E/ESCWA/ID/86/24

ECONOMIC AND SOCIAL COMMISSION
FOR WESTERN ASIA (ESCWA)

ARAB INDUSTRIAL DEVELOPMENT
ORGANIZATION (AIDO)

DEVELOPMENT IN THE OIL REFINING, PETROCHEMICAL
AND FERTILIZER INDUSTRIES

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

ESCWA Industrial Development Series No. 2

Prepared jointly by:

ESCWA/UNIDO Industry Division

AIDO Global Studies Department

October 1987

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Arab Industrial Development Organization or the United Nations Economic and Social Commission for Western Asia concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

E/ESCWA/ID/86/24

87-1025

CONTENTS

CONTENTS (CONT'D)

CONTENTS (CONT'D)

CONTENTS (CONT'D)

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF ABBREVIATIONS

ADNOC	Abu Dhabi National Oil Company
AIDO	Arab Industrial Development Organization
AIIC	Arab Industrial Investment Company
AL-RAZI	Saudi Methanol Company
AMINOIL	American independent oil company
APICORP	Arab Petroleum Investment Corporation
ARADET	The Arab Detergents Chemical Company
ARAMCO	Arabian American Oil Company
AREC	Arab Engineering Company
b/d	barrels per day
BSCF	Billion Standard Cubic Foot
CAN	Calcium Ammonium Nitrate
cu ft/d	Cubic feet/day
cu m	Cubic metres
DMT	Dimethylterphtalate
EIDDC	Engineering & Industrial Design Development Centre
ENPPI	Engineering Petroleum Projects Industries
FCC	Fluid catalytic cracker
GAS	National Industrial Gases Company
GEPC	General Egyptian Petroleum Company
GFC	General Fertilizer Company
GLP	Gas Liquefication 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
IDTC	Industrial Development Technical Centre
INOC	Iraqi National Oil Company
IPI	Intermediate Petrochemical Industries Company

LIST OF ABBREVIATIONS (Cont'd)

JOPETROL	Jordan Petroleum Refinery Company
KEMYA	Al-Jubail Petrochemical Company
KFAS	Kuwait Foundation for the Advancement of Sciences
KISR	Kuwait Institute for Scientific Research
KNPC	Kuwait National Petroleum Company
KOC	Kuwait Oil Company
KPC	Kuwait Petroleum Corporation
KREMENCO	Kuwait Refinery Maintenance and Engineering Company
KSB	Kuwait Santa-Fe Braun Engineering and Petroleum Enterprises Company
LDPE	Low Density Polyethylene
LLDPE	Linear low density polyethylene
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
MAP	Mono ammonium phosphate
MTBE	Methyl Tertiary Butyl Ether
MVC	Mono Vinyl Chloride
MT/Y	Million Tons/Year
NGL	Natural gas liquid
NODOC	The National Oil Distribution Company
NPK	Nitrogen Phosphate Potash Compound Fertilizer
OAPEC	Organization of Arab Petroleum Exporting Countries
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PETROKEMYA	Arabian Petrochemical Company
PETROMIN	General Petroleum & Minerals Organization
PIC	Petrochemical Industries Company
PRC	Petroleum Research Centre
PTA	Purified Terephtalic Acid
PVC	Polyvinyl Chloride
QAFCO	Qatar Fertilizer Company

LIST OF ABBREVIATIONS (Cont'd)

QAPCO	Qatar Petrochemical Company
QGPC	Qatar General Petroleum Company
R and D	Research and Development
RSS	Royal Scientific Society
SABIC	Saudi Basic Industries Corporation
SAFCO	Saudi Arabian Fertilizer Company
SANCST	Saudi Arabia National Centre for Science & Technology
SBR	Styrene-Butaine Rubber
SHARQ	Eastern Petrochemical Company
TIC	Technology Investment Company
TSP	Triple Super Phosphate
TPA	Terephtalic Acid
UNIDO	United Nations Industrial Development Organization
UOP	Universal Oil Products
VCM (MVC)	Vinylchroride monomer
YANPET	Saudi Yanbu Petrochemical Company

PART ONE

INTRODUCTION

INTRODUCTION

1.1 Objectives

The objectives of this study are:

- To identify and assess the present technological capabilities in the oil refining, petrochemical and fertilizer industries in the Arab countries;

- To review expected future developments in the technologies of these industries in the industrially advanced countries;

- To provide a proper framework for a master plan for the development of technological capabilities in the Arab countries.

The present report is one of three studies undertaken jointly in 1986-1987 by the Economic and Social Commission for Western Asia (ESCWA) and the Arab Industrial Development Organization (AIDO) on the development of technological capabilities. The studies cover the following industries:

- Oil refining, petrochemicals and fertilizers;
- Capital goods and engineering industries;
- Iron and steel.

This study incorporated and updated a study that was completed by ESCWA in 1985 which covered the ESCWA region. The scope of the present study was enlarged to include non-ESCWA Arab countries, in line with the terms of reference and requirements of AIDO.

1.2 Background and justification

1.2.1 The industry

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

The oil refining industry in the region started in 1912 in Egypt, with the establishment of a 2,000 b/d topping plant. Iraq followed in 1927 with a 5,500 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 50 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 2.4).

The petrochemical industry, which includes here the fertilizer industry based upon natural gas, started much later, in the 1960s, with the establishment of an ammonia plant in Kuwait (see table 2.3). 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 the following:

(a) The price of crude oil was not significant in the manufacturing cost of most bulk petrochemicals. Secondly, the commercial plant size was larger than the domestic market. Thirdly, the required huge investment capital was not available in the countries of the region. Fourthly, the physical and human infrastructures were inadequate.

(b) Joint venture type agreements were too restrictive because of the conditions demanded by the technology and the cost of royalties and licence fees was considered too high to be acceptable. This situation changed dramatically with the two oil price increases of the 1970s and the subsequent higher costs of energy and feedstock.

The first generation of projects in the late 1960s was 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 were the result of many infrastructural problems related to the initial preparation of a project site when roads, housing utilities and port facilities had to be built at the same time as the construction of the plant itself. However, the main problem was the lack of experience and of 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 accumulation 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 take full advantage of industrial development.

The refining and petrochemical industries in the region have developed and evolved into a key element in the industrialization policies adopted since the 1960s in the region and in the structure of world markets. This rapid development was promoted by the desire of the petroleum-producing countries to utilize fully the oil and gas potential 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 matterials is carried to the manufacturing stages, it will encourage at the same time local production of end-products, and in this way the countries not only diversify their industrial base but also create new jobs, provide training and technical experience and promote backward and forward linkages.

1.2.2 The technology

The production complexity of the petrochemical industry requires 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 olefins 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.

There are two primary processes for the production of petrochemicals, steamcracking of naphta for olefins and 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, VCM, ethyleneglycol, ethylbenzene, styrene, phenol, caprolactam, DMT and TPA. The category of finished products encompasses a group of products that require minimal processing to be transformed into consumer goods. They include PVC, high and low density polyethylene (HDPE/LDPE), polystyrene, SBR and various polyester and nylon fibres.

Countries in the region have only recently begun to establish petrochemical plants which can produce the basic petrochemicals, with a view to optimizing 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; 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 acquired 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 continuously increasing requirements for motor gasoline and less for fuel oil. More 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 the advantage of having the available flared gas as well as capital finance.

In the petrochemical industry, with few exceptions, it is the big international manufacturing companies that have the financial and scientific capacity to develop new processes. 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 10 years is not only too ambitious a programme but also not necessary, even with the huge financial resources available. Therefore, a carefully planned and implemented programme, taking into account the manpower situation in the region, would be needed to develop the required technological capabilities to sustain, operate, and renovate these industries to respond to the needs of the region and their future objectives and prospects.

There is no doubt that the countries of the region have established and are continuing the construction of refining and petrochemcial 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 are the questions that this study attempts to analyse.

1.3 Scope of technological capabilities

The above paragraphs clearly show the complexity and wide range of the activities required by the industry, not only for the acquisition of equipment and process technology know-how but also to operate and maintain a complex industrial plant. There is a need for advanced technology, which requires fewer but highly skilled people.

The manpower required 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 part three of this report, these capabilities are assessed separately and in-depth in various countries and for different projects. However, it is to be noted that these capabilities cannot be easily generalized since their scope may differ from one project to another. If a capability to undertake pre-feasibility or feasibility studies exists, this may 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 capabilities becomes necessary. It also depends on the type of project undertaken, whether it involves a new plant or an extension of an existing one, whether it is a study for a new installation or for additional equipment, whether it is for the introduction of a new process or the improvement of an existing one, whether it is for the installation of a new production line or modification of an existing line, and so on.

1.4 Methodology

In order to assess the existing technological capabilities in the Arab world, it was necessary to collect all information pertinent to the oil refining petrochemical and fertilizer industry. The data collection activity was undertaken in two phases: desk-work and field-work. The first phase, the desk-work, covered the collection and analysis of all relevant published information at the national, regional and international levels. It included surveying the literature on the subject, including technical and economic periodicals and specialized reports. A comprehensive list of issues and topics related to the development of technological capabilities in the oil refining, petrochemical and fertilizer industries was prepared.

The field-work started with the preparation of different questionnaires for each of the four groups of organizations engaged in the technological development process relating to these industries, namely:

- Manufacturing establishments;

- Engineering design, consulting companies and contractors;

- Engineering design, consulting companies and contractors;

- Laboratories, industrial and specialized research centres;

- Universities.

The questionnaire for the manufacturing establishments solicited specific and, whenever possible, quantified information regarding the size and composition of the work force (by nationality, educational level, function, etc.) as well as the capabilities of the establishment itself and other national and foreign organizations and companies involved in its activities (selection of technology, negotiations with foreign sources of technology, pre-feasibility study up to marketing and after-sale services). The questionnaire sought to determine the major achievements of the establishments as well as their plans for the future. In addition it sought to identify and determine the linkages between those establishments and other organizations at the national, regional and international levels.

The questions submitted to consultants and contractors dealt with the relation between the branch office and mother company, sectoral activities they were engaged in, number and composition of employees and specific capabilities possessed.

The universities and research centres were asked to provide information on the number and respective specializations of their graduates and staff, the major research programmes completed, and co-operation with industry and possible work done for the benefit of manufacturing establishments on a commercial basis.

For each country, a list of relevant organizations was compiled, and local consultants in a selected number of countries were recruited as focal points. Their task was 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 and to submit a case-study dealing with the transfer and development of the technology process in at least one national organization.

Pilot testing of the initial questionnaires was undertaken in the Gulf region and a number of modifications were made subsequently, taking into consideration the views of some leading organizations and experts.

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 number of field missions were undertaken by the consultant and/or the team members of the project to gather unpublished data in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, Jordan, the Syrian Arab Republic, Egypt, Algeria, Tunisia and Morroco. This was done through questionnaires and reports prepared by local experts (see annex II).

The questionnaires which were filled out and returned contained useful and relevant information in many cases. However, the response from different countries varied greatly. Many organizations did not respond to the questionnaires at all. Furthermore many questionnaires were only partly completed and most of the questions relevant to the study remained unanswered. In several cases the meaning of the question was not properly understood and the answer given was therefore not relevant. In addition, in some countries, the lack of response by an entire sector of the industry made generalization of the results of the questionnaires difficult.

For example, in Saudi Arabia no replies were received from the petrochemical sector. In Iraq, petrochemical, fertilizers and oil refineries did not reply. Only one questionnaire was received from Bahrain and in the United Arab Emirates and Qatar the universities and/or research centres did not reply. Worse yet, no North African countries completed any questionnaire and no background papers were prepared. This lack of necessary data can be seen in part three of the study, wherein it was not possible to assess the status of technological capabilities in these 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. Profiles were subsequently prepared for countries, outlining the historical development of the oil refining and petrochemical industry, the technological capabilities developed so far and the 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.

In conclusion the study presented a number of recommendations and proposals for enhancing the development of technological capabilities in the Arab world.

Table 1.1.

Returned questionnaires

	Response %	Questionnaires returned Mtg. Establ.	Conslt.	Univ.	Lab/R&D	Background papers
Bahrain	20	1	-	-	-	-
Iraq	n.a.	n.a.	n.a.	2	1	+
United Arab Emirates	25	1	2**	-	-	+
Syrian Arab Republic	82	3	2	3	1	+
Kuwait	47	2	4	1	2**	+
Egypt	n.a.	1*	1*	-	1	+
Qatar	40	1	3	-	-	-
Jordan	20	-	2	1	1	+
Saudi Arabia	50	12	6	2	-	-
Algeria	n.a.	-	-	-	-	-
Libyan Arab Jamahiriya	n.a.	-	-	-	-	-
Tunisia	n.a.	-	-	-	-	-
Morocco	n.a.	-	-	-	-	-
Total		21	20	9	6	-

Source: ESCWA compilation.

* Combination of several companies/organizations in one question.

** Including regional organizations OAPEC, GOIC and AREC.

\+ Paper provided.
\- Paper not provided.

1.5 Organization of the report

The report consists of five parts and two annexes as follows:

Part One : Introduction
Part Two : Status of the industry
Part Three : Current technological capabilities
Part Four : Future technologies
Part Five : Conclusions and recommendations
Annex I : Case-studies
Annex II : Field-work

Part two provides basic country data on the oil refineries and petrochemical industries. It includes available information on capacity, technology and manpower of the plants as well as on the organizational set-up and managerial responsibilities for production and expansion. In addition a short historical overview of the industry is provided.

Part three assesses the technological capabilities at the following levels: project; sectoral (specialized training centres, etc.); and national (universities, consultants, contractors, etc.). It assesses the capabilities of regional organizations engaged in technological development. In addition to examining the capabilities in each of these organizational elements and the linkages and interactions between them, the study assesses and examines the manufacturing establishments. The constraints and stimulants which influenced the approach in part two of the study are also valid in this part.

Part four assesses the impact of the future technologies on the development of these industries in the Arab countries and on the capabilities which will be required in the future.

Part five highlights the main findings of the study and presents proposals for strengthening and developing technological capabilities at the various levels.

Annex I consists of case-studies and annex II is a report on the field-work activities undertaken.

2.1 Algeria

Oil production in Algeria is mainly in the hands of the State-owned, Sonatrach company, although there are four other oil-producing companies in Algeria. Sonatrach is following a development programme in order to increase oil production at Hassi Messaoud; a 350 million Algerian dinar contract was awarded to Nuovo Pignone (of Italy) for expansion at Hassi Messaoud in 1984.

Algeria's oil production fell to 640,000 b/d in 1986 from 672,400 b/d in 1985 due to the recession in the oil market and the collapse of prices.

2.1.1 Oil refining

Algeria's oil refining capacity has increased from 137,000 b/d to 525,000 b/d in 1978, divided among the following refineries: Hassi Messaoud, In Amenas, Arzew, El-Djazair, Arzew "Jumbo GPL" Plant, and Skikda.

(a) Hassi Messaoud is Algeria's first refinery, and was built in 1962; its capacity is 170,000 tons/year. A second refinery was implemented at Hassi Messaoud and started production in 1979; its capacity is 1.08 million tons/year. The first refinery produces gas oil, paraffin, regular gasoline and butane. The second refinery produces super and regular gasoline, gas oil and kerosene.

(b) In Amenas has a capacity of 7,000 b/d only and has started production in 1981; it processes crude oil.

(c) Arzew started production in 1972. Almost 50 per cent of the refinery production is consumed locally while the other half is exported to Europe and the United States. This refinery capacity is 2.79 million tons/year of Saharan crude and 295,000 tons/year of residue crude.

(d) El-Djazair came onstream in 1973; its capacity was 2.7 million tons/year; it processes crude received from Hassi Messaoud. Its total output is consumed locally except for naphtha, which is exported.

(e) The Arzew "Jumbo GPL" plant was officially launched in 1984 and has the capacity to produce 4 million tons/year of butane and propane. The first LPG plant in Arzew has the capacity of 2.15 million tons/year, the second LPG plant raised Algeria's annual LPG exports from 1 million tons/year in 1983 to over 2 million tons/year in 1984.

(f) Skikda started operating in 1980 and is known to be the largest refinery in Algeria. The Skikda refinery processes 15 million tons/year of Saharan crude oil and 300,000 tons/year of imported reduced crude.

(g) Other projects include the launching in 1984 of a lubricants unit (120,000 tons/year capacity) at the Arzew refinery and a bitumen unit (145,000 tons/year capacity) which was added to the El-Djazair Refinery.

Algeria's output increased sharply in 1982 but later declined in 1983 owing to the shut-down in the Skikda refinery. Production of motor fuel fell to 386,000 b/d, but rose again to 407,900 b/d in 1984. Oil refinery average annual capacity was 6,1 million tons in 1978-1981 and then rose in 1982 to reach 6,8 million tons. In 1984 it reached a level of 23.1 million tons/year.

2.1.2 Petrochemicals and fertilizers

The petrochemical industry includes the Annaba complex, the Arzew methanol and synthetic resin complex, and the refinery's aromatic units.

(a) The Annaba complex consists of four units; (i) the phosphate fertilizer plant; (ii) the sodium tripoly phosphate unit launched in 1980 with a capacity of 40,000 tons/day of TSP. The Societe Nationale des Industries Chimiques (SNIC) receives all the plant output for detergent manufacture; (iii) the ammonium manufacturing unit, the production capacity of which is 300,000 tons/year which is utilized in the nitric acid unit and the phosphate fertilizer complex; (iv) the ammonium nitrate and nitric acid units, the capacity of which is 300,000 tons/year of ammonium nitrate, which is used for local agricultural purposes as well as for export.

(b) The Arzew Methanol and Synthetic Resin Complex capacity is 100,000 tons/year. The plant was launched in 1976. Most of the plant products are for export. The complex has resin units which have been operating since 1978. Each unit has a production capacity of 500 tons of melamine resin, 600 tons of urea resin, and 600 tons of phenol resin.

(c) The Arzew Complex was constructed in 1970 and consists of four units: a 400 tons/day urea unit, a 400 tons/day nitric acid unit, a 500 tons/day ammonium nitrate unit and a 1,000 tons/day ammonia unit. The fertilizers are consumed locally while most of the ammonia output is exported.

(d) In the Skikda Ethylene Complex, Snamprogetti was awarded a contract for the construction of a polyethylene unit, which came onstream in 1978 and produced 41,272 tons in 1979. Toyo Engineering Company (of Japan) was awarded the contract by Sonatrach to construct an intermediate petrochemicals complex, a VCM unit with a 40,000 tons/year capacity and a PVC unit with a capacity of 35,000 tons/year were established. In 1980 a 48,000 tons/year low-density polythylene unit was established, as well as a chlorine unit and a hydrochloric acid unit with 35,000 and 10,000 tons/year capacity respectively.

(e) The Skikda Refinery's Aromatic Units have a production capacity of 90,000 tons of benzene, 247,000 tons of xylenes, 5,000 tons of toluene and 38,000 tons of paraxylenes.

PART TWO

STATUS OF THE INDUSTRY

2.2 Bahrain

Bahrain's oil production is expected to be maintained through the end of the century. In 1980, estimated crude oil reserves were in the range of 225 million barrels. Bahrain oil production reached its peak in 1970 at 76,000 b/d. Since then there has been a decline in production, which dropped in 1980 to 48,000 b/d. Crude oil comes from the oil field of Jabal Al-Dukhan. Associated natural gas production started in 1938. Non-associated natural gas production started in 1950 at the Al-Khuff formation. The total estimated natural gas reserves of the country are 255 billion cu.m. Natural gas production in 1980 reached 3.5 billion cu.m.

2.2.1 Oil refining

Bahrain has one of the oldest refineries in the Gulf. The Awali refinery of the Bahrain Petroleum Company (BAPCO), built in 1936, has a current designed capacity of 12 million tons/year. The refinery was wholly owned and operated by Caltex (American company). The Bahraini Government became a 60 per cent shareholder of the refinery in 1980, and therefore was obliged to supply 60 per cent of the crude oil input which was imported from Saudi Arabia.

The average annual capacity of oil refining in Bahrain was at a standard level of 12 million tons during the period 1978-1984. Exports of refined products reached 192,875 b/d in 1984.

An agreement between the Bahraini Government and Caltex continues to provide the refinery with operational expertise; this agreement was renewed in 1985 for another four-year period.

2.2.2 Petrochemicals and fertilizers

The Gulf Petrochemical Industries Company (GPIC) was established in 1979 as a joint venture between Bahrain, Kuwait and Saudi Arabia. The complex consists of a 1,000 tons/day capacity ammonia plant, and a 1,000 tons/day capacity methanol plant, and became fully operational in 1985.

Italy's Snamprogetti was selected to do the detailed engineering, equipment procurement, construction and commissioning while King Wilkinson was selected to provide technical assistance during project execution; Uhde Gmbh of the Federal Republic of Germany was selected to provide the basic engineering package with Uhde being the licensor of the ammonia plant and sublicensor of I.C.I for the methanol plant.

GPIC has prepared a comprehensive training and career development programme for Bahrain and other Gulf nationals to provide the future management, operational and maintenance personnel.

As well as receiving special training at technical institutes, the company's trainee engineers have been attached temporarily to the offices of the licensor and contractor. Additional on-the-job training has been provided in plants and refineries in Bahrain, Kuwait and Saudi Arabia.

GPIC has set up an ambitious recruitment and training plan for the period 1985-1990 to develop and qualify the national staff in various occupations in order to run the operations of the plants by 1990.

GPIC has two marketing agreements, one with the Saudi Basic Industries Company (SABIC) and the other with Petrochemical Industries Company (PIC) of Kuwait for marketing of ammonia. The production level in GPIC was for 1985 at 104 per cent for methanol and 103 per cent for ammonia, which is higher than the designed level.[1/]

2.3 Egypt

The General Egyptian Petroleum Corporation (GEPC) fully owns and manages several 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 under construction in Assiout. There is a petrochemical plant which is also under construction near Alexandria and a natural gas company. The total capital invested in these nine companies is over 1.2 billion Egyptian pounds and the annual sales are over 5 billion pounds. The work force in the refining and petrochemical plants reached a total of 13,500 workers in 1983; in the entire petroleum industry the total number of workers is 42,000. The total future investment for the petroleum industry within the 1983-1987 five year development plan is 1 billion Egyptian pounds.

2.3.1 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 efficiency 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. However, 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.

1/ GPIC, Experience in Developing the Petrochemical Industry in Bahrain, Paper presented to the Seminar on the Petrochemical Industry in the Arab Countries, Bahrain, 20-22 January 1986.

The installed crude oil refining capacity in 1983 totalled 15 million tons as compared with 12 million tons in 1980 and 7 million tons in 1973, which means refining capacity grew at 10.2 per cent per year after the 1973 war. The total petroleum production amounted to 13.1 million tons in 1980, as compared with 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 with 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 3.2 million tons in 1970 to 13 million tons in 1980, while crude production rose at 15.2 per cent.

The refined oil output in 1983 reached 18.1 million tons, out of which 560,000 tons were from the Ras Tanura terminal in Saudi Arabia; this represented an increase of 7.9 per cent over 1982.

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

1. Benzene/Naphtha	2,323
2. Kerosene/Turbine (Jet oil)	2,135
3. Gas oil/Diesel oil	2,862
4. Mazout (fuel oil)	8,879
5. Asphalt	508
6. Base lubricants	122
7. Others	121
Total	16,950

Production by refinery in (thousand metric tons) was as follows:

Year/Plant	Ameriyah	Suez 1	Suez 2	Tanta	Monstards	Alex	Total
1980	3,040	2,137	1,092	9,69	4,489	5,040	16,767
1983	2,913	3,282	1,142	1,005	4,895	4,907	18,144

Refining capacities are being expanded at the Alexandria refinery and the reforming unit in the Suez refinery is being expanded; its capacity will reach about 22 million tons in 1985. Further increases of refining capacity are also planned, in order to reach a capacity of 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). The current expansion programme includes construction of a new refinery at Asyut and recommissioning of the Suez refinery. Asyut is scheduled to start production at an initial rate of 40,000 b/d by 1987. The revamped Suez refinery is to come onstream at 112,000 b/d in late 1987. There are also plans to increase output 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 per year against an annual rise in output of no more than 7 per cent. Domestic consumption accounted for 46.5 per cent of output in 1983/1984. 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.

2.3.2 Petrochemicals and Fertilizers

The only petrochemical plant established in Egypt is currently under construction. The first stage includes the erection of 3 plants: for MVC, at a capacity of 100,000 tons/year, for PVC 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 were awarded to international companies. The plants were due to be completed in 1985/1986. A second stage is planned for the production of ethylene at 200,000 tons/year and low density polyethylene.

The fertilizer sector is under the authority of the Ministry of Industry. The four plants using natural gas resources are all currently operating, the Dekheila plant at a capacity of 500,000 tons of urea/year and 100,000 tons/year of ammonium nitrate, the Talkha I plant, opened in 1976, at a capacity of 380,000 tons/year of nitrogenous fertilizers and Talkha II, 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 nitrogenous fertilizers.

Future expansion plans in fertilizers includes a new plant to be established in the Suez area, with a capacity of 1,350 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, 1,000 tons/day, will be used to produce 2,550 tons/day (765,000 tons/year) of ammonium nitrate. Construction of the plant was scheduled 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.

Table 2.1. 1980 refining production capacity in Egypt

(000 tons)

Products Refinery	Ameriyah	Suez 1*	Suez 2*	Tanta	Mustard	Alexandria	Total	%
LPG	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
Gas oil	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	

Source: ESCWA, based on national information.

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

2.4 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 and 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 were 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 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 the Fertilizer Industry. The production of crude oil reached over 2.5 million b/d while natural gas production reached over 11 million cu m in 1980.

2.4.1 Oil refining

- Al Wand Refinery: established in 1927, at a nominal capacity of 250,000 tons/year, its capacity was later increased to 500,000 tons/year.

- Haditha Refinery: established in 1949, at a capacity of 250,000 tons/year.

- The Al-Multiya Refinery: established in 1953, at a capacity of 200,000 tons/year. This refinery was closed in 1973.

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

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

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

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

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

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

Iraq's total refining capacity in 1980 reached approximately 15.5 million tons/year.

The main refined products and total production in 1979

Product	Thousand tons
LPG	364
Gasoline	1,258
Kerosene	975
Jet	443
Gas oil/Diesel/Oil	2,214
Fuel oil	5,404
Asphalt	1,000
Total	11,658

There are two established and operating LPG plants, with a total designed capacity of 150 million cu.ft/d, currently producing 450,000 metric tons/year of mixed LPG products. A third plant is planned, with a designed capacity of 1.2 million metric tons/year.

LGP plant location and designed capacity

Location	Designed capacity million cu ft/d	Mixed LPG products (000) metric tons/year
Tahji	80	250
Zubair	70	200
Southern Iraq (planned)		(1,200)
Total	150	1,650

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

2.4.2 Petrochemicals and fertilzers

The State Organization for Petrochemical Industries was established in the late 1970s to sponsor the execution of work on 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 130,000 tons/year; feedstock will be 90 million cu ft/day of natural gas.

Ethylene is to be used to produce the following final products 60,000 tons/year of PVC; 60,000 tons/year of LDPE and 30,000 tons/year of HDPE, making up a total designed capacity of 150,000 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 2,046 workers, including 100 engineers and 13 administrators, the majority of staff will be recruited locally. The main contractors for the complex are a Federal Republic of Germany-United States group, Thyssen Rheinstahl Technik and C.E. Lummus.

Technipetrol was contracted by ARADET (the Arab Detergents Chemical Company)* in 1984 to build a 50,000 tons/year, linear alkyl benzene plant at Baiji. The plant's construction cost was $95 million. Some of the engineering work and equipment will be supplied by the Techno-export company, 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 State Enterprise for Fertilizer Industries was established in 1970 to undertake the operation of the first nitrogen fertilizer project, A second and third plant were constructed in 1976 and 1979 respectively.

The three plants are designed to produce nitrogen fertilizers (ammonia and urea). The three plants' total capacity for ammonia was 900,000 tons/year, and the actual production nearly 461,000 tons in 1980.

A plan for a fourth plant which is included in the expansion programme of the Enterprise was recently (1983/1984) reformulated, and the location was 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.

A State Enterprise for Phosphates was established in 1976, to undertake the execution and operation of the phosphate fertilizers project in Al Qaim. This project is designed to produce:

600,000 tons/year	TSP
250,000 tons/year	MAP
272,000 tons/year	NPK or NP

The two above-mentioned State Enterprises are responsible only for the production of fertilizers, while domestic sales and exports are the responsibility of other local specialized organizations.

---

* ARADET was established in 1981 and based in Iraq as a joint Arab 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).

The total of estimated manpower in the fertilizer industry for the period 1970-1980 is given below:

Year	Total employees
1970	700
1975	900
1980	3,262

2.5 Jordan

Jordan is not an oil-producing country; it has no hydrocarbon resources, nor gas reserves and 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 chemical 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 the country's 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/year. Several extensions were subsequently carried out, bringing nominal capacity to its present 5 million tons/year. The Zarqa refinery has also been modernized through the construction of two conversion units: a hydrocracking unit of 198,000 tons/year and a FCC unit of 211,000 tons/year. It has 26,000 employees, all of whom are nationals. The refinery's actual production in 1980 was as follows:

Products	1,000/tons
LPG	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 fulfil the national requirements in the near future.

2.6 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. The 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 liquefication operations, and Kuwait Oil Tankers (KOTC) is in charge of transporting crude oil, liquefied 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:

	Millions b/d	Millions 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.

2.6.1 Oil refining

KNPC, which is the focus of this study, was established in 1960 with a capital of KD 15 million of which 60 per cent was initially held by the State and the rest by private Kuwaiti interests. In 1961 KNPC first took over 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. The Shuaiba refinery was the first refinery fully owned by the Kuwait Government; the refinery was established in 1965 and put onstream in 1968. The Shuaiba refinery has been considered one of the largest world refineries which mostly uses hydrogen in its operating units to produce export-oriented high quality fuels. At its inception, the refinery had a designed capacity of 95,000 b/d. The current capacity was brought up to 195,000 b/d after carrying out some debottlenecking and revamping of the vacuum distillation unit. The Shuaiba refinery comprises now the following principal operating units:

- Atmospheric and vacuum distillation unit, capcity 195,000 b/d.
- Hydrogen production unit, capacity 220 million cu ft/d.
- Naptha fractionator unit, capacity 41,000 b/d.
- Naphtha, kerosene, light diesel and heavy diesel hydrotreatment units, capacity 36,000; 45,000; 18,000; and 14,000 b/d, respectively.
- Heavy gas oil hydrocracking unit, capacity 23,000 b/d.
- Heavy residue hydrocracking unit, known to be the first of its kind to be commercially introduced, capacity 50,000 b/d.
- Naphtha platinum reforming, capacity 16,000 b/d.
- Sulphur recovery, capacity 570 tons/d.
- Lube oil blending unit, annual capacity 32,000 tons.

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

The Ahmadi refinery started with a crude distillation unit (25,000 b/d) to produce fuels for bunkering and local marketing, gasoline, kerosene and gas oil. The refinery later added two distillation units of 110,000 b/d each, whose capacities were increased by revamping to reach a total capacity of 270,000 b/d. Other units, acquired by the Ahmadi refinery through its development, include propane and liquefied gas recovery, 90,000 b/d, gasoline, kerosene and atmospheric residue desulphurization, and naphtha platinum.

The Mina Abudulla (MAB) refinery started with a distillation unit of 30,000 b/d which was destined to process the high sulphur crude oil from the Walfa oil fields, which represents Kuwait's share of the neutral zone. The capacity of the MAB refinery was increased to reach 47,000 and 110,000 b/d in 1960 and 1962 successively. Some modifications of the distillation units were later introduced and a vacuum unit was added, culminating in a capacity increase to 144,000 b/d. In 1968, a hydrogen unit, (38 million cu ft/d), a heavy gas oil desulphurization unit (35,000 b/d) and a sulphur recovery unit (325 tons/d) were added. A modernization upgrading plan for the MAB refinery envisions the commissioning in 1986 of two atmospheric residue desulphurization units (33,000 b/d each), two delayed coker units (30,000 b/d each), in addition to a kerosene desulphurizer (16,000 b/d) and a gas oil desulphurizer (55,000 b/d). In 1978 the MAB refinery was fully taken over by the Government from Aminoil. For the fiscal year 1982/1983, the 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 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 the Ahmadi refinery to meet domestic consumption of these gases. This was followed later by the establishment of two units (65,000 b/d) which process the condensate collected from oilfields. The capacity of these two units was thereafter increased to 80,000 b/d. A propane recovery unit was added in 1971, thus increasing the total output of propane-butane gases to 90,000 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 (1.7 billion cu ft/d) comprising three trains (575 million cu ft/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 100,000, 55,000 and 40,000 b/d of propane, butane and natural gasoline respectively, in addition to 1.1 billion cu ft/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 was 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 cu ft (BSCF) of gases and condensates. The plant produced 773,000, 653,000, 59,000 and 457,000 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) was 967,000 and 54,000 tons, for 1982/1983. Domestic power stations consumed 482,000 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 are approximately KD 714 million, indicating added assets due to expansion in the same fiscal year (1983/1984). The total crude throughput to the three refineries was 170 million barrels (an average of 464,000 b/d). The refined products amounted to 24.2 million metric tons, distributed as follows:

Shuaiba 46 per cent; Ahmadi 30 per cent; and MAB 24 per cent. Production was as follows: 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 for the gas liquefaction plant was 180 BSCF and the propane-butane output amounted to 1.8 million metric tons. 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 tons.

A breakdown of the distribution of sales for 1980 was issued by the Ministry of Oil and indicated 180,000 b/d for the domestic market (37 per cent), 22,000 b/d for the Arab market (4.5 per cent) and 286,000 b/d for other markets (58.5 per cent).

Liquefied gas export was estimated for 1980 at 2.27 million metric tons the distribution of which according to destination was about 66,000 tons for the domestic market (3 per cent), about 11,000 tons for the Arab market (0.5 per cent), and about 2.2 million tons for the other markets (96.5 per cent).

Hydrocarbon exports in 1983 totalled approximately 366 million barrels, which is distributed as follows: 200 mn b/d crude oil (54.6 per cent); 150 mn. b/d refined products (41 per cent); and 16 mn b/d LPG (4.4 per cent). The total value of all hydrocarbon exports was estimated at about $US 11 billion. The approximate values of the exported refined products (except for sulphur) are as follows: naphtha, $850 million; aviation fuel, $40 million; kerosene, $400 million; diesel oil, $1 billion; marine diesel, $20 million; furnace fuel, $1.7 billion; and LPG, $380 million. 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 noting that the implementation of the KNPC refining programme is made through a processing agreement between KPC and the three refineries whereby KNPC acts as a profit centre. The integration of the three refineries enables 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.

2.6.2 Petrochemical and fertilizers

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 ensure 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 of using natural gas, considered to be

Kuwait's second most important 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, a sulphuric acid plant, an ammonium sulphate plant, and a urea plant. The first three plants were put onstream 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 commissioned 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 the Shuaiba area, while having retained the fertilizer company as a separate legal entity. 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 of producing 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 1983/1984 is as shown below:

(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: ESCWA, based on national sources.

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) Destination and sales value

A breakdown of the distribution of sale of products manufactured by PIC during the period 1983-1984 indicates 70,000 MT for the domestic market (11 per cent), 5,000 MT for the 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 a chemical agent for water treatment in refineries and power generation stations which consume annually 8,000 tons of chlorine, 2,000 tons of hydrochloric acid and 10,000 tons of sodium hydroxide. About 100 tons of liquid ammonia are consumed annually by the Kuwait Industrial Gases Company. Consumption of the above chemical products is expected to increase to reach 20,000, 40,000 and 10,000 tons for chlorine, hydrochloric acid and sodium hydroxide respectively.

(c) New and envisaged projects

A new ammonia plant with an annual capacity of 330,000 tons was commissioned in the third quarter of 1984. In addition detailed engineering and civil construction work were completed for a new plant for production of chlorine and sodium chloride, with a daily capacity of 75 and 150 tons, respectively. The plant was due to be completed in the first quarter of 1986.

Expansion projected for the next five years includes a unit for production of polypropylene (60,000 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.

A unit for the production of ammonium diphosphate is planned (330,000 ton annual capacity), which consumes annually 70,000 tons of ammonia. PIC is thus 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.

2.7 Libyan Arab Jamahiriya

Crude oil production was at its peak in 1970, at 3.3 million b/d, and then was reduced to a level of 2 million b/d in 1980. In 1985, Libyan production reached 1.1 million b/d.

2.7.1 Oil refining

The first Libyan refinery was established in Mersa El-Brega in 1970 with a 10,000 b/d capacity. In 1977 another refinery came onstream with a

120,000 b/d capacity at Zawia which was expanded later on to reach 180,000 b/d. A third plant was completed in 1983 with a capacity of 220,000 b/d. Two asphalt units were installed at Benghazi and Zawia with a 3,600 b/d capacity. A small refining plant was also established with a 20,000 b/d capacity in 1985. The Libyan Arab Jamahiriya is planning to reach a total refining capacity of 672,200 b/d in 1987, with three new refineries due to be completed.

The Ras Lanuf refinery which was due for completion in 1984 was delayed for more than a year due to failure to conclude term contracts. The refinery started production by mid-1985, at a capacity of 120,000 b/d. The refinery's products are for export since the Libyan Arab Jamahiriya is already self-sufficient with respect to refined products. Ras Lanuf processes fuel oil, gas oil, naphtha and kerosene.

In 1985 a $US 50 million turnkey contract was awarded to Tecnimont (a subsidiary of Italy's Montedison Group), for the design and construction management of a number of new additional units in the refinery, including vacuum distillation, naphtha processing, hydrocracking, coking, calcination and viscosity reduction units, all scheduled to be completed by 1990.

At present a petroleum coke plant with a capacity of 179,000 tons/year is to be built by Marubeni of Japan at a cost of $1.25 billion. It will also supply materials and equipment. Daewoo of the Republic of Korea is responsible for the civil works, Belleli the mechanical and electrical machinery, and the project management will be by Foster Wheeler Italiana. The petroleum coke plant will include a vacuum distillation unit, an LPG extraction unit, and a fluid catalytic cracking unit; the entire plant will cost $300 million.

Oil refining average annual production capacity was 6.8 million tons in 1978 and 1979; it rose to 7 million tons in 1980, but declined in 1981 to a level of 6.4 million tons. In 1984 it increased once again to reach a level of 16 million tons.

2.7.2 Petrochemicals and fertilizers

The petrochemical development programme in the Libyan Arab Jamahiriya consists of two major petrochemical complexes. The first complex is located in Marsa El-Brega, and the second at Ras Lanuf. The Marsa El-Brega complex was completed in two phases; the first phase started operation in 1981 and comprises a 1,000 tons/day methanol plant, a 1,000 tons/day urea plant, and a 1,000 tons/day ammonia plant.

The second phase of the complex was completed in 1985 and consists of a 1,750 tons/day urea plant, a 1,000 tons/day methanol plant, and a 1,000 tons/day ammonia plant.

The first phase of the Ras Lanuf complex was planned to come onstream in 1986; it consists of a 50,000 tons/year low-density polyethylene unit, a 50,000 tons/year high density polyethylene unit, a 50,000 tons/year high density polyethylene unit, a 50,000 tons/year polypropylene unit, a 52,000 tons/year ethylene glycol unit, a 58,000 tons/year butadiene unit, and a 330,000 tons/year ethylene unit.

The design, project management and co-ordination of the second phase of the complex was awarded to Tecnimont (of Italy) under a $50 million contract.

2.8 Morocco

Morocco's crude oil production declined in 1976 to reach 9,000 tons compared with 42,000 tons in 1973, but then showed a gradual increase to reach 16,500 tons in 1984. The fluctuation in oil production was due to the depletion of some of the producing fields. Morocco's demand for crude oil is met partially by its own production and partially by imports from Saudi Arabia, Kuwait, Iraq and the Soviet Union.

2.8.1 Oil refining

Morocco's oldest refinery was built in 1940 at Sidi Kacem; its capacity is 1.1 million tons/year. Its second refinery is located at Mohammedia and was launched in 1959; the refinery's capacity was 1.3 million tons, and was raised to 6.75 million tons/year, due to the expansions which included a 300,000 tons/year hydro-desulphurization and gas separation plant, an olefin unit capable of producing 150,000 tons/year of ethylene, a 300,000 tons/year ATK unit, and a 700,000 tons/year reforming unit. These expansions were finalized in 1980; in 1984 a lube oil complex was added to the refinery on a turnkey basis and at a cost of $140 million by Technip (of France), and Technipetrol (of Italy).

Morocco has been self-sufficient in its domestic needs for refined products due to its two refineries. Its oil refining average annual capacity rose from 3.6 million tons during 1978-1981, and increased gradually to reach 4 million tons in 1984.

2.9 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 it is expected to be producing in 1988. The country's total population is 200,000 (1984) with 46 per cent below 15 years, and the active population 37 per cent. The Qatari work force 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 was not more than 15 per cent of the Qatari work 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. In addition, 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 generated 66 to 80 per cent of GDP in the period 1980-1983. Oil revenues represented 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, to take over, expand and control all operations of its oil resource production base and marketing services, to diversify the sources of national income, to create a balanced economy not totally dependent on oil production and sales, to invest oil revenues for expanding the country's productive industries, to build the needed infrastructure in transport, communication, housing, water, energy, electricity, education and health facilities, to increase agricultural production and to better direct the trade, finance and services sectors in Qatar.

To accomplish this, Qatar's Government was faced with the problems of a shortage of local managerial and skilled manpower, limited local markets and deficient infrastructure. Thus export orientation 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 a comparative investment advantage in addition to cheap energy and raw materials, mainly petroleum and gas.

Industrial development started in Qatar on a limited scale during the 1960s, and on an individual project basis. For both economic and technical infrastructural reasons, during this stage few basic industries, such as oil refining and chemical fertilizers, were developed.

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 and a deep water industrial port is in full operation, as are power and desalination plants. Other facilities are provided, such as housing, roads, social and cultural facilities for workers, and there are 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 which 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 as of 1984 had consumed a State investment of 8,875 Qatar riyals.

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 a 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, exchanging information and experience between local companies and co-ordinating training of local manpower and exchange of experience.

IDTC has built up a team of local and Arab professionals, comprising 80 full-time staff. All are experts in related specializations. They include experienced engineers, scientists and economists, of whom 80 per cent work on the technical side, plus support personnel (for 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. IDTC also has a standing consultancy agreement with a leading international firm in engineering consultants, plus drawing as required, on 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 the environment from industrial pollution 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. The goal of preventive maintenance is to secure successful long-term operations of plants and to ensure 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 up by this committee tests samples of products as a quality control and operates a mobile laboratory to serve the different companies. The committee studies their problems and its experts participate in co-operation with the companies technical staff in finding solutions and working to develop productivity measures.

An example of the IDTC 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. IDTC 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 IDTC 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 IDTC has in the past 12 years acquired experience and knowledge in 11 project identifications 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) and 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 1970s, 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 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.

In 1983 the number of employees at QGPC and its subsidiaries (NODOC, QAPGO and QAFCO) numbered 5,553. Many Qataris at QGPC occupy the decision-making positions and most management personnel are Arabs. In 1982, 27 Qatari university graduates were employed by the company and its subsidiary industries. In the area of training, 29 trainees had training courses in 1982. Another seven of the Qataris employed continued their higher education abroad in the same year. A number of Qataris have been trained as computer programmers and operators through courses in the United Kingdom 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.

2.9.1 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 QR 40 million. 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 Said, with a name plate capacity of 6,700 barrels per day. It was commissioned in 1975, the refinery was subsequently in 1977 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 6,000 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 designed capacity expanded to 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.

The 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 engineers 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 staff of 292 in 1979. At present the two refineries are run 100 per cent by a Qatari and Arab work-force.

In March 1971 Qatar started a large QGPC project, 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. It was decided to reconstruct on the same site at Umm Said and the reconstructed 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 metres of methane rich gas. The ethane rich gas is used in the petrochemical complex of QAPCO. Production started at the NGL.1 factory 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 the 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 units of ethane rich gas, butane, propane and natural gasoline condensates was 0.8 million tons in 1982, 1.1 million tons in 1983, and 1.43 million tons in 1984. Local consumption in 1984 reached 638,742 tons and 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 the Companie Francaise des Petroles (CEF Total). QGPC has 85 per cent of the 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 probably of 300 to 400 trillion) cubic feet are estimated to make up some 10 per cent of the world's total gas reserves. The cost of the development plan is estimated at QR 6 billion 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 2.4 trillion 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 Federal Republic of Germany company) have completed a feasibility study for developing the project, and the United State company Fluor Inc. was chosen to provide consultancy work, such as detailed facility definitions, planning and design of the NGL stripping facilities for phase I, which was to be completed in 1985. Flour would also provide staff to work on the job.

2.9.2 Fertilizers

Established in Qatar in 1969, QAFCO was the first petroleum project which was 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 authorized capital is QR 100 million, in addition to its paid up capital, while its total assets are QR 1 billion.

QAFCO's first nitrogenous (ammonia/urea) plant began production in 1973 and was built at a cost of QR 360 million. 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 QAFCO exported 201,589 tons of ammonia and 717,146 tons of urea (two thirds of the ammonia produced is used in urea production). The exports are sent to the Arab world (Jordan, Morocco, Oman) and other countries including the United States, China and India. Though its operational efficiency is high and all products are sold to world markets, 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.

2.9.3 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 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 cost was QR 2,500 million ($687 million). The designed capacity of the plant is 280,000 tons/year ethylene and 140,000 tons/year low density polyethylene, and 50,000 t/year sulphur.

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

	Ethylene(t/y)	LDPE (t/y)	Sulphur (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 and 1984 were:

	Ethylene(t/y)	LDPE (t/y)	Sulphur (t/y)
1983	7,000	132,000	25,000
1984	64,130	151,921	23,000

The main destinations of sales (1983) were 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 LNG plants at Umm Said.

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

To solve partially 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 the QAPCO petrochemical complex. The new unit will increase QAPCO 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).

2.10 Saudi Arabia

2.10.1 General

Saudi Arabia is the world's largest oil exporter and was a founding member of OPEC. Oil was discoverd in the country in 1938, but large-scale development of oilfields began only after the Second World War. 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 figures for 1980-1984 are as follows:

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 varieties. 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 million b/d unless plans to increase heavy oil production were implemented. Secondly, Saudi Arabia's Master Gas System - a $20 billion project for the gathering of natural gas - cannot absorb associated gas output beyond approximately 7.3 million 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 million barrels
Arabian Oil	69.9 million barrels
Total	3,623.5 million barrels

This constituted 16.6 per cent of world production.

The principal ARAMCO 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 m in 1983. Net production in 1981 totalled 52,382 million cu. There is an NGL plant at Abqaiq and an 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 centres:	Berri	NGL	54,000 bl
		Methane	400 mn cu f
	Shadqum	Feed	1,500 mn cu f
		NGL	160,000 bl
		Ethane	780 mn cu f
	Othmaniyah	Feed	1,400 mn cu f
		Methane	525 mn 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 infrastructural 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 infrastructural 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 the setting up of 17 primary industries, 136 secondary industries and over 100 tertiary industries by the year 2000. Once into 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 the eastern province with the port of Yanbu. Its throughput is 1.6 million b/d, which can be upgraded to 2.3 million b/d. It was completed in 1981 by the United States Mobil Overseas Pipe Line Co. (cost $1,600 million). Aramco has also completed the construction of a high pressure pipeline for transporting 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 approximately 300,000 b/d.

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

Electricity	SRls 0.07	or	$0.52/kWh (one fourth of generating cost)
Land	SRls 0.08	or	$0.03/sq m.
Water rate	SRls 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; importing raw materials needed, conducting studies; conducting petroleum and mineral operations such as exploration, production, refining, transportation and distribution, and co-operating 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 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 SRls 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 Fertilizer Company (SAFCO), established in Dammam in 1964. Since 1981 it has been producing 300,000 t/y of urea. SAFCO also markets Samad output.

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

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

Under construction and/or near completion are:

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

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 an 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

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

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

---

* MTBE is an agent used to upgrade the octane level of petrol.

The products of the first generation of SABIC industries are:

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

The following table gives the name(s) of the partners of SABIC in the joint venture:

	Joint venture partner of SABIC	Partner share (percentage)
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 Fertilizer Co. (Taiwan)	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 (Republic of Korea)	15 %

2.10.2 Oil refining industry

Saudi Arabia's oil refining capacity in 1984 was put at 2,045,000 b/d with most of it at the ARAMCO 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.

In addition a number of refineries have been expanded and modernized. The first one was the Riyadh Refinery, which is now able to run at 6 million tons a year. Since this capacity is not enough to satisfy local demand, a new refinery at Suraidah will be built, with a capacity of 7.5 million tons a year. This refinery serves the central province. Start-up was scheduled for 1986-1987, but latest information indicates that this project has been rescheduled.

In the western region a refinery was built at Yanbu (cap. 7.7 million tons a year). 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.

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.

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

Name	Location	Employees	Capacity (000 b/d)
PETROMIN-Shell Refinery Company	Jubail	645	250
PETROMIN-Mobil Company	Yanbu	706	150
PETROMIN Refinery Company	Rabigh	515	325
Yanbu Refinery	Yanbu	509	170
Riyadh Oil Refinery	Riyadh	400	120
Mina Saud	Neutral zone	No data	55
Al Khafji	Neutral zone	No data	33
	Buraydah	No data	160
	Shakaikh	No data	160
Jeddah Oil Refinery	Jeddah	556	100
Ras Tanara	Ras Tanara	No data	745

Furthermore, there are a number of lubricating oil refineries in Riyadh, Jeddah and 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); this plant had many technical problems after its establishment, resulting in poor performance in production output. Actual output was far below designed output. However, 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 million to $250 million), with a capacity of 1,500 t/d. This plant will come onstream in 1987 and engineering and feasibility 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 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 SABIC project, 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 construction 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 jointly established the 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.

2.11 Syrian Arab Republic

The Syrian Arab Republic has formulated Five-year Development Plans since 1960. The industrial sector has always been given 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.

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.

2.11.1 Oil refining

There are three main petroleum-based industries in the Syrian Arab Republic. They are as follows:

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

Each of these organizations is described below:

Table 2.2 Allocations for the Third, Fourth and Fifth Development Plans in the Syrian Arab Republic

Industrial branch	Third Plan 1970-1975 allocations	Fourth Plan 1975-1980 allocations	Fifth Plan 1981-1985 allocations a*	b**
	(Million of Syrian pounds)			
- 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	1,228.0	890.7]	
- Engineering	115.1	673.3	177.4]	
- Chemical	207.0	3,402.4	748.5]	
- Food processing	70.4	163.5	79.8]	
- Sugar	10.1	617.4	244.8]	
- Portland cement and building materials	150.0	2,570.6	951.2]	4,050.2
- Tractors and agricultural implements	97.3	1,500.0	34.5]	
- Flour mills and bakeries***	66.0	361.0	1,817.3]	
- Tobacco***	37.0	136.0	79.7]	
- Oil refining***	-	1,429.2	1,290.0]	
			6,794.8	4,050.2
			a+b	
TOTAL	982.4	9,386.3	10,845.0	

Source: ESCWA, based on national sources.

* 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.

(a) Homs Oil Refinery Company

This refinery was established in Homs in the late 1950s 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 1960s, the refinery underwent six expansion schemes, whereby its capacity was increased fivefold 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) The Banias Oil Refinery Company

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 turnkey 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. The 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: Rumanian, Federal Republic of Germany and American.

2.11.2 Fertilizers

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 plant is given below:

(a) The calcium ammonia nitrate plant

Originally this plant was to be built by the Soviet organization Nephtechim Promexport in the early 1960s. 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 as follows:

- The nitric acid unit, with a design capacity of 8,700 tons/year of 100 per cent nitric acid: supplied by Nephtechim Promexport;

- The ammonia unit, with 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) with 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 115,000 to 120,000 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 above, 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 was planned for 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 Rumanian 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.

2.12 Tunisia

Oil crude production reached 5.54 million tons in 1983, but fell to 5.49 million tons in 1984. El-Borma and Ashtart are the two main producing oil fields. Output at El-Borma reached 3.4 million tons in 1984, while it dropped in Ashtart from a peak of 2 million tons in 1979 to 1,284,000 tons in 1984, due to the failure of water injection systems in the field. Tunisia imports crude oil mainly from Saudi Arabia.

2.12.1 Oil refining

Tunisia depends mainly on the Bizerte refinery for most of its demand for refined products. The refinery's capacity was raised from 34,000 b/d to 3 million tons/year in 1985, due to expansions that cost $20 million.

Tunisia's demand for refined products is much larger than what it can produce locally; it imports its needs from Italy and Greece. Its refineries output met only 53 per cent only of local demand in 1983.

Consumption decreased by 4.8 per cent due to the increase in demand of natural gas instead of fuel oil. In 1983 the gap between supply and demand fell to 1.1 million from 1.3 million tons.

The Government has planned to expand the capacity of the Bizerte refinery in order to cut down on its imports. Therefore, a project for doubling the refinery's capacity was launched in 1985, at a cost of $20 million. Production of oil refining reached an average annual capacity of 1.7 million tons during 1978-1984.

2.13 United Arab Emirates

In view of the importance of oil derivatives in industry in generating electric power and in supplying fuel for various means of transportation, thinking was focused in the early 1970s 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. The work included exploration of oil and natural gas. The Company produces, refines and transports these products and other by-products, market them, exports them and distributes 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, the execution of many development programmes in oil fields and reservoirs and the 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.

2.13.1 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 the refinery was 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 the Ruwais Refinery is 120,000 b/d or 5.2 MT/y of crude oil produced from the main onshore and offshore fields. It comprises six units: a crude distillation unit, a naphtha desulphurizer unit, a platforming unit, a kerosene hydroheater unit, a heavy gas oil desulphuric unit and a sulphur recovery unit. It also has the necessary installations to produce electric power and steam, pump sea-water and desalinate it, and to produce compressed air and nitrogen. Adjacent to the refinery, 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 MT/y 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)	1,595,000 tons
Fuel oil	1,785,000 tons
Sulphur	9,000 tons

Umm-Al Nar second refinery

The second Umm-Al Nar Refinery was established to expand the petroleum industry and maximize benefits from oil revenues, thus increasing their contribution to the national income as well meeting 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. The refinery was designed to refine 60,000 b/d of crude oil. The refinery comprises the following main producing units: distillation and desalination unit; unit to improve products by chemical catalyst; unit for treating kerosene with hydrogen; unit for desalination and fractionating of gas; unit for extraction of sulphuric water; and 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: a vacuum distillation unit with a capacity of 46,000 b/d; a 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 project's annual production capacity for petroleum products:

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 production capacity of 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.

2.13.2 Fertilizers

FERTIL was established by decree in October 1980 as a joint venture, with ADNOC holding 66.6 per cent of shares and the Compagnie Francaise Des Petroles holding 33.3 per cent.

With FERTIL Abu Dhabi entered a new era of industrialization whereby its natural resources were 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 design, 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 preparing for the operational and marketing phase of the project.

Construction ended in July 1983. The following process plants and related facilities were built:

- One 1,000 million tons per day ammonia plant

- One 1,500 million tons per day 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 transition of the newly recruited personnel to their posts went smoothly; they commissioning operations, carried out with ease and professionalism.

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

Table 2.3 Capacities of petrochemical and fertilizer plants in the 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	Sitra	1985	Methanol	365	Snamprogetti
			Ammonia	365	
Egypt					
	Talkha 1	1976	Ammonia	380	
	Suez	1983	Ammonia	250	
	Talkha II	1979	Ammonia	396	
	Dekheila	1985	Ammonia	500	
Egyptian Petrochemical Company	Amiriya	-	PVC	80	
			MVC	100	
			Chlorine	160	
			LDPE	160	BF Goodrich
			HDPE	160	
Iraq					
State Enterprise for Fertilizer Industry	Abu Flus I (Basrah)	1971	Ammonia	60	Chemico
			Urea	48	
			Ammonium sulphate	126	
State Enterprise for Fertilizer Industry	Abu Flus II (Basrah)	1977	Ammonia	240	Holder Topsoe
			Urea	390	Snamprogetti
State Establishment for Petrochemical Industries	Khor El-Zubair	1979	Ammonia	600	Holder Topsoe
			Urea	960	Snamprogetti
State Establishment for Petrochemical Industries	Khor El-Zubair	1981	Ethylene	130	C.E.Lummus
			PVC	60	Staufer
			LDPE	60	Distillers
			HDPE	30	Phillips
State Enterprise for Phosphates	Al-Qaim	1976	TSP	600	
			MAP	250	
			NPK	272	
Jordan					
Intermediate Petrochemical Industries Co. (IPI)		1984	D.A.P	8	Rio Tinto
			PVC	6	Rhone Poulenc
			Polyester	3	
			Solvents	3	
			F.G. Reinforced PE sheets	500(m^2)	
			Urea formaldehyde	6	

Table 2.3 (Continued)

Country/company	Location	Start-up year	Products	Designed capacity (ooo T/y)	Technology supplier
Kuwait					
PIC	Shuaiba	1966	Ammonia	660	Holdor Topsoe
	Shuaiba	1971	Urea	824	
	Shuaiba	1971	Ammonium sulphate	165	
Qatar					
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	
Saudi Arabia					
SAFCO	Dammam	1970	Ammonia	200	CHEMICO
"	Dammam	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	Jubail	1984	Methanol	600	I.C.I
IBN SINA	Jubail		Methanol	650	Celanese/Texas Eastern
PETROKEMYA	Jubail		Ethylene	500	
SHARQ	Jubail		LDPE	130	Mitsubishi
		1985	Ethylene glycol	300	
IBN HAYyAN	Jubail	1986	VCM	300	
			PVC	200	B.F. Goodrich

Table 2.3 (Continued)

Country/company	Location	Start-up year	Products	Designed capacity (ooo T/y)	Technology supplier
Syrian Arab Republic	Homs	1972	Nitric acid	8.7	Nephtechim Promexport
	Homs	1972	Ammonia	50	Snamprogetti (Casale)
	Homs	1972	Calcium-ammonium nitrate	148	Technoexport
	Homs	1980	Ammonia	300	Kellogg
			Urea	330	Stamicarbon
	Homs	1981	TSP	450	Industrial Export
United Arab Emirates					
ADNOC	Al Ruwais	1984	Ammonia	330	
			Urea	500	
Algeria					
	Annaba	1980	Sodium tripoly phosphate	14,600	
		1979	Ammonium nitrate and nitric acid	300	
			Ammonium	300	
	Arzew	1976	Methanol and synthetic resins	100	
		1970	Urea	400	
			Nitric acid	400	
			Ammonium nitrate	500	
			Ammonia	1,000	
	Skikda	1978	Polyethylene	41,272	
			VCM	40	
			PVC	35	
			HCL acid	10	
			Chlorine	35	
			Aromatics		
			Benzene	90	
			Xylenes	247	
			Toluene	5	
			Paraxylenes	38	

Table 2.3 (Continued)

Country/company Technology supplier	Location	Start-up year	Products	Designed capacity (ooo T/y)
Libyan Arab Jamahiriya				
	Marsa El-Brega (Phase I)	1981	Methanol	365
			Urea	365
			Ammonia	365
	Mursa El-Brega (Phase II)	1985	Urea	365
			Methanol	365
			Ammonia	365
	Ras Lanuf	1986	Low density polyethylene	50
			High density polyethylene	50
			Polypropylene	50
			Ethylene glycol	52
			Butadiene	58
			Ethylene	330

Source: Compiled by ESCWA from national sources.

Table 2.4 Capacities of existing (and under construction) refineries in the region

Country	Location	Start-up	Designed capacity (MT/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

Table 2.4 (Continued)

Country	Location	Start-up	Designed capacity (MT/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	
	Buraydah		7.5	Postponed
	Shukaikh		7.5	Postponed
	Total		96.6	
Syrian Arab Republic	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	
Algeria	Hassi Messaoud	1962	0.7	
	In Amenas	1981	0.1	
	Arzew	1972	2.6	
	El-Djazair	1973	2.5	
	Skikda	1980	14.7	
	Total		20.6	
Libyan Arab Jamahiriya	Mersa El-Brega	1970	0.1 b/d	
	Zawia	1977	0.18 b/d	
	Total		0.28 b/d	
Tunisia	Bizerte	1962	3.0	
Morocco	Sidi Kacem	1940	1.1	
	Mohammedia	1959	6.75	
	Total		7.85	

Source: Compiled by ESCWA from national sources.

Table 2.5 Training centres in the petroleum industries

Country/centre*	Responsible org.	Year est.	Trainee cap.	Training staff T	Training staff A	Training staff 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	2,500	191 (1983)			2 years	36	Construction, Unit operation, electric, Mechanic, Electronic Technology Production	620	584	933	n.a
c. Arab Petroleum Training Institute	OAPEC	1978	n.a.	50					Training trainees in all related subjects	-	-	-	-
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
Syrian Arab Republic													
Training Institute for Petroleum Mineral Industry		1972	400	139	139	-	2 years	18	Electric, refining, precision instruments production	246	213	188	n.a
United Arab Emirates													
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			5,956	566	486	80							

Source: Arab Petroleum Training Institute.

Notes: T = Total, A = Arab, F = Foreign

* No information was provided on Algeria or the Libyan Arab Jamahiriya.

PART THREE

CURRENT 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 under construction, 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 in the past two decades developed 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.

A survey indicates that the Egyptian refining industry is still in a state of limited technological development, the interrelations between companies and R and D are not well organized, and future development of capabilities is dependent on availability of international expertise and technological 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 reliance on foreign expertise and know-how. Turnkey agreements were signed for 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, are 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 expansion and the refinery relocated 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 1970s, and with the adoption of the "open door" policy, which encourages 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 contracts awarded to use local capabilities in consultancy, engineering design and construction for at least 50 per cent of the workload, to ensure 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 contact directly 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 (see also table 3.1).

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

The specialized personnel in GEPC and the concerned refining company undertake, usually 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 plant 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 beneficiation plant from Suez to Cairo.

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

- The 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, beneficiation 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 in order 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, 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 work-load of the installed units. They diagnose bottle-necks and propose solutions, or request foreign expertise to help to solve difficulties. They request spare parts to be manufactured by 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. However, 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 were acquired in the period 1975-1985, but it is not clear with regard to what activity or scope of work. Furthermore, the research centres 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 carried out 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, to test their quality and adaptability 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;

- Carrying out periodical tests to guarantee the products quality using international and locally developed standardizations;

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

- Exchanging information and experience with similar local and international centres and industries;

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

The Egyptian Organization for Standardization has formulated Egyptian standards which can be applied to a wide range of refined products and fertilizers. All laboratory tests conform to these standards.

(f) Research and development

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 and cover the following:

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

- Market studies, indicating factors to develop production capacities;

- Preparation of product design according to local needs;

- Study of suitable raw materials available locally;

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

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

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

Research undertaken by R and D departments in the petroleum companies includes studies on bottle-necks in production units. Solutions are found internally or through the help of specialized consultancy offices in the case of more difficult problems. There is follow-up of production performances and evaluation of 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 come 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 include:

- Modified chemical compositions of locally produced diesel oil, 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 which were acquired within the period 1975-1985 in petroleum and petrochemicals;

- Industrial contracts for research projects which contribute some 50 per cent to the Centre's financing. (However, it is reported that the Centre's collaboration with industries is limited.)

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

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

- Poor linkages between the R and 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 also seems to be lacking.

The Institute for Petroleum Research has a wider range of applied research work covering petroleum exploration and production of wells, assessment and analysis, refining, petroleum uses, petrochemicals and operational 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, economics, agriculture and business. Some 108 employees have post-graduate qualifications, 40 are graduates of industrial vocational institutes and 116 are secondary school 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 capabilities in manufacturing of equipment (spare parts) by manufacturing independently - or through co-operation and joint ventures with international companies - compressor gears, exchangers, vessels, furnaces 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

The survey indicates that since all products are consumed locally there is continuous feedback from customers. Research centres regularly 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 of performance of products in their different fields of use with regard to the main consuming agents,and provide direct solutions to 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.

Table 3.1 below summarizes the above listed capabilities for a number of projects presently under execution. In addition, an overview is given of linkages which exist between GEPC and the local research centres, universities or national consultancy/engineering centres (table 3.2).

Table 3.1 Technological capabilities in projects under execution* in Egypt

	1	2	3	4	5	6	7	8	9
Pre-feasibility		———	———	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	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, based on national sources.

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

* See list of projects following.

List of projects established and under execution

1. Asyut Refinery
   Capacity 2 million tons/year 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. Beneficiation 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. Beneficiation of Oils Unit (Hydrocracking) (Al Suez Petroleum Processing Company)

10. Benzene Complex
    40,000 tons/year (Al-Naser Petroleum Company)

11. Petrochemical/PVC Plant, capacity 80,000 tons/year

12. Petrochemical/MVC Plant, capacity 100,000 tons/year

13. Chlorine project, capacity 160,000 tons/year

(i) 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 was 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, symposia and workshops, especially for new graduates.

All contracts with international companies include the training of local employees in all stages of implementation of new projects. This is usually accomplished by the formation of working groups with relevant qualifications which are required to work at the contracted international companies offices and on the construction sites. During the stages of engineering design, procurement of equipment and construction, these working groups are provided with foreign experts and consultants with specialized qualifications and these groups have authority to attend the meetings related to project implementation and review the designs and background papers. 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 and energy conservation. 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 of between four and eight months, in addition to training abroad in production plants and in other specialized international training centres.

One engineering company is 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 organized with the help of international trainers, to develop 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
Pre-feasibility		X	X
Feasibility		X	X
Engineering			X
Plant design			
Construction			X
Supervision			X
Product design			
Process design			
Production management			X
Marketing			
R and D	X	X	
Customer services	X		
Maintenance			X

Source: ESCWA, based on national sources.

3.2. Iraq

3.2.1 Historical development

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

More advanced technology was used in the establishment of the 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 on alterations and expansion;

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

3. Executed alterations under 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 marked a step forward in promoting local capabilities. Since then the local personnel and the concerned organizations have undertaken 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, up to the signing of 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 150,000 tons/year depending on natural gas as feedstock. In spite of the collaboration with a foreign consultancy company, which 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:

- Training of locals abroad to expose them to patent and plant processes;

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

- Supervision of construction by locals 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 foreign technology from trained and qualified nations.

3.2.2. Assessment of capabilities

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

(a) Pre-feasibility/feasibility (techno-economic studies) stage

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 problems are:

- Lack of basic statistics and data, plus the long-term time 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 on the part of the local industrialists of the benefits of such studies;

Although many decision-making 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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 workload 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	n.a.
7. Plant and customer technical services	C + F	C + F	F	C	C	n.a.
8. R and D	C + F	C + F	F + C	C	C	n.a.

Source: ESCWA, based on national sources.

Notes: C: Company possessing capability.
F: Capability provided by foreign company.
N: National organization possessing capability.

(f) Research and development

R and 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 and D centres have been established within petroleum organizations. Major research projects are related to production bottle-necks, increase of production, quality control and development of technical specifications of products in addition to study of corrosion problems.

The petrochemical industry in Iraq has not yet entered into the full production stage. The fertilizer industry, on the other hand, has entered into the marketing stage: the three plants started in the 1970s have developed the R and D capabilities in the fertilizer industry and the technical personnel have gained 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 section 3.2.3 (c) on the 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.

(g) 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 advanced technology in order to reach and increase plant production capacities. For this reason, two specialized training centres were established:

- The Industrial Training Centre (under the Ministry of Industry);

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

Both train graduates of secondary schools requiring specializations such as mechanics, electricity, plant operations and industrial chemistry. 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, 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 patent company;

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

In addition to the above, there is also an Arab Petroleum Training Institute in Baghdad, established in 1978 by 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 its 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 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 and technical and vocational centres

There are six universities in Iraq, established in the period 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 departments. One university located in Baghdad is a specialized technological university and offers training in chemical, electrical and mechanical engineering.

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 large supply of scientists, engineers and technicians in Iraq. The table below provides detailed information about the number of students enrolled and the 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	Local	Arabs	Foreign
Administration	1,833	17	201	14	-	40	-	-
Economics	958	40	165	9	-	40	-	-
Science	2,557	253	486	54	-	206	1	-
Engineering	3,695	129	524	42	-	149	7	2
Civil engineering	397	59	-	-	-	20	-	-
Total	9,440	456	1,435	99	-	455	9	2

Source: ESCWA, based on national sources.

(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 by 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 Council or are proposed by industrial and government organizations. The Council's role in the process of technology transfer is manifested in its activities as a local consultant and in its efforts to plan the policy of technology transfer in Iraq. It aims at co-ordination 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 and 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 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 two decades of substantial technological experience. Local capabilities in the refining, petrochemical and fertilizer plants are solid and mature though limited. It should be noted that the above three manufacturing areas 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, given the small size of its population.

Nevertheless, the fact 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 has become 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 are partly due to their complexity in relation to available operating skills and the lack of independent R and D capacity. The main problem 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 is devoted to in-house R and D activity in Jordanian firms. Even this activity is primarily concerned with fairly minor adaptation of existing products and processes.

According to a 1982 survey, the total expenditure on R and D and associated scientific and technological activities in Jordan amounted 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 and 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 analysed and assessed below (see also table 3.4).

(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 because of the 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 and 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 is 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 on equipment in addition to the manufacture of some parts and spare parts.

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

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 production of new oil products, recovering sulphur from gases and refining used oils. 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:

- Technical requirements of the local and regional markets;
- Diversity of process schemes;
- Local availability of skills;
- Financial conditions;
- Market constraints.

The feasibility study of the project was conducted by the Industrial Development Bank of Jordan, which 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 construction work and product design, and the company on its own is undertaking the management, the market services, the R and D and the plant and customer services.

The existing complex comprises seven process units and one plant for steel drum reconditioning, 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 Rhone 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 licensing 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 and shafts. 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 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.

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 with regard to the results obtained. IPI conducts test runs for them on 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 and glues.

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 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 also revises 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 and D work and to provide scientific and technical consultancy services, RSS conducts work on quality control, product development and feasibility studies. The Society indicates that 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 RSS in 1983 totalled 197 out of 397 employees, distributed between four substantive divisions. They undertake contract work for the industry, including the refining, petrochemical and fertilizer industries, mainly in quality control, trouble-shooting, testing and economic studies, but no specific details were provided. The main divisions of work and distribution of major jobs at RSS can be seen in tables 3.5 and 3.6.

(c) Jordan and Yarmouk Universities

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

	Total enrolment	Engineering	Science
Jordan University	11,731	1,024	1,441
Yarmouk University	10,322	1,223	1,024

There are 46 technical and vocational schools in Jordan, with over 27,000 students enrolled. Besides that, a sizeable number of students are studying abroad (see table 3.7).

Table 3.4. Technological capabilities in Jordan refinery and petrochemical plant

Capabilities	Refinery	Petrochemical plant
Project identification	C	C
Pre-feasibility	C & F	F & C
Feasibility	F	C
Engineering and construction	F	F
Supervision of construction	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: ESCWA, based on national sources.

Notes:
C: Company possessing capability.
N: National organization possessing 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: ESCWA, based on national sources.

Table 3.6. RSS number of scientists and engineers by specialization and degree for 1983

Specializations/degree			Bachelors	Masters	Doctors	Total
Scientists:	a.	Chemists	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: ESCWA, based on national sources.

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, based on national sources.

Table 3.8. Yarmouk University dgrees granted in 1983

Field of specialization	Number of degrees		
	Bachelors	Masters	Ph.D.
Arts	601	125	-
Science	406	3	-
Engineering	131	12	-
Architecture	11	-	-
Management	290	-	-
Total	1,439	140	-

Source: ESCWA, based on national sources.

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.

Kuwait has thus 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:

- Lack of skilled manpower;
- Scarcity of engineering and managerial skills;
- Requirement for highly specialized supporting engineering and capital goods firms;
- Most important, the limited size and growth of its domestic market.

3.4.2 Assessment of capabilities

(a) Oil refining (KNPC)

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

Project identification and technology selection

To assess present technological capabilities in Kuwait, information has been collected on the capacities in the oil refining industry (mainly KNPC), the fertilizer industry (PIC), 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 national capabilities at the moment, and the activities they have undertaken to strengthen their own capacities in this respect. The allocation of the oil resource is currently fully controlled by the State organization KPC. In the refining sector during the early 1960s, the Government of Kuwait decided to promote the endogenization of operations related to petroleum production, transportation, refining and marketing, a move which was facilitated by its oil revenues. This endogenization policy ensures Kuwait's self-reliance in the long run, even at the risk of reduced profitability in the short run. Kuwait has thus 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 expanded from 350,000 barrels per day in the 1950s to 650,000 barrels per day in the 1980s (about 65 per cent of crude oil production). Another feature that characterizes the refining industry is that no role has been given to the transnational companies in oil refining. This facilitates the control of KPC over the different aspects of the refining business. KNPC is empowered 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 met with a number of constraints in attempting to meet the technological requirements of investments with its own capabilities. These constraints include: first, a lack of skilled manpower; secondly, a scarcity of engineering and managerial skills; thirdly, the requirements of highly specialized supporting engineering and capital goods firms; fourthly, and most important, the limited size and growth of the domestic market.

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

For project identification and process technology selection, KNPC has developed 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 enabled KNPC engineers to undertake refinery modelling and process configuration studies in a self-supporting manner, when they opted for 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. The H-oil process, commercialized in the early 1960s, helped KNPC to learn by firsthand 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, since a technology where competing licensers are available is a better choice than a monopolized 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.

KNPC engineers and economists in the refineries expansion programme 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 project specifications, invitation of tenders and examination and negotiation of bids.

Such practices strengthen the KNPC 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 a substantial part of the construction and civil engineering work has been accomplished by local national contractors.

Process design and engineering

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

To build projects of such magnitude and complexity, KNPC practice has been to rely on turnkey projects as a vehicle for obtaining technology and know-how. There is a high concentration of oil refining technology suppliers. Furthermore, the choice of the turnkey option limits the choice for Kuwait to a few companies, e.g. Lummus and Kellogg, 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 department 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 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.

A contract for the expansion of the KNPC refineries has been granted to foreign contractors, namely Chiyoda and J.G.C. Corporation of Japan. The technical assistance and know-how of technology licensers such as UOP, Chevron, Union Oil Company of California, the Institut 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.

Marketing

KNPC is also responsible for the local marketing and selling of the refined products. Natural gases and fuel gases are transported by KNPC to their destinations through pipelines or trucks. 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.

Research and development

Activities related to R and 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 the Shuaiba, Ahmadi and MAB refineries. The Shuaiba refinery enjoys autonomy in its maintenance capabilities, which were established at its inception and developed through in-house training and recruitment of skilled and experienced manpower. The Ahmadi refinery has an agreement with a British company to supervise maintenance of the recently commissioned processing units and utilities. The MAB refinery is expected to follow suit after completing its current expansion and modernization plans. Some alternatives are envisioned by KPC, which includes pooling of maintenance crews, or entering into a joint venture with a foreign firm which has 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 for 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 ensure 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 selection of technology were given in the following order of priority: (i) minimum restrictions imposed on the transfer of technology; (ii) marketing; (iii) rate of return; (iv) skilled manpower requirement; and (v) 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 up to KPC as the parent corporation which ultimately supervises the arrangements of technology transfer in Kuwait.

PIC reported that the source of the technology selected was foreign. Stamicarbon of the Netherlands, 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 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 ensure speedy and expeditious arrangements. They are preferred by Kuwait, where capabilities in fabrication of equipment, manufacture of capital goods and design engineering are lacking.

After carrying out the process of evaluation and screening of alternative possible technologies, PIC selects the technology that best meets a prior criterion 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 by. This implies that KPC, as an importer of technology, is an independent party with full autonomy to select and transfer the technology it finds suitable in Kuwait.

PIC has to file its application to obtain foreign technologies with the KPC legal office, which 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 of maximizing 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 to maximize utilization of resources included 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 include establishing a urea de-dusting system downstream from 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 cover installing tube plates in heat exchangers and coolers, that can serve efficiently in a fresh-water or sea-water 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 an oxygen analyzer in gas reforming units and boilers to reduce excess fuel utilization, recovery of heat from the 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 the carbon dioxide removal system, providing an emergency power supply to critical equipment, and debottlenecking the 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. The Kuwait Industrial Refinery

Maintenance and Engineering Company (KREMENCO) is an exemplary illustration of such an 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 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 constraints 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 much attention. However, the Kuwait Petroleum Company has recently acquired the Santa Fe Corporation, which can provide KPC companies like KNPC and PIC with a supporting capability in areas where these companies are handicapped. Thus, the Kuwait Santa Fe Braun Company for engineering and petroleum enterprises (KSB) was established in 1982, owned fully by Kuwait Petroleum Corporation (KPC). KSB has 82 employees domiciled in Kuwait and distributed according to professional engineering specializations as follows: 8 electrical, 16 mechanical, 15 civil and 23 other. Twenty administrators (5 Arabs and 15 foreign) make up 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 to 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 a 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 sum, 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 accelerated the replacement of foreign employees by Kuwait nationals and Arabs by establishing the transfer of their specialized and advanced technology on both an individual and national level.

<u>Research and development</u>

The capability to perform R and 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 for Scientific Research to carry out applied research.

The allotments for R and 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 budget.

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 polymers 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 the 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 founded in 1981, the Technology Investment Company (TIC), has the objective of applying the inventions from the patents and trademarks generated by the scientific organizations in Kuwait. In this respect, the establishment of 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 to the KISR role in the generation, modification and transfer of technology lie mainly in the weak working relationship that prevails among the scientific communities, industrial sector and government departments. A lack of interaction has a negative effect and slows down the contribution of KISR to the welfare of the society. To enhance the role of KISR, it is advisable to have closer and healthier relations between the government, industrial and scientific organizations.

Manpower and training

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 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: ESCWA, based on national sources.

In this regard, the Kuwaitization programme has been continuing successfully. Nearly one third of all new employees hired during 1983 were Kuwaiti. As to manpower breakdown by nationality, the number of employees, as of June 1983, was 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 combating environmental hazards. 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 the Kuwait Ministry of Oil as of end-1981. Since then no updated statistics have been available.

KNPC	Number of employees	Kuwaiti percentage
Engineers	209	17
Administrators	360	38
Technicians	1,524	27
Clerks	767	24
Skilled labourers	311	17
Unskilled labourers	1,048	5
Trainees	327	100
Total[a/]	4,546	

Source: ESCWA, based on national sources.

a/ 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 in high school graduates to enrol in natural science and engineering disciplines; (b) preference of many graduates of natural science and engineering 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; and (d) scarcity of university teachers with industrial experience.

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

	Number	Kuwaitis Percentage
Senior managers	35	85
Administrators	127	42
Scientists	249	27
Chemists (35)		
Engineers	81	16
Technicians	731	12
Skilled labourers	204	13
Semi-skilled labourers	104	8
Unskilled labourers	39	5
Clerks	161	6
Trainees	55	100
Total	1,786	20

Source: ESCWA, based on national sources.

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 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. Arab nationals who undertake technical activities outnumber both Kuwaitis and foreigners and make up 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.

Figures indicate that, according to level of education, manpower is distributed as follows: 1,956 from technical school, high school or intermediate school, 369 university graduates, 3 holders of masters degrees and one Ph.D. The percentage of Kuwaitis 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 organized by local training centres, by KISR and by KPC oil companies. Areas of training include operation, maintenance, quality control, computer application, accounting and marketing. Trainees reported they were satisfied with 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, hiring was controlled by oil companies, which practised a policy of hiring a larger number of foreigners, particularly Asians. To change 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 of forming a Kuwaiti core staff 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 sum, 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 carried out 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 (Repuplic of 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 per cent);
Process design	PIC (25 per cent), Tokuyama Soda (75 per cent);
Product design	PIC (50 per cent), Tokuyama Soda (50 per cent);
Production management	PIC (100 per cent);
Marketing services	PIC (100 per cent);
Maintenance	PIC (1 per cent);
Customer technical services	PIC (100 per cent) 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 per cent);
Detailed feasibility studies	PIC (100 per cent);
Engineering	PIC (25 per cent), others (75 per cent);
Plant design	CF Braun and others;
Construction	CF Braun and others;
Product design	CF Braun and others;
Production management	PIC (100 per cent);
Marketing	PIC (100 per cent);
Maintenance	PIC (100 per cent);
Research and development	PIC (50 per cent), KISR (50 per cent);
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) The Kuwait Institute for Scientific Research

Established in 1973 to undertake applied research in the scientific field, KISR had as of June 1983 951 staff, distributed as follows: 548 personnel engaged in R and D; 247 auxiliary personnel; and 156 support staff.

The breakdown of employees according to their categories is as follows (see 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 (see table 3.9): 32 chemists (30 per cent); 4 physicists (3 per cent); 31 agricultural scientists (29 per cent); 22 engineering scientists (20.5 per cent); and 18 others (17 per cent).

Professionals categorized as research assistants and research associates are distributed according to specialization as follows (see table 3.10): 28 electrical engineers (9.5 per cent); 10 electronics (3.4 per cent); 11 mechanical (3.7 per cent); 16 civil (5.4 per cent); 46 chemical (15.6 per cent); 5 industrial (1.7 per cent); 48 agricultural engineers (16.3 per cent); 25 physical sciences (8.5 per cent); 24 mathematical sciences (8.2 per cent); 69 social sciences (23.5 per cent) and 12 others (4.1 per cent).

(b) University of Kuwait

Kuwait University presently has 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 theoretical 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 a B.Sc. degree from the College of Sciences was 210 and the number from the College of Engineering and Petroleum was 43. As to the number of faculty and professional staff, the College of Sciences reported a total of 182: 53 Kuwaitis (29 per cent); 66 Arabs from other countries (36 per cent); and 63 foreigners (35 per cent).

Table 3.9. KISR: number of employees per division
(for 1984)

	Petroleum materials div.			Division of engineering			Techno-economics div.			Technical support div.			Env.and 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
Subtotal	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, based on national sources.

Notes: Na - National (Kuwaitis)
Ar - Arab
Fo - Foreign.

Table 3.10. 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, based on national sources.

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

Table 3.11. 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, based on national sources.

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

b/ Agricultural sciences - including staff members majoring in agronomy, food science, zoology, agriculture and botany.

c/ Physical sciences - including staff members majoring in physics, chemistry and geology.

d/ Mathematical sciences - including staff members majoring in mathematics, computer sciences, information systems and statistics.

e/ Social sciences - including staff members majoring in economics, library science and accounting.

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

KU does not provide consultancies on a 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 1970s, 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 the 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 out 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) 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) detailed engineering comprising civil, structural, mechanical and electrical engineering, implementation planning and other services; (f) training of local manpower; (g) management and maintenance; and (h) marketing of final products abroad.

The main contribution of IDTC 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. In 1983 IDTC established an industrial information base which serves the needs of the Qatari Government and all industrial companies in the field of industrial development.

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 establish in such a short period, given the weak initial infrastructural base available. However, 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 has its 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 strong local participation.

3.5.2 Assessment of 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 the United Kingdom, Mitsui Toatsy of Japan and DSM/Stamicarbon of the Netherlands, C&F Chimie of France and KII all have participated in establishing QAPCO 1. QAPCO 2 was built in a co-operative project of Norsk Hydro, Dauy Power Gas Limited and Costain Process Engineering and Construction Limited of the 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, ICI (UK and IDTC
2. Technical and economic services	Norsk-Hydro, ICI C&F Chimie, (France)Mitsui Toatsy (Japan) and KII
3. Engineering services	Norsk-Hydro, ICI, Sir Alexander Gibb and Partners
4. Managerial and marketing services.	Norsk-Hydro

Source: ESCWA, based on national sources.

The number of QAFCO personnel in 1976 was estimated at 625. This number increased to 1,000 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 was 905, of whom 350 were Qatari and Arab employees. The number of Norwegian staff decreased from 63 in 1978 (at the end of plant 2 construction) to 42 in 1983. In the same period, the number of Qataris increased from 157 to 161, while the number of Arabs increased from 123 to 154. The following distribution in posts and professions in 1983 was reported.

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

Source: ESCWA, based on national sources.

The foreigners are distributed in professions as follows: 10 scientists and 11 engineers.

At present (1985) the company has no programme for increasing the number of personnel in the company. The productivity of QAFCO manpower in the period 1974-1983 increased in both the urea and ammonia lines. For the ammonia it increased from 207 T/man-year to 576 T/man-year and for urea from 126 to 676. This is almost a threefold increase in productivity of manpower in ammonia and a fivefold increase in urea.

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.

(b) <u>The experience of QAPCO</u>

The idea of QAPCO was generated in early 1973 through IDTC, which studied available published data concerning processing technology and economic and market studies. IDTC did an in-depth study which led to the selection of 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 time. IDTC prepared project specifics and entered into 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.

The following special standards were added to take into account the local conditions:

- Special protection of foundation from under ground water;
- Special protection of equipment and buildings from sandstorms;

- Special cooling systems;

- Use of special materials for equipment.

For the benefit of the complex the following services were 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 (mechanical, electrical, electronics), and spare parts are available in stock; the maintenance task-force is more than 35 per cent of the whole staff of QAPCO. Safety measures are observed 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 level staff
- 16 medium level staff
- 12 highly skilled workers.

Total 58

The intention was to reduce the above number from 58 to 25 two years after start-up. The total staff required for QAPCO was 626. Recruitment policy in the company was to recruit first from Qatar and the Gulf States, then from other Arab States and 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) by level and country or area

(percentage)

	Qatar	Egypt	Palestine	India	France	Other	Total
Senior staff	11	20	7	2	46	13	100
Intermediate	7	39	11	14	9	20	100
Operative staff	23	23	8	29	0	17	100
Total	14	30	10	19	9	18	100

Source: ESCWA, based on national sources.

In addition 171 trainees were sent to France for a long-term training programme, concentrated on the technical field. In-house training was also used. Over 20 per cent of trainees dropped out during the training period or transferred to other jobs.

In 1983 the number of workers was 642 (distributed as follows: 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 were still foreign, mainly French. However, the ratio of Qatari and Arab staff is increasing, the management contract with CdF Chimie was scheduled to end in two to three years, and it was expected that most of the key positions would be held by Qatari and Arab employees, except for two to three French personnel who might 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 and 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 to encourage 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 acquire the required machinery and materials. Therefore, in Qatar the high-technology projects are expected to remain, for the foreseeable future, the province of experienced international companies.

The few local contracting companies which ventured recently into 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 McDermott) to go into offshore oil 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 the 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 the 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 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 only 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 commensurate with 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 3.12. 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 erection	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 and D	F	F	F	F
Plant technical services	C	C	C	C
Customer technical services	C	C	C	C

Source: ESCWA, based on national sources.

Notes: C- Company possessing capabilities.
N- National organization possessing capability.
F- Foreign capability.

3.6. Saudi Arabia

3.6.1. Historical development

Since the 1960s, the development of the industrial sector in Saudi Arabia's economy has mostly been achieved through the establishment of joint ventures between private enterprises and 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 five-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. In addition, many plans for the downstream development of the petroleum-based industry were drawn up. These included 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 five-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 of 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, to 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 and adhesives.

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. It has already established several large-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 specializations.

Status of the technology used: The technologies used in petroleum refining and petrochemical industries in Saudi Arabia are from industrialized countries such as the United States, Western European countries and Japan. In the case of fertilizer production, the technology developed in Japan and Taiwan has been transferred to Saudi Arabia. At the same time, the Ministries of Planning, Industries and Petroleum and Minerals drew up the macro-plans to forge ahead with the required policy formulations. These organizations were assisted by a number of international consultants, multinational corporations and international agencies such as the World Bank. The feasibility studies passed through various evaluation and review stages after which the Government took decisions to establish petroleum refineries and other basic industrial projects.

The local content in the technology chosen for manufacturing petrochemicals in Saudi Araia is virtually non-existent. Starting from the stage of project identification, all other subsequent activities such as products planning, plant design, equipment slection, installation, start-up and technical management are handled by foreign consultants and technical personnel.

In the case of petroleum refining projects in Riyadh and Jeddah, for instance, Universal Oil Products Ltd., a United States petroleum consulting firm, conducted feasibility studies, prepared technical plans and specifications including tender documents and evaluation bids by contractors to supply the plant and equipment. UOP provided management assistance in implementing the projects. It also undertook through a long-term training programme to provide training to the Saudi employees at a training centre run by a consulting firm under UOP.

The Chiyoda Chemical Construction and Engineering Company of Japan did the construction work for the initial and subsequent expansion of both the Jeddah and Riyadh refineries. PETROMIN established a Project Control and Co-ordination Department with its own manpower (including several expatriates) to oversee the management of the project implementation, and co-ordinate on-site supervision and cost control.

In the case of the petrochemical projects, SABIC conducted the feasibility studies and other aspects of project implementation in close co-operation with joint venture partners like Shell Oil, Mobile Chemical Company, Dow Chemicals, Calanese-Texas Eastern, and a numer of Japanese petrochemical companies forming a consortium. SABIC's own participation in project preparation, and implementation and currently in operation and management is particularly noteworthy. SABIC has been able to attract a large number of young Saudis with university education who are being trained to run the basic industry projects. Thus, in both petroleum refining and petrochemical manufacturing, the country's capability is improving with respect to understanding and managing the imported technologies as well as utilizing them for its benefit. This, however, does not mean that Saudi Arabia has been able to assimilate foreign technology and to adapt it to changing conditions if necessary. Saudi Arabia will have to depend on foreign technology if it wants to renew the same investments or expand existing ones.

The basic criteria for selecting technologies were the inherent characteristics of the domestic resources. The following were given due consideration in choice of technologies:

- Abundant availability of domestic raw materials, i.e., hydrocarbon resources;

- Relative abundance of capital funds;

- Shortage of national manpower;

- Potentiality of the development of energy;

- Shortage of underground water, and abundance of sea-water for utilization as process and cooling element;

- Limited domestic market (and hence the project technology has take into consideration the need of the world market;

- Viability of technology (proven historically).

Thus the most suitable technology was chosen after due consideration of the factors mentioned above. The level of competence in both the process of selection and the technology itself was of the highest order in petroleum refining and petrochemical industries in Saudi Arabia. There is hardly any difference, so to speak, in either appearance or basic contents between a petrochemical plant in Jubail and one in the United States or Japan. This was necessary since the petrochemicals produced in Saudi Arabia were primarily for the developed country markets. In order to meet the market specifications of the industrialized countries it was not only necessary but advantageous to utilize the technology developed by them for such production. Saudi Arabia could not have waited until it developed its own technology to process its primary resources.

All SABIC projects were planned as joint ventures with major international participants in the petrochemical industry. The decision to proceed on a joint venture basis was taken in the firm belief that such an approach is the best way to ensure continuing access to foreign technology, project commitment, operating and training expertise and assistance in entering world markets for Saudi-produced petrochemicals.

The petrochemical projects implemented so far in Saudi Arabia are on a large world scale. They are oriented to international export markets. The present size and growth prospects for the domestic market are incidental to SABIC plans. While products will be available to this market from the new plants, domestic market considerations have not been a significant factor in the decision to establish the basic or intermediate petrochemical plants now being implemented.

Because of the product characteristics as determined by the market, it was not necessary for Saudi Arabia to introduce any change in the technology which was already developed and in use in the developed countries for the same purpose. SABIC simply imported the available technology to process the country's abundant hydrocarbon resources and then sell the products in the world market. This does not mean that the domestic market demand or further industrialization was not considered. It is anticipated that, because of the availability of local intermediate products, new industrial projects will be established.

The above-mentioned transfer of technology was made possible due to a host of incentives and favourable environments available in Saudi Arabia.

First, as already stated, the Government was eager to exploit the abundant hydrocarbon resources of the country by importing foreign technology. Several steps were taken in the right direction such as the establishment of various organizations with funds and responsibilities for project preparation and implementation.

Secondly, along with the institutional facilities, the Government created the necessary infrastructural conditions such as industrial cities with all the necessary facilities like utilities supply, road and communication networks, ports, housing and various commercial and industrial supports.

Thirdly, the Government introduced a generous package of monetary incentives including concessionary loans, tax holiday, subsidized feedstock, and utilities and tax-free import of machinery and raw materials.

Finally, the Government policy on the import of foreign technology and know-how was highly favourable. In order to make the projects viable by application of appropriate technology and management know-how, the Government encouraged, through differential incentives, joint ventures between Saudi Arabia and various multinational corporations, as mentioned above. Importation of tested and proven foreign technology has been highly encouraged by the Saudi Government. In fact, the most important criterion for approving joint-venture projects is the level of the foreign partner's contribution in technical and management know-how.

In order effectively to utilize the imported technology, i.e., to understand the nature and scope of the production processes and operate the plant and equipment, and thereby participate in the selection and management of the technology, the country has relied on the following:

- Having Saudi managers "learn by doing", one of the important reasons for encouraging joint ventures with foreign partners;

- The ability of both PETROMIN and SABIC to attract a relatively large number of Saudi manpower as compared with other manufactures. All the PETROMIN projects implemented up to 1983 employed altogether 10,927 persons of whom Saudis accounted for 69 per cent. Similarly, the Saudis constituted 51.2 per cent of the total manpower (8,000) employed by SABIC. In contrast, only 11 per cent of employees in the overall manufacturing sector were Saudis (see table 3.12). As can be seen from table 3.13, while the share of Saudi employees in professional and technical categories is very small in the overall manufacturing activities, it is substantially larger in both petroleum refining and petrochemical industries.

Table 3.13. Employment by occupation and nationality in Saudi Arabia

	All manufacuring (1982)			Petroleum refinery[a]			Petrochemicals[b]		
	Total	Saudi		Total	Saudi		Total	Saudi	
	employment	Number	%	number	Number	%	number	Number	%
Professional	17,869	1,180	6.6	152	77	64.2	1,151	785	68.2
Top management/admin.	9,238	1,374	14.9	81	52	54.2	375	320	85.5
Clerical, sales & services	49,513	8,596	17.4	2,746	1,590	57.9	236	81	34.3
- Clerical	18,106	5,849							
- Sales	11,282	1,308							
- Service	20,125	1,439							
Production & operation	273,308	28,938	10.6	-	-	-	3,605	1,941	53.8
- Production	216,543	21,602	10.0	737	330	-	-	-	-
- Others	56,765	7,336	12.9	453	323	-	-	-	-
Other workers	6,996	221	3.2	670	668	99.7	-	-	-
Total	356,924	40,309	11.3	4,839	3,040	62.8	5,367	3,127	58.3

Source: Saudi Arabia, Central Department of Statistics, The Labour Force.

a/ Total for three refineries and two lubricating oil projects.
b/ All petrochemical and fertilizer projects under SABIC.

Table 3.14. Employment by education and nationality in Saudi Arabia

Educational level[b]	All manufacuring (1982) Total employment	Saudi Number	Saudi %	Petroleum refinery Total number	Saudi Number	Saudi %	Petrochemicals[a] Total number	Saudi Number	Saudi %
1. Literate	266,468	24,687	9.1	–	–	–			
2. Illiterate	90,456	15,622	17.2	–	–	–			
Total	356,924	40,309	11.3	–	–	–			
3. No formal schooling	82,094	15,445	18.8	–	–	–			
4. Some primary school	56,588	4,939	8.7	–	–	–			
5. Primary school	30,134	6,701	22.2	–	–	–			
6. Intermediate school	24,267	2,591	10.7	–	–	–			
7. Secondary school	62,850	1,554	2.5	–	–	–			
Subtotal (pre-university)	173,839	15,785	9.1	1,955	1,286	65.8			
University	33,140	1,403	4.2	946	399	42.2			

Source: Table 3.13.

a/ No data available.
b/ Employees aged 25 years and above.

Similarly, in the total number of university graduates employed by the overall manufacturing sector in Saudi Arabia in 1982, the share of Saudis was as low as 4.2 per cent. The share of Saudis with a university degree was considerably larger in the petroleum refining and petrochemical fields.

It may be concluded from the above statistics that the assimilation of foreign technology is likely to be more pronounced in petroleum refining and petrochemicals than in other manufacuring because of the presence of a large number of educated Saudi manpower, particularly in the professional and technical category in these industries.

In addition to carrying out a policy of attracting a large number of educated Saudis for employment in management, professional and technical categories, both PETROMIN and SABIC have created elaborate facilities inside and outside the Kingdom to train national manpower. There are, however, certain constraints which impede the effective development of the local capability in the field of technology transfer. The most important of these is the shortage of national manpower, particularly in the professional and technical category. The Government has already undertaken all possible measures to develop human skills.

The other problem is the limited size of the domestic market. Because of this limiting factor many industries fail to grow. It is well known that in the initial stage of industrialization, production fo the export market is difficult given the uncertainties. The availability of the domestic market is probably the greatest morale booster in deciding industrial investment. One of the most important ways to expand the domestic market is to establish those projects which create maximum possible inter-linkage, i.e., vertical and horizontal expansion of industries where intra- and inter-industry trade gets expanded. The petrochemical industries are being developed in Saudi Arabia so as to create industrial linkages.

It is clear that the national content was rather small in the identification and selection of technologies employed in several projects implemented so far by PETROMIN and SABIC. It is pertinent to inquire if Saudi Arabia has been making any progress in developing consulting/research capability to enlarge national content. The Kingdom has made considerable headway in the fields of research and consultancy. A large number of private consulting organizations have been established in Saudi Arabia, particularly in construction areas. However, most of the professional and technical manpower of such organizations are expatriates.

Both PETROMIN and SABIC have established in-house facilities for project evaluation, control and co-ordination of various implementation aspects. The objects of such departments are:

- To co-ordinate with consulting firms, participate in various studies and partially supervise some technical aspects of the projects under consideration;

- To conduct research, planning and development;

- To determine the range of projects by analysing alternative possibilities;

- To evaluate accurately the feasibility studies on projects;

- To participate in the planning of projects and the progress of joint ventures;

- To participate in post-operational activities connected with projects;

- To participate in developing plans for the exploitation of natural resources;

- To carry out activities connected with gathering technical information related to the present and future projects. Such data form a major link with the technological development between the outside world and PETROMIN and SABIC industrialization efforts.

In spite of the creation of the above facilities, both PETROMIN and SABIC remain dependent on outside consultants for project identification, evaluation of feasibility studies, technical specification, construction and management. The following illustrate the nature of the country's dependence on foreign consulting services. This is taken from the PETROMIN-MOBIL Refinery Project with is being implemented in Yanbu at a total capital cost of SRls 2 billion.

	Activity	Responsible organization	Nationality
1.	Pre-feasibility study	Mobil Research & Devt. Corp. (MRDC)	USA
2.	Feasibility	As above	
3.	Plant design	UOP/MRDC/Philips	USA/Europe
4.	Engineering	Foster-Wheeler/Chiyoda	USA/Japan
5.	Construction	Chiyoda/Hyundai/Fluor Mitsubishi	Japan/USA
6.	Construction supervision	MRDC/Chiyoda/Hyundai/ Hitachi/Foxboro/Shinwa	USA/Japan/ Republic of Korea
7.	Process design	MRDC/UOP/Philips	USA/Japan
8.	Product design	Mobil Oil Cort/PETROMIN	USA/Saudi
9.	Market services	As above	
10.	Research	MRDC	USA
11.	Plant Tech. service	UOP/Philips/Foxboro	USA/Europe

12. Customer Tech. Service	NALCO/Philips/UOP Humphrey & Glasgow Petrolite/Grace/BASF	Saudi/USA/Europe

As can be seen from the above Saudi Arabia's own contribution in project feasibility or specification of construction is insignificant.

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 to identify petrochemical projects for implementation, and organizations such as SABIC were created to co-ordinate the investment projects identified 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. There is reason to believe that 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 partners in these joint ventures.

Under this activity the ability to negotiate a contract can also 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 to "unpack" the technology, and evaluate 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. Another 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 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.

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 large-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 was it reported 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 and D centres or universities in industrialized countries. Detailed engineering and design work needs 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; although Saudization efforts are under way, 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 could the huge numbers of unskilled workers not be found in the Kingdom, but equally important, the required skilled manpower and supervisory staff were not available. This situation necessitated a 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 Jubail were constructed by Far Eastern companies working under the supervision of Japanese and United States contractors. 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 technology to 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 proprietary 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 section 2.4). 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's premises or at 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 services. This applies particularly to 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 onstream 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 its own marketing organizations through strategic acquisitions of distribution and storage facilities around the world.

As for PETROMIN 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 and 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 the refinery's Ph. D. or master's degree holders were Saudi.

This situation is somewhat better among other categories of staff, e.g. skilled technicians, especially in some of the older domestic refineries where 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 (not including universities) is estimated as 5 to 10. In the same report, SANCST states that in order to strengthen existing research facilities the following measures are needed: development of management capability, training of scientists and manpower development. The problem of availability of scientific equipment or journals and other publications is not perceived to be a significant obstacle to the present functioning of research institutions.

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

The Saudis need to strengthen the role of regional centres of technology by: (a) exchanging information on new and traditional technologies; (b) promoting pilot and demonstration activities; (c) participating in data banks on technological alternatives; and (d) setting up advisory services and technological consulting.

According to estimates by SANCST, the percentage of scientific personnel engaged in R and D in Saudi Arabia was 15 to 25 per cent; the rest were involved in 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 and D are 1 to 2 per cent of GNP. Internally generated contributions for R and D are very limited. Almost all resources for R and D are from the 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 contractors who otherwise use the R and D services of local universities.

Still more effort is needed to strengthen the linkages between national R and D institutions and the production system. These can be summarized as follows: (a) national policies to encourage or protect the development and use of local technology; (b) generation of interest on the part of researchers to develop technologies for the local market; (c) generation of interest by enterprises to make use of locally developed technologies; and (d) 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-solving 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.

3.6.3 National institutions

Education

Educational facilities have increased considerably in Saudi Arabia during the past decade. The total enrolment of students below university level was 1,692,300 in 1986. The universities and colleges of the Kingdom had a total of 51,484 male and 28,326 female students enrolled in the same year. In addition to the above, there is a large number of students in the vocational and technical schools.

Science and technology

For the importation, adaptation and development of suitable technology the Kingdom had created facilities at the universities and established the Saudi Arab and National Centre for Science and Technology (SAC), which has the following functions:

- To conduct scientific research studies;
- To collect information on technological development;
- To arrange international scientific and technical co-operation;
- To organize the transfer, development, adaptation and use of advanced technology;
- To strengthen research and development capabilities within the Kingdom.

Technical and management consultancy

Along with the establishment of SANCST, the Government has encouraged the development of local consulting capabilities. The universities in Saudi Arabia, particularly the University of Petroleum and Minerals, have their in-house facilities for research. In addition, they take an active part in conducting research studies at the Saudi Arabian National Centre for Science and Technology. There are several private consulting companies providing services, esepcially in engineering and construction. The Government itself has established a large consulting organization (Saudi Consulting House) which, in association with several Western consulting firms, provides services in the economic, management and engineering fields.

The research and consulting organizations are expected to play a considerable role in transferring advanced technologies from developed countries to Saudi Arabia. They can identify the appropriate technology and its sources for given production purposes, give advice on the methods of its availability (terms and conditions), provide guidance in adapting the imported technology to suit local conditions and conduct market and feasibility studies for local manufacturing of components, manpower needs and training recruitments. Research and consulting organizations can keep track of alternative technological developments in a particular field and can make the information available to local users.

To perform the above-mentioned functions, the consulting organizations require professional and technical consultants. As there is a shortage of professional manpower in Saudi Arabia, most of the consulting firms have formed joint ventures with overseas companies which provide the expertise lacking in the Kingdom. These consulting organizations themselves employ expatriate consultants on an individual basis.

In addition to the research and consulting facilities created by the Government, various government-sponsored corporations, particularly PETROMIN, SABIC, SAUDIA and the national oil company (ARAMCO) have set up their own research and training arrangements. Although these organizations are still dependent on foreign experts, they have made good progress in creating a new generation of Saudi youth who are acquiring know-how in running the business. As stated above, this type of manpower and infrastructural development is the primary condition for the effective transfer of technology which is gradually being brought about in the Kingdom.

In conclusion, it should be noted that Saudi Arabia, after analysing all the available options, has been able to select and import the most up-to-date technology for implementing petroleum refining and petrochemical projects. Thus, the first necessary condition of technology transfer was met in these cases.

As to the assimilation and adaptation of the imported technology and then development of the local technology capability, the Kingdom has yet to make any significant progress. However, in comparison with the overall manufacturing activities, the prospect for an effective transfer of technology is brighter in the case of petrochemicals as the Saudi participation in both management and operation is significantly larger here.

In sum, the Government has started a process for effective transfer of technology by creating local research, consultancy and manpower development facilities.

Table 3.15 Manpower employed by PETROMIN

(by nationality and skill category: 1984)

Skill category	Saudi	Expatriate	Total	Saudi as % of total
Top management	114	37	151	75.5
Professional	186	151	337	55.2
Technical	639	601	1,240	51.5
Clerical	3,566	1,837	5,403	66.0
Manual	2,266	744	3,010	75.3
Trainees	784	2	786	99.7
Total	7,555	3,372	10,927	69.1

Source: PETROMIN, Saudi Arabia.

Table 3.16 Manpower employed by SABIC

(Employment by nationality: 1986)

Skill category	Petrochemical and fertilizer Saudi	Petrochemical and fertilizer Non-Saudi	Iron and steel Saudi	Iron and steel Non-Saudi	SABIC head office Saudi	SABIC head office Non-Saudi	Total Saudi	Total Non-Saudi
Top management	41	33	16	17	7	-	64	50
Administration	279	22	141	245	100	14	520	281
Professional and others	785	366	69	333	63	43	917	742
Finance and accounts	81	155	32	61	50	17	163	233
Technical	1,941	1,664	434	921	57	16	2,432	2,601
Total	3,127	2,240	692	1,577	277	90	4,096	3,907

Source: Saudi Basic Industries Corporation.

Table 3.17 ARAMCO employment by skill category, 1985

Skill category	Saudi	Other Arab	Non-Arab expatriates	Total
Senior management	23	-	15	38
Administration	395	28	498	921
Scientists	62	84	825	971
Engineers	544	213	3,599	4,356
Economists	44	18	494	556
Technicians	91	74	1,745	1,910
Others	35	77	597	709
Total	1,194	494	7,773	9,461

Source: ARAMCO.

Note: This does not include production, semi-skilled and manual workers who are below level of technicians.

Table 3.18 ARAMCO employment by nationality and education, 1985

Educational level	Saudi	Other Arab	Non-Arab expatriates	Total
Vocational school certificate	486	362	4,945	5,793
Bachelor's degree	795	1,357	11,281	13,433
Master's degree	37	141	2,150	2,328
Doctoral degree	1	34	328	363
Total				21,917

Source: ARAMCO.

Note: This does not include operators and manual workers with less than vocational school certificates.

3.7 The Syrian Arab Republic

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 in the Syrian Arab Republic differs from that of 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 forced the Syrian Arab Republic to rely more on indigenous capabilities; the 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 fertilizer 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 build up over a period of 25 years, very good skills through training schemes designed for its personnel, whether new employees or old, 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 a lack of experienced engineers or skilled technicians and workers. All repair and maintenance work is undertaken by Company personnel without foreign assistance. The Company's achievements have 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
Economists	24	27
Technical staff	854	897
Total	1,043	1,103

Source: ESCWA, based on national sources.

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	-	-	337
Bachelor	93	1	19	113
Masters	-	-	21	21
Ph.D	-	-	3	3
Total				474

Source: ESCWA, based on national sources.

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 has undergone six expansions and upgradings since its establishment. 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 capabilities 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 and 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 HDS and the sulphur units is provided by the French IFP and Hurtey companies.

(b) 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. The educational background 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 in each category. As in the Homs Refinery, there are various capabilities. 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 in addition to local 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, the 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	1,360	-	-	1,360
Bachelor	340	7	15	362
Masters	2	-	12	14
Ph.D.	-	-	5	5
Total	1,702	7	32	1,741

Source: ESCWA, based on national sources.

The Company depends mainly on 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 acquainting 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 and welding technology. Some of the courses are run outside Company 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. In the case of the calcium ammonium nitrate plant, however, 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 training 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 that it possesses or has access to, through 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
Construction		X	
Supervision of installation		X	
Product design	X		
Process design			X
Production management	X		
Marketing	X		
R and D	X	X	
Plant technical services	X		
Customer technical services	X		

<u>Source</u>: ESCWA, based on national sources.

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.

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 example: due to the high chlorine content of the Syrian phosphates, a corrosion problem developed, which was remedied by the application of a suitable lining in the installations.

The Company thus does not resort to 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, the services of foreign experts are required to deal with the complex problem of pollution of the water needed, for the production processes. Experts' 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 services from qualified local technical institutions, such as the Faculty of Engineering at Damascus University, which furnishes the engineering and design work.

In fact, the technological capabilities of the Company have enabled it to undertake a wide range of jobs, such as pre-feasibility and detailed feasibility studies, product design, maintenance and repair operations and construction work. 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 was established in 1969 and in 1980 became the General Company for Technical Consultancy and Studies. It provides consultancy services in a 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, formulates criteria for the procurement of equipment and provides training for its 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 1,500 employees, divided as follows:

	Engineers	Technicians	Administrators	Total
Damascus	592	363	215	1,170
Aleppo	125	52	21	198
Homs	19	14	6	39
Lattakia/Tartous	45	36	17	98
Total	781	465	259	1,505

Source: ESCWA, based on national sources.

The Company 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 Syrian-owned company is carrying out its studies independently. Only in a few cases has it relied on foreign expertise to augment skills.

The 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 Damascus, Aleppo, Baath university (Homs) and an engineering institute in Lattakia. Information was supplied only by Aleppo university and the Baath university in Homs; therefore the situation cannot be generalized, but is mentioned here only for purposes of illustration.

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

	1982-1983		1983-1984	
	Students	Graduates	Students	Graduates
Engineering				
Civil	3,080	353	3,194	336
Architecture	1,337	202	1,162	138
Electrical	2,731	211	2,677	247
Mechanical	2,952	248	2,812	214

	1982-1983		1983-1984	
	Students	Graduates	Students	Graduates
Science				
Mathematics	1,464	79	1,244	71
Physics	1,558	195	1,405	145
Biology	869	72	826	77

Source: ESCWA, based on national sources.

The total number of post-graduate degrees for the academic year 1983-1984 included 50 engineering diplomas in the Faculty of Engineering; 51 students received diplomas in the Science Faculty, in addition to nine who obtained masters degrees.

The teaching staff, by nationality, was as follows:

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

Source: ESCWA, based on national sources.

The university has possibilities for undertaking applied research programmes outside the university laboratories. This is part of the masters and doctorah 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 the German Democratic Republic, Democratic Yemen, the United Kingdom, France, India and China, but it did not specify in which areas.

The Baath University in Homs, which was established in 1979, reported 3,114 students enrolled during the year 1983-1984, of whom 2,054 were in engineering, 811 in science and 249 in civil engineering. During that year, 266 graduates were registered of whom 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 therefore offers 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, that 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 the non-national labour force. For example the staff 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	1,064

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 career development also deals with developing the skills of nationals and is oriented towards fulfilment of a pre-planned career responsibility. These employees are generally sent abroad to professional training centres as well as companies in similar businesses.

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

There are 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 two years - is kept available in order to avoid possible operational disruptions. Only small items are (or can be) manufactured in local workshops - simple castings and piping. A plastic packaging factory providing polypropylene sacks for FERTIL has recently been built and is using imported raw materials.

The absence of supporting industries is a general charateristic of the young industrial sector in the Emirates.

More information on present capabilities in the UAE can be found in the case-study on AREC in annex I.

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 such as synthetic polymers, plastics and textiles, have come in stages and caused quantum leaps in technology. However, in recent decades, there has been a technological explosion associated with enhanced capabilities owing 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 precautions 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 infrastructural 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 ensure 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 institutions 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 and biomass) 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 (the 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 twenty-first 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 trend 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 trends. 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 petroleum and petrochemical industries

Along with the above developments, new patterns 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 large-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 by 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, the emphasis in the restructuring has been on the achievement of economies resulting from: increasing 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 (at least for them due to distance of the feedstock supply). Therefore, they have shifted their emphasis onto specialized 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 the Arab 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 breakthroughs 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 be depleted during the next decade, more natural gas will be obtained from non-associated gas fields, in contrast to 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, ethanol 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 Butyl 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 Arab region will maintain a leading position among the petroleum producers of the world. Refinery capacity in the region will represent an important proportion of overall world refining capacity. In view of this, the competitive position of the region can be protected by ensuring access to up-to-date developments 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 practically to replace all existing metal cans and glass bottles with plastic 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 and polyamede. 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 Arab 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 possibly to 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 region in the form of packaging manufacturing. However, many of the resins involved in this area could be produced in the region.

Obviously, for successful penetration of the above very important markets and in order to ensure a long-term competitive position, it would be important for the relevant countries in the 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 Arab 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 region to enter a high technology field on the foundation of the plastics industry, where the 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 institutions in material sciences 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 fields 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 upheavals in the petroleum market that led to large price increases 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 ease 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 the region's petroleum and products. This factor will maintain pressure on the Arab region to attain a high level of productivity and efficiency in the processing of resources and the marketing of products. Furthermore, in the long term, it might prove most advantageous for the region to shift oil and gas consumption to petrochemicals rather than energy products. Besides the clear advantages in value added, this strategy would extend the life of the hydrocarbon resources in the region and ensure 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 Arab 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 with 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 10 years ago, while it represents only 32 per cent at present. This proportion 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 with 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.

Besides 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. There are new research 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, Arab 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 to the oil and gas and petrochemical technology fields.

4.4.3. Computers and associated 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.

Besides 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 data bases 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 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

5.1 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 ultimately to 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 analysed 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 ultimately to 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 complementarity, 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). In other cases, organizations cover a broad range of disciplines and industrial activities (e.g. consulting groups, laboratories and universities.) (table 5.1).

Table 5.1. The technology network: organizations and activities

Universities	Public and private laboratories	Consulting groups	Engineering/ construction	Industrial establishment
Teaching				
Training	Training	Training		Training
R and D	R and D			R and 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

Source: ESCWA compilation.

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, the Syrian Arab Republic and Jordan. The second group includes the Gulf countries - Saudi Arabia, Kuwait, Qatar and the 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 data-base and information services, and some effort is under way to establish indigenous data bases. 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 of 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 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 subregional basis (e.g the Gulf region). This has led to the establishment of joint petrochemical industries (e.g the Gulf Petrochemical Company) and infrastructural establishment (e.g the Gulf Organization for Industrial Consulting). 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-based.

It has been indicated in the 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 earn 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 problems suggest the need to develop suitable personnel and incentive practices.

More specific conclusions can be drawn. With regard to 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 the Syrian Arab Republic. These countries benefit clearly from their longer established and wider industrial base as well as their better developed educational facilities. Another related 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.

In view of the above situation 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 in production management and plant technical service. 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 capability 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 growth will eventually decrease to a much lower level, in view of the reduced 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 shown in part four, future petrochemical technologies are being developed that have an impact on the demand for certain types of products, and consequently the countries of the region should be ready to adapt to the changes in demand patterns.

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 of 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 ensuring 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 should be 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 indigenization process which is being implemented by several countries in the region.

In addition, training and upgrading programmes should be developed for the management development institutes which exist already in countries like Egypt, Iraq and the Syrian Arab Republic.

Plant technical services

This essential function in each production process has to be developed further, since together with production management it forms 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 should be 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, there are sufficient capabilities to undertake the above activities. 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 the strengthening of existing ones by providing them with part of the work undertaken would 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 organizations in each project, others have not yet extended this practice to all levels of this activity.

After the above priority goals 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 a large degree by nationals.

Engineering and plant design

This capability is not often 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 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, most important, programmes should be initiated in relation with future developments in petrochemical technology, such as research on "single carbon chemistry" and high-performance composites. By devoting resources to future development, research centres can play an important role in the needs of the petrochemical industry in the region.

Finally, in order to utilize the findings and results of this study for strengthening of local technological capabilities, it may be necessary for each government to prepare, within this framework, its own master plan for developing its technological capabilities in accordance with its particular technological needs and socio-economic conditions. Once the national master plans are developed, it may be possible to integrate them into a regional or Pan-Arab master plan, or at least to co-ordinate them.

References

1. Domestic Technology Generation in LDC's: a review of Research Findings, (Jorge Katz) (ECLA/IDB/IDRC/UNDP) (W.P. 35). 1980.

2. International Technology Transfer: Issues and Policy Options (a background study for World Development Report), World Bank, (Staff Working Paper No. 334). 1979.

3. Handbook on the acquisition of technology by developing countries - prepared by UNCTAD (UNCTAD/TT/AS/5) New York, 1978.

4. 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.

5. Development and Transfer of Technology Series, 14 (vol. I & II) No. 14: Case-Studies in the Acquisition of Technology, (I & II). 1981 No. 17: Technology Exports from Developing Countries (I). Agrentina and Portugal. 1983.

6. Opportunities for Co-operation among the Developing Countries for the Establishment of the Petrochemical Industry. (UNIDO/IS.876) (Sec. Work Paper Series 1). 1983.

7. Basis for the Formulation of Strategies Pertaining to Development of the Petrochemical Industry in ECWA Region. (E/ECWA/ID/WG.5/3). 1981.

8. Manpower Needs in Oil and Gas Industry (Arabic) (E/ECWA/NR/83/6) 1983.

9. Expert Group Meeting on the Petrochemical Industry in the ECWA Region, 9 to 12 June 1981, Vienna - Report of the Meeting (E/ECWA/ID/WG.5/5).

10. Future Possibilities of Development in Petrochemical Industries by AIDO and Saudi Consulting House 1983 (Arabic).

11. OPEC/UNIDO Fund Seminar on Co-operation among Developing Countries in Petrochemical Industries, Vienna, 7 to 9 March 1983.

General magazines, journals and other periodicals

- Arab Oil and Gas Directory
- Arab Oil and Gas
- Middle East Economic Digest
- Petroleum Intelligence Weekly
- Oil and Gas Journal
- OPEC Bulletin
- Middle East Economic Survey
- OAPEC Monthly Bulletin
- OAPEC Annual Report
- OPDP Annual Statistical Yearbook
- UNIDO Statistical Yearbook

ANNEX I

CASE-STUDIES

I.1 Fertilizer company in Kuwait

Historical background

Kuwait established a nitrogen-based fertilizer industry by founding the Petrochemical Industries Company (PIC) with the aim of maximizing the utilization of natural gas associated with recovered crude oil and to diversifying sources of national income. A cheap natural resource, augmented by the tremendously growing need of this commodity in developing countries, particularly those in close proximity to 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 of 396,000, 330,000, 132,000 and 132,000 respectively. In 1971-1972, PIC decided unilaterally to undertake the establishment of two more ammonia plants (330,000 tons per annum, each) and two more urea plants, which brought the total installed capacity for ammonia and urea up to 990,000 and 792,000 tons per annum respectively. Later in 1973, PIC acquired the foreign share and thus wholly owned the assets of the chemical fertilizer plants in the 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 to the control of the Corporation.

Highlights relevant to the fertilizer industry in Kuwait

The general features that characterize the fertilizer industry in Kuwait are summarized in the 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, which undertakes the responsibilities of technology evaluation and selection, feasibility studies, production management, technology adaptation and development, maintenance, marketing and customer technical services;

- The plants installed 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 from 660,000 to 990,000 tons;

- PIC plans to install a plant for production of ammonia diphosphate (annual capacity 330,000 tons) which will consume 70,000 tons per annum (tpa) of ammonia, an illustration of forward integration;

- Other illustrative examples of forward integration are the utilization of about 300,000 tons per annum of ammonia for the manufacture of urea, and the production of melamine which consumes about 55,000 tons per annum of urea;

- PIC employs a staff 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 number of staff effectively engaged in direct technical activities (operation, maintenance, quality control and other engineering services) is 1,408; the breakdown of the manpower is Kuwaitis 15 per cent; other Arabs 74 per cent; and non-Arabs 11 per cent. The percentage distribution of Kuwaitis, Arabs and non-Arabs classified as university graduates, specialists and engineers and engaged in technical activities is 24, 59 and 17, respectively. The percentage distribution of Kuwaitis, Arab and non-Arabs performing activities requiring skilled and semi-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 tons per annum) for production of ammonia, urea, sulphuric acid and ammonium sulphate are 381,000, 486,000, 4,600 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 tons) 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 36,000 and 564,000 tons, respectively;

- PIC imports technology on a lump-sum turnkey basis, reimbursable cost plus and as licensed patents. The foreign contractors, Haldor Topsoe for the ammonia plant and Stamicarbon for the urea plant, are generally in charge of the whole 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 services, PIC recruits Arab and non-Arab engineers, specialists and skilled labourers who augment the number of national personnel;

- PIC is handicapped in developing its domestic expertise in plant design, engineering, plant construction, product design, process design, and research and development. In this regard, it is planned that the Kuwait Santa Fe C. F. Braun (KSB) office which is located in Kuwait will provide technical assistance to PIC, particularly in areas which require special expertise, such as plant design and engineering. PIC is collaborating with the Kuwait Institute for Scientific Research (KISR) by conducting joint research programmes in areas such as combating corrosion in carbon dioxide removal systems, developing coatings for slow nitrogen release and improving urea yield;

- PIC collaborates with downstream industries (melamine) to ensure 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 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. A contract was also accorded to Daelem engineering (Republic of Korea), Hitachi Zosen and Tecnipetrol (Italy) for civil engineering and construction of the ammonia plant;

- Career development of 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.

Major technical problems encountered by the fertilizer industry and measures taken to overcome them

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 spare parts; (c) shortage of skilled manpower to carry out maintenance and repair services; and (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 the PIC staff: (a) adjusting continuously the operating parameters so as to ensure 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 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 through 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 to boost the capabilities of PIC personnel.

Domestic attempts to adapt, assimilate, modify and develop imported technology

The accumulated capacities and acquired expertise at the PIC fertilizer division have enabled its staff engaged in operational and engineering activities to cope with the challenges of the transferred technology. In response to management directives, efforts have been redirected 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 purposes; (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 the fertilizer industry in Kuwait

On the basis of information collected from PIC and the assessment of the technological capabilities of the fertilizer industry in Kuwait, the following analysis has been made:

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 unfavourably high design capacity compared with actual capacity for the ammonia and urea plants suggests either a lack of planning and assessment of trends in market demand supply balance or a needlessly oversized unit capacity. In either case the initial investment was high for such sizeable 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 economies 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 semi-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 ranges from a low of 9 per cent for skilled and semi-skilled labour to a high of 19 per cent for jobs requiring a high level of education and specialization. Arab national who undertake technical activities outnumber both Kuwaitis and foreigners and make up 59 to 79 per cent of total manpower, excluding administrators, clerks and trainees.

Effect of obsolescence of equipment

Rapid technological breakthroughs in ammonia production may be a factor in rendering much of the older plant equipment obsolete. This led PIC to resort to replacement of aged or obsolete equipment to avoid the plant being idle due to non-availability of spare parts and due to enormous expenses incurred by buying materials.

Turnkey contracts and transfer of technology

As 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 and is responsible for all technological decisions, 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's capacity, and render the importer of technology dependent on foreign sources. Stamicarbon and Haldor Topsoe were the technology exporters of urea and ammonia plants. 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 and constructors, as this practice entails long delays due to the necessity of co-operation between the concerned parties. Turnkey projects generally ensure speedy and expeditious arrangements. They are 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 the following 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 foreign courts in case of arbitration. In this regard the clauses of the contracts honoured by PIC restrict arbitration to local courts and 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 the exchange of information with other companies within KPC or Kuwait;
- Obliging PIC to return plans, drawings, manuals, diagrams and technical knowledge if the agreement is terminated;
- Entitling the licenser to managerial control in development, marketing, etc.;
- Restricting R and 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 licenser's 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 expires 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 which 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 Santa Fe C.F. Braun in Kuwait as well as by C.F. Braun Engineering offices 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 out independently activities related to feasibility studies, product design, production management, R and 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 and air and water treatment to combat pollution. Very limited capability has been acquired by PIC in regard to manufacturing spare parts locally.

I.2 Petrochemical plant in Iraq

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 the 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 organization BEICIP to undertake a feasibility study on the following basis:

(a) Giving priority to internal demand;

(b) Selecting a plant location close to Baghdad, because of the availability of qualified personnel and raw materials;

(c) Selecting a product mix (mixture of propane, butane and natural gasoline) as raw material and light naptha as alternate source. The sulphur recovery plant in Kirkuk was to provide the product mix and the Dorah refinery near Baghdad was to provide the light naptha;

(d) The capacity for the ethylene production unit was determined at:

60,000 tons/year to produce
30,000 tons/year of PVC
20,000 tons/year of HDPE
20,000 tons/year of LDPE

After long debates on the project specifics, the following changes were decided:

- Doubling the capacity;

- Selecting associated natural gas as a raw material instead of naphta to exploit the southern flared gas, and benefiting 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, including 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 project specifics and tender documents and analysing tender offers.

After this part was accomplished the local party entered the negotiation phase, finalized the analysis of tenders signed the agreement with the selected consortium.

2. <u>Location of project</u>

The location was selected by the national personnel based on the following factors:

(a) Proximity to the source of raw material (near Basrah);

(b) Proximity to Arabian Gulf, to use the port for exports;

(c) Appropriate expansion opportunities.

3. <u>Announcements of tenders</u>

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 announced by the Mining and Industry Ministry, and bids came from a number of consortiums in Japan, Europe and America.

4. <u>Analysis of bids and negotiations with companies</u>

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 an agreement was reached and the protocol signed, 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, (United States and Federal Republic of Germany).

5. <u>Selection of technology and production process</u>

The selected technology was based mainly on the following terms:

(a) The patent's reputation and the number of plants in the world using this method;

(b) The success of the production process and comparison with competitive producing companies;

(c) Applicability of such production methods to Iraqi needs and local market.

These factors determined the following selection:

The Lummus Company was selected as the patent owner of ethylene production. Phillips Company was selected for HDPE, Hooker Company for its electrolysis, Staufer (American) Company for patents of PVC and VCM and National Distiller Company (American) for LDPE. The selection of processes was done jointly with the contractor prior to the signature of the contract but negotiations with the mentioned companies were undertaken independently by the local personnel.

6. <u>Execution stage</u>

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, chemical and electrical) to follow up on-site erection of plant.

At the companies' headquarters, a working local group with several specializations was working on reviewing the engineering design and technical specifications. This group was assisted by Indian specialized experts.

The working group negotiated with the patent owners on matters related to the project design and revised the drawings and approved 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 commissioning stage.

<u>Plant operation training</u>

The contracted companies were committed to train locals on-site and abroad. This was accomplished at the same time as execution. A number of technical local personnel where trained in similar units in the United States.

- On-site training was given in the production units by using theoretical and practical methods.

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.

<u>Conclusion</u>

The steps undertaken by the Iraqi part in the pre-feasibility study in the participation in engineering design and following up on execution and on-site implementation of the contract conditions in an organized manner were active and important steps towards mastering technology transfer and have been proven to be one way of gaining applied experience.

The introduction 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 <u>Organization of Arab Petroleum Exporting Countries (OAPEC)</u>

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 potentials to establish joint ventures and create an integrated petroleum industry as a step towards realizing the cherished ambition of Arab economic complementarity.

Saudi Arabia, the Libyan Arab Jamahiriya 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 the United Arab Emirates, Bahrain, Tunisia, Algeria, Saudi Arabia, the Syrian Arab Republic, Iraq, Qatar, Kuwait, the Libyan Arab Jamahiriya 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 oil production in the 1970s was about 30 per cent of 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 individually and collectively; co-ordination efforts to ensure the delivery of oil to the consuming markets under just and acceptable conditions and providing circumstances conducive to attracting 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 groundwork in order to achieve Arab complementarity in the oil industry field, starting from exploration to multi-faceted industrialization.

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.

This represents a serious attempt to establish an independent Arab oil industry to contribute to the preparation of the Arab technical cadres and 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 in the various aspests of the oil industry to meet the shortages in national institutes and centres; conducting research and studies on the new techniques in industrial management; preparation of curricula and methods of training technical manpower for productive efficiency necessary for Arab oil projects; establishment of central data and documentation centre as a base for research and studies relating to manpower in the oil industry; and development of the technical know-how in areas of education and training and industrial management as well as the preparation of specialists 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 under way.

I.4 Arab Engineering Company (AREC)

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 it is still growing in size and scope. Secondly, it is developing into an "umbrella" organization for improving 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.

The AREC head office was established in Abu Dhabi, but since that time, branch and representative offices have been set up in London, Tunisia, Algeria and Tripoli. It is planned to open an office in Saudi Arabia in 1985.

AREC 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 the Libyan Arab Jamahiriya, Tunisia, Algeria, Saudi Arabia and the United Arab Emirates. These countries have required AREC employees to operate in not only the above countries, but also in the United Kingdom, France, Spain, the United States and Italy. Negotiations are now underway for projects in black African countries as well as other Arab countries.

The workload of AREC 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. The income has grown accordingly, and the total income for 1984 was over $7 million.

AREC manpower are of 20 different nationalities, and over 30 per cent of the staff are Arab. The number of staff increased from 1 in July 1981 (the General Manager) to 240 at present. Over 50 per cent of the staff are university graduates, 10 per cent of whom also have higher degrees.

2. <u>AREC basic structure</u>

AREC was set up, and has since operated, on a very different basis from a local 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 directors are from the 10 shareholding companies and meet every four months to discuss and decide on major policy matters;

(d) 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 whereever needed;

(f) AREC has no limitations on the industrial sector, although it predominantly operates at present in the oil, gas and petrochemical sectors;

(g) AREC is commercially based, just like a private company, requiring that all its expenditures be supported by 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. <u>AREC objectives</u>

The basic structure of AREC provides considerable opportunities for developing a large engineering capability, with controls to ensure that the company is commercially viable, and responsible for developing a truly Arab engineering capability.

AREC objectives can therefore be ambitious, yet practical:

(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., Africa and South America);

(e) Arabization : AREC will attract Arab professionals from the international engineering companies as well as national companies in 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 assistance not only for itself, but also 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 that a large source of top quality Arab professionals is available;

(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. AREC has 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 matching the technical and commercial capability of any competitor is considered a vital part of AREC objectives, ensuring AREC does not fall into the trap of being an overbureaucratized and self-indulgent organization.

AREC 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. Manpower

The challenge of having to develop novel approaches is nowhere more apparent than in the manpower field. Of the 240 AREC 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 the 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 ventures with experienced companies, the AREC 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 design, engineering and procurement for upgrading the Bu Hasa and Asab oil gathering facilities. This involved 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 total AREC expenditure each year, over 70 per cent are directly related to manpower - salaries, allowances, insurance, benefits and housing. This is typical for an engineering company. Typical also, virtually all of AREC 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 first to relate to overheads. Management and central staff functions (personnel, finance, etc.) are an overhead cost which cannot be recovered from clients. It is of paramount importance that this overhead be cut to the minimum. 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. All of these systems had to be developed specifically for AREC purposes owning to the uniqueness of the organization. Moreover, over time, these systems have had to be modified, improved and refined with experience and the expansion of the working environment.

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, like any other international engineering company, cannot carry a significant number of professional staff if there is no project for them to work on. 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 this being reflected in remuneration packages.

7. AREC future role in Arab countries

The objective of AREC, 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 the following:

(a) AREC initially will set up representation offices in each country. (So far, this has been done in Tunisia, Algeria, the Libyan Arab Jamahiriya 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) AREC's international experience will be used to develop the manpower, systems and procedures, and management of these joint ventures companies.

(d) AREC's experience and proven capability will be used to obtain projects in the country for the joint venture company, employing and training local engineers as much as possible, backed up by AREC's international staff where necessary;

(e) These joint venture companies will be developed 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 for local companies can be overcome through AREC involvement.

I.5 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 eliminating harmful duplication in programmes and increasing 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 by a decision taken by the seven Ministers of Industry meeting in Doha, Qatar. GOIC is an intergovernmental organization. All the seven Gulf countries are members, i.e., 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-ordinating and developing technical and economic co-operation between existing or planned industrial companies and establishments;
- Supplying technical assistance to prepare and evaluate industrial projects;

- Preparing studies concerning industry.

GOIC structure consists of a 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 into 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 an industrial data bank, providing 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 feasibility, pre-feasibility and techno-economic final studies for joint industrial projects, and providing technical training to local professionals in the region.

GOIC had 129 employees in 1985. Senior administrators included a general secretary, 2 assistant general secretaries, and 10 technical consultants. In the regional planning department there were 11 employees, in the data bank 22, in the sectoral studies department 13, in the projects department four, and in the administration and finance department 36.

The distribution according to local (Gulf), Arab and foreign staff shows that 15 employees are from the Gulf countries (five in administrative posts, three engineers, two economists and five technicians). Thirty-four employees come from different Arab States (one in administration, five engineers, four economists and 24 technicians). There are eight foreigners in all (one economist and seven technicians).

GOIC is a consultancy organization, it does not undertake basic scientific and technical research, testing, product or process design. The facilities available in the Doha centre include a computer system, a data bank mainly established for storing petrochemical and industrial statistics and information on advanced technological developments. The centre has 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 has provided an internal training programme for the members of its organization, in the form of lectures, and has sent members to participate in training provided by other organizations.

The internal lecture subjects cover: development of industrial projects econometric forecasts, industrial investment and joint projects. GOIC 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 clear that GOIC has managed to build its own organizational capabilities in consultancy services, in industrial development in general and in a wider scope in petrochemical industries and marketing, with the main feasibility studies undertaken in downstream industries.

GOIC can provide technological and economical services such as:

- Sectoral and industrial planning;

- Market studies and demand forecasts;

- 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 experience 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, United Arab Emirates Bahrain, Saudi Arabia	11 to 25 February 1985
6. Bahrain, Saudi Arabia, Jordan	12 to 24 September 1985
7. Algeria, Tunisia, Morocco1/	April 1985

II.2 Contracted Local Consultants

1. KISR/Kuwait
2. AREC/United Arab Emirates
3. Mohammed IDRISI/Iraq
4. Mohamed HILAL/Egypt
5. Abdulla SALLUTA/Syrian Arab Republic
6. Akram KARMOUL/Jordan
7. IDTC/Qatar

II.3 Questionnaires distributed and returned

Bahrain

1. Bahrain National Gas Company2/

Egypt

1. Egyptian General Authority for Petroleum2/
2. Petroleum Engineering Industries Company2/
3. Petroleum Research Centre (Egypt) Petroleum Company2/
4. Engineering and Industrial Design Development Centre
   - Industrial Construction and Service Company
   - Abu Kir Fertilizer Company
   - Talkha Fertilizer Company

1/ Questionnaires were distributed to all refining and petrochemical companies.

2/ Questionnaires were filled out and returned to ESCWA.

- 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

Iraq

- Scientific Research Council[1/]
- Baghdad University[1/]
- Technology University[1/]

Jordan

- Dar Al-Handash[1/]
- Contracting Consolidated Company
- Yarmouk[1/]
- University of Jordan
- Royal Scientific Society[1/]
- Talal Abu Ghazaleh, Jordan[1/]
- Jordan Fertilizer Industry
- Jordan Petroleum Refinery Co.
- Intermediate Petrochemical Materials Industry

Kuwait

- Kenomac[1/]
- KISR[1/]
- PIC (K.Sc)[1/]
- Kuwait University[1/]

1/ Questionnaires were filled out and returned to ESCWA.

- KERMENCO[1/]
- Kuwait Chemical Manufacturing[1/]
- OAPEC
- K.C.F. Brown[1/]
- KPC[1/]
- Santa Fe International[1/]
- Three refineries
  - Mena Abdulla Refinery
  - Mean Al-Ahmedi Refinery
  - Shuaiba

<u>Qatar</u>

- QAFCO[1/]
- Qatar National Navigation and Transport Company
- GOIC
- Middle East Construction Company[1/]
- IDTC[1/]
- ALMANA-INEGO
- QAPCO
- Qatar University
  - Science Faculty
  - Applied Research Centre[1/]

<u>Saudi Arabia</u>

- Fluor[1/]
- King Wilkinson[1/]
- Saudi Consult[1/]
- Foster Wheeler[1/]
- Kanoo[1/]
- Chiyoda Petrostar[1/]
- King Abdul Aziz University[1/]
- SAFCO[1/]
- Yanbu Refinery[1/]
- PETROMIN Mobil Yanbu[1/]

1/ Questionnaires were filled out and returned to ESCWA.

- PETROMIN Shell1/
- King Saud University1/
- ARAMCO1/
- Rabigh Refinery1/
- Riyadh Oil Refinery Co.1/
- Jubail Oil Refinery Co.1/
- Jeddah Lube Oil1/
- Riyadh Lube Oil1/
- PETROMIN Lube Refinery1/
- Petrochemical Plants
- AR-RAZI
- IBN-SINA
- SAMAD
- YANPET
- KEMYA
- SADAF
- PETROKEMYA
- SHARQ
- IBN HAYYAN

Syrian Arab Republic

- University of Damascus1/
- Aleppo University1/
- General Company for Executing Industrial Projects1/
- Industrial Testing and Research Centre (ITRC)1/
- General Establishment for Designs and Studies1/
- Oil Refinery Co. (BANIAS)1/
- Oil Refining Co. (HOMS)1/
- The Fertilizer Co. (HOMS)1/
- The Ba'ath University (HOMS)1/

1/ Questionnaires were filled out and returned to ESCWA.

United Arab Emirates

- FERTIL[1/]
- National Petroleum Construction Company[1/]
- AREC[1/]

Algeria*

Morocco*

Tunisia*

Libyan Arab Jamahiriya*

---

* No replies were received by ESCWA.

1/ Questionnaires were filled out and returned to ESCWA.