively. No information was released by PIC on the details of the turnkey contract agreements held with these technology suppliers.

It is worthwhile mentioning that PIC in processing the technology transfer did not prefer the splitting of contracts between suppliers, designers, constructors, as this practice entails long delays due to the necessity of co-operation between the relevant parties. Turnkey projects generally insure speedy and expeditious arrangements. They are mostly preferred by developing countries in general and Kuwait in particular, where capabilities in fabrication of equipment, manufacture of capital goods and in design engineering are lacking.

It is worth highlighting the following information released by an authoritative source in PIC:

1. No limitations have been imposed on PIC (fertilizer division) as to the inclusion in contract agreements with foreign technology suppliers of clauses:

- Prohibiting exportation of products made under licence agreement;

- Obliging PIC to purchase primary or intermediate products, tools, equipment or materials from certain firms designated by the contractor/licenser;

- Controlling of sales in terms of obliging PIC to sell exclusively to the licenser or to a company designated by him, to set a miniumum/maximum limit of sales and set a price structure of products;

- Obliging PIC to submit cases to foregin courts in case of arbitration. In this regard the clauses of the contracts honored by PIC restrict arbitration to local courts and abiding with Kuwaiti laws;

- Prohibiting the purchase of certain parts from other manufacturers not designated by the contractor/licenser;

- Entitling the licenser/contractor to intervene in the management of PIC;

- Prohibiting exchanging information with other companies within KPC or Kuwait;

- Obliging PIC to return plans, drawings, manuals, diagrams and technical knowledge if the agreeement is terminated;

- Entitling the licenser a managerial control in development, marketing, etc.;

- Restricting R & D undertaken by PIC or the exchange of information with national scientific institutions;

- Obliging PIC to assign gratuitiously an improvement in technology to the licenser;

- Obliging PIC to extend the life of the contract agreement beyond the present expiry date (7 to 10 years);

- Prohibiting the use by PIC of a technology that complements the licensers technology. In this regard an incubation period of three years is allowed before PIC is permitted to add a complementary technology to the one that it imports.

2. The secrecy agreement signed between PIC (fertilizer division) and the contractor/licenser has a validity period of 7 to 10 years at most, beyond which PIC is free to disclose any information relevant to the imported technology and the contract is expired automatically.

3. No royalties are paid on any of the fertilizer projects undertaken by PIC.

4. The fertilizer division of PIC is the autonomous party who signs the contract with the contractor. The latter undertakes the responsibility of the construction of the plant until it is put onstream. KPC is not involved in the contract agreement process, nor in overseeing the guaranteed performance of the commissioned plant. PIC is free to negotiate the terms of technology transfer; the legal office of the company is the authority who undertakes the legalization of the contract agreement.

5. PIC as enterpreneur and importer of technology relies on two styles of contract agreement with the supplier of the technology, namely lump-sum turnkey and reimbursable cost plus.

6. Clauses for penalty in case of a delay by the contractor in commissioning the plant are included in the contract agreeement.

7. PIC is benefiting from the expertise and special capabilities made available to them by the Santa Fe C.F. Braun domiciled in Kuwait as well as by C.F. Braun Engineering office at their headquarters in Alhambra, California. This expertise compensates PIC for its lack of specialized personnel in areas such as plant design and engineering and process design.

8. PIC's fertilizer division carries independently, activities related to feasibility studies, product design, production management, R & D (in co-operation with KISR), marketing and customer technical services.

9. A local process engineering capability has been established by the fertilizer division. This is well demonstrated by their undertaking of activities related to debottlenecking, plant revamping to double urea production capacity, energy conservation, air and water treatment to combat pollution. Very limited capability has been acquired by PIC in regard to manufacturing spare parts locally.

I.2 Iraq - Case study of the petrochemical plant

The steps taken for implementing the petrochemical complex.

1. Pre-feasibility study

Pre-feasibility studies for the establishment of the petrochemical plant were undertaken in the period between late 1950s and early 1960s. The most important was the study done by the American Doolittle Organization but this plan was not implemented then. Another contract was later signed with the French (BEICIP) organization to undertake the feasibility study on the following basis:

(a) Giving priority to internal demand;

(b) Selecting the plant location close to Baghdad, because of the availability of qualified personnel and raw materials;

(c) Selecting naphta as raw material and liquid gas as an alternate source. The Dora refinery in Baghdad provides the naptha and the liquid gas from Tahji Refinery north of Baghdad;

(d) The capacity for the ethylene production unit was determined at;

60 thousand tons/year to produce
30 thousand tons/year of PVC
20 thousand tons/year of HDPE
20 thousand tons/year of LDPE

After long debates on the project specifics, the following changes were decided:

- Doubling the capacity.

- Associated natural gas was selected as raw material instead of naphta to exploit the southern flared gas, and to benefit from exporting the excess in production capacity in the early years.

The local partner participated in full in all the stages of the prepared study - collection of internal data and statistics phase, - analysing the data by using advanced methods, - evaluating the project economically and giving recommendations after deciding the capacities, - preparing the projects specifics and tender documents, - analysing tenders' offers.

After this part was accomplished the local party entered the negotiation phase, finalized the analysis of tenders and the signing of the agreement with the selected consortium.

2. Location of project

The location was selected by the national personnel based on the following factors:

(a) Near to the source of raw material (near Basrah);

(b) Near the Arabian Gulf, to use the port for exports;

(c) Appropriate expansion opportunities.

3. Announcements of tenders

After deciding on capacities, and preparation of project specifics and conditions with the help of BEICIP some international companies were proposed for tenders based on the following:

(a) Their co-operative reputation;

(b) Their experience in package deals or turnkey agreements and acceptance of Iraqi conditions and requirements;

(c) Their experience in the petrochemical technology;

(d) Their acceptance of the principle of a consortium.

The contractual conditions proposed were based on the following terms of reference:

- United Nations publications on contract requisites;
- Chemical engineering consortium contract requisites;
- Iraqi planning council rules and contract regulations.

The tender was called upon by the Mining and Industry Ministry, and bids came from a number of consortiums in Japan, Europe and America.

4. Analysis of bids and negotiations with companies

A group of Iraqi personnel from the State Organization for Industrial design and Construction (SOIDAC) analysed the bids and negotiated with the bidders at this stage the French consultancy role ended.

The period of analysis of bids and negotiations extended one year and a half before reaching an agreement and signing the protocol, based on the following:

- Lowest price offered;

- Best technical and contractual conditions;

- Best technology and experience in the petrochemical sector.

The consortium was made up of two companies, (American and German).

5. Selection of technology and production process

The selected technology was based mainly on the following terms:

(a) The patents reputation and the number of plants in the world using this method;

(b) The success of the production process and comparison with competative producing companies;

(c) Applicability of such production methods to the Iraq needs and local market.

These factors determined the following selection:

Lummus Company was selected as the patent owner of ethylene production, Phillips Company, selected for HDPE, Hawker Company selected for its electric analysis process, Stanfer (American) Company for patents of PVC and VCM and National Distiller Company (American) for LDPE. The selection of processes and negotiations with the mentioned companies were undertaken independently by the local personnel.

6. Execution stage

The execution stage was divided into three phases:

(a) Determining technical specifics and authorizing designs;

(b) Authorizing plant layout and supervision of erection;

(c) Commissioning and start-up.

In the early stages and after signing the agreement a local group was established within the organization to follow-up on the project execution, another on-site group of engineers was established (civil, mechanical electrical) to follow-up on on-site erection of plant.

At the companies headquarters, a working local group of several specialization was working on reviewing the engineering design and technical specifications, this group was assisted by Indian specialized experts.

The working group negotiated with the patents on matters related to the project design and revised the drawings and authorized them, the group had the authority required to perform its assignments, and participated in selecting source of equipment according to the available information on its technical reputation and previous performance.

The same group after finalizing its job at headquarters, returned to work on-site in addition to the above-mentioned group and participated in supervising the erection of the plant up to the commissiong stage.

Plant operation training

The contracted companies were committed to train locals on-site and abroad, this was accomplished at the same time of execution. A number of technical local personnel where trained in similar units in the United States of America.

- On-site training was accomplished, using applied training in the production units by using theoretical and practical training.

These training programmes were undertaken under the supervision of experts from the foreign company, at the same time the Iraqi personnel undertook separate training programmes internally and abroad.

Conclusion

The steps undertaken by th Iraiq part in the pre-feasibility study and in the participation in engineering design and following up on execution, and on-site implementation of the contract conditions, in an organized manner was an active and important step towards mastering technology transfer, and has been proven as one way of gaining applied experience.

Also the insertion of training and the collaboration of locals in executing agreements was a great step towards the assimilation and adaptation of technology and therefore its development.

I.3 The Organization of Arab Petroleum Exporting Countries (OAPEC)

OAPEC is a regional specialized commodity organization with an international orientation. It was formed by an agreement among countries that own and export petroleum. It works for co-operation among its member States and towards consolidating their efforts to achieve the best possible means for developing the Arab petroleum industry in its various aspects, in addition to utilizing their resources and potentialities to establish joint ventures and creating an integrated petroleum industry as a step towards realizing the cherished Arab economic complementarity.

Saudi Arabia, Libya and Kuwait agreed to form the Organization. The convention of the Organization was signed in Beirut on 9 January 1968, and Kuwait was chosen as the host country of the Organization. Since its inception, membership of the Organization has grown from three to eleven petroleum exporting countries. These are United Arab Emirates, Bahrain, Tunis, Algeria, Saudi Arabia, Syria, Iraq, Qatar, Kuwait, Libya and Egypt (whose membership was suspended in April 1979). The population of member countries constitute 60 per cent of the population of the Arab world. OAPEC's oil production in the 1970s was about 30 per cent of the world oil production and the oil reserve of all member countries is more than 50 per cent of world oil reserves. These countries contribute to more than half of the oil traffic across oceans and seas of the world.

Article 11 of the Organization's basic agreement stipulated the main objective of the Organization as follows: co-operation among member countries in the various economic aspects of the petroleum industry, determining ways and means of protecting the legitimate interests of its member countries in the individually and collectively; co-ordination efforts to ensure the delivery of oil to the consuming markets under just and acceptable conditions and providing conducive circumstances for capital and expertise for investors in the oil industry in the member countries.

The agreement has also stipulated the means of achieving these objectives. Some of these means are:

- Co-ordinating oil economic policies among member countries;
- Achieving some sort of harmony among legal systems in the member countries to facilitate the work of the Organization;
- Exchanging information and expertise and providing opportunities for training and employment for citizens of member countries;
- Co-operation among members to solve any problems facing them in the oil industry;
- Making use of the resources and potential of member countries to establish joint ventures in the oil industry where all or some of them will invest.

In a relatively short time, the Organization established five affiliated companies and a training institute. Thus it has achieved its objective in laying down a strong base for joint Arab action and economic complementarity in the oil industry field. Although these companies were established by the Organization they work independently through their respective boards of directors. The five companies are: the Arab Maritime Petroleum Transportation Company, the Arab Ship Building and Repairing Yard, the Arab Petroleum Investment Company, the Arab Petroleum Services Company and the Arab Engineering Consulting Company.

Within the framework of its future strategy the Organization is in the process of completing its basic elements in order to be capable of achieving the cherished Arab complementarity in the oil industry field starting from exploration until it reaches the multi-faceted industrialization by hydrocarbons.

The formation and establishment of these companies by the Organization ensured the investment of US$ 1,250 million in joint Arab oil industry. This sum represents the paid capital of these companies.

They are a serious attempt to establish an independent Arab oil industry to contribute greatly towards the preparation of the Arab technical cadres as may be required to ensure the development and success of this new industry considered so far as a monopoly for international companies.

The Arab Petroleum Training Institute

Based on the basic objective of the Organization relating to the establishment of an integrated Arab oil industry with Arab manpower, the creation of the Arab Petroleum Training Institute came as a complementary step to the formation of the specialized companies.

The Institute was established in 1979 in Baghdad. Among its objectives are the following: preparation of trainees technically and educationally to meet the shortages in national institutes and centres; in the various aspect of oil industries; conducting research and studies relating the new techniques in industrial management; preparation of curricula and methods of training and technical manpower as well as productive efficiency of manpower necessary for Arab oil projects; establishment of central data and documentation centre as a base for research and studies relating to manpower in oil industry; and development of the technical know-how in areas of education and training and industrial management as well as the preparation of specialist's in the production of educational and audio-visual aids.

Ten countries are being represented in the Institute. Construction of permanent premises for the Institute is underway.

I.4 Case-study for future development: Arab Engineering Company

The significance of AREC in the international engineering world is two-fold. In the first instance, it is an Arab engineering company that has proved successful, and its size and scope are still growing. Second, it is developing into an "umbrella" organization for evolving the local engineering capability in each of the Arab countries. In view of the difficulties of developing Arab engineering, the success of AREC is particularly important.

1. Historical Outline

AREC was officially established in July 1981. The concept had been developed within OAPEC during the previous three years, and the final plans agreed by the OAPEC Council of Ministers. The shareholders of the Company are mainly the national oil companies of the member States, with shares divided equally.

AREC's head office was established in Abu Dhabi, but since that time, branch and representative offices have been set up in London, Tunis, Algeria and Tripoli. It is planned to open up an office in Saudi Arabia in 1985.

AREC's are of activities are mainly in the oil, gas and petrochemical industries, providing techno-economic studies, conceptual engineering design, detail engineering, procurement, construction management and commissioning. The main area of activity has thus far been the Arab world, with projects completed, or in progress, for Libya, Tunisia, Algeria, Saudi Arabia and the

United Arab Emirates. These have required AREC's employees to operate in not only the above countries, but also in England, France, Spain, United States and Italy. Negotiations are now underway for projects in black African countries as well as other Arab countries.

AREC's workload has grown rapidly during the last three years. The first major project began in late 1982, and since then the workload has grown to over 200,000 man hours per annum. This is shown in figure 3. The income has grown accordingly, and the total income for 1984 was over $ 7 million.

AREC's manpower has 20 different nationalities, and over 30 per cent of the staff are Arabic. The manpower has grown from 1 in July 1981 (the General Manager) to 240 at present, as shown in figure 4. Over 50 per cent of the staff are graduates, 10 per cent of whom also have higher degrees.

2. AREC's Basic Structure

AREC was set up, and has since operated, on a very different basis from a normal Arab engineering company. This basis can be summarized as follows:

(a) AREC is a truly multinational company in so far as it has 10 shareholders from eight different countries;

(b) AREC has a solid financial base, with a subscribed capital of $ 12.8 million;

(c) AREC's directors are from the 10 shareholding companies, and meet every four months to discuss and decide on major policy matters;

(d) Otherwise, AREC is run by a multinational Arab management team headed by the General Manager;

(e) AREC has no geographical limitations, being able to seek business in any part of the world, and establish technical and representation bases where ever so justified;

(f) AREC has no limitations on industrial sector, although it predominantly operates at present in the oil, gas and petrochemical sectors;

(g) AREC is commerically based, just as a private company, requiring to support all its expenditure from income received from projects;

(h) AREC has no limitation on the nationality of its employees, other than the obvious need for a predominantly Arab management and responsibility to develop Arab engineers;

(i) Although AREC is supported in obtaining work from its shareholding companies, it is required to compete with the foreign international companies in terms of rates and technical capability, often in open bidding situations;

(j) AREC is legally accepted as a national company in each of the OAPEC states.

3. AREC's Objectives

The basic structure of AREC provides considerable opportunities for evolving a large engineering capability, with controls to ensure that the company is commercially viable, and responsible for developing a truly Arab engineering capability.

AREC's objectives can therefore be ambitious, yet practicable:

(a) Size : AREC has no limitation on size, but its objective was to reach a staffing of 500, mainly professional engineers, by 1987;

(b) Profitability : AREC has now achieved a profitable status and is required in the future to fund its growth and internal development from its own profits;

(c) Standards : AREC is required to be as capable as any other international engineering company in its technical and management professionalism;

(d) Geographical Scope : AREC aims to have a significant presence in all Arab countries and the main technical centres of Europe and North America, supporting projects throughout the Arab States and other developing countries (e.g. black Africa, South America, etc.);

(e) Arabization : AREC will attract Arab professionals from the international engineering companies, as well as national companies of the Arab world. Moreover, it will actively develop young Arab engineers to international standards. However, AREC's Arabization will proceed slowly so as not to jeopardize its high professional standards;

(f) Internal Development : AREC has a major responsibility to develop the systems and procedures relevant to a large engineering company. Such developments are to provide not only for itself, but also as a source of assistance to other developing engineering companies of the Arab world;

AREC has the responsibility to train and provide experience to young Arab engineers and managers, and ensure a large source of top quality Arab professionals are produced;

(g) Technology : In the longer term, AREC is required to become a major technology source for the Arab world, having an in-house technological capability comparable with any international engineering company;

(h) Competitivity : In spite of AREC having some support from its shareholding companies, this support will only be provided when AREC can justify it has the technical capability comparable with foreign competitors, and can offer rates that are equally competitive. Indeed, AREC is often engaged in open bidding situations, with no commercial advantages granted for it being Arab. This objective of attaining the technical and commercial capability of any competitor is considered a vital part of AREC's objectives, ensuring AREC does not fall into the trap of being an overbureaucratized and self-indulgent organization.

AREC's structure and objectives are both novel and challenging. The hybrid structure enables it to have the advantages of both the national and private companies. However, novel structures require novel methods of operation, with the inherent problem of not being able to follow the well trodden paths of previous companies. Some of these new approaches are described below.

4. <u>Manpower</u>

The challenge of having to develop novel approaches is nowhere more apparent than in the manpower field. Of AREC's 240 staff at present, there are 20 nationalities and operational bases in four European countries, four Arab countries and the United States. Morover, this situation is by no means static. Recruitment of staff averages two per week throughout the year, and staff are being continually transferred between projects and locations, whilst others are being demobilized. This tremendous flexibility and mobility takes place in an environment where technical ability, job suitability, and high motivation are essential, whilst the costs of inefficiency in the deployment of staff can be crippling.

To resolve these considerable complexities of manpower, AREC has adopted two basic approaches. In the first instance, staff salaries, benefits and conditions of employment are based on a set of personnel policies developed within AREC that were specifically designed to account for the wide geographical spread of the company and the mobility of the staff. A single status policy was adopted, whereby the salary, benefits and conditions were based solely on professional seniority and not on nationality or race. This was important. For Arab engineers, in particular, to be motivated to achieve comparable professional seniority with European or American engineers, they must be treated in all respects the same. Unfortunately, this is not the case in most Arab engineering companies.

The second approach to the manpower problems was the adoption of a matrix management style. This implies that Professional staff are responsible in the normal manner within the management within the management structure of a project, but also, they have reporting relationships to the functional Heads of Department in Head Office. Within the project structure, normal day to day matters are resolved by the project management, whilst the functional structure attends to recruitment, transfers demobilization, and career development. This matrix management approach has proved crucial to the efficient development and deployment of manpower.

5. Joint ventures

Another crucial policy adopted within AREC has been that of joining the large international engineering companies in the bidding for, and execution of projects. Thus far, AREC has been engaged in projects with Bechtel, Fluor, Brown and Root, Stone and Webster, NPCC, Howe Baker, Snamprogetti and Technip. The advantages gained have been considerable:

(a) In bidding as a joint venture company, AREC has overcome the problem of having no past record to justify its capability. Moreover, AREC has learned a considerable amount from the experience of bidding with companies of such experience;

(b) By operating in joint venture with experienced companies, AREC's learning process has been equally substantial, especially in the area of engineering systems and procedures;

(c) Joint ventures have assured AREC of acceptance in the international engineering fraternity. It was initially feared that AREC would be a "protected and kindly treated contractor" to its shareholding companies. However, the international companies have now had first-hand experience of AREC having to comply with the same standards and pressures which they face. This gaining of acceptance by the international community has brought AREC considerable advantages in both technology transfer and business development terms.

A typical example of the joint venture approach is that of the Bu Hasa Oil Gathering Project in Abu Dhabi. This project was won in January, 1984 by a joint venture between AREC and International Bechtel Incorporated. The project was for the design, engineering and procurement for upgrading the Bu Hasa and Asab oil gathering facilities. This involves approximately 150,000 man-hours over 18 months.

In this AREC/Bechtel joint venture, half of the 70 technical staff are from AREC, and the other half from Bechtel. The staff have worked together in a completely integrated team under a Bechtel project manager and an AREC deputy project manager. One third of the AREC team are Arab engineers, several of whom had not previously worked on an engineering project before. The experience they have gained in these 18 months will prove invaluable. As this project comes to its completion, the AREC staff will be reassigned to other projects in Abu Dhabi, London or North Africa. Their experience will grow and AREC will have established Arab engineers on a par with any in the world.

6. Systems and efficiency

Of AREC's total expenditure each year, over 70 per cent is directly related to manpower - salaries, allowances, insurance, benefits and housing.

This is typical for an engineering company. Typical also, virtually all of AREC's income arises from the man-hours being charged to clients in the performance of projects. For AREC to be financially viable, efficiency in the use of manpower is essential.

This efficiency has firstly to relate to overheads. Management and central staff functions (personnel, finance, etc.) are an overhead cost which cannot be reimbursed from clients. It is of paramount importance that this overhead is minimized ruthlessly. However, in the complex operational requirements of an engineering company, this is by no means easy.

The key to this problem is a systematic approach. Over the past three years, AREC has produced and now operates over 30 major systems (see figure 5). All of these systems had to be evolved specifically for AREC's purpose due to the uniqueness of our organization. Moreover over time, these systems have had to be modified, improved and refined as our experience has grown, and the working environmental expanded.

The contribution of these systems is invaluable. They have enabled AREC to maintain only a skeleton "overhead" staff, yet react quickly and positively to the problems that inevitably arise, and changing circumstances.

The second basis of efficiency is in the utilization of professional staff. Professional staff employed by AREC are expensive - under utilization can quickly destroy the financial viability of the Company. Consequently, it has been vital to have complete mobility and flexibility, and this requirement will persist indefinitely. The Professional staff have to be capable of moving, either permanently or temporarily, from one country to another, and from one project to another, often at short notice. This mobility, especially as families are often involved, requires a professionalism and commitment that is unusual to most industries. Those who cannot be immediately employed have to be terminated - this requires a firm management style. AREC, as any other international engineering company, cannot carry a significant number of Professional staff if there is no project for them to work. This is a demanding environment for the Professional staff. It is not surprising, therefore, that their remuneration is high by normal national scales. However, in engineering, one cannot recruit and maintain the quality of staff required, and obtain the mobility and commitment that is vital, without reflecting this in remuneration packages.

7. AREC's future role in Arab countries

AREC's objective, thus far, has been to create a high quality (both in technical and commerical terms) international Arab engineering company. This has been successful, and there is considerable scope for more growth.

However, a further objective, which is now becoming viable, is to contribute to the development of engineering companies in each of the OAPEC states. This ambitious programme will be based on:

(a) AREC, initially, setting up representative offices in each country (so far, this has been done in Tunisia, Algeria, Libya and the United Arab Emirates, with an office in Saudi Arabia planned for 1985);

(b) Based on these offices, AREC seeks means of joining with existing local engineering companies, normally those under state control, to form joint venture companies;

(c) Use AREC's international experience to develop the manpower, systems and procedures, and management of these joint ventures companies;

(d) Use AREC's experience and proven capability to obtain projects in the country for the joint venture company, employing and training local engineers as much as possible, and backing up with AREC's international staff where necessary;

(e) Developing these joint ventures companies into medium to large autonomous companies that can make a substantial contribution to the engineering capability in each country, with AREC's international and commercial back-up to ensure that the companies are operated efficiently and at the highest international standards.

By means of this approach, AREC will be a catalyst for expanding the capabilities of local engineering companies in each of the OAPEC States. AREC's contribution can be considerable, and many of the difficulties analysed in chapter II for local companies can be overcome through AREC's involvement.

I.5 The Gulf Organization for Industrial Consulting (GOIC)

The Gulf countries evolved mutual co-ordination and co-operation policies by concluding various economic agreements which aimed at the elimination of harmful duplication in programmes and to increase the internal market capacity. Within the framework of this co-ordination and co-operation policy, the Gulf organization for industrial consulting (GOIC) was established in 1976. A decision taken by the seven ministers of industries meeting in Doha, Qatar. GOIC is an inter-governmental organization. All the seven Gulf countries are members. The United Arab Emirates, Bahrain, Saudi Arabia, Iraq, Oman, Qatar and Kuwait.

The main objective of GOIC is to achieve industrial co-operation and co-ordination among the member States through:

- Proposing the establishment of common industrial projects in the member States;
- Recommending ways and means of co-ordination between the industrial development projects;
- Co-ordination and development of technical and economic co-operation between existing or planned industrial companies and establishments;

- Supplying technical assistance to prepare and evaluate industrial projects;

- Preparation of studies concerning industry.

GOICS structure consists of the council and the general secretariat. The Council includes in its membership representatives of the seven member States.

It has five main departments:

(1) Sectoral development department;

(2) Regional planning department;

(3) Projects department;

(4) Industrial data bank department;

(5) Administrative and finance department.

In its nine years of work, GOIC has studied possible strategies for the development of major industrial sectors in the region, and has put an effort to help enhancing industrial development in the Arab Gulf states. Its activities include preparation of industrial studies, including, pre-feasibility and techno-economic feasibility studies, promotion of joint venture projects, development of industrial data bank, technical consultation facilities, organizing seminars, conferences and training courses, and issuing appropriate publications on matters of industrial development.

The main achievements are:

(a) Industrial surveys for member countries;

(b) Studies on projects for investments in industrial projects;

(c) Strategic and sectoral studies, plus few feasibility, pre-feasibility and techno-economic final studies for joint industrial projects, and training of technical capabilities for the local professional in the region.

GOIC has 129 employees, in 1985 senior administrators are a general secretary, 2 assistant general secretary, and 10 technical consultants, in the regional planning department 11 employees, data bank 22, sectoral studies department 13, projects department four, administration and finance department 36.

The distribution according to local (Gulf), Arab and foreign shows that 15 employees are from the Gulf countries five in administrative posts, three are engineers, two economists and five technicians. Thirty-four employees come from different Arab States, one in administration five are engineers, four economists and 24 technicians. Foreigners are eight in all, one economist and seven technicians.

The GOIC is a consultancy organization, it does not undertake basic scientific and technical research, testing, product or process design, the facilities available in Doha centre are: computer system, data bank mainly established for storing petrochemical and industrial statistics and information on advanced technological developments, they have no laboratories.

The activities of the organization are initiated on the basis of recommendations and proposals from its experts, regional institutes and organizations and member States.

GOIC is working on promoting its capabilities in advanced industrial technologies to be able to participate in negotiating agreements, giving advisory and consultancy services and becoming a source of technological information for the member States.

GOIC since 1981 provided an internal training programme for the members of its organization, in the form of lectures - and has sent others to participate in training provided by other organizations.

The internal lecture subjects cover: development of industrial projects econometric forecasts, industrial investment, and joint projects. It organized lectures and seminars and training workshops for participants from the Gulf countries - mainly in:

1. Training on pre-feasibility studies of industrial projects.

2. Training in industrial statistical surveys.

3. Joint industrial projects, evaluation and implementation.

It is clearly noticed that in the past period GOIC has managed to build its own organizational capabilities in consultancy services an industrial development in general and in a wider scope in petrochemical industries and marketing, the main feasibility studies undertaken are in downstream industries.

GOIC can provide technological and economical services:

- Such as sectoral and industrial planning;

- Market studies and demand forcasts;

- Financial and social cost benefit analysis of projects;

- Information on product development and process adaptation.

In the period 1979-1984 GOIC staff participated in 86 seminars (industrial and external) out of which 12 were on petrochemicals and related subjects, 24 training activities organized locally or internationally and they prepared two seminars for promoting experiences in feasibility studies and petrochemical industrial skills.

ANNEX II

FIELD WORK

II.1 Missions undertaken during 1984-1985

1. Saudi Arabia, Kuwait Bahrain, Qatar, Jordan	30 May to 13 June 1984
2. Kuwait, Abu Dhabi, Saudi Arabia	27 October to 13 November 1984
3. Jordan	18 December 1984
4. Syria, Egypt	17 to 31 January 1985
5. Kuwait, Qatar, UAE Bahrain, Saudi Arabia	11 to 25 February 1985
6. Bahrain, Saudi Arabia, Jordan	12 to 24 September 1985

II.2 Contracted Local Consultants

1. KISR/Kuwait
2. AREG/UAE
3. Mohammed IDRISI/Iraq
4. Mohamed HILAL/Egypt
5. Abdulla SALLUTA/Syria
6. Akram KARMOUL/Jordan

II.3 Distributed questionaires (see table 1.3)

Bahrain

1. Bahrain National Gas Company	13 October 1985

Egypt

1. Egyptian General Authority for Petroleum	28 May 1985
2. Petroleum Engineering Industries Company	28 May 1985
3. Petroleum Research Centre (Egypt) Petroleum Company	28 May 1985
4. Engineering and Industrial Design Development Centre	
- Industrial Construction and Service Company	
- Abu Kir Fertilizers Company	
- Talkha Fertilizers Company	

- Kima Fertilizers Co. (Aswan)
- Suez Petroleum Co.
- Alexandria Petroleum Co.
- Misr Petroleum Co.
- Petrochemicals Co.
- Academy of Scientific Research and Technology
- Petroleum Institute
- Cairo University
- Ain Shams University
- Hilwan University
- Suez Canal University
- Major Consulting Company - Arab International Company

<u>Iraq</u>

- Scientific Research Council
- Baghdad University
- Technology University

<u>Jordan</u>

- Dal Al-Handash
- C.C.C.
- Yarmouk
- University of Jordan
- The Royal Scientific Society
- Talal Abu Ghazaleh, Jordan
- Jordan Fertilizer Industry
- Jordan Petroleum Refinery Co.
- Intermediate Petrochemical Materials Industry

<u>Kuwait</u>

- Kenomac
- KISR
- PIC (K.Sc)
- Kuwait University
- KERMENCO

- Kuwait Chemical Manufacturing
- OAPEC
- K.C.F. Brown
- KPC
- Santa Fe International
- Three refineries
    - Mena Abdulla Refinery
    - Mean Al-Ahmedi Refinery
    - Shuaiba

<u>Qatar</u>

- QAFCO
- QNNTC
- GOIC
- MECON
- IDTC
- ALMANA-INEGO
- QAPCO
- Qatar University
    - Science Faculty
      Applied Research Centre

<u>Saudi Arabia</u>

- Fluor
- King Wilkinson
- Saudi Consult
- Foster Wheeler
- Kanoo
- Chiyoda Petrostar
- King Abdul Aziz University
- SAFCO
- Yanbu Refinery
- PETROMIN Mobil Yanbu
- PETROMIN Shell
- King Saud University

- ARAMCO
- Rabigh Refinery
- Riyadh Oil Refinery Co.
- Jubail Oil Refinery Co.
- Jeddah Lube Oil
- Riyadh Lube Oil
- PETROMIN Lube Refinery
- CCC

Syria

- University of Damascus
- Aleppo University (ALEPPO)
- The General Company for Executing Industrial Projects
- Industrial Testing and Research Centre (ITRC)
- The General Establishment for Designs and Studies
- The Oil Refinery Co. (BANIAS)
- The Oil Refining Co. (HOMS)
- The Fertilizers Co. (HOMS)
- The Ba'ath University (HOMS)

United Arab Emirates

- FERTIL
- NPCC
- UAE University
- AREC