CRANFIELD UNIVERSITY

PhD THESIS

Technology Transfer: A Case Study Analysis of the Saudi Oil and Petrochemical Sectors

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ABSTRACT

In the recent past a number of technologies have been imported into The Kingdom of Saudi Arabia. This experience has affirmed the conviction that technology can make an invaluable contribution to the growth of The Kingdom of Saudi Arabia. However, in doing so, the Kingdom of Saudi Arabia, like other nations, faces some questions of possible obstacles, trials and errors during the course of industrial development and technology transfer, that can be addressed by utilising science and technology efficiently to develop many sectors, improve output of industry, develop standards and status of national manpower and its utilisation. This study analyses issues related to successful technology transfer in Saudi industry

As such, the purpose of this study is to examine the relationship between industrial development and technology transfer in the Kingdom of Saudi Arabia, and the important role that modern technology can play in development of the oil and petrochemicals sectors. The aims are to provide a better understanding of the linkage between technology transfer and industrial development strategies in general, with special emphasis on the performance of the Saudi oil and petrochemical industry in particular. As such, to avoid failures on technology transfer, it becomes an imperative to analyse technology transfer by considering various approaches, as follows:

- Technology and industry is a key to future growth in Saudi Arabia - The main objective here is to locate, attract and keep industry. The concept of technology and industry deals with role of technology and the dynamics of Saudi's industry environment to excel in markets.

- Strategy at the functional level – this relates to the various activities assigned to different departments in the organisational structure. The concept means that all functions must be conducted in accordance with industry, technology and strategy.

- Strategy and technology - this means how to transfer an already existing technology to Saudi industry.

- Strategy for research and development - The concept deals mainly with how to plan, finance and implement R&D for products, security, environmental protection etc. Where to draw the line between general and specific objectives in R&D.

The chosen method to study these issues is case study analysis of SABIC (Saudi Basic Industries Corporation) and Saudi Aramco (Saudi Arabian Oil Company). SABIC has been established for two main strategic objectives that go together in two parallel lines. The first objective aims to develop human resources and to turn them into a trained category that has the capability to transfer, assimilate and develop the most sophisticated technologies. The second objective aims to develop the natural resources and convert them to industrial products, helping to diversify the domestic income sources and open

the doors for building up processing industries to satisfy the local and external market requirements. The first case study (SABIC) provides an overview of the phenomenon of technology transfer to the Kingdom of Saudi Arabia. For comparative purposes the second case study involves a case study of Saudi Arabia's largest oil firm (Saudi Aramco). These two case studies have been selected for their:

i role in technology transfer in Saudi oil and petrochemical sectors,

ii approach and access to greater resources in technology transfer,

iii exposure of firm behaviour in the Saudi industrial sector,

iv contribution to Saudi economic development and realisation of additional income through improved operations.

The two case studies, typical of large companies not only in Saudi Arabia but also in the world, will address the obstacles in learning, committing and increasing performance through technology transfer. These cases highlight a range of choices available in technology transfer, which provide a wide range of means for technological learning through transfer. They offer different oppôrtunities for further innovation and technology development.

Although Saudi Aramco and SABIC claim 80 percent and 73 percent " Saudisation", respectively, the survey indicates that native Saudis need more participation and involvement in technology process in order to raise their technological know-how.

As a result of this study, a common approach to technology transfer into Saudi Aramco and SABIC may be developed and applied by industry, per its requirements to address existing and prospective problems. At present Saudi Arabia has the capacity to absorb new technologies in its growing industrial sector. This is required to meet its desired objectives of becoming industrialised and self-sufficient in required technologies.

The real test of effective technology transfer in this study is the need to build Saudi local technological capability supported by an effective learning strategy. The ultimate aim is to expand the scope of this study beyond the academic level towards the practical challenges of improving the efficiency and effectiveness of inward technology transfer for future Saudi industrial development.

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ABBREVIATIONS

Aramco	Saudi Arabian Oil Company (Saudi Aramco)
BS	Business strategies
DCs	Developing countries
ECGD	the Export Credits Guarantee Department, is the UK's official export credit agency
EDC	Ethylene Dichloride
EOC	Economic Offset Committee
EG	Ethylene Glycol
EXPEC	Exploration and Petroleum Engineering Centre
FI	Foreign investment
GEC	General Electricity Corporation
GCC	Gulf Cooperation Council
IEA	International Energy Association
IMF	International Monetary Fund
JV	Joint venture
KACST	King Abdul Aziz City for Science and Technology
KFUPM	King Fahad University of Petroleum and Minerals
KSU	King Saud University
KSA	Kingdom of Saudi Arabia
MCI	Ministry of Commerce and Industry
MF	Ministry of Finance
MPM	Ministry of Petroleum and Minerals
MP	Ministry of Planning and Economy
MNC	Multi-National Company
OPEC	Organisation of Petroleum Exporting Countries
OPIC	The Overseas Private Investment Corporation (OPIC) was established as a development agency of the U.S. government in 1971. OPIC helps U.S. businesses invest overseas, fosters economic development in new and emerging markets, complements the private sector in managing the risks associated with foreign direct investment, and supports U.S. foreign policy.
PE	Polyethylene
PIF	Public Investment Fund
R&D	Research and development
RCJY	Royal Commission for Jubail and Yanbu
RIKFUPM	Research Institute at King Fahd University of Petroleum and Minerals
SIDF	Saudi Industrial Development Fund
SABIC	Saudi Basic Industries Corporation
SCH	Saudi Consulting House
SDF	Saudi Fund for Development
SCECO	Saudi Consolidated Electric Company
SWCC	Saline Water Conversion Corporation
S&T	Science and technology

TT	Technology transfer
TTS	Technology transfer strategies
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organisation
WB	World Bank

CHAPTER ONE

INTRODUCTION

The purpose of this study is to examine the effectiveness of technology transfer in the Saudi oil and petrochemical industry. The study involves two elements. The first is the transfer of advanced technologies from industrialised countries, and also the various options and strategies through which a company may seek to build up technological capabilities. The second concerns the Kingdom's strategy for the technological development of Saudi industry.

1.1 Study background

During the past decade, Saudi Arabia has transformed its economy and society. In doing so, the Kingdom has laid special emphasis on importing technology to implement more complex and sophisticated projects, such as oil, gas, petrochemical projects, electric power plants, telecommunication, construction, medical services and commercial air line support services. Technology has been transferred in the following ways: joint partnerships/alliances; license agreements; co-operation with various research and development (R&D) centres worldwide; and offset programmes.

Whilst this study is concerned with evaluating outcomes from the Saudi Arabian experience in technology transfer from industrialized countries, it also examines the way Saudi Arabia has attempted to minimise dependence on imported technology, seeking self-sufficiency. The Kingdom is actively searching for the most modern imported technology as well as developing its own technology. Specifically, this study examines the viability and performance of Saudi Arabia's past and present technology transfer mechanisms, particularly in the oil and petrochemical industry. It explores in detail the processes of development and adaptation of technology in these two sectors.

The Kingdom of Saudi Arabia (KSA) has developed its education and training programmes to match its needs and future industrial growth. The numbers of schools and colleges have increased from 3,283 in 1980 to 23,435 in 2000, the number of teachers from 23,100 in 1980 to 363,100 in 2000, and numbers of students from 547,000 in 1980 to about 4.8 million in 2000.[1] The number of students enrolled at technical schools and institutes rose from 840 in 1970 to 38,893 in 2000; an increase of around thirty-five fold during the period.[2] The number of trainees graduating from vocational training centres also rose from 417 in 1970 to 6,689 in 2000.[3]

American, European and Japanese firms have played an instrumental role in Saudi development by supplying the needed machinery, equipment, expertise and know-how, together with management services for large projects in the Kingdom. In particular, joint venture arrangements have offered Saudi industry an important mechanism for the transfer of technology and technical know-how. Foreign partners of Saudi businesses are leading industrial manufacturers. They have also played a vital role in introducing Saudi firms and Saudi products to world export markets.

Table 1.1 Foreign investments in Saudi industry

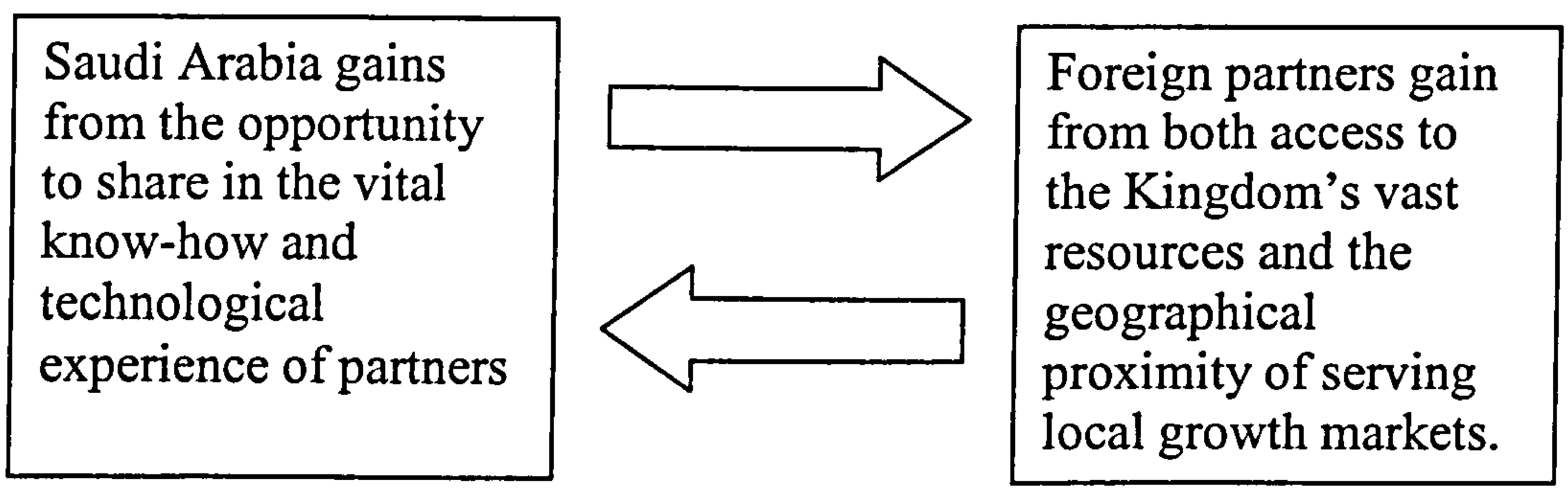
Country	Industrial projects	Capital ($ bn)	Foreign share (%)
USA	68	10.0	48.1
Japan	05	2.7	49.9
Italy	09	1.4	30.8
Taiwan	03	0.7	49.9
UK	31	0.5	46.9
S.Korea	07	0.5	18.8
Germany	24	0.3	27.0
France	11	0.2	28.8

Source: Ministry of Industry, Internal Report, p. 17, Riyadh, Saudi Arabia 1999

Saudi Aramco and SABIC are prime examples of the success and strength of industrialisation in the KSA. Through joint venture (JV) partnerships, 10 of SABIC's 16 manufacturing affiliates are joint ventures formed with leading international companies. Partners have been chosen on the basis of their proven record in the industry and on their willingness to provide advanced technology and training to develop Saudi manpower.[4]

By using foreign partners' expertise in creating marketing outlets overseas, joint ventures have also helped to ensure that such industrial projects have not become a commercial failure. Joint ventures represent a two-way street in commercial benefits.

Figure 1.1 Saudi joint ventures: a 'two-way street' in commercial benefits



The apparent growth of joint ventures around the world is a reflection of increasingly competitive business conditions. Joint ventures are not acquisitions or mergers, rather they are mutually agreed arrangements to achieve something specific together by combining technological capabilities, human resources and other respective strengths. In the competitive global marketplace, even very large companies sometimes need to collaborate with other businesses.

American firms constitute by far the most important industrial partners in the Kingdom of Saudi Arabia. The oil and hydrocarbon sector in the Kingdom has historically been dominated by pioneering US industrial firms, such as MobilExxon and Shell. It is logical for many American petrochemical companies to reach out for global markets and customers. The important role US participation plays in Saudi manufacturing is due to the strong influence that the national petrochemical sector wields over Saudi Arabia's current and future growth trends.

American technological partnering, however, is not confined to the petrochemical industry but also covers other manufacturing branches e.g. food and beverages, paper, fabricated metal products, machinery and equipment. In Saudi Arabia, international joint ventures are arguably efficient and viable conduits for technology transfer and business co-operation, gaining wide acceptability amongst partners. The 1989 Saudi Industrial Survey clearly revealed the vital role foreign joint ventures played in the early development and growth of Saudi Arabia's industrial sector. The JVs are even more important in the first decade of the new Millennium. In production, sales, profitability, value-added, and exports, JV companies out-perform the average industrial unit. It is the government's intention to use the private sector to transfer technology to Saudi Arabian industry by strongly encouraging joint ventures with foreign partners. In this process, the Saudi government seeks to facilitate co-operative business relationships and joint ventures between Saudi and foreign enterprises.

The Saudi industrial sector has played an effective role in diversifying the base of the national economy in order to reduce dependence on oil as the major source of income. The first major industrialisation effort was the development of SABIC's industries in the late 1970s and early 1980s. The other principal area of industrial growth has been manufacturing. By 2002, there were more than 3,300 manufacturing units operating in Saudi Arabia, including more than 200 downstream chemical and plastics industries, which rely on SABIC, as a major growth pole within the industry to supply raw materials.[5]

In 2000, capital investment in Saudi industries exceeded $80 billion, and production was valued at more than $25 billion annually.[6] The Saudi government has publicly stated that it wants to provide the appropriate economic infrastructure for industrial growth. Provision of the necessary infrastructure includes investment incentives for both Saudi and international investors, the encouragement of foreign technology transfer, and the transfer of technology from existing industries to smaller downstream industries.[7]

With regard to the oil and petrochemical industry, Saudi Arabia already offers advanced infrastructure for industrial development. For instance, two industrial cities - Jubail on the Gulf and Yanbu on the Red Sea - encompass between them more than 1000 square kilometers of airports, roads, deep-sea ports, housing, schools, and commercial support centres. There are also vital public utilities, including electricity, potable water, industrial waste treatment and sewage. Additionally, well-developed transport and communication networks link Jubail and Yanbu with six other regional industrial cities located throughout the Kingdom.

This modern industrial infrastructure provides Saudi Arabia with a competitive advantage to promote itself to overseas investors. Rents on building sites are nominal, as are the costs for water and electricity. And the government is eager to see the industrialisation process increasing via continued foreign investment. Many joint ventures have been established to develop downstream industrial projects. West European, Japanese and US firms are all playing a major role (as evidenced by 10 SABIC foreign projects in Jubail and Yanbu)[8] as joint venture partners, technology licensors, suppliers and construction contractors.

Transfer of advanced technology to the Saudi oil and petrochemical industry has had a positive impact on Saudi economic growth, as well as also improving living standards and skill levels. In the industrial sector, Saudi Arabia has considered technology transfer to be an important part of its industrial development strategy fostering the establishment of manufacturing facilities. For instance, the number of industrial projects including joint ventures, rose from 199 factories in 1970 to 3,418 manufacturing plants in 2002.[9] The total employment in these factories increased from 14,000 to 319,000 workers over the same period, representing around $64 bn worth of investments, including 360 international joint ventures from 27 countries.[10] Joint ventures account for a total investment of US $ 36 billion, with 60% of these investments in petrochemicals, 15% in steel and machinery, 9% in the food sector and 7% in transportation machinery.[11] Saudi Aramco refining production in the Kingdom grew at an average annual rate of 4.7 percent, from 225.3 million barrels in 1970 to 600.6 million barrels in 1996, and oil consumption increased by 25% over the last five years.[12]

The industrial report from the Ministry of Industry and Electricity (1998) shows that Saudi industrial non-oil sector added value (wages, salaries, services, profits and capital depreciation) was US$12 billion.[13] Saudi oil and petrochemical industry has played a very important contributory role in the creation of this value-added. SABIC's production climbed to an all-time high of nearly 40.6 million metric tons in 2002 and sales revenues were up by an impressive 5.0 per cent, at US $ 8 billion.[14] Apart from new and expanded plant operations, product diversification and increased production, Saudi oil and petrochemical industry enjoyed particularly strong growth in Saudisation. In 2002, Saudi Aramco and SABIC achieved more than 79 percent Saudisation from total employment of 68,887.[15] Output growth of this industry has been consistently strong primarily because it has been able to increase product sales across all its major markets.[16] Saudi Aramco and SABIC, are examples of the success of Saudi industrial and technological development strategy.

In 2003, SABIC represented: the largest petrochemical producer in the Middle East; a producer of all five essential commodity petrochemicals; one of the largest petrochemical producers in the world with a market share of more than 7%; the largest steel producer in the Middle East; a benchmark for the development of Saudi commercial downstream industrial sector; and a success story for the application of state-of-the art technology. SABIC enjoys several competitive advantages, including access to abundant supplies of natural feedstock; proximity to the marketplace (being centrally located between Europe and Asia); state-of-the-art manufacturing plants, with considerable economies of scale; and a well supported and integrated global marketing network backed by research and development facilities.[17]

For Saudi industry, effective technology transfer depends on company supplier links, industrial integration and also policy emphasis on education, training, and basic and applied scientific research. In this regard, Mr.Yotaro Iida, Chairman of Mitsubishi Heavy Industries (MHI) Ltd and SABIC's partner on the First Joint Japan GCC Business Conference (November 7, 1994 in Tokyo), remarked that:

> "Technology transfers require a certain firmness, to avoid merely handing technology over to the purchaser. The equipment supported by the technology must be seen to work well and to produce acceptable goods..." In the case of electrical power plants, Mr Iida went on to state: "...along with our main product, we used to build the machines and equipment and deliver them to the customer, and that was that. These days, however, planning begins at the stage when construction of the entire plant is examined. Refining the plans and undertaking the designing, manufacturing, installation and construction are now a matter of course.[18]

MHI undertakes all aspects of engineering, including organization of plant operation, management of security systems, and personnel training, to meet its customers' needs. MHI often transfers a part of its technology. In addition, other Japanese and Asian producers in Saudi Arabia introduce production technology in a gradual fashion. Typically, these firms begin by exporting products not yet available in the recipient country. Next, they create joint venture companies and dispatch specialists from Japan to train local personnel. Beginning with products that are relatively easy to manufacture, these firms begin producing locally. Mr Iida noted that local personnel could learn the production technology gradually. If the process goes further, personnel from the recipient country may be invited to the company's factory in Japan for training and education.

This suggests that mre investment in industries by a country does not necessarily equate to the acquisition of certain technological capabilities, particularly if this means depending completely on foreign technological resources. However, the transfer of technology along with local adoption must be economically and socially viable, enjoying comparative advantages. Therefore, the selection of a foreign technology should proceed with a detailed study to determine its need, cost involved, the extent of its ultimate local application and optimisation of the benefits through the development of national capabilities. The process of setting up an industry and selection of a given technology must be evaluated carefully, in terms of its suitability, effectiveness, and impact on productivity and quality as well as the potential for local development.

The two main goals of the Kingdom's industrialisation programme have been to reduce dependence on oil income through economic diversification and by the adding of value to the country's abundant hydrocarbon oil and gas resources. This is achieved by the establishment of downstream industries through import substitution. The Saudi government believes it can pursue oil and petrochemical development by the establishment of vertically integrated industrial structures, as has been done by other multinational companies.[19] Since the early 1970s, the Saudi government has used a large part of its development spending to establish an industrial infrastructure and also certain basic industries. The Second Five-year Development Plan (1975-1980) called for total public spending of US$142 billion, six times the actual spending between 1970 and 1975, with the aim of diversifying away from oil.[20]

The Third Five-year Development Plan 1980-1985 called for a total public spending of US$390 billion.[21] This plan placed more emphasis on diversifying the economy by developing large-scale industrial and agricultural projects, accelerated investment in infrastructure, health, education and social services. The Fourth Five-year Development Plan (1985-1990) placed further emphasis on economic diversification, export expansion and import substitution to reduce the growing public account deficit. The Plan also placed emphasis on private enterprise.

Government spending remained the main source of economic growth, and dependence on oil increased despite large public investment into mainly industry and agriculture. Although the main goal of Saudi development policies during the extended 1970 – 1990 period was to diversify the economy away from dependence on oil-export revenues, the indirect and direct subsidies needed to achieve this goal, increased the government's short-term dependence on oil.

As oil export revenues account for over 90% of Saudi foreign trade earnings, there is a significant relationship between the Saudi economy and exports of crude oil, refinery and petrochemical products. However, Saudi industry faces enormous constraints and problems in achieving indigenous and diversified industrial development. Long standing problems stemming from the failings of industrial strategy, weaknesses in the policy of education and training and misunderstandings in the process of technological innovation are still there, while new problems associated with the impact of the changing world economy, including increasingly competitive, globalized and changing business conditions, all represent major challenges for Saudi industrial development.

1.2 Study aim

In pursuit of Saudi industrialisation, the Kingdom has laid special emphasis on both inward transfer of industrial technology and indigenous technological development, not only to achieve self-sufficiency but also to implement more complex and sophisticated projects. Thus, the purpose of this study is to examine and evaluate the effectiveness of technology transfer in Saudi industry. In particular, the research will explore the transfer of technology from industrialized countries to the Saudi oil and petrochemical industry with emphasis on the nature and extent of technological absorption in this industry. This study has the following enabling objectives:

- Assessment of the impact of technology transfer on the development of Saudi capabilities in the oil and petrochemical industries
- Identification and description of the strategies Saudi firms have followed to support technological development, particularly with respect to:
  - businesses (development strategies)
  - product and process technologies (technology strategies)
- analysis of the contribution of the Saudi oil and petrochemical industry to the national economy
- Analysis of the models adopted by SABIC and Saudi Aramco in the development of technological capability

- Investigation of the costs and benefits of technology transfers to the Saudi oil and petrochemical industry. Identification of possible improvements to be achieved in enhancing the technology transfer process, highlighting areas where Saudi Arabia might become more self-sufficient in the operations of the oil and petrochemical industry.

There is a need to identify all opportunities and establish a series of appropriate science and technology strategies for the long and short-term development of Saudi industry. This study stresses that the development of appropriate strategies depends on an understanding of not only the external environment but also internal corporate strengths and weaknesses.

1.3 Study value and contribution to knowledge

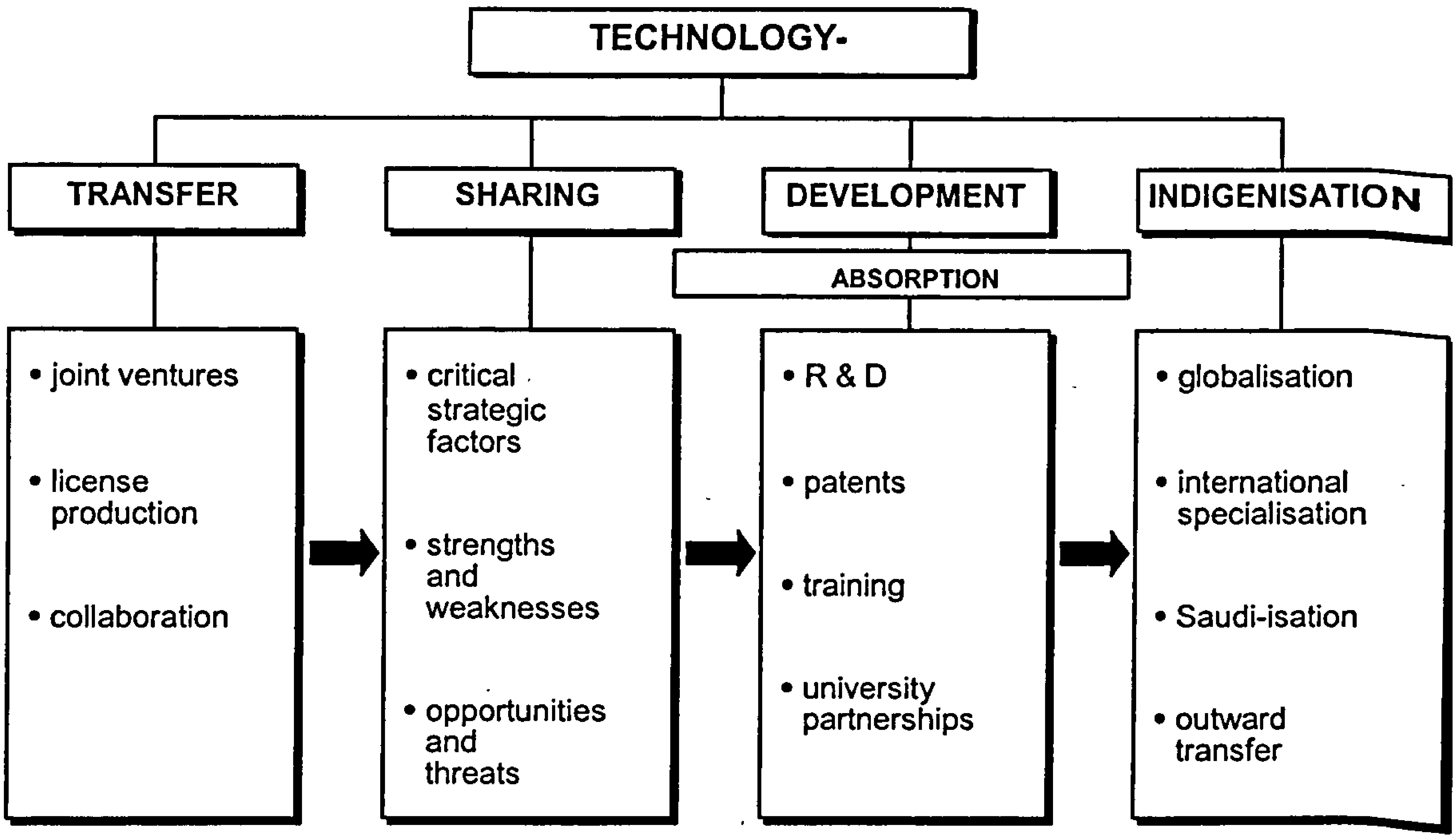
This study examines, for the first time, the effectiveness of technology transfer in the Saudi oil and petrochemical industry. Saudi Arabia is seeking to deploy modern technology as the primary engine of growth for developing the oil and petrochemical sectors. Partnering and joint ventures have become the prevalent strategy for technology transfer in Saudi industry. Therefore, in broad terms, this study will critically evaluate partnering as a strategy for technology transfer in Saudi Arabia with a particular focus on Saudi Aramco and SABIC.

1.4 Conceptual framework

'Effectiveness', in terms of technology transfer strategies, is screened by employing case study analysis of SABIC and Saudi Aramco. The costs and benefits of JVs will be identified and analysed by reference to the performance achieved in the key areas of sharing, development and indigenisation of technology. SABIC and Saudi Aramco have been selected to test specific assumptions underlying the key factors characterising the technology transfer and technology development process in Saudi Arabia. Choice of the mode of technology transfer represents the start point in the push towards achieving the long-term goal of self-sustaining growth (indigenisation). Various stages can be identified in the process of technology transfer. These stages can be grouped into four overlapping parts as shown in Figure 1.2.

Figure 1.2 sets out all the factors affecting the transfer mechanism and shows the interrelationships between them. The transfer starts with government and company policy for technology transfer. Then the vehicles of inward technology transfer leading to industrial and technological development, with due consideration of investment and employment trends, is determined. Once inward technology transfer has been effected, resulting in improvements/ innovation and diffusion of knowledge, the prospects for eventual outward transfer/export are identified and the search is then on for competitiveness. This figure classifies the mechanism of technology development. These mechanism and stages are important for the technology transfer. Therefore it will from the basis for the analysis in Chapter 6.

Figure 1.2 Technology transfer: mechanism for technological development



1.5 Research methodology

1.5.1 Primary Data.

The aim of this study is to explore the technology transfer process and the manner in which technological capabilities are acquired in the Saudi oil and petrochemical industry. Empirical research will be based on interviews using semi-structured questionnaires (see Appendix 1). Due to the considerable amount of data necessary for analysing business and technology and due to the confidential nature of most of this data, the chosen method is that of case studies. A case study of Saudi Basic Industries Corporation (SABIC), which is responsible for the development of basic industries in Saudi Arabia, will be considered along with another case study, for comparative purposes, of the largest firm in the Saudi Arabia, Saudi Aramco. The List of Saudi Aramco and SABIC affiliate companies included in the survey is shown at Appendix 2; the response rate for the former was 68% and for the latter, 63%. The survey coverage includes all Aramco and SABIC affiliates in the Kingdom, but not the SABIC Steal Plant (Hadeed) because it does not form part of the oil and petrol-chemical sector. The survey does not include Saudi Aramco and SABIC joint ventures and subsidiaries outside the Kingdom.

The case study method:

- is useful in the exploration of unknown or poorly understood areas. This is certainly the case of technology transfer in the context of Saudi Arabia. The case study approach is descriptive and based upon logical and causal connections

- permits the use of multiple research methods so that the complexity of technology transfer and the specificity of the context of the KSA are reflected, gathering data through different routes, i.e. triangulation of data

- helps to discover relationships and structures, providing an opportunity to become familiar with the process in detail, and the patterns of organisation and management that occur in practice

- allows a close relationship with firms and easy access to privileged and confidential information especially in the Kingdom's industrial sectors where access to corporate information is difficult to obtain

- is research-oriented in which feedback and modification of information and interpretation are important.

The major criticism of the case study approach is that it can be unrepresentative, and that the possibility for generalising is minimal. The extent to which generalisation may be made from case studies depends upon the adequacy of underlying theory and the whole corpus of related knowledge on which the case is analysed, rather than on the particular instance itself.

Case studies undertaken in this dissertation employ a data triangulation approach to ensure as far as possible the validity of the research findings. The case study data sources include:

- interviews with a questionnaire addressed to company managers, engineers and technology providers

- documentary sources at firm and government levels, and,

- physical observation of equipment types, in-house skills, organisational structure/changes, manpower training policy, adaptability of organisation systems to local conditions, and policy application by SABIC and Saudi Aramco with respect to technology transfer.

1.5.2 Secondary Data

Specific data sources in KSA and UK:

- Ministry of Finance (MF)
- Ministry of Petroleum and Minerals (MPM)
- Ministry of Commerce and Industry (MCI)

- Ministry of Planning and Economy (MPE)
- Public Investment Fund (PIF)
- Saudi Industrial Development Fund (SIDF)
- Saudi Aramco
- Saudi Basic Industries Corporation (SABIC)
- Economic Offset Committee (EOC)
- Royal Commission for Jubail and Yanbu (RCJY)
- King Abdul Aziz City for Science and Technology (KACST)
- The Research Institute of King Fahd University of Petroleum and Minerals (KFUPM)
- King Saud University (KSU)
- Saudi Consulting House for Industrial Development
- Saudi Industrial Development Fund (SIDF)
- Multinational enterprises and firms, which have been involved in the development efforts of the country in the following fields:
- Engineering firms
- Equipment suppliers
- Contractors
- Partners: mainly ExxonMobil, Shell, Mitsubishi
- Consultant firms
- UK Universities
    - Sussex
    - Oxford
    - Cambridge
    - East Anglia
    - Manchester
    - Glasgow
    - Edinburgh
    - Exeter
    - Bristol
    - Aston
    - Birmingham
    - Leeds
    - St Andrews
    - Aberdeen
    - Durham
    - York

Research visits to numerous UK universities led to an understanding of the concepts of technology and technology transfer. A particular focus here is on role of the multi-national as the primary means of technology transfer. Theoretical analysis derives from the theory of innovation, exploring in detail the processes of development and adaptation of technology by undertaking a review (primarily reflected in the discussion of chapter 2) of the technology-based literature. This includes books, periodicals and publications, emphasising the transfer of technology, in particular, and industrial development, in general. Emphasis is on the range of advanced studies conducted in the industrialising world and also more specifically, the developing Arab countries, together with the studies and debates conducted and recommendations made by UN organisations, such as UNIDO and the World Bank.

Moreover, the review of technology transfer bases (Chapter two) has been referenced to the experiences of international companies, so as to form a more accurate and precise view of the concept of technology transfer. The later case study analysis of the specific experiences of the oil and petrochemical industry in Kingdom of Saudi Arabia builds upon this theoretical analysis.

The visits were concerned with meeting expert people in specialized companies involved in technology transfer, such as The Industry Technology Facilitator (ITF) in Aberdeen and in Teaching Company Scheme (TCS), Faringdon, Oxfordshire. Also visited were technology parks at Cambridge University and Loughbourough University which are strong in the field of technology transfer.

1.6 Study structure

There are three parts to this study. Part I, the background to the study consists of three chapters. Chapter One outlines the scope of the research, and flags the importance of technology transfer to Saudi industry. It describes the research design and methodology of this project, including the process of fieldwork. In Chapter Two, the literature on industrial development and technology transfer studies is reviewed and evaluated. This forms the basis of the theoretical framework, where basic concepts important to the main themes of this study are defined and explored. Within this theoretical framework, the presumptions and research questions are highlighted, to be examined later in this thesis. Chapter Three describes the key elements of Saudi industrial development. It identifies and explains Saudi industrial policy, and the technology development that has resulted from technology transfer to Saudi Arabia.

Part II moves from the (theoretical and practical) contextual backdrop to the focused empirical fieldwork. Part II is concerned with two case studies and has two chapters devoted to the examination of the technology transfer and technology development processes within the two largest oil and petrochemical companies in Saudi Arabia. To set the scope for case study analysis, Chapters Four and Five analyse in detail the background development of Saudi Aramco and Saudi Basic Industries Corporation (SABIC).

The case studies explore the effectiveness of the process of technology transfer in the Saudi oil and petrochemical industries. The case studies address several aspects of the process of technological innovation (adaptation and improvement) and changes related to government technological and industrial policies. Acquisition of technological capabilities, along with identified problems, represents the core area of investigation.

Part III is concerned with lessons learned and has two chapters. Chapter Six analyses the lessons of oil and petrochemical technology transfer and development by reference to both the indigenous and technology transfer processes exposed in the two case studies. Finally, Chapter Seven presents conclusions of this study. It draws policy recommendations that recommend themselves, including areas for further research.

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CHAPTER TWO

TECHNOLOGY TRANSFER AND INDUSTRIAL DEVELOPMENT

This chapter critically evaluates the literature on technology transfer, particularly the issues relating to technological development, and industrial development. The sources used, and the frameworks presented reflect the thrust and particular concerns underpinning the research.

2.1 Concept of technology transfer

This section explores the concept of technology transfer through two perspectives: the first deals with the commercial aspect of technology transfer and the other focuses on technological adaptation. These perspectives highlight the effectiveness of technology transfer (from transferor to transferee), ensuring that the receiving party can employ, utilise, maintain and develop the technology.

Technology transfer can be defined as the diffusion and adaptation of new technology, equipment, practices and know-how.[1] The definition of technology transfer seems straight forward, but the process is complicated. Successful technology transfer needs attention to the following aspects, affordability, accessibility, sustainability, relevance and acceptability.[2]

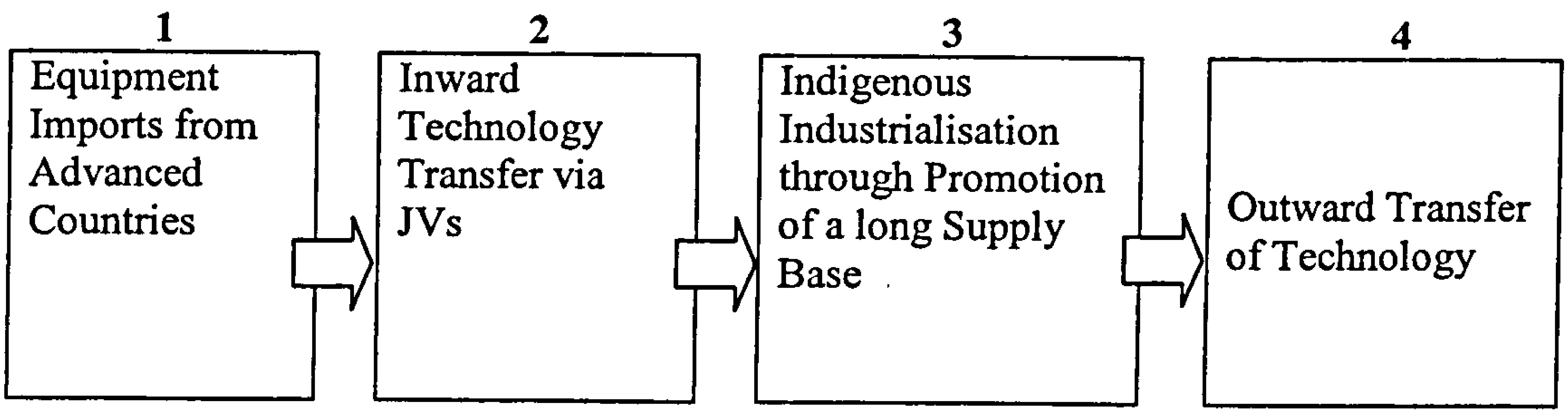
Multinational enterprises have a number of options for technology transfer. These include contractual arrangements, such as technology licensing agreements, joint ventures, technical assistance and management contracts, turnkey projects and direct foreign investment in wholly-owned subsidiaries or affiliates. Transfers also occur, for example, through education of students abroad and through trade in capital goods between unrelated parties. Technology transfer can be understood as the process by which technology moves from one physical or geographic location to another for the purpose of application towards an end product.[3] Transfer can take place either domestically from one sector to another, or from one country to another covering the required knowledge, experiences and skills.

Technology transfer may comprise some or all of the following: fabricated materials and capital goods such as machines, instruments, equipment and the rest of the technology and its necessities such as design and execution works; preparation of feasibility studies for projects, including technological experiences and skills comprising knowledge relating to production, patents, documents, drawings, operation programmes, maintenance instructions, training and education activities.

Figure 2.1 identifies technology transfer as a progressive process. The process might be mixed with the concept of technology trading, importing or the purchasing of technology products. A technology chosen, installed and operated by others without performing an active role in such operations may nevertheless involve technology transfer via the transfer of:

- capital goods and engineering management and administrative services
- operation and maintenance skills and,
- technological knowledge and experience to acquire new and productive capabilities through local manpower acquiring the knowledge and ability to produce ongoing technological change.

Figure 2.1 Development stages in technology transfer



Developing countries suffer from technological dependence on advanced industrialised countries, as they import all technology from abroad. There are historical causes for this dependence. The most significant is that advanced countries have experienced and overcome industrial isolation earlier, but in the developing world this experience is a serious constraint to technological development. Despite serious attempts by some developing nations, there is still a big gap between advanced countries and developing countries.

Amongst many theoretical approaches in the literature on developing countries, a central theme is that developing countries should simply repeat the industrialisation process of the advanced economies. What the less developed countries must do is to compress an essentially linear process into the shortest possible time-scale. The way to become "less backward" is to borrow, buy or copy those corresponding features of the rich countries felt to be instrumental in bringing about economic growth.[4]

However, the largely frustrating experiences of developing countries in the 1960s and 1970s and comparatively successful more recent experiences of the newly industrialized countries, have challenged these classical perspectives and opened new territories for development studies. Today, it has been by and large acknowledged that development is not purely an economic phenomenon, rather a multidimensional process involving the reorganization and reorientation of entire social as well as economic system. In particular, technological transfer has come to play an increasingly important role in the life of both developed and developing countries.

The negative consequences of technology transfer from industrialized countries, is given particular attention in the literature. A leading role has been played by Schumacher's publication, "small is beautiful". Schumacher argues that:

1. many western technologies are inappropriate to local conditions in developing countries

2. there is a huge imbalance in technology trade between richer and poorer countries

3. technology transfer has reinforced dependencies of all kinds

4. the values of less developed countries are being manipulated and people are being mobilized to support goals re-imposed from the external metropolitan economies of industrialized countries. [5]

Intermediate technology is supposed to be appropriate for local conditions in less developed countries and regions, and to meet certain criteria, e.g., being easy to access, easy to learn, and being suitable for small scale regional or district production with local resource supplies. Technology transfer appears to provide a promising model of technological development in development countries, by encouraging indigenous technological capabilities.

2.1.1 Definition of technology

Analysts have defined the term, technology, in various ways. Baranson conceptualised technology in the following terms "...Industrial technology consists of product designs, production techniques and managerial systems to organise and carry out production plans". [6]

Peno and Wallender, by contrast, define technology as "...knowledge embodied in products, processes, formulae and techniques needed for managing operations".[7] Hall and Johnson distinguish not only between product-embodied, process-embodied and person-embodied technologies, but also between general-, system- and company- specific technologies. The United Nation Conference on Trade and Development, UNCTAD, also provides a comprehensive description of technology. According to UNCTAD, technology "as an essential input to production" is bought and sold as capital goods, human labour and information of technical and commercial character.[8] The UNCTAD study also suggests the following as elements of technology:

- feasibility studies, market surveys and other pre-investment services
- determination of the range of technologies and the choice of technology
- industrial processes
- engineering designs and detailed engineering
- plant construction and installation
- training of technical and managerial personnel

- management and operation of production facilities
- marketing information
- improvements to processes and product designs.

There is some disagreement over the meaning of the term 'technique'. In most cases, it denotes only the material aspects of technology; that is the machinery, equipment and tools that are used by human beings in the production process. As for the term 'technology', it includes such non-materialistic aspects as technical knowledge, management and work organisation. For the purposes of this study, the term technology denotes both the material and non-material aspects. Thus, it may be argued that technology is the method of doing things. However, to use any definition of technique, three factors must be present:

- information about the technique
- ways and means to implement the technique, and
- understanding how the technique works.

Information and implementation flows and methods can be transferred. However, understanding technology may only be acquired by training, education, experimentation, research and previous experience. There are two approaches to technology transfer: vertical and horizontal transfer. Vertical technology transfer is transference from general to specialised levels or transference from the scientific level to the final product form. Horizontal technology transfer is transference from one country to another, or from one application to another, e.g. uses of warfare technology to the civilian sector. There are many forms of horizontal technology transfer, including the following:

- licensing agreements to use patents or trade marks
- know-how agreements
- technical cooperation agreements
- importation of machinery, equipment and primary and intermediate materials agreements
- training of personnel to raise their skill levels and efficiency.

Moreover, there is a close relationship between science and technology, particularly in the field of development. On the one hand, science provides the required basic knowledge to understand the origins and dynamics of the problems, measure their strength and direction and find out solutions. Technology, on the other hand, is the applied science that depends on scientific knowledge and that provides the scientific means for tackling the problems and implementing the results.

2.1.2 Technology transfer objectives

The main objectives of technology transfer may be summarised as follows:

1. *Productive capacity:* the capacity to operate a particular technology

2. *Investment capacity*: the capacity to establish new production units and to expand existing ones

3. *Innovation capacity*: the ability to develop new techniques to achieve certain objectives.

It should be noted, however, that importation of technology does not imply the immediate availability of production capacity. To make use of it, therefore, the local population must take part in the process by trying to understand the technology, identify how it works and adopt the scientific and practical methods it uses. Thus local people will be able to improve productivity and adapt the technology to the changing conditions. Gill Wilkins noted that technology transfer should assist local people in developing the skills to choose appropriate technology, adapt it to local conditions and service requirements and integrate it with existing indigenous technology.[9]

Productive capacity influences investment and innovation capacity. For example, production engineers might acquire engineering and spare parts manufacturing experience. In addition, they might also acquire the ability to adapt the technology because of knowledge in maintenance of machinery and solving production bottlenecks. However, this type of experience is usually not enough to acquire the ability to design new production units or invent new technology. Such experience is acquired in specialised scientific and technological institutions and machinery and equipment plants. Moreover, the increase in local productive capacity in a particular field will lead to the development of other sectors and industries, and could result in the establishment of specialised institutions for the transfer and development of technology.

2.2 Process of technology transfer

Possession of technological capability and the absorption of the appropriate technology necessitates the setting of programmes and activities and the gathering of available technological information and analyses in order to utilise it within the following frames:

- development of existing production techniques in general and those used in the military activities field in particular

- preparation of the system and terms of receiving and amending imported production techniques and selecting the most suitable to achieve national development objectives

- formation and development of national centres and offices for research, feasibility studies, engineering design and consultancies

- setting of programmes that guarantee the minimum limit of industrial structure as a basis for joint industrial efforts

- setting of programmes for new industries to serve other industries, based on industrial integration

- contribution in providing technological independence

- Coordination of the manufacturing programmes with technology selection programmes and human resources programmers.[10]

Saudi Arabia has exerted efforts to accelerate the economic development process, and such efforts have comprised the growth of a number of elements that directly or indirectly contribute in developing local technological capability. This has resulted in spreading education by preparing enough numbers of specialists, especially in higher education, for scientific research, organisations building productive units in different economic active sectors, setting basic structures, as well as the provision of services with differing grades of success in developing appropriate technological self-capabilities.

Thus technology transfer is a complex process comprising distinct components and a multitude of attributes. It is, furthermore, a relationship not only between various elements (human beings, machines, and rules), but also between the supplier and recipient. There are several important steps to be followed:

Policy decision: government should be committed to establishing local technology and such decisions should be taken with full awareness of requirements and the resulting rational change in all aspects

Provision of necessary resources: once the decision is taken and priorities are defined, a detailed study should be carried out in order to define the necessary resources and make it available in reasonable time

Direction of information: information is the most effective means in directing people and technology conduct

Direction of education: expenditure on education should be given high priority. The objective of education is to create individuals who are acquainted with all fields, such as social sciences, mathematics, science, engineering and technical skills

Supporting scientific research: scientific research as an application of that known which needs research and experimenting

Transfer of science and knowledge: science and knowledge is not only transferred from outside the country borders only but also from inside, i.e., from universities, research centres, industry as well as between different institutions

Training: capabilities of the society and the capacity to innovate and decrease dependency.[11]

The forms, objectives and features of technology transfer are shown in Table 2.1, below.

Table 2.1 Forms, objectives and features of technology transfer

Forms	Objectives	Features
Within the company	Technology production Enhancing the competitiveness of affiliates	Monopoly of technology ownership by parent company Risk of weakening monopoly power of parent company
Intercompany	Royalty gains Direct technology transfer Utilising outside elements Utilising supplementary assets	Technology markets Licences Least degree of transfer effect Technology transfer through contact with others Exchange licenses, cooperative R&D and joint ownership of technologies Operation and maintenance and exchange of supplementary assets and professions through joint venture companies, etc
Within the government	Technological assistance Technology joint development and uses	Political aims Joint use of technologies allocated to public good Human resources development

The technological success of newly industrialized countries, notably Hong Kong, Singapore, South Korea and Taiwan has attracted the attention of scholars from a variety of backgrounds.[12] Interpretations drawn from these countries' experiences are often highly controversial. For instance, classical economists see their laissez faire model in the successes of Taiwan, South Korea, Hong Kong and Singapore; others attribute this to the role of government intervention.[13]

It is commonly recognized that governments in Taiwan, South Korea and Singapore have played a substantial role in provision of macroeconomic policies and infrastructure, such as directing capital investment and technological development, issuing restrictions on imports for industrial promotion, etc. The market is guided by the long term national plans for investment and industrial development formulated by government officials; the content and pace of industrialization is not left entirely to the aggregate decisions of individual businessmen.[14] The extent of government intervention at the industry level varies according to perceived necessity. Some industries have accordingly been highly subsidized and directed by the government, others have experienced policy intervention only intermittently; the rest have been more or less left to take care of themselves within a broad framework of regulation.[15] One of the main areas of debate among different schools concerns whether these interventions have played a positive role in economic development in these countries.

East Asian countries attach considerable importance to the accumulation of technological capabilities. Singapore, South Korea, Hong Kong and Taiwan have attained technological competencies in such areas as consumer electronics, semi-conductors along with a range of manufacturing technologies in traditional industrial sectors. Moreover, in this process, these experiences show the feasibility and indeed necessity for dual technological development, transferring advanced technologies from developed countries on the one hand and facilitating the adaptation of foreign technologies into local conditions on the other.

The success of East Asian countries invites detailed research on the contribution of technological dynamism of national institutional structures and strategies (and how these have changed over time). In these countries, industrial policies of import substitution and export orientation are not contradictory; both have been applied in the process of industrialization. It is commonly recognized, for instance, that South Korea, Singapore and Taiwan began their industrialization drive with high levels of protectionism, and gradually became more export-oriented.[16]

An important observation from the studies of the East Asian countries' development experiences concerns the uniqueness of the development process in individual countries, reflecting their specific characteristics in terms of cultural, economic and political development. East Asian countries shifts the focus of development studies from generalized issues to more specific ones, such as the role of state and government policies on industrialisation, foreign trade, and science and technology.

More importantly, this new shift suggests that contemporary technology transfer can effectively promote economic development in developing countries. For Saudi

Arabia, it is tempting to try to follow the experiences of East Asian countries in achieving technological development and economic growth.

2.3 Vehicles of technology transfer

Technology may be transferred between two or more countries through international organisations. Technology transfer can be performed in a commercial or non-commercial exchange between the private and public sectors. Technology transfer channels include licensing, direct foreign investment, commodity reciprocity and strategic alliances. Likewise, technology transfer can be performed within the company or through mutual transfers between companies and the government.

Technology transfers are diverse due to the fact that technology is not merchandise to be sold and purchased in the market. Technology comprises a mixture of material and conceptual elements that cannot be separated. Several mechanisms exist for transferring technology; namely:

- foreign investment
- technical cooperation agreements
- Economic offset programmes
- licensing agreements
- international subcontracting
- joint ventures
- research and development cooperation

2.3.1 Foreign investment

According to Jose de Cubas, the foreign investment package, in most circumstances, is the most effective and cheapest way for technology to be transferred.[17] Foreign investment, by definition, implies ownership of capital by the foreign firm and the power to exercise control over operations of the entity in which such investment takes place. It is different from portfolio investment, as the latter involves only the acquisition of foreign securities by individuals or institutions without any control over or participation in management of the companies concerned. The most clear-cut case of foreign investment occurs where a firm sets up wholly-owned subsidiaries or affiliates abroad, where the operating control and usually the majority ownership of capital rests in the hands of the foreign firm. These subsidiaries may be established by the take-over of existing local firms or they may take the form of new green field ventures. These subsidiaries need not be wholly foreign-owned. Foreign investment may involve a joint venture agreement where a foreign based firm has a majority share, an equal share, or even a minority share, in the ownership of the enterprise abroad; the important requirement, as noted earlier, is that the foreign company has operating control.

Vernon noted several reasons why firms established subsidiaries abroad.[18] A subsidiary may be established as a meaningful business unit within the multinational system. However, a subsidiary may also be established to facilitate a learning process from which the system as a whole hopes eventually to profit. Other subsidiaries may be responsible for a data accumulating process intended to protect the system from risk. Some subsidiaries exist to reduce the system's tax burden. As Caves has noted, foreign investment and the multinational firm are often identified with each other.[19]

Another way of viewing a multinational enterprise, is as an economic institution that owns, in whole or in part, controls and manages income-generating assets in more than one country. In doing so, it engages in international production as a by-product of the imperfections in goods and factor markets across the globe. In a perfect market, no advantages can accrue to the prospective enterprise. However, normally MNCs possess some advantages enabling them to produce and compete successfully in an unfamiliar foreign environment. Theorists have suggested numerous ownership-specific advantages deriving from possession of technology and marketing skills, market structure and behaviour, and location-specific factors like trade barriers and host government policies. Several authors have noted the different kinds of enterprises and associated forms of foreign investment. For example Caves grouped foreign investment into the following categories:

- horizontally integrated enterprises, which are multi-plant firms that have established plants in different countries to produce the same or similar goods. Teece noted that the horizontal kind of investment directed at producing goods and services abroad, constitutes a significant portion of the world's stock of investment.[20] Horizontal enterprises internalise markets for intangible assets (covering the knowledge that represents new products, processes, proprietary technology and the like). The reasons behind such investment may include the following:

- possession of an intangible asset such as technology on which the multinational firm can extract the maximum rent through foreign production rather than licensing technology to some foreign producer

- high tariffs protecting national markets and/or supporting exchange rates may make production more desirable for the asset-holding firm than producing at its base location and servicing foreign markets through exporting

- vertically integrated enterprises - which are international multi-plant enterprises, producing outputs in some plants and supplying inputs to other plants. Vertical integration is an efficient method of achieving supply reliability of intermediate products

An international multi-plant firm whose outputs are neither horizontally nor vertically integrated is termed a conglomerate. The effectiveness of foreign investment as a mechanism of technology transfer and by implication, its role in the development process, has long attracted attention. For instance, Lewis and Caves have argued that the benefits of foreign investment include the generation of exports and foreign exchange, tax revenues, employment, accumulated capital and entrepreneurial skills.[21] But transferred technology can have benefits of various sorts to the recipient countries, including the reduction of product costs and processes. There are also negatives associated with foreign investment. One possible downside is that multinational companies may transfer inappropriate technologies.

Should production on host country territory be equated with transfer of technology, capital and management to the host country? This question reflects the effect of firm-entry on technological capabilities. Even if it is expected that enterprises transfer the best production technology, they do not necessarily transfer the capability to generate new technology to their affiliates. In some cases, they transfer know-how (production engineering) but not know-why (basic design, research and development). National companies that are subsidiary to foreign companies depend on technology presented by the central organisation for research and development. Research and development activities performed by the subsidiary companies are considered as extremely limited if not absent. Research and development activities necessitate only limited adaptation of products to suit the local conditions such as the climate, transmission network and certain usage.

2.3.2 Technical cooperation agreements

A technical co-operation agreement is a generic term encompassing a wide variety of contractual agreements between a foreign firm and a local firm for effecting technology transfer. These might include the following:

- *Technical assistance agreements*

These are agreements between a foreign firm and an entity created under local law and owned by local public or private interests, in which the foreign firm provides management services, technical information, or both, and receives payment in money. As later chapters will reveal, these agreements are widely used to transfer technology to the KSA.

- *Management contracts*

These are arrangements under which operational control of an enterprise is vested by contract in a separate enterprise. This latter enterprise performs the necessary managerial functions in return for a fee. Management contracts emphasise the increasing importance of services and know-how in international trade. The know-how transferred under such contracts usually involves the training of personnel. A crucial distinction may be drawn between a technical services agreement and a management contract: the former presupposes the presence of a functioning enterprise at the recipient's end, whereas the latter creates and maintains it. Although training of Saudi personnel by foreign experts is quite common, these 'training schemes' may or may not be part of the management contracts.

2.3.3 Turnkey operations (production in-hand method)

A turnkey operation involves the construction under contract of a project up to the point of operation, at which point it is turned over to the customer. The contractor, usually a manufacturer of some segment of the project equipment, undertakes full responsibility not only for providing the equipment, but also engineering and even project financing, as well as arranging the supply of complementary equipment, ensuring successful operation as a whole upon completion. The contractor also undertakes to provide the corporate skills required by the customer to operate and maintain the system following its completion. In such cases the foreign party not only builds the plant but also commissions it to the point of commercial operation. The contractor also provides technical experts, administrators and all other required manpower.

2.3.4 Direct purchasing of technology

Here, the technology transferee company will bear the full cost of the project together with the management of the operations relating to design, supply, installation and operation. The host firm will select the consultative direction and will assume responsibility of the supply and installation of machines and equipment. This form of technology is characterised by the local firm's ability to choose technologies that are compatible with the development strategy and also its direct participation in most of the operations that are necessary for establishing new projects. According to this form, the local firm could ask for the help of a consultant expert to advise the best way of taking decisions about the proposed choices.

2.3.5 Economic offset programme

Saudi Arabia is trying to maximise the benefits associated with defence offsets, and the Kingdom's large volume of arms purchases have provided it with a wealth of opportunities in this area. The Saudi government is aware of the value of defence contracts to Western arms vendors and has exploited this leverage to a measured extent by extracting offset investment compensation. The Saudi approach to offsets has several novel features. The Saudi government views defence-offset agreements as partnerships in which business entrepreneurs, not the Saudi Government, should be the driving force behind viable offset investment activity. The authorities view offsets as a way of achieving economic diversification, particularly in high technology fields exhibiting long-term business potential. Saudi Arabia has always measured the value of offset arrangements in terms of the long-term partnership which can be built: a standpoint stemming from the recognition that offsets act as a driver of industrial and technological development. However, Saudi offset programmes do not follow a conventional format since they reflect neither the dictate of government nor provide business with the prospect of guaranteed government purchases. Instead, the thrust of offset policy is to foster economic diversification by nurturing private sector joint venture projects in the civil and defence sectors. The authorities believe that this policy will stimulate industrial linkages and lead to further investment outside the formal offset structure. The importance of offset programmes to Saudi Arabia is evident from the following two statements. The first is from HRH Prince Sultan Bin Abdulaziz, 2nd Deputy Premier, Minister of Defence and Aviation, who stated:

"The Saudi economic offset programme is an important cornerstone for the future industrial development of Saudi Arabia. It creates additional investment opportunities for the private sector and employment opportunities for university and technical institute graduate".[22]

The second statement is an excerpt from the Ministerial Committee recommendations, which state that:

"The economic offset programme has strategic significance for achieving Saudi Arabia's industrialization objectives. These objectives necessitate expanding the programme to include major civil contracts in technology-oriented sectors as well as defence. Government agencies should implement procedures to ensure the programme achieves its goals".[23]

The Saudi offset objectives are ambitious, but not out of line with the goals of other countries' offset guidelines. The Saudi economic offset programme objectives are:

- industrial diversification
- employment growth
- technology transfer
- private sector growth
- import substitution
- utilisation of local raw materials

To achieve these objectives, establishment of profitable joint ventures between foreign and Saudi companies are encouraged and facilitated to diversify the economy and provide local investment and employment opportunities. Approved projects enjoy substantial investment incentives and support from senior government representatives. However, 'diversified' offset projects are more likely to cover risky ventures rather than straightforward business ventures, which would probably already have been implemented. Also export prospects can only be a long-term goal, once the more immediate competitiveness issues have been addressed. While offset ventures may provide access to modern technology, this will act against the creation of substantial amounts of Saudi jobs (indeed even older technology will not create jobs for Saudis, as these will probably fall to foreign workers from the Asia-Pacific region).

Despite all the hopes and apparent opportunities for progress, defence offsets in Saudi Arabia have followed a slow and tortuous path. The pedestrian progress in the formation of joint venture offset committees (JVOCs) stems from a number of factors. In reviewing the performance of Saudi Offset programmes, Ron Matthews emphasises that "...in line with the offset programme requirements seeking to combine local Saudi interests with the broader principles of economic development, the acceptable offset ventures should: facilitate the inward transfer of technology; make good use of Saudi national resources; provide appropriate training for Saudi staff; support short-term import substitution and long-term export promotion in the manufacturing sector; and stimulate growth-promoting linkages with existing Saudi industries.[24] Viewed from almost any angle, defence offsets have had only a marginal impact on the development of the Saudi nation. To date, Peace Shield is the only offset programme, which has achieved its offset target. Any assessment of the impact of offsets must go beyond a simple accounting approach. It should address also the effects of inward investment on the recipient's development. For offset projects to support Saudi Arabia's economy, not only should the JVOCs employ significant numbers of Saudis but they should lie within strategic industrial sectors. It is at this point that Peace Shield's apparent success becomes questionable:

> Of the approximately 1,400 jobs created so far only around 300 are held by Saudi nationals and of the existing JVOCs only AEC seems to be taking the issue of Saudization seriously.[25]

Saudi offset policy has a training policy aimed at developing the skills of Saudi nationals and management policies designed to help some Saudi nationals to become competent managers in the Western mould. Offset commitments of American, British, and French companies, including Hughes Aircraft, Lucent Technologies, Boeing, British Aerospace, McDonnell Douglas, General Electric, General Dynamics, United Technologies, and Thomson-CSF are among the key participants.

The 1997 expansion of the EOP to include major civil as well as defence contracts has dramatically increased its size and breadth. Additional joint ventures involving power, desalination, health care, communications and other government civil contracts are emerging. Enhanced Saudi government emphasis on compliance with offset commitments is accelerating the pace of venture development. Greater flexibility, innovation, and commercialisation are characterising the offset process. The Saudi Offset Limited Partnership (SOLP) is an example of this increased innovation and commercialisation. This dynamic development vehicle identifies, develops, finances, and implements profitable business ventures satisfying offset investment obligations. The SOLP combines the structure of a venture capital limited partnership with the operating methodology of a merchant bank. Offset contractors of all nationalities may invest in this partnership, which is managed by Dev Corporation International LLC as the general partner.

2.3.6 Licensing agreement

This is the most common of technology transfer vehicle, in which the receiver country will have the right to use the patent registered with its owner company in manufacturing certain merchandise. The license could be obtained against certain fees or as part of a complete deal or contract. Contractor has described licensing agreements as "...agreements which call for the transfer of patent and trademark rights from the licensor (supplier) to the licensee (recipient) on either an exclusive or non exclusive basis, or otherwise limited in various ways to reflect the territorial and marketing strategies of the patent holder in return for an agreed payment".[26] These agreements may also involve the transfer of technical know-how, as in Saudi industry the policy objective is to reproduce in the licensee firm the complete technological capabilities of the licensor. Such agreements will often specify separate provisions and payments for know-how. In the case of Saudi industries this agreement might take the form of a once-and-for-all transfer or a continuous transfer of knowledge depending on the nature and complexity of the operation. There may be two broad reasons why a foreign firm is prepared to license abroad. Firstly, to substitute for controlled direct foreign investment, if licensing proves to be more profitable. In this case, licensing to a non-controlled entity provides an alternative to entering foreign production with a controlled investment. Secondly, to gain access to technology from other firms through reciprocal grants or licenses. In this case, access to other firm's technologies provides an alternative to in-house R & D. From the perspective of the technology recipient, there may be a number of reasons why a firm may prefer to acquire technology externally through technology licensing rather than make it in-house. Sen and Rubenstein have compiled twelve reasons justifying such a decision, namely:

- reducing risk in product and process development
- saving resources to develop the technology in-house
- gaining time by increasing the speed of entry into the market
- gaining advanced know-how quickly
- ability for in-house development
- in-house work reaching a stage where it is worthwhile obtaining a license
- up-grading in-house technical skills
- existence of more reliable estimates on probable commercial and technical success
- availability of a proven cost saving process
- adoption of industry product standards providing compatibility to the in-customer
- house ability better suited to improving existing technology rather than creating own know-how.[27]

Licensing of technology is used by some companies as an alternative to direct investment, especially in situations where the host government restricts FDI. Most of the foreign licensing agreements occur between related organisations. According to Frances Stewart, intra-firm agreements accounted for about 82% of US receipts from royalties and management fees as far back as 1976.[28] Intra-firm licensing is often used to enhance control.[29] In an inter-firm licensing agreement, the licensee undertakes capital investment; the licensor simply agrees to provide technology in exchange for a fee, which may be in the form of a percentage of sale of the product. J. P. Killing provides a distinction between licensing agreements involving technology in use at the time of the agreement and that in which, in addition to current technology, future developments in the technology are included as part of the agreement.[30]

In his definition, there is a significant difference between these agreements, both in cost to the licensee and in the process of technology transfer. In future and current technology agreements with Saudi companies, a more efficient and effective transfer of information between the licensor and licensee is achieved when compared with current technology agreements. However, current and future technology agreements are usually more expensive and restrictive. Here, the licensee is prohibited from exporting the product especially to the licensor's market. Moreover, such products are those that have been long established in the licensor's market.

According to Blumenthal, licensing is often favoured as a means of technology transfer because it allows a company to purchase the required technology without implications on foreign ownership.[31] Japanese companies are often cited as a typical example, in that they have been able to use licensing agreements to achieve a successful technology transfer at a lower cost through isolating and purchasing the specific technological component that is required. Some writers have argued that in a licensing agreement package, the licensee is more concerned about the transformation of technology as rapidly as possible into an efficiently working and marketable form. Thus, relevant working knowledge and any associated rights, which can help assure the transfer process, are clearly sought. The licensor is more concerned about wrapping up the technology information, which may be the basis of a transfer in the use of Saudi Arabia, into a secure package which will encompass aspects of marketing and managerial know-how as well as marketing rights. In this way, the licensor is assured of maintaining its proprietary rights over industrial property. Marketability of the package is therefore improved and the basis of income generation extended. A licensing agreement package may have the following objects incorporated into the agreement:

- patents
- technical know-how
- trademarks
- marketing know-how
- managerial know-how
- designs

In addition to this list, the package may incorporate new aspects as the relationship develops. For instance, exports to the licensee, items such as plant and equipment, component parts or even raw materials.

Patents are an important aspect of a foreign licensing package, although studies by Helleiner, Pengulley, Carstains and Welch, reveal that technology recipients find the unpatented know-how more useful in the technology transfer process.[32] According to Helleiner, patents on their own do not contain sufficient information to permit efficient working of licensed technology.[33] However, patents do affect the process of technology acquisition and in some ways patents could be beneficial to both licensor and licensee. For the licensor, patenting remains the principal means of establishing proprietary rights to a firm's technology. Patents enable the licensor to test foreign markets at minimum expense and risk. It may also allow penetration of foreign markets obstructed by either high duties or import restrictions.

The other component of a licensing agreement package is know-how, which enables production to occur without repeating many of the learning costs associated with development. In addition, it allows the licensee to get the product to market more rapidly through utilisation of managerial and marketing experience and this may be incorporated by the licensor into the licensing agreement. Trademarks as part of the package may provide market penetration needed by the licensee, because the trademark of the licensor may have already received worldwide acclaim. There are several constraints, however, in the realisation of technology transfer objectives using licensing agreements. Diagnosis of these constraints is often made in the light of the technological competence of the recipient licensee, the transfer costs, and secrecy of the information exchange process.

In the case of some industries, it has been noted that foreign license agreements have possibilities as a medium for technology transfer.[34] This is true only where the licensee has achieved a certain level of industrial experience and sophistication, local infrastructure is adequate, and available markets are large enough to enable the licenser to recoup costs and make profits within a reasonable time. For the technology recipient, the first two conditions may be lacking and therefore technology transfer using licensing agreements may prove difficult. Contractor noted that the importing firm emphasises organisational and production management assistance in licensing agreements.[35] Moreover, in a study of Canadian firms manufacturing under a licensing agreement, P.J. Killing observed that licensing is not a viable long run growth option for firms lacking their own R&D base, and that licensing of technology breeds dependence upon the foreign licensor unless the licensee uses the knowledge acquired to build up an in-house R&D capacity.[36] Killing's findings help to strengthen the assertion that there is a need for a sound industrial base for successful technology transfer through the licensing route.

In addition, there may be a range of continuing maintenance costs, which will include the cost of updating technical know-how, and other implicit costs, such as managerial time spent either during negotiation or consultation after the agreement is established. The licensor may not release all information necessary for effective evaluation of the technology by the licensee. The licensor may be suspicious that the licensee could use the technology without signing the agreement if all information is released before the agreement is signed.

Thomas argues that a major disadvantage of a licensing agreement is that the licensed technology may be found to be obsolete or too expensive at an advanced stage of the agreement, when down payments may not be recoverable.[37] He also contends that accepting a license from one source may forestall access to other licensors, and the licensee may have chosen the wrong technology or licenser.[38] Another danger of licensing agreements is the possibility of unexpected unlicensed competition in situations where the licensor's patent is weak.

In spite of all the advantages and constraints of licensing agreements, the increasing complexity of its packaging, and a more demanding technology transfer process, Welch insists that foreign licensing agreements enable effective technology acquisition if the parties involved, i.e. licensee and licensor, can establish more interaction and information exchange in the short run as well as the long run.[39] This strategy would require a high degree of commitment by both parties, particularly the licensor.

2.3.7 International sub-contracting

This usually involves a firm that has contracts with one or more others to assemble or manufacture parts. Firms may establish linkages with local supplier firms both because of business considerations and government regulations. Business considerations include evaluation of potential costs of vertical integration against supposed benefits. Vertical integration may be an expensive way to acquire most commodity products but may be cheaper for some specialty products.

Thus the multinational firm might create linkages with local supplier firms to procure complementary but technologically dissimilar products. Backward linkages may be categorised into three distinct stages, the:

- decision to make or buy, i.e. whether a specific item is made by the firm or purchased from an independent supplier will depend on whether transaction costs are lower than internalisation costs

- decision to procure locally and give rise to the possibility of local linkage or import and the creation of national and international linkages

- linkage decision, i.e. what form of direct relationship has to be established with a supplier to overcome the deficiencies of pure market relationships.

Subcontracting, by definition, is an interrelationship between enterprises to provide not only an outlet to production by the suppliers, but also to establish a relationship between linked enterprises whereby long-term contracts are entered into, product information is exchanged, prices are negotiated, technology shared and other forms of assistance made possible. The term subcontracting may be used to encompass all purchases including the processing of parts and materials undertaken by one firm for another, but excluding the purchase made off-the-shelf, or those purchases of raw materials where no specifications are laid down. It is deficiencies in the market mechanisms with regard to inter-industry requirements that induce firms to deal directly with each other in what are referred to as extra-market relationships. These relationships can extend from simple information exchanges via collaborative information, planning, technical arrangements, to more dominant relationships where one firm virtually controls the linked enterprise without owning it. The common types of linkages may be noted as follows:

- informational: this involves exchange of information on demand, future investment and market conditions
- technical: this involves assistance given/received on innovation and product design, process know-how, production costs, quality control, training, testing and tooling
- financial: this involves loans on terms, grants, special prices or allowances
- procurement: this involves help in purchasing of materials
- location: this involves advice to suppliers to set up a plant in the country or location
- Managerial: this involves advice on better financial, accounting, inventory and other control procedures
- Pricing: this covers contractual and bargaining procedures for deciding on prices
- other: these may involve, for example, sales to other parties or on the open market, policies for diversification, assistance in exporting.

Subcontracting is one of the channels through which technology is transferred to Saudi industries. Several forms of backward linkages have been used between affiliates operating in the Kingdom of Saudi Arabia and supplier firms. The benefits of the various types of linkages established in a sub-contracting relationship are summarised in Figure 2.2 below.

Figure 2.2 Common types of enterprise linkages

Supplier Enterprise

This has linkages with a buyer, who can receive several benefits from the relationship, depending on its relative size and specialisation, information flows enabling it to plan current activity and longer-term investment, technical assistance to improve its products and processes, introduce new technology train its staff, achieve a higher degree of specialisation and lower its costs, and enhanced financial assistance terms improving its profitability and so on.

Lead Enterprise

The benefits to the lead enterprise in setting up linkages with suppliers depend on whether the linked enterprise can supply a given product at a lower cost than if the lead enterprise produces it itself. This can be the case when the linked enterprise pays lower wages, is more specialised, has lower overheads or is more flexible to fluctuations in demand.

Economy level

The benefits to the economy as a whole from the establishment of a wide network of inter-enterprise linkages arise from the stimulus given to the investment, the increased diffusion of technology and skills, the savings inherent in better planning, the more economical use of capital and labour, and a well-balanced pattern of growth of small versus large plants.

2.3.8 Joint ventures

The term joint venture has been explained in different ways by different sources. In industrial economics, joint ventures are commonly understood as operations where a legally independent and autonomously managed enterprise is set up by two or more partners to run a clearly defined set of activities in the common interests of the founding firms. Some earlier definitions of joint ventures are also in similar vein. One source puts it as "...a joint venture where there is a commitment for more than a short duration, of funds, facilities and services by two or more legally separate interests, to an enterprise for their mutual benefit".[40]

In one UNCTAD report, joint ventures are defined as all forms of agreements through which the operations of two or more firms are partially, but not fully, functionally integrated in order to carry out activities in one or more areas: buying or selling, natural resources exploration, development and/or production operation manufacturing, R&D engineering and construction.[41] This wide definition, encompasses, in reality, a series of agreements such as none-equity co-operation research agreements, technology sharing agreements, and customer-supplier agreements including the following forms of firm agreements under joint venture:

- joint-equity-venture
- comprehensive R&D, manufacturing and marketing consortia
- university-based co-operation research projects
- government-industry co-operative national and international projects
- research corporations
- agreements involving the use of corporate venture capital which are used by large firms to identify innovative processes within smaller organisations
- non-equity co-operative research agreements.

Defined by the United Nations, joint venture is a broad term designating an association between companies usually through a joint subsidiary company involving to varying degrees co-management, co-ownership of capital and sharing of profits and risks.[42] When no co-ownership is involved, joint ventures are sometimes referred to as contractual joint ventures. In a joint venture agreement involving a corporation and a local partner, the local partner essentially provides part of the capital in the form of an equity share. The capital share provided by the joint venture may have associated with it, advantages similar to those offered through direct foreign investment.

Whilst admitting to the complex and probably difficult utilisation of joint venture, its advocates argue that JVs are the linking bridge between business organisations, which have reached a mature stage of technical competence, and those with lower levels of technology, or between those who have marketing resources, business expertise and financial muscle, and the innovators.[43] There exist a number of advantages that will accrue to partners by going into joint ventures. In the case of Saudi firms, these advantages include improved:

- local market potential
- penetration of the market by utilising the domestic partner's knowledge and local customer service and local market capability
- customer appeal and greater sales for the patented product since the JV would build up an identity as a domestic producer
- sales to third-country markets to which it has limited access.

Unlike a licensing agreement, an executive of the technology-supplying firm may be on the board of directors of the joint venture. This way, access to technical information from the parent company in the case of a subsidiary as a partner can be retrieved with relative ease. In a licensing agreement, there is no such advantage to the licensee. Advocates of technology transfer through joint ventures further argue that joint ventures marry together basic needs of both partners and establishes a joint commitment to change the working environment. The expertise of the technology supplier, preplanning, mutual support and understanding between the partners in a joint venture, assists in the technology acquisition process.

There are a number of ways in which a joint venture may be established. P.J. Killing has suggested two types of joint ventures for ensuring successful technology transfer:

- one type is the 'dominant parent joint venture', in which the local partner may have the majority equity share, while the technology supplying firm is the passive partner

- the other type of joint venture is where the partners enter into a shared management venture, where both the local partner and the foreign firm have a say in the management of the venture.[44]

In the dominant parent venture, where the local partner has more control, Killing notes that the cost of transferring the technology may be higher compared to the other type, because here, equity is given in exchange for the technology.[45] However, the commitment on the part of the technology supplier may be considerably higher in the dominant parent JV. In a shared management venture, even though there are more tendencies towards failure, Killing further observes that the prospects for personnel transfer from the technology supplier and effective technology transfer is questionable. Unlike with a dominant parent, the control of the venture by the local partner in a shared management venture may be substantially limited. According to Gurprit the dominant parent joint venture type is common.[46] The equity share may even be on a 50:50 basis. However, the exact distribution of shares may be determined by each partner's contribution in the areas of technology, capital, machinery, managerial skills and the host government's policies on foreign investments.

Several constraints may interfere with effective use of the joint venture as a medium for technology transfer. Dependency theorists have argued that because of the need to provide continuing technical assistance, foreign firms, can have managerial leverage, which enables them to have explicit control by placing people in key managerial positions. This enables the joint venture to relate operationally to the foreign partner and can integrate their objectives into the JV's activities. Further criticism highlights the possibility of the foreign partner creating avenues for adding costs to the local partner through inflated transfer prices, or royalties for a licensed technology, of which the parent firm of the subsidiary partner has proprietary rights and management fees. Also, in certain situations, especially where the venture is for a relatively short period (3-5 years), the foreign partner may not have commitment in providing the technology. This criticism often emanates from those who see foreign partner firms as putting profit maximisation as the primary objective in any venture. As joint holders of the equity, the local company shares in the monopoly rent without having to incur any costs or risks in generating the technology embodied in the business venture. This may be an area of potential conflict since the foreign partner may have problems convincing the local company to buy the technology at a fair price. Another possible problem in joint venturing, according to J.S. Parker, is that decisions on production, sales and probably technology in use in the venture may not be taken at the local subsidiary partner level and the local partner may feel grieved at its lack of authority in these areas.[47]

2.3.9 Research and development cooperation

Another aspect of technology transfer is the establishment of offshore R&D centres by partners. Although the economics of R&D location dictate that basic design and development work by firms be highly centralised in the home country, they do perform R&D in host countries. Further, global R&D outlays of multinationals are positively linked to the extent to which foreign markets are served by their subsidiary's local production. According to Ronstadt - a number of US multinationals have established different types of R&D units abroad; both for the adaptation of existing technology and the generation of new knowledge.[48] These units specialise in:

- technology transfer
- indigenous technology
- global technology
- corporate technology

There has also been a growing tendency among enterprises to place R&D facilities in the industrially advanced countries, and technology development within a subsidiary is often identified by its performance in R&D. In industry, technology development may be simplified into the following categories:

Know-how, including assimilation, operation management, quality control, improved plant layout, and production practices

Know-why, involving understanding of the underlying process and product technologies, leading to adaptation, improvement, and even replacement by new products and processes

Applied research, involving application of given scientific knowledge to the process of commercial innovation

Basic research, comprising the ability to undertake basic scientific research, pushing back the frontiers of knowledge without regard to specific commercial application.[49]

The relationship of foreign affiliates and local firms is two-fold: firstly, local firms which supply inputs to the affiliates and, secondly, local firms that compete with affiliates in their product market. As far as the former group of firms [supplier firms] is concerned, enterprises may transfer technology [skill, know-how, product design,] to supplier firms by establishing backward linkages. These basic propensities to create linkages remain more or less the same from company to company.

As far as competing firms are concerned, the debate is conducted at a more general level. Competition from technologically efficient foreign firms induces local firms to improve their own technology, and the presence of affiliates lead to more rapid diffusion of technology by imitation and contagion. On the other hand, a strong company presence inhibits local firms from understanding risky and costly research activity. The two apparently contradictory views can be reconciled: local firms may well be induced to upgrade production technology by a much greater reliance on technology licensing when faced with competition with frontier technologies, and in the process independent know-how development may suffer. A strong company presence may be associated with better local know-how and shallower local know-why.

2.4 Technology transfer vehicles: a comparative evaluation

In this section, it is useful to focus on comparisons between the various modes of technology transfer. Comparison will be between direct investment and technology licensing and between technology licensing and joint ventures.

2.4.1 Licensing agreement Vs direct investment

As Caves has argued "...if the foreign firm holding licensable intangible assets could negotiate licensing terms to extract the local firms entire rent, it would always license and never choose direct investment".[50] He has further noted several empirical studies especially that of Baranson which have examined the factors governing the choice between licensing and foreign investment. These studies suggest that companies do contemplate direct investment and licensing as direct alternatives, preferring direct investment for its greater rent-extracting potential, turning to licensing only if that potential cannot be realised.[51]

From the perspective of a recipient company the following factors emerge:

- Licensing is encouraged:
  - when entry barriers deter the firm from direct investment
  - when the licensor lacks assets needed for investment
  - because the time required licensing an established producer is less than to start a subsidiary from scratch
  - by possibilities of reciprocity and co-operation
  - where there is risk of expropriation.

- Licensing is discouraged:
  - when licenses are difficult to arrange
  - if the opportunity cost of capital is higher in the recipient country than in the country of the potential licenser
  - where the relevant knowledge is subject to much lower transfer costs within the enterprise than between independent firms
  - when the risk of leakage of a technology into the hands of competitors deters a firm from licensing its core technology
  - where government regulations forced them to choose between licensing and joint ventures.[52]

From the perspective of a local firm, recipient acquisition of the technological element through a licensing agreement may appear a tempting prospect. It provides cheaper technology, not only under the control of the supplier but also more amenable to local adaptation and subsequent development. However, this analysis is valid only in certain circumstances. In industries, with relatively stable and mature technologies, the local firm with some industrial experience may do better by licensing the needed technology. In more complex areas of industry, however, the cost advantage of obtaining licensed technologies is not so obvious for several reasons:

- some leading-edge technologies are simply not available on license

- transfer may be less efficient, slower and less continuous under a series of licensing agreements than with an affiliate

- a licensee may be subjected to greater restrictive business practices than a subsidiary, simply because a parent company appropriates a greater proportion of profits in the latter case than the former.[53]

2.4.2 Licensing agreement Vs joint venture

It is easy enough to transfer hardware-blueprints, specifications, price lists, product samples but much harder to ensure transmission of the intangible know-how, which is in the minds of those who use the hardware. Effective transfer of know-how requires a strong personal relationship between sender and receiver. The strength of the relationship between sender and receiver are two functions of the amount of contact between personnel of the two firms, and the degree of commitment on the part of the technology-supplying firm to ensure that real learning takes place. Both of these factors, contact time between the firms and the level of supplier commitment, will be a function of the type of licensing agreement or joint venture chosen. In this discussion, the licensing agreement may be classified into:

- current technology agreements, which gives the licensee access only to technology that is in existence at the time the license agreement is signed
- current and future technology agreements which states that new development work is done by the licensor in a specified product area during the life of the agreement as well as current technology which be transferred to the licensee.[54]

It is apparent that this latter category offers a much greater contact between licensor and licensee, as meetings between personnel from each firm may take place over a number of years, in contrast to the one time contact of the former agreement. Joint ventures may also be categorised into the majority joint venture in which the technology dependent firm owns 70% or more of the voting stock and the 50-55 percent joint venture in which the technology dependent firm owns 50% to 55% of the joint company. In general, there may be more motivation and opportunity for contact between firms in joint ventures than exists in license agreements. Davies found that 78% of joint ventures made use of personnel from the technology-supplying parent to supervise plant construction versus 26% for license agreements.[55] He noted that the number of cases of technology transfer within the "package supplied" by British firms were greater through joint venture than in licensing agreements. If a weak relationship with a technology supplier is all that a firm requires, it should try for a current technology license agreement. As the strength of the relationship increases, which is not without cost implications, the target should be a current and future technology license agreement, or a majority joint venture, and where the strongest link is needed, a 50-55 percent joint venture.[56]

2.5 Partnership in technology transfer

One of the main points to be considered in technology transfer is evaluating the role of the partners, particularly their contribution to enhancing the scientific and technological capabilities in manufacturing. In this regard, a key issue to be considered is the availability of numbers of highly qualified scientists, researchers, engineers and technicians. Research and training facilities such as laboratories, engineering organizations, the educational system, industrial structures should be studied on the basis of the technology it depends upon.

These basic elements should be well managed and connected by the partners and the local company. By using this simplified objective, it is possible to determine the contribution that partners and the local company can render in order to exchange national scientific and technological capabilities that may affect technology transfer through various relationships between the two partners. The relationship between the subsidiary and the local company may be maintained through relations with the local labour market, local public and private research centres, and local suppliers and competing firms. Further, transfer of any technology to a new location entails substantial transmittal and receiving costs. Technology is more than just a stock of blue prints immediately accessible to all. Very often considerable resources have to be deployed by both the transferor and the transferee to ensure the success of a project. These costs arise regardless of whether or not the recipient is an affiliate or an independent firm.

Technology transfer is the primary reason for industrial development through a variety of mechanisms such as technology licensing agreements, joint ventures, technical assistance and management contracts, turnkey projects etc, or through direct investment in wholly-owned subsidiaries. Technology is a rather broad-based concept and has both tangible (e.g. capital goods) and intangible forms (e.g. technical know-how contained in the minds of the people who use the equipment). Production and distribution of industrial knowledge and development has three phases: invention, innovation and diffusion. Technology transfer may be understood as the process by which technology is moved from one physical location to another for the purpose of application toward an end product. Transfer can take place either domestically from one sector to another or internationally from one country to another. The profit motive is the prime impetus for transfer, both in the supplier and recipient environments.

There are relative merits and demerits of the different mechanisms of technology transfer. These merits and demerits will depend on the perspectives of the technology supplier and the recipient. This chapter has aimed to provide a familiarity with some aspects of the phenomenon of technology transfer including the various channels through which technology gets transferred. Thus it serves as a background to examine the effectiveness of technology transfer in the Saudi oil and petrochemical sectors.

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CHAPTER THREE

SAUDI ARABIAN INDUSTRIAL DEVELOPMENT AND TECHNOLOGY TRANSFER

3.1 Development of the Saudi economy

The purpose of this chapter is to explain the policy and process of technology transfer in Saudi Arabia's oil and petrochemical industry. To meet this objective, the chapter is divided into four sections, as follows:

1. An overview of the Saudi Arabian economy, focusing on industrial development

2. industrial development which has helped to transform sectors of Saudi Arabia into diversified manufacturing operations, with advanced technology, products and processes

3. Saudi joint-ventures, both industrial and non-industrial

4. future industrial strategies and technology transfer between Saudi Arabia and developed countries.

A major discussion theme is Saudi development planning. In this context, the Kingdom's Five Year Planning approach involved the development of a technology transfer regulatory framework. The chapter identifies, describes and analyses the principal characteristics of Saudi Arabia's technology policy, including the recent science and technology plan. Discussion closes with an examination of the sector's technology strategy. Although this has been bounded by the government's investment and technology transfer regulations, the Saudi oil and petrochemical industries have developed their own focused technological strategies to ensure rapid growth through both indigenous and international strategic collaboration. An associated purpose of this chapter is also to explore the impact of joint ventures on the development of Saudi Arabia in general; in so doing, it will examine the Saudi way of acquiring technology through joint ventures. Saudi joint ventures are the preferred channels of technology transfer, because they are the cheapest and fastest way to obtain technology. The broad thrust of discussion on the Kingdom's industrial and technology transfer policies provides the contextual backdrop to later, more focused analysis on the effectiveness of technology transfer mechanisms operating in the Saudi oil and petro-chemical sectors.

Table 3.1 summarizes 5 years of Saudi economic development from 1989-1993 and the most important aspect is the change in oil sector, non-oil sector and private sector which shows a bigger increase than the government sector. These years are very important in Saudi development because of the GDP growth from 81.5 in 1989 to almost 120 in 1993. The other significant aspect of this growth has been the confidence in the Saudi economy, as expressed by the private sector. While government expenditures declined in 1990, the growth rate of private sector GDP grew from 1.6% in 1989 to 4.4% in 1991 and 3.4% in 1993.[1] This growth of activity was accompanied by large repatriations of private capital and commercial bank inflows, which together amounted to over $50 billion between 1991 to 1993.[2]

Table 3.1 Saudi Arabia's economic development 1989-1993

Indicator	1989	1990	1991	1992	1993
GDP in current prices ($ Billions)	81.5	103.2	113.9	119.6	120.8
Oil Sector	19.3	25.4	24.8	24.9	23.5
Non-oil Sector	47.0	41.5	42.1	42.1	43.5
Private Sector	28.6	24.1	23.3	23.6	24.5
Government Sector	18.3	17.3	18.7	18.6	18.9
Consumer price inflation (%)	0.7	1.4	3.14	-0.3	1.2
National growth in GDP (%)	6.5	17.8	6.9	3.4	0.7
Oil Sector GDP (%)	20.9	41.1	5.1	3.3	2.9
Non-oil Sector GDP (%)	1.8	7.9	8.0	3.4	2.8
Private Sector (%)	1.6	4.6	4.4	4.0	3.4
Government Sector (%)	1.9	13.0	13.1	2.6	2.0

Source: Saudi Arabian Monetary Agency, (SAMA) "Statistical Summary", different issues 1990 - 1994

Over the last nine years, 1994-2002, Saudi Arabia made major advances in expanding the role and importance of the private sector as a major influence on overall economic development. Table 3.2 shows progress in this respect.

Table 3.2 Key economic data 1994-2000

Billion US $)							
	1994	1995	1996	1997	1998	1999	2000
Nominal GDP	117.80	125.52	136.49	146.00	130.10	140.92	152.00
% Change	1.39	4.4	8.00	6.6	-12.2	7.70	7.30
Real GDP (% change)	0.10	0.00	1.40	1.90	1.60	0.50	4.00
Population (million persons)	18.20	19.10	0.00	21.00	21.40	21.40	21.80
Saudi	13.20	13.60	14.00	14.50	15.00	15.40	15.80
Non-Saudi	5.00	5.50	6.00	6.50	6.00	6.00	6.00
GDP/Capita (US$)	6,472	6,571	6,820	6,952	6,195	6,584	6,972
Oil Price ($/barrel)							
West Texas Intermediate	17.25	18.30	21.57	21.00	14.00	20.50	22.00
Saudi Average	14.50	15.65	19.00	18.25	11.50	17.45	19.00
Current Account	-10.40	-5.30	0.70	0.30	-13.10	-3.90	0.00
As percent of GDP	-8.83	-4.29	0.45	0.21	-10.10	-2.77	0.00
Government Budget Balance	-9.28	-7.31	-5.07	-4.21	-12.27	-9.07	-7.46
Revenues	34.40	39.07	47.76	54.80	38.13	39.20	41.87
Expenditures	43.68	46.37	52.83	59.01	50.40	48.27	49.33
Budget balance as percent of GDP	-7.9	-5.9	-3.8	-2.9	-9.4	-6.4	-5.0
Government Domestic Debt (billion SR)	336	384	422	468	566	608	639
As percent of GDP	76	83	84	87	116	115	114
Official Foreign Assets	68.51	67.94	75.66	85.92	82.29	77.00	73.99
Central Bank	47.50	46.10	51.42	59.05	53.09	46.00	43.71
Government Pension Funds	21.00	21.84	24.24	26.88	29.20	31.00	30.28
Cost of Living (% change)	0.60	4.80	1.30	0.00	-0.20	-1.20	0.00

Sources: Ministry of Finance & National Economy "National Centre for Financial and Economic Information Reports" 1998-2000 and Saudi Arabian Monitory Agency" Statistical Summary" for the years 1995-2001

3.1.1 Saudi national development plans, objectives and strategies

For the past 40 years, Saudi economic development has been broadly governed by the implementation of Five Year Plans. The first five of these plans emphasized the development of the Kingdom's infrastructure, with later plans focusing on human resource and private sector development. During the 1960s, Saudi Arabia embarked on an ambitious economic plan to exploit and use its oil resources to create a full-blown industrial economy.

By 1970 the development plans had been refined, with the 1970-1975 plan aimed at quickening the pace of economic and social development. In the second Five Year Plan 1975-1980, apart from increased defence spending, a key component of this plan was the creation of industrial cities at Yanbu and Jubail. The growth of heavy industries could not have succeeded without a highly advanced industrial infrastructure in place, so linkage to sea, port, rail, highway systems and their proximity to energy sources were the main criteria for selecting Jubail and Yanbu as cities for heavy industries. Whilst there have been changes in emphasis since 1970, Saudi plans have highlighted the same four underlying themes, listed in Box 3.1, below.

Box 3.1: Saudi development planning themes and industrial objectives

Planning themes:

- Maintaining the religious values of Islam
- Ensuring the defence of religion and the country and to maintain internal security and social stability within the Kingdom
- Continuing balanced growth by developing the country's resources, specifically by increasing income from oil and by conserving depleting resources
- Reducing dependence on the production of crude oil as the primary source of national income

Industrial objectives:

- Widening and diversifying the productive base
- Developing income sources other than oil
- Raising the level of self-sufficiency
- Offering job opportunities outside customary labour markets
- Participation in a balanced economic build-up.

Sources: Ministry of Planning , Five-Year National Development Plans, 1985 – 1995

However, the Sixth Plan, which began in 1995, called for a broadening of the technical skills of the Saudi population, and an even stronger emphasis on economic diversification of the industrial and agricultural sectors by increasing the private sector's role in the economy. The highlights of the Sixth and Seventh Plans are listed in Boxes 3.2 and 3.3, respectively.

Box 3.2 Key Aspects of the 6th Five-Year Plan, 1995-2000

- Limiting government spending on development programmes and projects to actual revenues
- Relating government loans and support facilities provided to individual private firms to the implementation of Saudization commitments
- Deepening the dialogue with the private sector through adoption of suitable institutional mechanisms, through organising regular meetings with private sector representatives at the secretarial level and expanding utilization of private capital in the financing of many government projects
- Improving the financial conditions for small-scale enterprises and expanding the Saudi credit bank's activities
- Increasing efficiency and utilization of non-conventional water resources, such as desalinated water, treated waste water and agricultural drainage water in order to maintain natural water resources
- Developing necessary measures to encourage small industries, as well as studying the possibility of establishing an agency responsible for their development
- Achieving full privatisation of electric utilities over the medium to long term
- Establishing new industrial parks in locations with favourable growth potential
- Establishing a national system for the adoption of environmental impact assessments, particularly in industrial, agricultural and urban projects
- Meeting the increasing demand for modern infrastructure facilities in addition to safeguarding existing facilities through routine maintenance.

Sources: Ministry of Planning , the 6th Five-Year Plan, 1995-2000, 2001

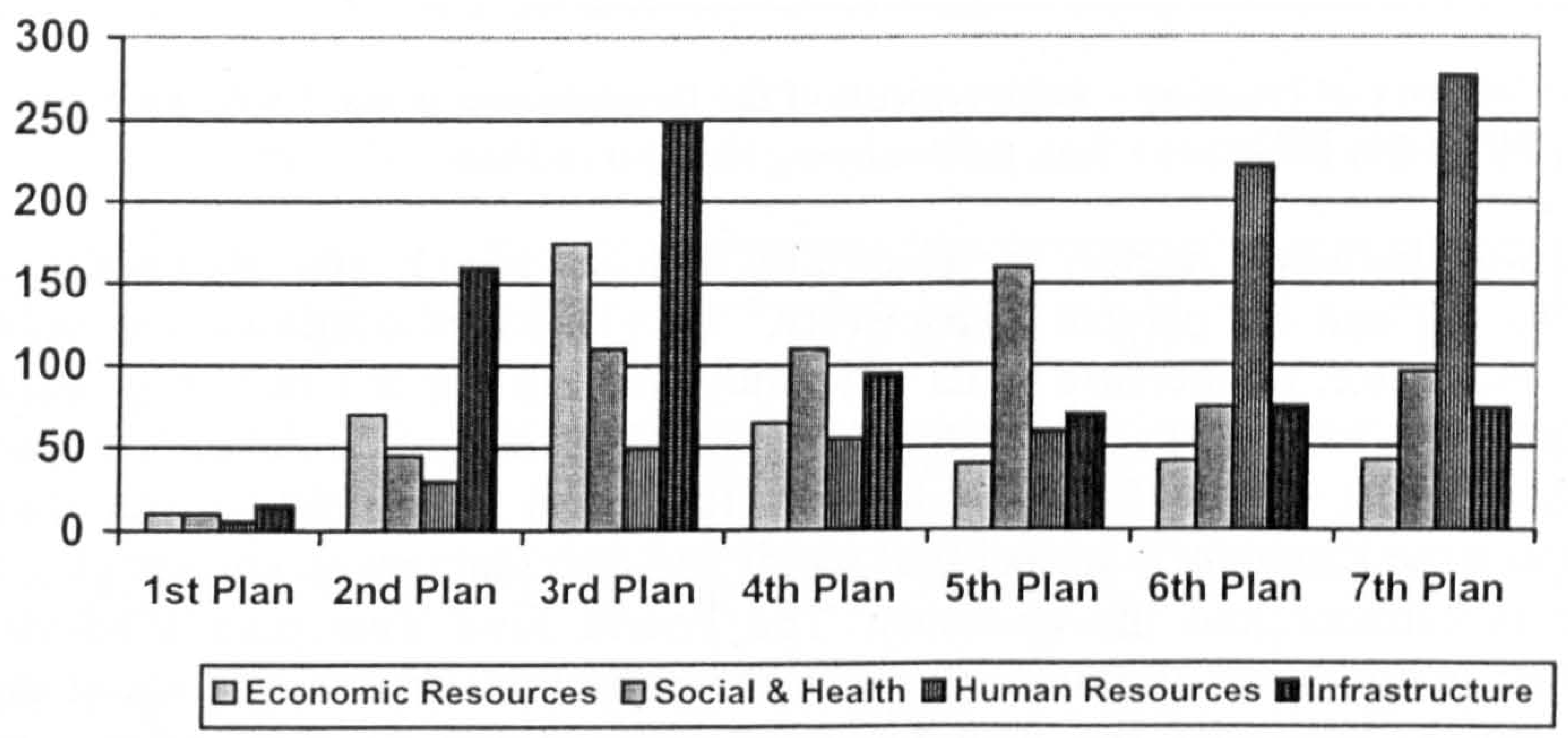
Box 3.3 Key Aspects of the 7th Five-Year Plan, 2000-2005

- Safeguarding Islamic values by duly observing and endeavouring to confirm, disseminate and defend the faith and the Nation, by improving the services provided to Hajj and Umrah performers
- Developing human resources to ensure an increasing supply of manpower and also to promote cultural and informational activities to keep pace with the Kingdom's development
- Enhancing the private sector's participation in socio-economic development, diversify sources of national income and expand the productive base of services, industry and agriculture
- Promoting integration among the Gulf Cooperation Council (GCC) countries and strengthening the Kingdom's relations with Arab, Islamic and friendly countries
- Consolidating the presence of a protective defence and security system, and furthering the continuous development of the Kingdom's intrinsic defence capability
- Encouraging the private sector to increase its investments in the fields of education, training, support and develop the research centres to undertake field studies for diagnosing the motives of voluntary work in the community
- Promoting the role of women in voluntary services in the context of Islamic values, and encourage women to participate in such services, ensure that all government departments which administer public services make economic efficiency fundamental to their operations by adopting the following basic principles:
    - i. total cost of producing such services to the Saudi Community should be reduced
    - ii. prices of such services should not be less than their production costs
    - iii. removal of monopoly and promotion of competition whenever possible
- Continuing the exploration and development of natural resources such as mineral and marine resources, achieving horizontal and vertical expansion of petrochemical industries, as well as the production of gas and petroleum derivatives, through private sector or joint venture companies
- Increasing the share of Saudi manpower in total employment of the various economic sectors, particularly in sectors with a high concentration of non-Saudi manpower
- Adopting a fiscal policy that aims at balancing government revenues and expenditures, reducing government expenditures and increasing government revenues along with the raising of performance efficiency in government agencies, reducing government expenditure in non-development sectors, increasing non-oil revenues
- Establishing a national science and technology base capable of innovating and inventing as well as adapting technology through: – provision of basic services, infrastructure and systems necessary for the development of science and technology; enhancing scientific and technological awareness by society and students at all levels of education, along with providing appropriate incentives in this respect; provision of opportunities for specialists and researchers to undertake scientific and technological research
- Encouraging technological invention and development by individuals and national institutions along with enhancing their innovative capabilities, and also fostering national industries to establish laboratories for research and development, quality control and the strengthening of relations between industry and these laboratories
- Developing and upgrading national human resources to meet changing needs of the population, diversifying skills of the citizen, increasing his productivity, and encouraging investment in human development fields, providing more health and social care and preparing the economic conditions to meet the increasing number of population. Placing emphasis on training and re-training of manpower to raise productivity, thereby achieving optimal utilization of technology and equipment used in development activities, through attention to cooperative training and on-the job training, giving priority to development of manpower through expansion of technological and technical education as well as vocational training programmes, developing means and mechanisms necessary for qualifying and training of national manpower in collaboration between both public and private sectors.

Source: Ministry of Planning , the 7th Five-Year Plan, 2000-2005,2001

Saudi Arabia has pursued development planning over the last 30 years and to date the Kingdom has so far completed six development plans with the 7^{th} plan now nearing completion. Implementation of these plans has contributed to the development of the Saudi Arabian economy. Figure 3.1 shows the expenditure in the Seven Saudi National Development Plans. The planning objectives support and encourage advanced technology flows to meet the Kingdom's development needs.

Figure 3.1 Expenditure of the Saudi development across the 1^{st} to 7^{th} National Plans
(SR. Billions)



Sources: Ministry of Planning – Achievements of the Development plans, Facts and Figures, 20^{th} issue, 2002

3.1.2 Saudi National Development Plans and industrial development

Industrial development has taken place in accordance with the country's National Development Plans, focused on local industries producing crude oil and natural gases, available in abundance in the Kingdom. Dynamic growth of both oil- and gas-based industries together with non-oil industries have transformed the country from a crude exporter to a highly diversified economy producing advanced material and goods for captive use as well as for export.

The importance of industrial development has increased gradually and attained fourth rank in the gross domestic product. Industries, including oil refineries have increased from 5.1% in the GDP in the year 1983 to about 9.1% in the year 1993.[3] The average share of the industry sector to gross product amounted to 6.5% during 1975-1993.[4] Table 3.3 shows the data revisions in the Saudi economy from 1998 – 2002 indicating that whilst the oil sector output value has declined across this period, the non-oil private sector shows a strong trend of increase.

Table: 3.3 Data revisions – 2001 to 2002

Macro-economy	2001	2002
GDP (SR Billions)	698.4	685.5
GDP (US$ Billions)	186.2	182.8
Real GDP growth (%)	1.2	0.2
Oil Sector (%)	-1.2	-5.8
Non-oil private sector (%)	3.5	4.2
Government (%)	1.7	1.0
GDP per capita –US$	8.691	8.309

Sources: Ministry of Planning – Achievements of the Development plans, Facts and Figures, 20th issue, 2002

The non-oil industrial sector, the electricity and gas sector, are estimated to have grown by 6.3 and 3.9 percent respectively.[5] This indicates continued expansion of the private sector, an increase in its efficiency and less dependence on government spending. In particular, as mentioned above, the non-oil industrial sector has witnessed robust growth for several years. The Third Plan 1980-85 was aimed at developing the Kingdom's agricultural sector and also manpower, encouraging more private investment into the economy. The Fourth Five Year plan 1985-90 was published in mid-1985, to improve education and health services, encourage private investment in industrial and manufacturing projects and develop defence in the Kingdom. Saudi Arabia emphasizes co-operation in its foreign policy, maintaining strong relations with the West. Due to its history as an oil exporter, Saudi Arabia has pursued free market economic policies and economic integration with the outside world.[6]

3.2 Oil and natural gas represent the main source of Saudi income

Oil and associated products account for much of Saudi Arabia's export value, constituting the major part of government revenues. Hence, it has been important to deal with hydrocarbon resources on a modern technological basis to achieve the maximum level of efficiency. Oil's contribution to the provision of present requirements, meeting the future needs, as well as investing in the elements of the sustainable development will compensate for any decrease in the contribution of such non-renewable resources in the long run. Utilization of hydrocarbon resources takes place according to a comprehensive strategy. The aim of this strategy is to maximize oil reserves through intensive exploration and programming of production in accordance with domestic conditions and the needs of the world oil market. This takes into consideration the role of the Kingdom as a major oil producer and an influential exporter, and the consequences of such a role on price stability.

The Saudi oil strategy also concentrates on increasing the valued-added of crude oil and natural gas through refining, production of pharmaceuticals and export of refined products instead of crude oil. This strategy has contributed to boosting the

Saudi economy and averting the many adverse impacts of price fluctuations in the world market. It has also been responsible for channelling oil revenues towards the achievement of socio-economic development, supporting the Saudi budget, restructuring the economy, and building a non-oil economic base.

The Kingdom's proven oil reserves by the end of 1970 stood at 138.7 billion barrels (bb) and as a result of new discoveries and a reassessment of known reserves has brought the Kingdom's oil reserves to 262.8 bb in 2000.[7] Accordingly, the country's reserves now account for 25% of the world oil reserves.[8] Exploration efforts have doubled the Kingdom's oil reserves over the past six Five Year Plans. Crude oil production in Saudi Arabia for the period 1998 – 2002, is shown in Table 3.4, below.

Table 3.4 Saudi crude oil production and revenue1998 to 2002

Saudi oil industry	1998	1999	2000	2001	2002
Saudi oil production (mbpd)	8.28	7.65	8.09	8.02	7.4
Benchmark price, North Sea Brent (US$)	12.76	18.25	28.96	24.4	24.50
Average price Saudi Crude oil (US$)	11.50	17.45	27.00	221.50	21.75
Oil revenue for Govt. budget (US$ billions)	21.33	27.86	57.17	49.33	47.5

Source: Ministry of Planning "Achievements of the Development plans, Facts and Figures", different issues 1998 -2002

With increased proven oil reserves, the Kingdom's crude oil production rose sharply from 3.8 million barrels per day in 1970 to 8.5 m b/d in 1974 reaching a peak of 9.5 in 1979.[9] However, as a result of world oil market developments, the entry of new producers such as the North Sea countries, and increased production in the former Soviet Union, production gradually declined to 4.1 m b/d in 1984 and 3.2 in 1985. In 1986 production increased to 4.9 m b/d, but once again dropped to 4.2 m b/d in 1987 before rising again to 5.1 in 1989.[10] Due to the conditions of world oil market and after the Gulf War, production rose to 8.3 m b/d in 1992 and maintained almost the same level in 1998.[11] However, in 1999 as a result of OPEC's policies to overcome the sharp decrease in crude oil prices through control of production rates in the member countries, the Kingdom decreased its production to 7.56m in 1999.[12] Saudi Arabia increased the level of production to 8.1 in 2000 due to world demand and the requirements for world price stability.[13] Table 3.5, below, shows the global oil supply from OPEC and non-OPEC countries from 1998 to 2001.

Table 3.5 Global oil supply (mbpd)

Year	OPEC	Non OPEC	Total global
1998	30.79	44.88	75.47
1999	29.43	44.69	74.12
2000	30.82	45.86	76.68
2001	30.12	46.6	76.72

Source: International Energy Agency Reports, 2001

The short term and long-term objectives of government intervention in the oil industry are aimed at maximizing the management, control and direction of Saudi Arabia's hydrocarbon resources. Saudi oil policy objectives have been in line with the development stages characteristic of the oil industry, as identified in many of the important oil producing countries, and listed below in Box 3.4

Box 3.4 Oil industrialisation 'Stage' development model

Stage I- This first stage is characterized by the offer of maximum incentives to oil exploring companies by the host country. The objective is to attract the oil companies' capital and know-how, which the host country lacks. After the initial discovery of oil in commercial quantities and its production establishes the country as a proven oil producer, the second stage sets in.

Stage II- Here, generous incentives given for exploration are gradually and progressively modified and replaced by new exploration agreements. Meanwhile, the host country increasingly gains insight into the nature and operations of the oil industry.

Stage III - The third stage depends on the attainment of adequate know-how in exploration and production, access to sources of equipment and knowledge of actual costs. At this stage, the country uses service contracts and bears all the exploration risks instead of granting concessions or production-sharing contracts. In the course of stage one through three, the country acquires know-how.

Stage IV - The fourth stage starts when the country on its own is able to undertake exploration, production, refining and marketing. However, the country may still depend heavily on foreign partnerships especially in the areas of technology.

Sources: Ministry of Planning, "objectives and strategies of the Development Plan", 2000

Implementation of the Saudi Five Plans has boosted the production base of the non-oil sectors, increasing their growth rates. Exports have also expanded. Oil exports form a crucial element in the balance of payment situation for the Saudi economy. They exhibit tremendous volatility in line with fluctuating oil prices and production. Nearly 90% of exports comprise oil, and hence oil export movements will be the key to estimating the current account balance. In order to maintain oil price stability, as shown in Table 3.6, OPEC has cut its production drastically during 2001 and 2002. OPEC hopes to maintain a price of $20/b to $ 22/b for OPEC Basket, which translates to a price of $ 17 to $ 19/b for Arab light.[14]

Saudi economic and fiscal performances were much improved in 1999. The strong rebound in oil prices has reversed Saudi Arabia's growth prospects for that year.

Table 3.6 OPEC Countries crude oil production

000 b/d			2002					% change
	2000	2001	Jan.	Feb.	Mar.	Apr.	May	Jan-May 02
Algeria	808	821	785	775	790	802	829	27
Indonesia	1279	1216	1142	1145	1143	1151	1130	-21
Iran	3671	3665	3353	3324	3359	3359	3353	-6
Iraq	2551	2385	2255	2447	2431	1193	1718	525
Kuwait	2101	2032	1859	1826	1846	1862	1878	18
Libya	1405	1361	1262	1268	1292	1296	1310	14
Nigeria	2031	2097	1987	1947	1949	1951	1917	-34
Qatar	698	683	598	589	606	619	638	19
Saudi Arabia	8247	7918	7228	7159	7293	7378	7398	20
UAE	2251	2163	1944	1957	1956	1972	1954	-18
Venezuela	2897	2830	2577	2559	2584	2466	2670	204
Total	27939	27171	24990	24996	25249	24049	24795	746

Source: Organization of the Petroleum Exporting Countries OPEC, Annual Statistical Bulletin (ASB), 2001

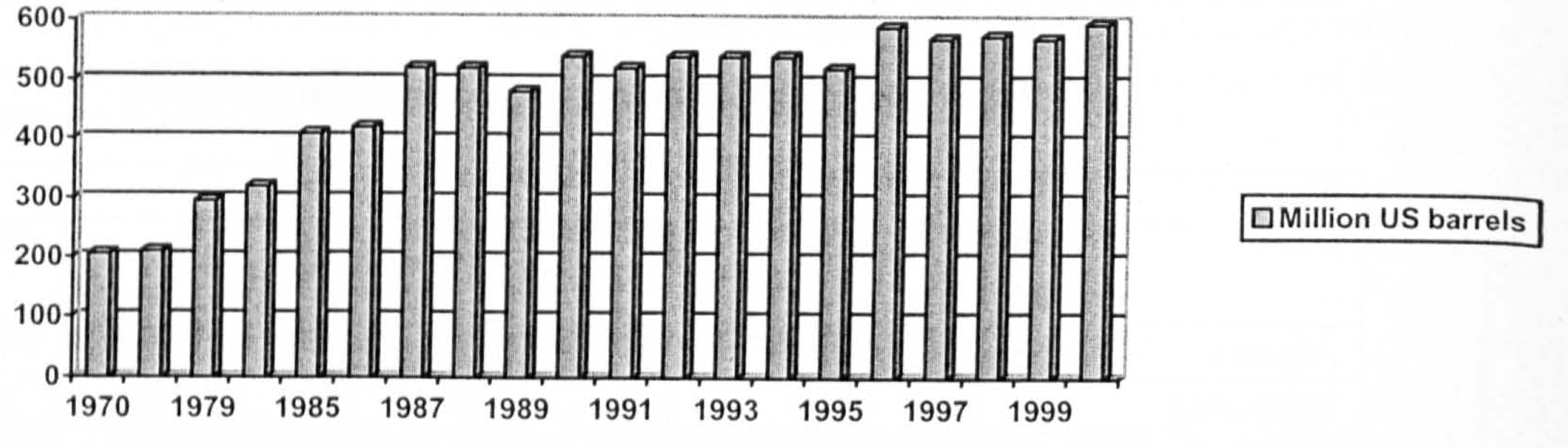
On the whole, Saudi Arabia expects production to average 7.5 million barrels a day[15] during 2002 including leakage and therefore exports at 7 million barrels a day. The price strength allowed OPEC members, including Saudi Arabia to gradually exceed production quotas without causing a price collapse.[16]

Because of declining oil production in the subsequent years, production of associated natural gas declined to about 32 bcm in 1987.[17] Thereafter, it rose gradually to 54.3 bcm in 1994, and then declined to 48.7 in 1999. The Kingdom has made significant progress in utilizing the produced quantities of natural gas in an economic manner. In 1970, only 2.3 bcm or 11% of the produced natural gas was effectively utilized, but the rate of natural utilization reached 94% of the total production in 1999.[18]

3.2.1 Refined products

Saudi Aramco refined production has increased substantially and consequently so has the value added from crude oil. Refineries now represent an important industry in the Kingdom. The installed capacity of Saudi Aramco's refineries in Jeddah, Riyadh, Yanbu, Jubail, Ras Tanura and Rabigh rose by more than three-fold, from 512000 barrels per day in 1970 to about 1.74 mbd in 2000.[19] Refining operations increased at an average annual rate of 3.6% during the same period.[20] Figure 3.2 shows the total production of refined products for the period covering 1970 to 2000.

Figure 3.2 Total production of Aramco's refined products, 1970 to 2000



Source: Ministry of Planning, "Achievements of the Development plans, Facts and Figures", 19th issue 2001 p.95

3.2.2 Gas: a new strategy

A potential source of future income in Saudi Arabia is from gas, and hence development plans to the extent of US$ 25 billion over the next 5 to 10 years, are in place. The development of the upstream gas sector is the most profitable portion of the proposal and is likely to make derivative projects in water desalination, petrochemicals and power generation more viable. The Kingdom signed a preparatory agreement to develop gas in June 2001. According to a press release issued from the Ministry of Petroleum and Minerals [21], the authorities unveiled a Gas strategy called 'Gas Initiative' aimed at achieving the following objectives: rapid penetration of supply to the underserved regions of the Kingdom; displacement of oil and NGL burning in power generation and desalination facilities; optimal deployment of current and future NGLs into petrochemical use; and rapid expansion of power and desalination production capacity.

The initiative opens the Kingdom to foreign oil companies for domestic production and consumption of gas in three core ventures valued at $25 billion.[22] Not only will the implementation be expected to generate about $25 billion in up-front investment but may also attract additional investments through associated projects and related foreign investment. Power and water projects are associated with the core ventures of the gas initiative. In 2001, the Saudi Government selected eight companies split into three consortia, two led by Exxon Mobil and one by Shell, and were tasked with bringing a gas on stream and also building facilities that will use production as feedstock for electricity, water desalination and petrochemical plants. However, finalizing of the agreements has remained deadlocked over the terms of the investments required from the companies.

3.2.3 Interaction between Saudi oil policy and industrial policy

Oil is the lifeline of the Saudi economy. Oil plays an important role both in the context of the national economy and international economy. From the national side, since 85% of total revenues accrue from oil, any change in oil prices and production will directly impact on the performance of the domestic economy. Similarly with the world economy, if Saudi oil production is disrupted. Saudi Arabia, however, has been keen to diversify its economy away from dependence on oil. Industrial development, for instance, has lessened the degree of dependence on crude oil production and has also helped to expand and diversify the non-oil production base. This has led to an increasing degree of industrial self-sufficiency and to a larger amount of exported products.

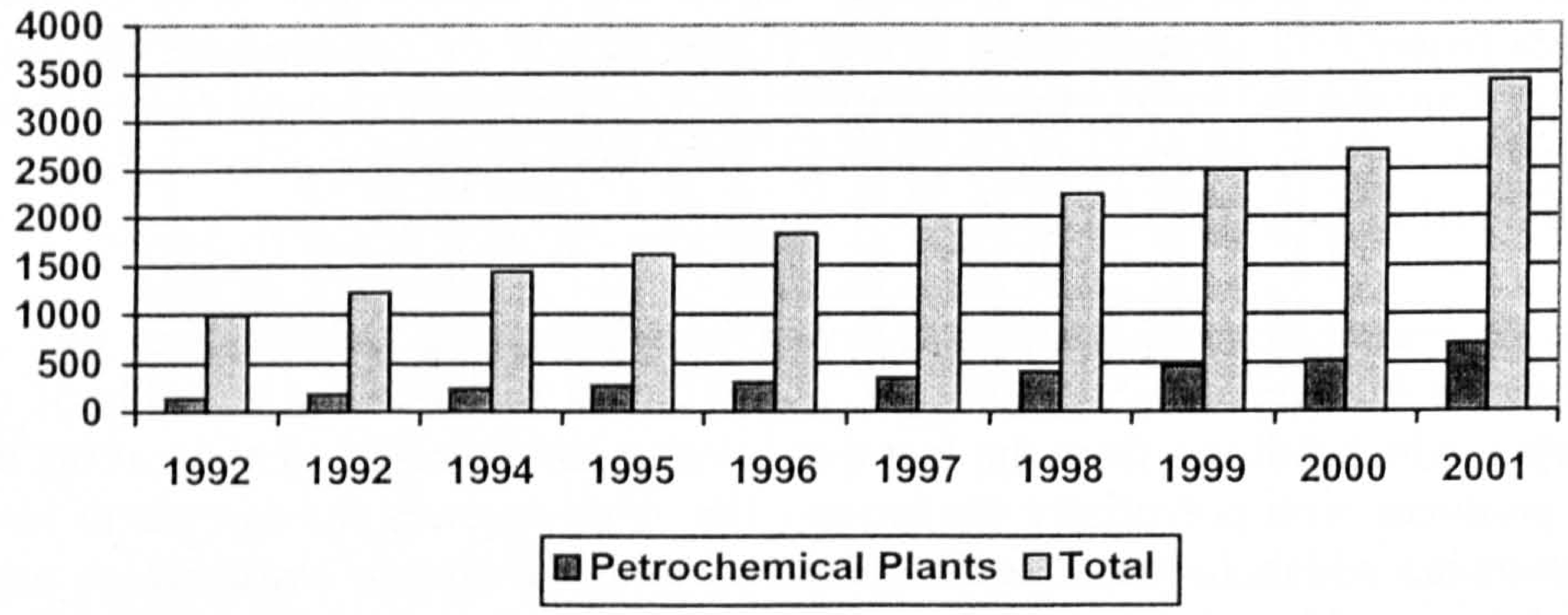
The general objective of Saudi oil policy is security and stability, and this can be translated into three sub-goals: first, is to secure the long-term health of the oil market, which follows from the fact that Saudi Arabia's reserves make it the biggest oil producer with potentially the longest life. This requires the long-term health of customers, which in turn requires that supplies of oil are available at adequate levels/reasonable prices; second, is to diversify the economy away from its virtual total dependence on crude-oil exports. This implies moving down-stream in the oil industry, which in turn suggests the need for greater control over the industry both domestically and internationally; and, third is to use oil as the leading development sector to secure real economic development. Apart from reducing export dependence, and for that matter import dependence, real structural change in the economy would also, in theory at least, help to diffuse the benefits of oil down through the population, thereby forestalling instability arising from economic conditions.[23]

3.3 Saudi industrial development

In a move to diversify and develop the economy, and particularly its industrial base, the Saudi Government in 1961 created two new departments, namely: the Department of Industrial Affairs and the Department of Electricity, both under the Ministry of Commerce. The purpose was to formulate appropriate infrastructure plans and create proper environment for industrial development. Then, in 1974 the government issued a new industrial policy to accelerate the process of industrial development. Due to the growing importance of the industrial sector the Saudi Government set up an independent Ministry of Industry and Electricity in 1975 to oversee industrial development programmes.

To facilitate economic and industrial growth, the Saudi Government also set up industrial areas in Riyadh, Dammam, Jeddah, Jubail and Yanbu. These industrial areas were provided with the essential infrastructure requirements like ports, road, airports, power and water etc. The Government provided various incentives to attract investments in the Basic Industries such as government Loans, Tax holdings, cheap raw material and free repatriation of profit by the foreign partners. The Saudi Government also embarked on developing manpower to support this industrial growth. As a result of joint efforts by the public and private sector, the industrial sector grew rapidly during the 1990s. Most industry is concentrated in just three regions: Riyadh, Jeddah, and the Eastern region where there is as relatively high population density. These policy measures have led to a trend of increase in Saudi manufacturing output, as shown in Figure 3.3, below.

Figure 3.3 Saudi industry output, 1992-2001



Sources: Ministry of Industries, Internal Report, 2001

Saudi industrial development strategy aims to decrease dependence on crude oil as the only source of revenue, diversify the productivity base of the economy, and accelerate progress and economic growth. Saudi industrial strategy also aims to encourage and widen the Kingdom's industries whereas oil revenues have been utilized and invested during consecutive development plans to develop infrastructure facilities such as roads, seaports, airports and other means of transport. Most of these projects have now been completed. With the infrastructure in place, Saudi Arabia has promoted industrial cities and the associated factories. Plots of land in such cities are allotted on nominal prices (8 halalah) m^2/ year.[24] The industrial cities establishment began in the Kingdom in 1970. The total area of industrial cities amounts to (55315) m2 and about SR (2885) millions had been spent on their development up to the end of 1999.[25]

The objectives of industrial development are summarized in Box 3.5, below.

Box 3.5: Objectives of Saudi industrial development

- increase economic productivity and diversify it through utilization of available natural resources by producing a variety of low cost products that are competitive at the local and international markets. This, however will not only increase growth rates of industrial annual output, but also increase the sharing of industry in gross domestic product (GDP), and increase income from value added, hence increasing national income
- exploit resources and local raw material, encouraging projects that depend on local raw materials, making use of the advantages of energy availability at competitive prices, including petroleum and its by-products; additional exploitation of available agricultural, mineral, and fish resources
- encourage utilization of private sector industry potentialities so as to increase industry's role in execution of projects
- widen the transfer of modern technology and sustain its relation with the Kingdom through encouraging the establishment hi-tech projects
- attain balanced industrial development between the Kingdom's regions
- increase industrial productivity by encouraging the establishment of factories with ideal production capacity
- develop the national labour force to reduce dependence on foreign labour through promoting national skills, education and training potentialities
- increase integration and co-operation between various industries by encouraging more horizontal and vertical overlapping of industries, and the establishment of allied and supporting basic industries to increase industrial interrelationships and integration.

Source: Ministry of Planning,"*General Objectives and strategies base of the Seventh Development Plan, 2000-2004*", Ministry of Planning, Saudi Arabia, 2000

A comparison between the scale and nature of Saudi industry in 1970 and that in 2002 reveals the positive impact of industrialization. This is why all developing countries are so anxious to industrialize. Saudi Arabia is determined not to remain an economy that exports just crude oil and imports everything else.

As one Minister of Industry and Electricity on his 1985 visit to European Countries in stated:

> "...Saudi Arabia has invited trading partners to become industrial partners encouraging them to participate in the growth of the Saudi market. Saudi Arabia has tried the system of foreign investment through joint ventures and has found that it works. Saudi Arabia gains the benefit of value-added, the linkages, and the multiplier effect on other sectors of the domestic

economy, by the local production of goods and services, all of which strengthen the whole economy and accelerate the trends to diversification. Industrial partners also gain the benefits of participation – their joint ventures win a greater share of the local market, they gather all the benefits of profitable business without hindrance on the flow of capital".[26]

The benefits of foreign investment in Saudi Arabia are considerable. Fully serviced sites are offered at attractive rates on industrial parks provided by the government. The Saudi Industrial Development Fund (SIDF) offers finance for up to 50% of the capital cost of a project. Imported raw materials are exempt from customs duties. There are grants provided for the training of Saudi staff. There are no restrictions on the repatriation of profits or on currency transactions. There are no personal income taxes on expatriate staff, and ten-year tax holidays for industrial projects.[27] As a result, industrial license applications are increasing. At the start of this decade they were 30% higher than in the 1980s. In 2001 licenses were issued to thirty foreign joint ventures.[28] Capital-intensive production systems are also vital for Saudi industries to remain competitive, with state of the art technology to sustain efficient, relatively small-scale production systems. Saudi Arabia has emphasized the importance of investment in advanced technology. This is needed to develop the industries and services, and if necessary, wait until the necessary technology can be deployed efficiently within the country, rather than encourage industries which are already obsolescent but which might still be profitable in the short term.

Saudi experience with advanced technology in the armed services, in petrochemicals industries, and in airlines suggests that Saudi labour can absorb the technology. For example, Saudi Airlines now carries out all its own maintenance, and has been awarded full certification by the US Federal Aeronautics Agency. The military purchase offset programme has successfully identified a very wide range of over 50 potentially viable high technology projects that could be introduced.[29] There is also scope for the development of computer software, and adapted hardware and system architecture. However, many of the systems, which have been developed in the US, UK and Japan, need adaptation and modification before they can be successfully introduced to the Saudi market.

3.3.1 Saudi industrial structure

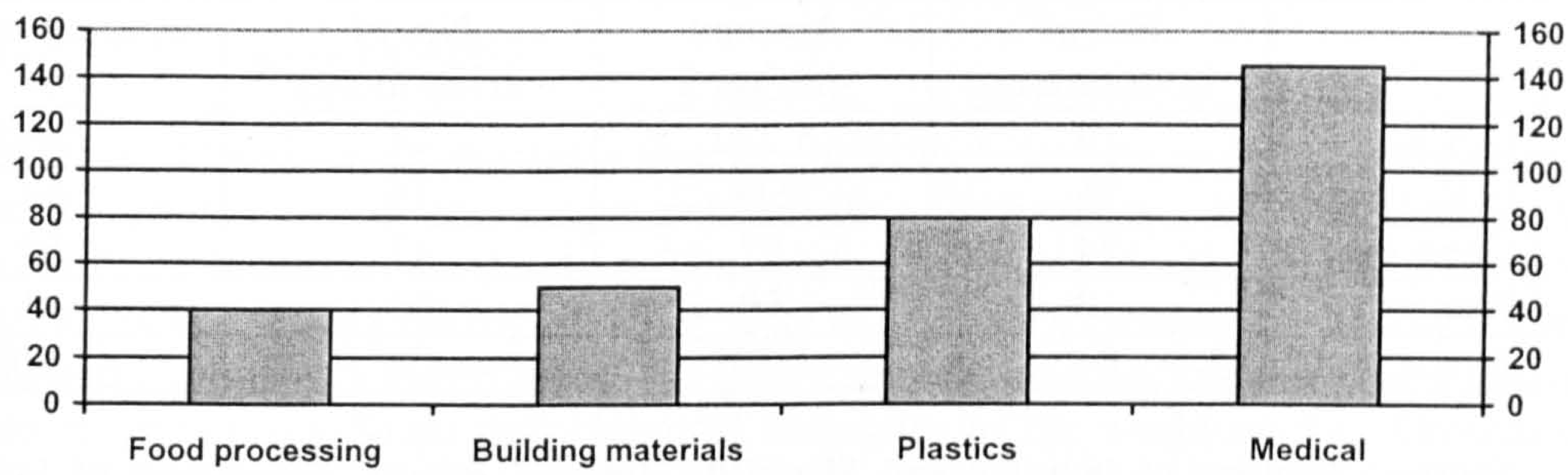
The importance of the Saudi industrial sector can be shown by an impressive array of statistical indicators about factory activity. For instance, the number of licensed, operating factories increased 63% between 1984 and 1993 and by the middle of 2002 totalled 3,418.[30] During the same time period, growth in technology and capital intensity was even more impressive as shown by the fact that factory capital investment increased 130% to nearly $65 billion.[31] Total industrial employment also increased nearly 40% to 319,000 workers by the end of 2001.

The early structure of Saudi industry also changed due to the growing importance of joint venture industrial projects with nearly 60 countries. By the end of 1992, there were over 350 such projects and their capital investment totaled nearly $21 billion.[32]

The Saudi government attaches great importance to foreign joint venture projects since they provide one of the major ways of transferring technology and technical expertise educating and training Saudi employees, utilizing domestic raw materials and generally helping to implement the Kingdom's industrial development policy. Several Saudi industrial sectors, which have benefitted from foreign joint venture projects, are noted in Figure 3.4.

Figure 3.4 Saudi joint ventures by sectors

No. of factories



Sources: Ministry of Planning, Saudi Committee for Economic Review, "*Liberalized Foreign Investment Rules come into Force*, Special Report- May, 2000

A significant aspect of Saudi industrial development has been the large increase in the number of locally produced products, which now number more than 2,000.[33] Many of these products were originally imported; however, their local production has now become sufficient to meet all or a large share of domestic demand. A growing number of these products are also exported to nearly 90 countries throughout the world, indicating that Saudi products have become internationally competitive in many industrial sectors. Included in this list are various petroleum-based products, which are manufactured by the Saudi Basic Industries Corporation SABIC; the largest and most technologically advanced petrochemical company in Saudi Arabia. In addition, exports from other industrial sectors have increased dramatically in recent years.

Basic industries consisting of the petrochemical and metals industries are characterized by their intensive use of capital and energy resources, as well as the advanced technologies they apply. The largest portion of products of such industries are exported after local market demand is met. The industrial sector has effectively made use of government support and encouraged industrial development. The following economic indices show the achievements during 1970-1998. In 1970 there were only 613 factories in the Kingdom. In 2001 there were 3,418, an annual growth rate of 10.5%.[34] Capital invested in establishing factories during 1980 was approximately SR 21.1 billion. In 2001 such investment reached nearly SR 240.1 billion, an annual increase rate of 16.9%.[35]

Numbers of existing projects operating according to foreign capital regulation amounted to 344 and employed 48,918 workers.[36] As already mentioned, protection and encouragement of national regulations was issued in 1961 and industrial policy in 1974. This was followed by foreign capital investment regulation in 1979.[37] Table 3.7 clearly shows the extent of investment in industry by major countries as well as country investment trends over a period of 6 years, from 1990 to 1995.

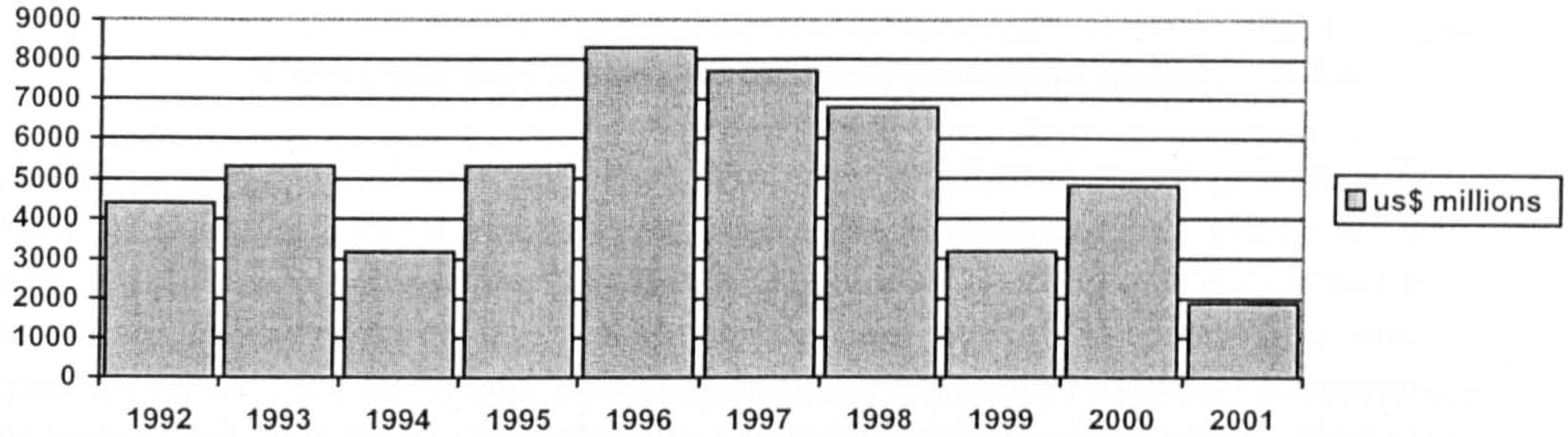
Table 3.7 Major countries' investments in Saudi industry

Country	Based on the number of licenses issued		Based on the number of actual operations	
	No. of investments	Amount million $	No. of investments	Amount million $
U.S.A.	79	5,222	44	2,885
U.K.	31	218	15	53
Germany	24	87	13	50
France	10	59	03	23
Japan	04	1,505	04	1,505

Sources: Ministry of Industry and Electricity, Internal Report, Department of Industrial Development, 2000

Technology is extremely important to Saudi industry in sustaining production of distinct goods capable of competing in domestic and international markets. As a consequence, Saudi regulations include incentives and custom exemption for foreign investors. These are aimed at transferring industrial technology to the Kingdom in the form of modern production means and methods through joint ventures between national and foreign capital. Saudi Arabia has promoted industrial co-operation programmes with many industrial countries. Table 3.8 sets out the expenditure involved in Industrial contracts, transferring technology to Saudi industries between the years 1999 – 2001. Moreover, Saudi Arabia is currently formulating a mechanism for the utilization of research facilities to major companies, such as SABIC and Saudi Aramco as well as in specialized research centres such as King Abdul Aziz City for Science and Technology. The figure 3.5 shows the value of Industrial contracts that brought new technological innovations from the developed countries to the Saudi industrial sector during the period 1992 to 2001.

Figure 3.5 Value of industrial contracts providing technology to Saudi industries from 1992-2001



Source: MEED Issues 1999-2001

The Saudi Government initiated a plan to utilize hydrocarbon and mineral resources for the production of various petrochemicals and fertilizers, by establishing the Saudi Basic Industries Corporation. The Saudi petrochemical industry has developed rapidly since creating SABIC in 1976. Due to the heavy development programmes initiated by the Saudi Government, the petrochemical manufacturers played a crucial role in introducing Saudi petrochemical industries to the world market. Growth in this industry has reinforced the Kingdom's position on the global industrial map while building long-term relationships with its customers. The Saudi industrial export sector has experienced sound growth and has contributed significantly to achieving national economic development objectives.

Table 3.8 Percentages of technology transfer contracts to Saudi industry, by sectors 1999 to 2001

Sectors	%
Oil & gas	43
Petrochemicals	24
Power	7
Cement & glass	6
Metallurgical	6
Water	5
Waste management	2
Fertilizers	2
Food	1
Electronics	1
Other	3

Sources: MEED Issues 1999-2001

Table 3.8 is an indicator of the different percentages accounted for by technology transfer contracts in Saudi industry during the years 1992 to 2001. The oil and gas sectors and the petrochemical sector stand above all others, with an over all share of 43% and 24% respectively of all industrial contracts that had taken place in Saudi Arabia during this period.[38]

3.3.2 Saudi economic diversification: the mining sector

The mining sector occupies a prominent position in the Saudi government's strategy to diversify the Kingdom's economic base. Saudi Arabia is home to the largest mineral deposits in the Gulf, including about 20 million tons of gold ore, 60 million tons of copper, 10 billion tons of phosphates, and a large spectrum of industrial minerals.[39] Saudi Arabia's objectives for this sector include reaching out to the private sector and foreign investors to establish industries for extracting and processing those minerals, providing the Saudi manufacturing sector with its requirements in raw materials, as well as becoming a leading exporter of minerals.[40] The mining sector in the Kingdom is expected to become the second largest source of government revenue within the next decade. The Saudi Arabian mining sector presents a high-growth potential. The Kingdom's sixth Five-Year Development Plan (1995-2000) anticipates the sector to grow at a rate of 9.9 percent per annum.[41] To date, according to the Ministry of Petroleum and Mineral Resources, over 920 licenses have been given to companies for the exploration of mineral resources.[42] The incentives the Saudi government has granted private investors have made investment in this sector highly profitable.

A further catalyst for private sector investment in mining has been the creation of the Saudi Arabian Mining Company ("Ma'aden") in 1997, with an initial capital of more than $1 billion. Ma'aden is responsible for regulating the mining sector, consolidating the mining projects wholly or partially owned by the government, and rebuilding them on a commercial basis in partnership with private investors. Ma'aden is also involved in the revision of the mining code, with the goal of streamlining administrative procedures, and making the sector more appealing to private investors. The Saudi government has also been working on building the infrastructure necessary for the development of the Kingdom's mining industry. The Ministry for Mineral Resources has located 1,273 sites of precious metals and 1,171 sites of non-precious metals.[43] Over 30 minerals have already been identified in the Kingdom, with at least 15 industrial minerals that could be successfully exploited by investors. The Ministry for Mineral Resources has identified more than 64 mining projects that offer investment opportunities for private investors. The Kingdom has moved beyond the mere extraction of the minerals, into the creation of a well-integrated mining industry.

3.3.3 Import substitution for Saudi industrialization development

Import substitution is the industrial development strategy adopted by many countries. It is expected to ensure rapid industrialization and export competitiveness of locally manufactured goods. Import substitution is based on the principle of importing semi-finished 'knocked down' components in place of finished goods, such that the local entrepreneur could assemble the unfinished goods and sell locally or export if the market condition was right. This way local entrepreneurs can gain manufacturing experience as well as technological experience. Unfortunately, though, the Saudi experience of import substitution strategy resulted in cheaper and better-imported finished goods rather than the assembled 'made in Saudi Arabia' goods. Import substitution strategy, however, has had little impact in the Saudi oil and petrochemical industry as government had the strategy targeted only on manufacturing goods.

3.3.4 Industrial incentive programme

Saudi Arabia has a full range of internationally competitive industrial investment incentives for investors wishing to engage in technology transfers and joint ventures with Saudi companies. The range of incentives are listed in Box 3.6 below.

Box 3.6: Saudi investment incentives

- no currency restrictions and unlimited movement of capital into and out of the country
- low-cost land for factories and related facilities located at various industrial cities around the Kingdom
- low-cost electricity and water for industrial use
- exemption from all duties for imported raw materials, machinery and equipment used by industry
- 10 year 'tax holiday' for all industrial projects with 25 percent or more Saudi capital. Recent changes to this provision also allow for further 10 year "tax holidays" for additional invested capital from outside investment or undistributed profits
- tariff protection from competing imported goods for certain critical manufactured products
- eligibility for no-interest industrial loans for up to 50% of project cost
- preference for national products in government purchases.

Source: Ministry of Industry and Electricity, *"Doing Business in Saudi Arabia"*, Published by MIE, Riyadh, KSA, 2000

3.4 Human resource development and Saudisation

High rates of investment in human resources in Saudi Arabia have resulted in an impressive improvement in human and social indicators in the past three decades. Saudi Arabia has paid much attention to establishing linkages between industrial development and manpower development. The industrialization concept is not limited to technical and economic aspects only, but also has a connection with organization and managerial aspects which depend on qualifying and training of Saudi labour force so as to participate in production process and acquire industrial behaviour. However, the Saudi labour force represents about 75% in SABIC and about 80% in Saudi Aramco.[44] Yet, the Saudi employment proportion is still low in the private sector industries, i.e. 8%.[45] For this reason the Saudi government has initiated a number of policy measures, as listed in Box 3.7.

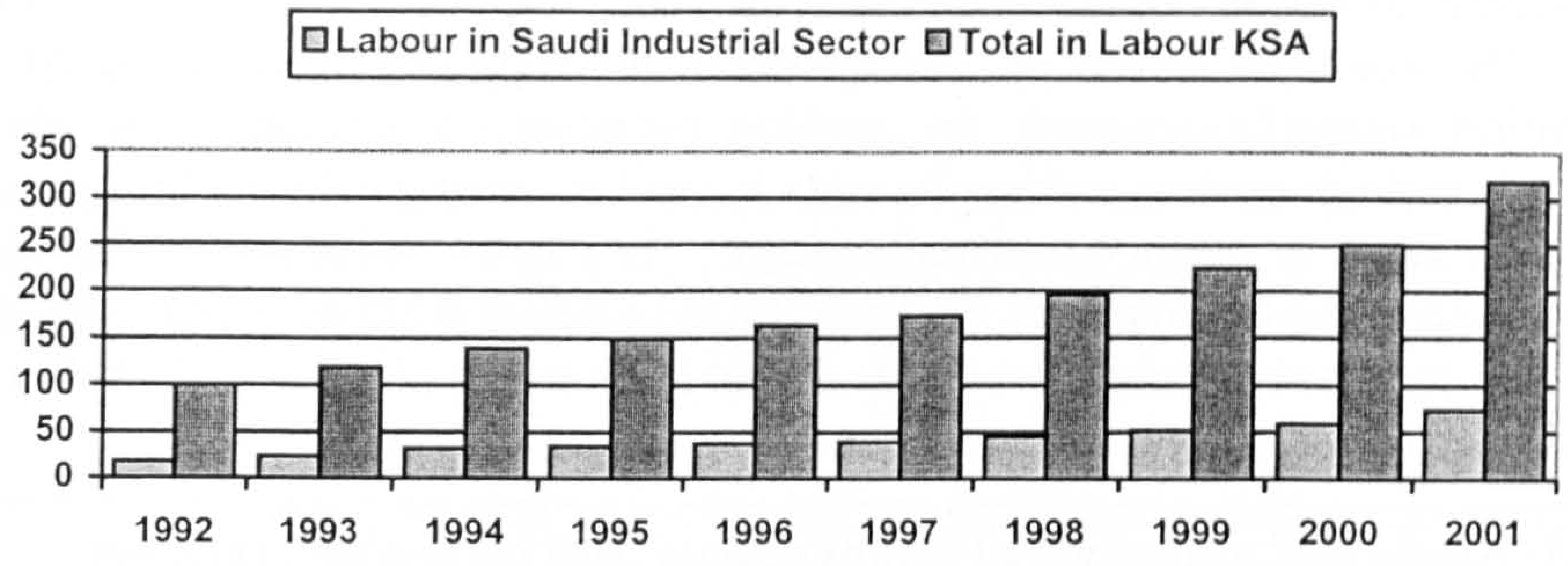
Box 3.7: Key Saudization policy issues

- take necessary procedure and measures to attract Saudi employment in projects and industries
- encouraging industrial private sector to be responsible for achieving national objectives of Saudization
- linkage of industrial incentives to industrial establishment efforts towards Saudization
- developing more intensive vocational and technical training programmes
- adoption of industrial apprenticeship by establishing technical institutes whose programmes includes theoretical studies as well as providing job training
- granting incentives and taxes exemption for industries that offer training to technicians
- establishing industrial training institutes and centres in the Kingdom together with formulating curricula that keep pace with real needs of factories.

Sources: Ministry of Planning, "7th *National Development Plan*" MP, Saudi Arabia, 2000

Manpower is important for Saudi Arabia and hence the Saudi Government has been investing considerable monies and time into developing human resources. Labour growth in Saudi manufacturing industry is shown in Figure 3.6, below.

Figure 3.6 Labour growth in Saudi industry 1992-2001



Sources: Bourland, Brad, "*Saudi Arabia's Employment Profile*", Saudi American Bank, Riyadh, Oct. 2002

Saudi Arabia emphasises the linkage between industrial development and manpower development. The industrialization push is not limited to technical and economic aspects only, but also has a connection with the organizational aspect that depends on qualifying and training of Saudi labour force so as to participate in the production process and acquire industrial behaviour. The focus on managing performance improvement throughout the year requires top performance from trainees as a key responsibility.

3.4.1 Expatriate labour

The Saudi Government's Central Department of Statistics (CDS) provides detail on the size and makeup of the expatriate labour force in Saudi Arabia. According to the CDS, in 1999 there was a total non-Saudi population of 5.0 million, of which 3.0 million both comprised the labour force and were employed.[46] The remaining are largely family members of expatriate workers. The expatriate population includes some 1.4 million children, 19 years old and under. Most of the non-Saudi workers are employed by the private sector. Of the 3.0 million non-Saudi workers, only about 89 thousand worked for the government. The government also employed 579 thousand of the 2.8 million Saudis working, according to the Ministry of civil service.[47] It is worth noting that private sector compensation is generally lower than compensation in government. There is generally a view that the government has better pay and benefits for Saudis than the private sector, and this is born out by the wage and compensation data that were also published by the CDS for the year 2000.

3.5 Technological development and King Abdul Aziz City for Science and Technology

The Kingdom's development plans have placed major emphasis on implementation of many influential projects in the domain of technological development. Among these projects are educational, academic institutions as well as training and research centres foremost among which comes King Abdul Aziz City for Science and Technology (KACST). KACST was established in 1977 as per Royal Decree M/60 as an autonomous scientific body reporting to the Prime Minister. Its main objective is concentrated in supporting, encouraging and implementing scientific research for applied purposes, coordinating the various activities of research centres and institutions as well as setting national priorities and policies pertaining to science and technology. The main objective of The Saudi National Strategy for Science and Technology is to develop science and technology in the Kingdom mainly to meet the needs and objectives listed in Box 3.8, below.

Box 3.8: Needs and objectives of Saudi science and technology strategy

Needs:

- to ensure the safety and national security of the Kingdom
- using all the national resources
- support the improvement of living standards in the Kingdom
- support Saudi developments in general
- secure opportunities for the new generations
- develop a human culture with Islamic principles

Objectives:

- manpower development for Science and Technology
- research and Development activities to meet general requirements
- support development capability of national technologies in all sectors and make them capable to accommodate technology transfer
- continue development of regulations for Science and Technology to encourage Scientific innovations
- develop activities to support Science and Technology on information/ communication / patents, office consultancy
- invest in information technology as per the needs of the Kingdom
- develop national sources for environmental protection through science and technology
- create national awareness of the importance of science and technology and its effects on national security and development of the economy.

Source: King Abdul Aziz City for Science and Technology "*Saudi National Strategy for Science and Technology* ", KACST, Riyadh, Saudi Arabia, 2000

3.5.1 Saudi national policy for science and technology

In collaboration with the Ministry of Planning and agencies concerned, King Abdul Aziz City for Science and Technology (KACST) – see Appendix 3 for Organisation Chart, has completed the third phase of the long-term national master plan for science and technology concerning the preparation of The National Policy for Science and Technology in the Kingdom. It has finalized all elements related to this policy including general objectives, strategic bases and the implementation approach based on the outcomes of phase I and II of the plan for approval by the agencies concerned.

Both King Abdul Aziz City for Science and Technology (KACST) and the Ministry of Planning have jointly developed a national policy for science and technology in the Kingdom through scientific methods as a result of comparison of studies locally and internationally. This policy has two parts:

i. Science and Technology focusing on all scientific and technological long-term innovative programmes in the Kingdom as a framework for general strategies including objectives and visions. The Saudi Cabinet has approved The Saudi National Policy for Science and Technology and this makes Saudi Arabia the 1st Arabian country that has developed a national policy for science and technology, according to KACST.

ii. This considers the methods of implementation of the policies and strategies of the different sectors which link science and technology with projects and programme efforts and operation plans.

The Kingdom considers the Saudi National Policy for Science and Technology as a national project aimed at developing of science and technology on a long-term basis. King Abdul Aziz City for Science and Technology and the Ministry of Planning, all Saudi public sectors and the important private sector institutions have been invited to share their needs and opinions on this project. The study itself has been a huge effort with more than 150 Saudi scientists and engineers and 110 Saudi specialists representing 45 Ministries and Government and public institutions participating in basic studies and information gathering.[48]

3.5.2 Importance of R&D for Saudi industry

Research and development is the means by which an economic establishment secures its position in modern technical industries. The petrochemical industry, although it is relatively mature, is fast changing especially in the fields of new developments and applications of its products. Economic studies have indicated that the effect of human resources dealing with the processes of production, maintenance, machinery and utilization of R&D activities is far more than the effect of capital investment in securing continuing progress of an establishment. Today a successful economic establishment is one that has a mutual relationship and cooperation with R&D and technology producing centres. An applied study executed in Saudi Arabia, aimed at analysing the role of spending in R&D and training of manpower in the Saudi industry, has indicated that an increment of one percent in spending for R&D resulted in a positive and progressive change in the sales volume by about 31 per cent.[49]

Technology and activities intensive industries need to invest in R&D more than manpower intensive ones. The petrochemical industry is a capital and technology intensive activity. It should be emphasized, however, that manufacturing processes of the modern petrochemical industry based on imported technology are susceptible to loss of effectiveness in a competing international market unless these processes are supported by R&D activities. Resolution of this problem cannot be realized without effective interaction with local R&D institutions. However, whilst Research and Development is an important aspect of industrial development in any developing or industrialized country, the Saudi Government's progress in this direction has been minimal. No Saudi Government policy emphasised R&D development until the 7th Plan. Significantly the contributions of SABIC and Saudi Aramco have been the main stay in the field of research and development to date.

3.5.3 The importance of R&D to expand domestic technology

Arab countries rank first in crude oil reserves, with around 65% of world known total reserves and their natural gas reserves are around 22% of the worlds total.[50] In spite of these reserves, petrochemical production in the Arab world does not exceed 5% of the world output.[51] One of the reasons for this weakness is the fact that the Arab countries have not paid attention to R&D. This fact is reflected in the low:

- number of the scientists in the Arab world (equal to 1.5% of the world total number) while Europe enjoys 21% and North America 18%

- total Arab expenditures on R&D (0.7% of the world total compared with that of North America's 43 %).

The need of the Saudi Petrochemical Industry for R&D became obvious after starting production in the early 1980s. In addition to the R&D activities that are conducted at different departments within Saudi universities in the fields of the petrochemical industries, there are three research centres that have separate divisions in their structures for petrochemical research: King Saud University (KSU); King Abdul Aziz City for Science and Technology (KACFST); and, the King Fahad University for Petroleum and Minerals (KFUPM).

In order for the petrochemical industry to break through the dependency on foreign technology and new products/materials, it focused research on chemistry and chemical engineering to create new materials, industrial chemicals, and chemical processes. Advances in this area expanded markets when mature products were unable to meet customer requirements for customization, specialization, and segmentation. It has been reported that new products generated 26 percent of sales revenues or products in growth stage, as compared to 62 percent from products in the mature stage.[52] This suggests that incremental changes in mature products has a positive contribution to sales revenues. As competition between companies became intense, companies began to give more focus to product quality. Market leaders were emphasizing product innovation and responsiveness to customers. Chemical companies have involved their customers in product development by partnering with them to get early feedback and to better understand complex requirements. Major chemical companies were also using Internet technology to link business processes directly with customers in real time to improve services, responsiveness, and delivery. The recent growth of national, regional and international competition has resulted in great pressure on the operating profitability of many companies. Management has challenged the cost effectiveness and ability of R&D to be of value to the corporation. R&D has been mostly driven by technology rather than pure science.

Saudi Arabia has pursued an ambitious programme, which early on called for expenditure of over $235 billion by 1990.[53] These vast sums provided the country with a modern infrastructure, to diversify an economy which essentially rests upon oil, and ultimately to transform the country into a modern society. In this effort technology was explicitly accorded a major role and, since Saudi Arabia possesses little indigenous technological capability, the emphasis is currently upon the transfer of technology from abroad.

3.6 Transfer and adaptation of strategic technology in Saudi Arabia

Adaptation of high technological sectors relating to the oil and petrochemical industries has had a direct impact on Saudi national security as well as the Saudi Economy. Table 3.9 shows the percentages of technology imported to Saudi Arabia by different sectors between the years 1999 and 2001.

Table 3.9 Technology imported to Saudi Arabia by different sectors 1999 to 2001

Sectors	%
Infrastructure	24
Services	15
Transport	6
Defence	6
Tourism	1
Agriculture & fishing	0.3
Industry	48

Sources: MEED Issues 1999-2001

There are also other promising activities such as communication, information and electronics that support future developments in the fields of oil, gas and petrochemicals. Expansion of Saudi gas and petrochemical industries is the most important for the development and future growth of Saudi economy. These two sectors require new science and technology cooperation in the areas listed in Box 3.9

Box 3.9: Science and technology cooperation in the Saudi oil, gas and petrochemical sectors

- research to develop technology that can help increase production capacities and reduce costs of production
- develop research to introduce new practices
- develop projects to reduce the local consumption of petrochemicals and gas, which represents 1% of world consumption, with a population that represents only 0.3% of the world population
- increase capacities of the local refineries in the Kingdom and support their position in the oil market
- add value to the oil and refined products through expansion of vertical and horizontal activities in the Kingdom
- develop more cooperation opportunities between Saudi Aramco and SABIC in the integration of oil industry.

Sources: Ministry of Planning, "7th *National Development Year Plan*", MP, Riyadh, KSA, 2000

Science and technology, considered to be the backbone of the success of Saudi industry, enjoys advantages from oil price increases. Therefore, additional finance has the potential of raising the Kingdom's investments to ensure creative innovations and improvements to the products and process of industry, mainly in technology and operations through joint ventures. Research and development activities in the Kingdom can be developed in Saudi Aramco and SABIC in order to improve their capabilities to own new technologies and minimize raw materials and operational costs. The other areas that can be considered as requiring further improvement are re-design of the existing refineries and petrochemical plants in order to reduce the cost of operation and maximize production. Research and Development activities should be concentrated in the technologies that provide low costs and better quality products, and also give other alternatives in raw materials. One of the successful examples of Research and Development within SABIC is the new technology of acetic acid which was developed through SABIC's own scientists and engineers. This is the first time that such new technology has been developed in the Middle East and SABIC is aiming to build a commercial plant for acetic acid using the new technology.[54] SABIC's Research and Development activities provide another example of successful development of new technology to produce Butane-1 leading to better quality and lower cost production. This has been scientifically undertaken jointly through SABIC and the French Petro Institute collaboration.[55]

3.6.1 Saudi industrial cooperation with the developed countries

Cooperation between Saudi Arabia and developed countries has developed and prospered for many years. In the area of foreign trade, Saudi Arabia has maintained an overall trade surplus with most of the developed nations. For instance and presumably imports of Japanese goods to Saudi Arabia, Saudi exports to Japan exceeded Japanese imports largely due to large exports of Saudi mineral fuels to Japan. However, although Saudi Arabia enjoys an overall trade surplus, it has a substantial trade deficit with Japan in the manufactured product sector, particularly machinery and equipment. The imbalance in trade with Japan relative to mineral fuels and manufactured products is shown in Table 3.10 below. The trade deficit with Japan for manufactured products shows that there is a substantial market for products in this sector and indicates the potential for new joint-venture industrial projects which can benefit Saudi manufacturers and lessen Saudi Arabia's dependence on foreign imports.

Table 3.10 Value of top Saudi imports from Japan in 1992

Industrial sectors	Billion yen
Electrical machinery and equipment	567.5
Automotive vehicles	456.0
Machinery and equipment	362.3
Iron and steel products	47.9
Man-made filaments and fibres	25.4
Textiles and apparel	17.5
Paper and paper products	1.9

Source: Ministry of Finance, "*Import Statistics*" , MF, Saudi Arabia, 1995, p. 123

Besides trade, there are a number of joint venture projects between Saudi Arabia and developed countries. In 1994, there were a total of 31 Saudi joint venture projects, of which 8 are industrial and 20 are non-industrial.[56] The industrial projects are the largest in terms of capital investment and represent 98% of total invested capital.[57] However, nearly all invested capital in these industrial projects is from two SABIC affiliate projects (Eastern Petroleum Corporation and Saudi Methanol Company). The Composition and variety of products, which are produced under Saudi-Japanese industrial joint venture, are petrochemical products; methanol, glycol, and polyethylene comprise most of the value of production from these joint venture projects. As noted earlier, recent structural changes in Saudi industry and expanded product markets have opened up new opportunities in sectors such as, food, wood and paper products, machinery manufacturing, consumer goods, mineral resources, and certain 'high technology' in which Saudi Arabia has encouraged new development. Thus, in order to move positively towards expanded Saudi industrial cooperation, a stronger industrial partnership needs to be considered which takes account of Saudi Arabia's market strengths, its emerging industrial sectors, and new opportunities for innovative, high technology forms of industrial cooperation between Saudi Arabia and other countries. Table 3.11 shows the major country investment in Saudi industrial projects.

Table 3.11 Major top Developed Countries investment in Saudi industry, 1999

Country	Industrial projects	Capital (B.US$)	Foreign share (%)
USA	68	10.0	48.1
Japan	5	2.7	49.9
Italy	9	1.4	30.8
Taiwan	3	0.7	49.9
U.K.	31	0.5	46.9
S. Korea	7	0.5	18.8
Germany	24	0.3	27.0
France	11	0.2	28.8

Source: Ministry of Industry and Electricity, *Internal Report*, KSA, 2000

The Saudi market, in general, has changed considerably over the past years both in terms of its size and composition. Some of the important changes from the standpoint of future Saudi joint ventures are listed in Box 3.10, below

Box 3.10: Key aspects of Saudi joint ventures

- the Kingdom's population growth rate is one of the fastest in the world and a recent population census showed that the population more than doubled during the last 25 years
- household incomes are among the highest in the world and consumer spending as a percent of total income is growing
- recent industrial surveys indicate that Saudi manufacturers are using more products made by other Saudi manufacturers rather than importing these from abroad
- 'state of the art' telecommunications, transportation, and utility systems have reduced the cost of business operations compared to other countries
- advanced technology products and process are being used in Saudi Arabia that were not possible several years ago. This has created a much-improved market for high technology products or for products, which use high technology production processes
- due to its overall investment climate, Saudi Arabia is a logical choice for establishing a regional production base for exports throughout the Gulf and Middle East region.

Sources: Royal Commission for Jubail and Yanbu, "*Annual Reports*", Saudi Arabia, 1988

3.6.2 Saudi Arabia and technology transfer

Today, science and technology has become a prime determinant of a nation's status. Therefore, if a country wants to acquire development, it must build its indigenous technological capability. This capability represents an essential prerequisite for modernization, which can be demonstrated through a consideration of different kinds of technology transfer. Thus, since its establishment in 1976 SABIC has been responsible for the kingdom's petrochemical industry, which has become an internationally competitive, technologically sophisticated company, ranking among the world's top ten petrochemical manufacturers. The most successful of the import-substitution projects promoted by the government since 1977, SABIC has succeeded in reversing the position of Saudi Arabia from that of a nation almost entirely dependent on petrochemical imports to a major exporter of petrochemical products. Saudi Petrochemical products now flow to many advanced countries. Economically speaking, the Saudis have opted for the most rational long-term industries, those of petrochemicals, which are downstream of oil production. The question is can Saudi Arabia exploit its comparative advantage of having an abundance of the necessary raw materials, gas and oil. Petrochemical industries are by definition energy and capital intensive and are thus seemingly tailored for Saudi Arabia, which has an abundance of everything except labour.

SABIC exemplifies the progress that Saudi Arabia has made in reducing technological dependence and foreign control over key industries through a new strategy of national development. Previously, Saudi Arabia allowed national firms to license foreign technology and import capital goods and foreign investment without providing countervailing protection for national technological industries. Since the late 1970s, Saudi Arabia has challenged the traditional modes of direct foreign investment in a determined effort to achieve technological independence. Saudi Arabia's strategy has been to expand national industries through a new pattern of rules governing technology-acquisition agreements. Instead of just licensing technology, Saudi Arabia has sought to acquire it indirectly through joint ventures whose terms have been clearly more favourable to Saudi firms than to foreigners. Moreover, by limiting foreign investment in joint ventures, Saudi Arabia has ensured national control of key industries, particularly those producing petro-related products.

SABIC's particular approach to overcoming technical problems has been to develop a partnership formula, whereby international oil and chemical companies would be invited to take a stake in Saudi heavy industries, and to share in the profits, in return for providing the technology, management, and marketing know-how. Competitions in the construction industry and cheap government financing have been used to keep down production costs.

3.6.3 Saudi joint venture strategy and the criteria for partner selection

Instead of turning to advanced countries to import foreign investment and to license technology, Saudi Arabia offered them joint-venture agreements. Saudi Arabia has chosen outside partners to share the risks and the profits. This approach has benefited the economy of Saudi Arabia so much that today every other newly established company is a joint venture. To seek out foreign firms interested in setting up joint ventures and to better coordinate petrochemical production in Saudi Arabia for both domestic and foreign sales, the Saudi government agreed that joint ventures would allow for expansion of the petrochemical industry, facilitate the transfer of technology to Saudi Arabia, and enhance Saudi Arabia's status in the international market.[58]

Foreign firms were put on notice that they must undertake co-production with a Saudi partner to qualify for bidding on petrochemical industry contracts in Saudi Arabia. The new conditions required that the foreign investor be the minority shareholder in any new joint venture with a Saudi firm, with 40% participation by Government capital, 30% by the foreign firm, and 30% by Saudi private enterprise.[59] SABIC adopted a policy of establishing joint ventures with foreign firms as the principal means of acquiring technology and development support manufacturers for petrochemical industries. American companies realized that joint ventures with the Saudis would be a means to gain better access to the Middle East petrochemical market and reduce production costs by using relatively cheap Saudi petroleum. This association has enabled Saudi Arabia to acquire advanced technology gradually, and in the process to attain increasing self-independence in petrochemical industries.

SABIC is aware that the selection of joint venture partners requires care. Since partnerships are long-term relationships, five criteria are used to judge overseas companies in the course of making joint venture partner selection: proven experience; record of profitable operations; ability to market products from proposed projects; possession of the required technology; and a willingness and ability to train Saudi manpower.[60] SABIC's first important joint venture in the petrochemical field was a 10 year contract signed with Exxon in March 1978. This contract resulted from a joint-venture competition with two Japanese companies to produce and market 'polyethylene' at SABIC plants. Although Japanese petrochemical companies held a high percentage of the Saudi market, Exxon won the contract because it was more willing to accommodate the Saudi's new set of conditions.[61] Other joint ventures in the heavy industry projects were 10-year contracts signed with several companies.

With the signing of the SABIC-Exxon agreements, the Saudi Government proceeded to provide the promised protection for the new cooperative venture. In 1982, it imposed a 30% tax on imported petrochemicals. In 1983, the government closed the door to further imports of petrochemical products and started exporting its production. Therefore, joint-venture agreements illustrate the Saudi way of acquiring foreign technology. The contracts with these MNCs bind them to be responsible for supplying the necessary manufacturing know-how and assisting in such areas as quality control, handling materials, and manufacturing.

The agreements called for the production capabilities of these MNC models to be transferred to SABIC in different stages, including importation of complete equipment, building factories, producing petrochemical products, marketing the products, and training the Saudi firms' workers to replace these MNCs at the end of the contracts. The first fruit of that joint-venture agreement was the establishment of the first Saudi corporation participating in heavy industry projects, which is responsible for planning the development and manufacture of various petrochemicals, metallurgical products and fertilizers.[62] SABIC believes its policy of developing downstream through joint ventures with established producers will ease the entrance of Saudi material into World markets.

In Saudi Arabia, regulation is more evident in the downstream operations such as oil refining and domestic marketing, where there is substantial participation. Saudi Aramco's equity participation in the foreign oil companies has given the corporation a majority at the board level and accordingly can influence investment and production policies. As the host country government's interventionist policies develop, so inevitably do the areas of potential conflict with the transferors of technology. As reported earlier, the interests of the host government and of the joint ventures do not always coincide. A joint venture subsidiary for example may attempt to implement a multinational competitive strategy set by the parent company, while the host government insists that the subsidiary enter into joint venture arrangements with local companies, which the joint ventures may consider less efficiently operated. SABIC's projects at Jubail and Yanbu show that the Saudi joint venture approach adopted by SABIC can speed up technology absorption by Saudi labour. Saudi Arabia's industry in general has made rapid progress in its production of a large variety of advanced materials. From this experience, Saudi Arabian's industrial joint venture model can be summarised in Box 3.11.

Box 3.11 Saudi Arabian's industrial joint venture model

- setting up an independent company to run the joint venture
- production is shared according to a formula
- each partner markets his share as a profit centre
- profits are distributed according to equity shares
- expansion is financed from profits.

Sources: SABIC, *Planning Department*, 1995

Saudi participation in petrochemical projects has, arguably, succeeded in acquiring greater technological capabilities. SABIC has succeeded in transferring technology to Saudi Arabia. Although Saudi Arabia has made rapid progress in reducing its dependence on foreign suppliers of industrial equipment, Saudi industry continues to be dependent on foreign for know-how and imports of key components and other advanced-technology products such as machinery. Saudi industry has yet to achieve the technological capability, skilled manpower, and investment capital needed to complete industry projects of small capacity in which it hopes to develop a competitive advantage and to achieve technological independence in the long run.

3.6.4 Saudi-US Joint Commission for transferring technology

The Saudi–US relationship promotes technology transfer to Saudi Arabia, through US corporations, to a greater extent than for any other country in the Third World. The strength of the linkage between the two countries speeds up the transfer of technology to Saudi Arabia. This condition can be seen through the creation of the U.S.-Saudi Joint Commission, a government-to-government facility for transferring technical expertise to Saudi Arabia. The greater the supplier of technology is involved with the recipient in joint ventures, the greater the likelihood that technology will be transferred to the recipient. The American companies geared to take advantage of the situation in Saudi Arabia include Ralph M. Parsons, which was planning and managing the industrial complex at Yanbu, and Bechtel, which drew up the master plan for Jubail. Other large corporations already involved include Exxon Mobil, Dow Chemical, Texas Eastern Corporation, and Celanese – all with petrochemical plants at Jubail. These corporations have been involved with Saudi firms in joint ventures; however, the Saudi side is generally not looking for capital investment when entering a joint venture, but rather wants technology and management and marketing skills.

3.7 Saudi economic offset programmes

With a view to achieving a qualitative move in the Saudi Arabian Economy, there emerged the concept of Saudi economic offset programmes. Strategically, the most important of these was the Saudi American and Saudi-British economic offset programmes. These two programmes were aimed at transfer of American and British advanced technologies to Saudi Arabia, supporting the Saudi industrial base, qualifying national manpower elements, and providing an opportunity for Saudi investors to participate in national development of highly profitable projects. This Saudi economic move was initiated in early 1980s when the Saudi government obligated foreign companies having contracts within Saudi Arabia to invest a certain percentage of the value of their respective contracts in joint ventures with Saudi firms with a view to enhancing the future development process in the country. The major goals of the economic offset programmes in the Kingdom are listed below:

1. contribution to develop and support the economic infrastructure of the Kingdom of Saudi Arabia, and transfer advanced technologies to Saudi Arabia to support its industrial base

2. contribution in reducing the Kingdom's reliability on imports

3. contribution to provide necessary services to citizens and to increase job opportunities for the Saudi population, encouraging the flow of private investments (national & foreign) in the private sector.

As an extension to its participation in education, health and social affairs, the ministry of defence and aviation introduced a new way of implementing the economic offset programme in the Kingdom of Saudi Arabia. The offset programme covers military as well as some major civilian contracts and encourages firms from the US, Britain and France to set up local high tech plants in joint ventures with Saudi companies. The programmė creates new diversified industries, increases training and productivity, facilitates technology transfers and stimulates economic growth. The offset programmes require an investment of about 35 per cent of contract value giving the foreign company 10-12 years to identify potential investment projects, receive approval, find Saudi partners, and initiate operations. Among the major American companies involved in the programmes are Boeing, General Dynamic, General Electric and United Technologies. Boeing Industrial Technology Group has formed four high technology firms capitalized at over SR 325 million.[63] Lucent Technologies has an offset investment requirement for viable industrial joint ventures and has been an active participant in the Kingdom's ongoing telecommunications expansion programme.

A Ministerial committee, headed by Prince Sultan Bin Abdul Aziz, the Second Deputy Prime Minister of Defence and Aviation and Inspector General, heads the Offset Programme. It falls under the direction of the Ministry of Defence. It directs the Kingdom's economic development policy and prepares and implements the development strategy. The Ministry establishes and adopts policies, strategies and actions necessary for developments. The committee is responsible for arranging the necessary procedures and follow-up for implementing the investment agreements. In addition to the above there is an executive committee. This committee is supported by the secretary of economic offset programme, to follow-up on the performance of day-to-day affairs. Table 3.13 summarises Saudi offset achievements and sets out the projects, capital investments and number of employees.

Table 3.12 Saudi offset agreements and projects

Foreign partner	No. of projects	Capital investment in (million SR)	**No. of employees**
Boeing Group	04	1298	1818
General Electric	02	281	64
British Government	04	665	410
French Government	03	217	94
Hughs Co.	01	219	50
AT & T	01	17	90
Total	15	2699	1516

Sources: Saudi Offset Program Secretariat, Internal Reports, 1997

Saudi Arabia's investment environment reflects the country's traditions of liberal, open market private enterprise policies. Foreign investment in the Kingdom has been rising steadily. Saudi Arabia had 1,753 joint venture projects in operation in the Kingdom.[64] The Saudi Economic Offset Programme has provided opportunities for more than 27 national companies; out of this four of them are partnership companies and about 40 individual investments.[65] The total capital is about 2670 million, distributed in Riyadh, Dammam, Jeddah, Jubail and Al Khobar. This programme has transferred several technologies to the local companies in aviation, space, petrochemicals, electronics, computer systems and medical equipment.

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CHAPTER FOUR

OIL EXTRACTION AND THE DEVELOPMENT OF SAUDI ARAMCO

4.1 Introduction

Saudi Arabia's economic development has been driven for decades by the success of its oil industry. Proven oil reserves amount to 261.8 billion barrels and gas reserves to 224.2 trillion cubic feet.[1] British Petroleum estimates that Saudi Arabia has 213.8 trillion cubic feet ((6.05 trillion cubic meters) of reserves, which is also 4% of the world's total reserves.[2] Both US Department of Energy and unofficial Saudi estimates put the Kingdom's total ultimately recoverable holdings as high as one trillion barrels, and the total could be even higher with more advanced EOR techniques.[3]

After the Second World War, oil quickly became the main source of revenue for the Kingdom. In the 1960s, Saudi Arabia embarked on an ambitious economic plan to use its massive oil resources to create full economic development. In addition to being the world's major oil producer, Saudi Arabia is now also the world's largest exporter, consuming only about 1 million bpd of its 8.8 million bpd of production (see Table 4.1, below).[4] Revenues from oil export sales are an important source of national income and Saudi Aramco is responsible for the Kingdom's proven crude oil reserves.

The oil sector accounted for over 39% of the Saudi GDP in 2000.[5] The Energy Information Agency of the US Department of Energy (DOE) estimates 90-95% of total Saudi export earnings in 2000, 70% of state revenues, and 35-40% of the country's gross domestic product (GDP) come from oil.[6] The EIA estimates that net petroleum exports brought the Kingdom $ 68.7 billion in 2000.[7] It should be noted, that Aramco reports that export earnings do not include total income from the entire petroleum sector including downstream operations, related manufacturing, and domestic earnings which Aramco puts at $70-$80 billion in 2000.[8]

Given that Saudi Aramco is the principal corporate vehicle for oil extraction in the Kingdom, this chapter examines the focused development of this company. It describes the process of oil technology transfer to Saudi Aramco, and analyses how the technology transfer policy was shaped. It shows how Saudi Aramco benefited from oil technology and the knowledge available from international oil companies, examining R&D achievements in the development of technological capabilities at firm level. Finally, it focuses on how technological learning took place in the firm as well as the problems that remained relating to technology transfer in particular.

Table 4.1 World top ten oil producing Countries (million barrels per day)

Country	2000	2001
Saudi Arabia	9.1	8.8
U.S.A.	7.8	7.7
Russia	6.5	7.1
Iran	3.8	3.7
Mexico	3.5	3.6
Venezuela	3.3	3.4
Norway	3.3	3.2
China	3.2	3.2
Canada	2.7	2.7
Iraq	2.6	2.4

Sources: British Petroleum World Report, 2002, p.62

4.2 Industrial antecedents

The history of Saudi Aramco dates back to 1933 when the famous agreement to commence oil exploration was signed between the Saudi Government (Ministry of Finance) and Standard Oil Company of California (SOCAL), the predecessor of today's Chevron. Despite initial optimism, early results were frustrating, with oil only discovered in commercial quantities in 1938 by the Standard Oil of California Arabian American Oil Co. After the commencement of the Second World War, on May 1, 1939, King Abdul Aziz Al Sa'ud, the founder of the Kingdom, inaugurated the first oil shipment, opening the valve which let oil flow into the first tanker at Ras Tanmura. In 1940 it was decided to expand the operation by adding more oil companies (Exxon, Texaco and Mobil) to the operation and establishing the Arabian American Oil Company (Aramco) in preparation for the development of Saudi oil reserves.

This was the start of an era which opened a large part of Saudi Arabia to hydrocarbon exploration. The period from 1933 until 1947 was the period of exploration and consolidation, not just of natural resources, but also of social and educational provision and economic restructuring and development. During those early years, American–Saudi work teams built the first stabilization plant at Dhahran, the first refinery at Ras Tanmura, marine terminals at Ras Tanmura and Al Khobar plus more than 50 miles of pipelines and a score of storage tanks and permanent roads from Dhahran to al Khobar and Ras Tanmura. The teams drilled 19 wells on the Dammam structure, five of them in 1939 alone, and seven more were started in 1940.[9]

In the early 1950s, Aramco expansion projects and manpower recruitment peaked. Crude oil production had reached 830,000 b/d, but when Aramco expanded its operations, drilling and production, its need for manpower, materials, and logistical support became the limiting factor to the expansion programme. Nevertheless, outside the government, Aramco became the main source of direct employment.

Today, Saudi Aramco ranks as the largest oil and gas company in the world and sixth in refining, owning seven operating refineries in the KSA. Five of these refineries are wholly operated by Aramco, and the remaining two are in partnership with major oil companies; specifically, Shell at Jubail and Mobil at Yanbu. Saudi Aramco reports to its owner, the Saudi Government, through the Supreme Council of Petroleum and Minerals Affairs, chaired by the King. The Council is responsible for the general policy of Saudi Aramco, as the national oil company. It approves the company's five-year plan, which provides for crude oil production, exploration programmes for new reserves of hydrocarbon materials, and plans for developing new reserves. The council also approves Saudi Aramco's five-year programme for future capital investments. Saudi Aramco's Board of Directors, chaired by The Minister of Petroleum and Mineral Resources, makes high-level planning, budgeting and project decisions. The company's president is the chief executive officer. To accomplish its missions, Saudi Aramco is organized into key business areas, each headed by a member of corporate management (see Appendix 4).

4.2.1 Development characteristics

Saudi Aramco's activities are focused on oil exploration and development. Saudi Aramco's exploration and producing business line has four general functions:

- find new oil and gas reservoirs
- drill new wells and maintain them
- produce crude oil and gas from wells
- perform primary crude oil and gas processing for delivery to regional export and marketing facilities within Saudi Aramco.

Saudi Aramco is committed to these responsibilities. The depth of this commitment is reflected in its fourfold mission statement:

- safely and efficiently produce oil and gas
- develop employees to their fullest potential
- protect and preserve the environment
- undertake all of the above with the best technology available.[10]

In broadest terms, Saudi Aramco's mission is to find, produce, process and deliver oil and gas, as well as their refined products, for the Kingdom of Saudi Arabia and for world markets. To accomplish this, Saudi Aramco is administratively divided into functional groups called 'business centres', with subgroups called 'business lines'.

Saudi Aramco's relationship with its suppliers is built on trust, cooperation, understanding and respect. In order to achieve mutually positive results, Aramco views its ties with suppliers not simply as a business arrangement, but as a true partnership. That is also the spirit Aramco bring to relationships with joint venture partners as well as customers. From its inception, Saudi Aramco has nurtured long lasting partnerships; a successful strategy that has continued to provide far- ranging benefits. With such an effective business philosophy, Saudi Aramco places a high value on its continuing relationships with suppliers and the business community. This is evidenced by the following comment from a senior company official "...To succeed as a Saudi Aramco business partner in a highly competitive environment, it is important that Saudi Aramco suppliers bring added value through product quality, support, competitive pricing and focused supply-chain models".[11] In addition, Saudi Aramco senior vice president Dhaifallah Al Utaibi told a 2002 supplier conference in the Kingdom "...Suppliers must position themselves to utilize enabling technologies that allow supply-chain participants to effectively realize concrete results and access relevant supply-chain information".[12]

Saudi Aramco, through its policy of promoting the development of the Kingdom's economy, awards 86% of its contracts to own or joint venture companies.[13] Saudi factories have supplied over $330 million worth of goods, and more than 11,000 local contractors were registered with Saudi Aramco as at the end of 2002.[14] The Company has helped in developing private sector contractors, which in turn have helped other developing companies to achieve knowledge, experience and expertise in project operation and management of huge projects in the oil and gas sector.

4.3 Industrial status

4.3.1 Product portfolio

In 2003, Saudi Aramco was responsible for managing 90 oil and gas fields throughout the Kingdom including the Red Sea area. The proven extractable crude oil reserves in the fields managed by Saudi Aramco amounted to 262.8 billion barrels.[15] These reserves constitute about a quarter of world's total reserves making Saudi Arabia the country with the largest oil reserves in the world. That is more than twice the output of the next highest producer and nearly five times greater than the largest US oil company.[16] Saudi Aramco maintains a maximum sustained crude production capacity of 10 million bpd, underscoring its determination to meet customer demand.[17]

The majority of Saudi Aramco's oil production is concentrated in just eight fields out of a total of 90, with estimated remaining reserves of 70 billion barrels, accounting for around half of Saudi Aramco total oil production capacity.[18] The largest offshore field is Safaniya with estimated reserves of 19 billion barrels.[19] These two fields, together with Abqaiq and Berri, account for around 45 percent of the Kingdom's oil reserves and 85 per cent of production capacity.[20] Saudi Aramco's efforts to develop new fields and improve processing facilities and transmission networks is expected to boost production capacity by 2.5 million barrels per day of oil by 2005.[21] Table 4.2 shows the crude oil production and reserves of the fields managed by Saudi Aramco for the 10-year period, 1990 to 2002. It shows that in 2002 Saudi Aramco produced 2.5 billion barrels of crude oil or an average of 6.8 million barrels per day (bpd).

Table 4.2 Saudi Aramco crude oil production and reserves

Years	Production billion barrels	Reserves billion barrels /day
2002	2479.2	259,500
2001	2763.3	259,300
2000	2847.0	259,300
1999	2655.0	259,200
1998	2922.2	259,200
1997	2829.4	259,100
1996	2878.5	261,444
1995	2928.5	261,450
1994	2937.9	261,374
1993	2937.4	261,203
1992	3049.4	261,203
1991	2962.8	260,936
1990	2340.1	260,300

Sources: Ministry of Planning, *Achievements of the Development Plans* 2002, 20th issue p. 318 and Saudi Aramco, *Annual Review*, 1995-2002

Saudi Aramco production reacts to political and military events, and OPEC energy strategy, as well as market conditions. But the fact that production capacity is normally larger than actual Saudi production gives added importance to Saudi oil, because Saudi Arabia is one of the few countries that can make sudden major increases in oil production to provide additional supplies in an emergency.[22] Saudi Aramco also has the advantage that oil can be produced cheaply in the Kingdom. It has been estimated the cost of production at under US$1.5 per barrel, compared with a global average of US$ 5 per barrel.[23] Exploration costs are also low, less than 10 cents per barrel, making difficult fields such as the remote Shaybah field in the empty quarter economically viable. This field has reserves of up to 7 billion barrels and production capacity of 500,000 barrels per day and, despite needing a 385 kilometre road and a 635 kilometer pipeline, the field was brought on stream for a total of just US$ 2.5 billion.[24]

Saudi Aramco is also an important producer of gas. In 1970, only 11 percent of 2.3 billion cubic metres of produced natural gas was effectively utilized, the rest was either re-injected or flared.[25] By 1984, nearly all natural gas produced was utilized.

Saudi Aramco is engaged in the provision and development of natural gas supplies produced mostly in association with crude oil in the Eastern Province, for water desalination, electric power generation and to provide energy for oil production. Fuel gas and NGL, produced from natural gas, support industrialization and petrochemical production in the industrial cities in Jubail and Yanbu, yielding LPG for export. The Saudi Aramco gas development programme has successfully utilized gas in downstream activities, mainly petrochemicals, as shown in Table. 4.3. The table shows that the quantity of the flared gas has been reduced, thereby utilizing most of the gas gathered through the Aramco Master Gas System (MGS) to enhance related gas products. This reflects the change in Saudi industrial policy towards downstream industry to diversify the Saudi economy.

Table 4.3 Production and utilization of natural gas

		Million Cubic Metre			
Year	Gas utilized as % of gas produced	Flared	Utilized	Re-njected	Produced
1999	94.9	310	46,200	2,180	48,690
1998	97.1	430	46,720	990	48,140
1997	96.4	990	45,840	720	47,550
1996	96.2	930	44,510	820	46,260
1995	97.6	240	42,930	830	44,000
1994	69.4	10,200	37,700	6,400	54,300
1993	69.6	9,900	35,900	5,800	51,600
1992	67.1	11,520	34,000	5,180	50,700
1991	64.6	13,100	32,000	4,400	49,500
1990	73.7	7,550	30,500	3,350	41,400

Sources: Saudi Aramco, Annual Reviews,19991- 1999

In processing natural gas, toxic hydrogen sulfide is removed and converted to yield sulfur for export. Greater quantities of propane, butane and gasoline – the main components of NGL- are directed towards Kingdom-based petrochemical industries to add value to feedstock through exports as petrochemicals. All excess NGL continues to be exported. Table 4.4 indicates the extent of Saudi Aramco production of Natural Gas Liquids NGL (barrels per day) 1993 – 2001.

Table 4.4 Saudi Aramco NGL productions 1993-2001

Year	NGL (barrels per day)
2001	801,054
2000	780,843
1999	731,354
1998	764,830
1997	767,450
1996	758,218
1995	731,846
1994	687,925
1993	639,759

Sources: Saudi Aramco, "Facts and Figure", Public Relations, Dhahran, 2002

Saudi Aramco ranks among the top 10 companies in gas production worldwide.[26] The company is also a leader in both the production and export of Natural Gas Liquids (NGL) and a major producer of refined products. The company produces natural gas in association with crude oil and non-associated gas from deep, independent gas fields. This gas is used as fuel and feedstock for the Kingdom's backbone industries and utilities, and for export and domestic consumption as NGL. Gas production has done much to meet domestic energy needs and to reduce the domestic demand for oil, which is easier and more economical to export. Saudi Aramco gas production now accounts for roughly 2% of all world production. Virtually all this gas production is consumed in Saudi Arabia, and domestic demand for gas is expected to increase at an average rate of 7% a year for at least the next decade.[27]

Saudi Arabia's natural-gas reserves of 224 trillion cubic feet are the world's fourth largest, after Russia, Qatar and Iran. The Kingdom's gas-production rate of 6.7 billion cubic feet per day is in the top five worldwide and represents the Middle East's highest.[28] Saudi Aramco's exploration programme has added significantly to the Kingdom's gas reserves. In the five years to 2001, those reserves increased by nearly 30 trillion standard cubic feet.[29] Gas production has increased by more than 2 billion cubic feet a day - a growth rate of more than 10 percent a year. In the 10 years to 2009,[30] Saudi Arabia has become the world's largest exporter of natural gas liquids as well as gas-based methanol, octane enhancers and ammonia fertilizers.[31]

A further field of activities for Saudi Aramco is its operation of five domestic refineries at Jeddah, Rabigh, Yanbu, Riyadh and Ras Tanmura, with a combined capacity of more than 1 MBPD. Table 4.5 indicates domestic refineries partly or fully owned by Saudi Aramco and their production and ownership percentages.

Table 4.5 Aramco's domestic refineries, production and ownership percentages

Refinery	Operator	Saudi Aramco ownership	'000 b/d
Ras Tanmura	Saudi Aramco	100%	325
Jeddah	Saudi Aramco	75%	60
Riyadh	Saudi Aramco	100%	150
Yanbu (Domestic)	Saudi Aramco	1005	225
Yanbu (Export)	Saudi Aramco/ Exxon Mobil	50%	378
Jubail	Saudi Aramco/Shell	50%	310
Rabigh	Saudi Aramco	100%	400

Sources: Saudi Review- Economic & Political Analysis Issue 12 Nov. 2001, p.56

Saudi Aramco plans to increase the operating performance of its five refineries by the use of modern technologies to enhance proficiency and return on capital. The Company has set an overall refining strategy to make each of the wholly owned refineries 'pacesetter refineries' by the year 2006.[32] To implement this strategy the company has developed action plans to move the downstream refining business towards a more profitable operation. Table 4.6, below, shows the principal products manufactured in the domestic refineries wholly owned by Saudi Aramco.

Table 4.6 Production of Saudi Aramco local refineries, 2000

Products	Ras Tanura	Yanbu	Riyadh	Jeddah	Rabigh	Total
LPG	6,178,473	2,321,973	1,467,201	1,064,131	-	11,031,778
Naptha	(2,382,760)	464,362	-	3,107,095	26,279,391	27,468,088
Gasoline	20,538,925	13,464,817	10,990,311	4,582,752	-	49,576,805
Jet Fuel/ Kerosene	2,320,702	1,688,570	5,352,702	(606,172)	12,175,955	20,931,757
Diesel	44,794,104	27,077,402	12,072,880	6,527,523	43,903,769	134,375,808
Fuel Oil	40,603,381	26,189,542	21,737	4,626,299	46,125,138	117,566,397
Asphalt & Misc	1,712,202	-	3,786,341	1,127,429	-	6,625,972
Total	113,765,327	71,206,666	33,691,172	20,429,187	128,484,253	367,576,605

Sources: Saudi Aramco Annual Review, 2001

Saudi Aramco joint ventures located at Yanbu on the Red Sea and at Jubail on the Gulf are 50/50 joint ventures and commenced operations in 1984 and 1985. Table 4.7 sets out the principal products manufactured in the joint venture refineries owned by Saudi Aramco.

Table 4.7 Saudi Aramco joint venture refineries' production (2000)

Products	SAMREF	SASREF	Total JV**
LPG	(178000)*	1,341,500	1,163,500
Naptha	-	12,202,500	12,202,500
Gasoline	23,263,000	2,174,000	24,659,000
Jet Fuel/Kerosene	11,652,000	10,956,500	22,608,500
Diesel	18,018,500	12,529,000	30547,500
Fuel Oil	11,586,000	12,975,000	24,561,000
Asphalt & Misc	-	-	-
Total	62,235,000	52,222,500	115,657,500

Sources: Saudi Aramco, Annual Review, 2000
*** Negative figures primarily indicate products that were reprocessed into other refined products.**
**** Saudi Aramco 50 percent share of production.**

The refined products of Saudi Aramco's refineries meet the needs of domestic markets, including the needs of the industrial sector, with the excess exported to other countries. Diesel oil production grew at an average annual rate of 7.7%, increasing from 21.5 million barrels in 1970 to 198.2 million barrels in 2000.[33] Production of kerosene and jet fuel increased at an average annual rate of 4%, rising from 20.6 million barrels to 66.9 mb during the same period.[34]

4.3.2 Diversification policy

Saudi Aramco's gas infrastructure and processing plants are being expanded to meet downstream domestic demand. Saudi Aramco has identified three specific targets with regards to its gas reserves, to:

- optimise ethane and natural gas liquids (NGL) utilization up to 2025 and beyond
- identify the ultimate economically-recoverable gas reserves of the country
- identify the appropriate near-term actions which allow ongoing development of the gas sector.

Since the 1970s, the MGS has offered substantial economic benefits by gathering and utilizing the associated gas to diversify the country's sources of income, stimulating industries such as petrochemicals and providing more affordable utilities.[35] The vision is to create a prosperous Saudi Arabia, that is less dependent on crude oil exports. The Saudi Government believes that a well-planned programme would not only achieve this goal but also accomplish several other objectives:

- petroleum based industries would produce fuels, petrochemicals and other feed stocks, thus adding value to crude oil and expanding Saudi Arabian manufacturing and export opportunities

- non-petroleum industries – including steel, cement and agriculture would reduce the Kingdom's dependence on imports

- development of industries in different parts of the country would contribute to regional and national prosperity, distributing wealth across the country

- operation of these industries would entail the training of large numbers of Saudis, thus raising the nation's manpower skills and providing new job opportunities.[36]

4.3.3 Saudi Aramco exports

Saudi Aramco exports 78.6% of its oil production and 48% of its refined products.[37] Countries in East Asia are by far the most significant customers for oil exports. Building on its reputation as a reliable supplier of crude oil, Saudi Aramco has established a strong position downstream in the international oil industry. The company has a global marketing organization with subsidiary offices in New York, London, Tokyo and Singapore, and sells crude oil, refined products, NGL and sulfur to customers worldwide. Indeed, Saudi Aramco has become the world's largest crude oil marketer and owns the world's newest crude oil tanker fleet.[38] Accordingly, Table 4.8, below, sets out the exports of Saudi Aramco's crude oil, refined products, and NGL (in barrels) for the 5 years from 1996 to 2002.

Table 4.9 shows the world market percentages of Saudi crude oil exports by Saudi Aramco according to different regions of the world. It shows that Saudi Aramco is a key oil supplier for USA, Europe and Asia. However, the importance of the market has varied according to market conditions.[39] While Saudi Aramco production levels have altered sharply over time, it has been a critical exporter for at least three decades. Saudi Aramco sells oil as a global commodity at market prices on a relatively free world market, and the destination of its oil is determined largely by current transportation costs and other marginal price differences affecting a given consuming region. The only major exception has been the oil that Saudi Arabia supplies to the United Kingdom under a defense procurement agreement by which it obtains advanced aircraft and infrastructure development for the Saudi air force. This oil reached a peak of 600,000 b/d but declined to about half that amount in the late 1990s. Saudi Aramco sells it at market prices.[40]

Table 4.8 Saudi Aramco exports (barrels)

Year	Crude oil	Refined products	NGL
2002	1,897,875,597	145,084,881	239.265,378
2001	2,178,400,024	169,281,494	230,072.047
2000	2,263,876,508	175,609,350	237,803,981
1999	2,085,712,815	176,445,226	235,032,625
1998	2,349,177,143	191,780,263	240,536,573
1997	2,284,246,362	187,304,346	244,015,639
1996	2,283,963,361	211,589,896	252,277,979

Sources: Saudi Aramco, Annual Reviews, 1996-2002 and Saudi Review- Economic & Political Analysis Issue 12 Nov. 2001,p.78

Table 4.9 Percentages of Saudi crude oil exports – World market 1996-2001

Region	1996	1997	1998	1999	2000	2001	2002
Europe	11.0	13.2	12.5	10.1	10.7	8.6	7.9
Far East	39.1	38.0	37.2	38.8	40.7	42.8	43.7
Mediterranean area	14.2	13.8	14.6	11.3	10.3	9.5	10.1
USA	20.2	20.0	21.5	23.4	23.3	24.2	23.7
Other	15.0	14.0	14.2	16.4	15.0	14.9	14.6

Sources: Saudi Aramco, Aramco Reviews, 1996-2002

World market percentages of Saudi Aramco's refined product exports for the 5 years from 1996 to 2001 are set out in Table 4.10 below. The company expands its exports by creating massive downstream refining capabilities through seven refineries with capacity more than 2.8 million b/d.

Table 4.10 Percentages of Saudi refined exports- World market

Region	1996	1997	1998	1999	2000	2001
Europe	1.3	0.4	3.2	2.87	3.1	6.7
Far East	57.7	51.3	57.2	68.4	61.0	61.1
Mediterranean Area	7.4	5.2	5.9	4.5	5.8	6.4
USA	11.0	11.0	6.1	1.8	1.5	1.6
Other	32.6	32.1	27.6	22.5	28.6	24.2

Sources: Saudi Review- Economic & Political Analysis Issue 12 Nov. 2001,p.80

Table 4.11 shows the world market percentages of Saudi Aramco NGL exports during 1996 to 2000. However, Saudi Aramco use most of its gas production to meet domestic demands and it is focusing on the gas development to provide energy as well as feedstock for local petrochemical plants. As a result, it is focusing on the development of gas to provide a nation-wide source of energy as well as feedstock for product and petrochemicals. The EIA reports that Saudi Arabia has not expressed great interest in liquefied natural gas because it is more cost-effective to use it as feedstock or fuel.[41]

Table 4.11 Percentages of Saudi Aramco NGL export - World market

Region	1996	1997	1998	1999	2000	2001
Europe	0.2	0.5	0.6	0	0	0
Far East	68.5	68.1	65.8	73.2	49.6	62.6
Mediterranean Area	7.9	8.6	7.6	4.5	2.6	4.7
USA	1.8	0	0.5	0.4	0.9	0.4
Other	23.6	22.8	25.5	21.9	46.9	32.3

Source: Saudi Aramco, "Facts and Figures", public Relation, 2001

Saudi Aramco has two main oil pipelines, the East-West Crude Oil Pipeline (Petroline) that carries up to 4.8 million barrels per day of crude to refineries in the western province and to Red Sea terminals for export, and the, Abqaiq, Yanbu natural gas liquid pipeline which carries up to 270,000 barrels per day to the Yanbu petrochemicals plant.[42]

4.4 Technology development levers

At Saudi Aramco, there is the realization that technology contributes significantly to growth and development. All divisions of the company therefore encourage the acquisition of technological know-how. As noted earlier in Chapter three, Saudi Arabia relies on joint ventures for the importation of technology with a view to diffusing it through the economic structure, encouraging development of indigenous technological capability. Unfortunately, though, for many joint ventures, imported technology has seldom resulted in the development of indigenous 'know how'. The direction and formulation of policies require knowledge and awareness of the technology transfer process. Many of the companies often have to adjust their policies with changing realities. Such policies have often been in response to the effects of the past working of the transfer process, and have neither the scope nor the depth required to meet present and future needs.

4.4.1 Technology strategy and policy objectives

In recent times, Saudi Aramco's oil policy has focused on the following factors:

- necessity of maximizing returns from oil
- need to ensure internal self-sufficiency in the supply of products
- continuing efforts to increase petroleum reserves
- diversification of the energy and financial base of the economy
- international framework of Saudi's oil policy.[43]

The Minister of Petroleum and Minerals Mr. Al Naimi amplified on these points in 2001 at Conference on Energy Policy in Norway. He noted that oil was seen as "an extension of our governing system, as a tool to help achieve our economic and social prosperity, and to make meaningful contributions toward peace and economic development at the regional and global levels – especially to less fortunate societies. " He describes Saudi oil strategy as follows:

"...Oil policy is (determined by) our position on the world's oil map. We have about 25% of all proven conventional reserves, currently more than 260 billion barrels. If you add the reserves of our neighbors in the Gulf, the total comes to around 500 billion barrels. It is natural, therefore, that we work to expand the use of, but prolong the life of, oil, far into the future. I feel we are succeeding; yet we face problems from within the oil business and from outsiders. Within our business, there are those who have doubts about the future of our commodity. Others may look only at short-term interests, where in the end they might not see the long-term issues".

"And from the outsiders, there are those whom we might call the anti-oil groups, who are using every tactic to discredit oil. Sometimes, they talk about the insecurity of supply or independence from foreign sources. Other times they are disguised under the guise of environmental protection or restriction of globalization which they fear multinational enterprises.

"The debate can often rise to highly emotional levels. We in Saudi Arabia and, I believe, the majority of all of producers feel it is unwise to be guided by emotions. Rather, we consider it a duty to protect our long-term interests from any influence that might impair our ability to function as major oil suppliers to the world. Only by remaining focused on such a mission will stability prevail".

"The Saudi government is working diligently to reduce the level of dependency on oil. The Kingdom is currently undertaking major steps toward economic and financial reforms, which will eventually facilitate diversification of the economy and lessen our dependence on a single depleting natural resource".

"To summarize, Saudi Arabia's oil policies are grounded in the prudent management of an abundant and valuable natural resource. We share with our GCC neighbors the desire to conduct business world wide in a very competitive market economy. And we have been working hard to create a stable environment for much needed commodity oil while promoting a better understanding of the challenges and risks that its delivery entails. Our goal is a stable market, a reasonable price for our commodity and the realization of prosperity for ourselves and those we serve". [44]

Up to now, Saudi Aramco has been successful in developing its existing fields in the most economically efficient manner, bringing new ones on line when needed, creating efficient refineries and creating a large petrochemical industry. Unlike many other oil and gas exporting states, Saudi Arabia also has invested in the kind of production capacity, refining output, and downstream operations which are suited to a strategy of maintaining moderate prices and high long-term demand. Saudi Arabia has demonstrated its commitment to securing its markets indefinitely into the future by keeping production high and prices at levels that ensure that it can steadily expand its exports.[45]

All these criteria emphasize the financial proceeds from oil resources. Although the third point highlights Saudi Aramco's effort in oil exploration, no mention is made of production. Presumably this is expected to be carried out by the foreign oil companies for an indefinite period. The policies in the past highlighted Saudi Arabia's quest for oil technology. This was first manifested prominently, and clearly distinguished between oil exploration licenses which entitle the holder to 'explore' for petroleum and oil prospecting licenses which entitle the holder to 'prospect' for petroleum .The prospecting policy attracted a number of foreign oil companies. Even though oil prospecting licenses imposed certain obligations on the government. Retained in earlier legislation, the oil prospecting licenses agreement made it mandatory for oil-prospecting concessions to develop indigenous manpower and to provide certain infrastructure and utilities in the areas of operation.

In 1970 the Saudi Council decreed that a petroleum technology institute should be created, but it was not until 1971 that the Petroleum Institute was established through a joint technological collaboration agreement with King Fahd University for Petroleum. As part of a separate decree, which established the Oil Company (Saudi Aramco), training responsibilities were emphasized. And since its inception, Saudi Aramco has conducted manpower recruitment for its exploration and production departments, with heavy concentration on geologists, geo-physicists, petroleum engineers and production engineers. A petroleum technology development fund was also established and is currently administered by a division of the company. The fund provides scholarships, especially on postgraduate courses, in petroleum technology and related fields. The strategies or policy actions enumerated above are oriented towards transferring technology from upstream operations. From the work of past researches into the oil industry, Saudi Aramco and governmental approaches to the acquisition of 'know-how' for downstream activities has increased markedly. It reflects Saudi Aramco's strategy for the development of local entrepreneurial capability especially in international marketing operations, which is based on envisaged cooperation between foreign companies and the national corporation. The construction of refineries subsequently was based on turnkey contracts.

In the oil sector, policy has not been clearly spelt out. However, general statements have been made in national development plans emphasizing the need for indigenous participation in the oil service sector. Saudi Aramco as part of its policy for the development of indigenous technology capability has given priority to research and development locally. At the same time, the Research and Development department was formed to provide services to almost all departments. Turnkey projects involve the construction and initial operation of the project by specialist contractors who demonstrate the running of the project with a view of eventually transferring control to nationals by conducting basic and applied research. In addition, laboratory services, both routine and non-routine, are transferred to support operational needs of the corporation.

4.4.2 Research and Development: expenditure and trends

Saudi Aramco has strong experience in technology development. Research prepared by Dr. Fuad Al-Adil has thrown light on Saudi Aramco's strategic decision directing its engineers, researchers, scientists and technicians to search for technologies to increase profits and productivity. It also seeks those technologies which help to maintain the environment and to increase safety levels of operations. The creation of technical programmes can be traced back to the early nineties and the main objective behind them was to effectively participate in increasing Saudi Aramco income through development of technologies that enables the company to occupy a leading position in its field. The means and methods used for transference and development of technology can be summarized according to four major milestones:

First: undergoing pure and applied researches by the company to find suitable technologies

Second: Saudi Aramco welcomes cooperation with national universities and is aware of the practical importance and strategic dimension of such cooperation. This is evidenced by the company's agreement between King Fahd University of Petroleum and Minerals and collaboration with King Abdul Aziz City for Science and Technology, King Saud University and all Kingdom Universities

Third: transference of development and introduction of modern technologies into company operations. This can be summarized as a continuous search for technologies pertinent to petroleum and gas production activities

Fourth: participation in the company's international programmes for technology development. The company is keen to cooperate with advanced international universities and specialized research centres. It already participates in joint industry projects, enabling funding of specific technologies for specific areas, and also allows division of expenditure between all companies. It is estimated that the average research revenue resulting from these projects is US$ 25 for each dollar paid by the company.[46]

Table 4.12 shows that Saudi Aramco spends little money on R&D compared to the size and magnitude of its activities as one of the leading oil companies in the world. The table also suggests that Saudi Aramco is heavily dependent on technologies imported from foreign countries rather than the development of local technologies to meet requirements.

Table 4.12 Saudi Aramco expenditure on R&D, 1997- 2001 (In SR. Million)

1997	1998	1999	2000	2001
50	40	30	60	70

Source: Figures are estimates based on data from different reports and information from Saudi Aramco, 2002

However, Saudi Aramco has made strenuous efforts to introduce advanced technology into its disparate activities. For instance, the company has locally developed technologies in prospecting for the accurate specification of oil fields, especially large fields such as the Al-Ghawar field, (the largest petroleum field in the world).[47] Also, the local development of three-dimensional seismographic search (3D-Seismic) technologies contributes to the acquisition of precise information about fields. Computer experts of the petroleum engineering centre at Aramco use locally developed sophisticated computer software to help increase productivity of petroleum and gas wells.[48] Such technology enables experts to follow precisely changes that take place in 'lurking' situations. And gives opportunity to accurately locate petroleum sites which are not developed. The research and development laboratories centre in Dahran was also able to obtain an invention patent from the US for developing a heat-breaking technology that helped in assessment of petroleum reserves of the Al-Sheeba field in the Al-Rab Al-Khali region.[49] Appendix 5 shows that Saudi Aramco is successful in locally developing its own technology, as well as making improvements to imported technologies. The list contains 91 patents granted to Saudi Aramco and registered in the United States between 1976 and 2002.

Saudi Aramco has also added new technologies through the establishment of an automatic experimental laboratory that deals with hydrogen breakage.[50] Moreover, researchers at the Company's research and development laboratory have designed a mobile laboratory equipped with the most modern analytical devices used at refineries during the catalyst generation process.[51] The company is using the latest technologies in control of different manufacturing stages in petrol refineries, including those types of technologies that rely on infrared radiation. This allows precise spontaneous measurement of manufactured compound properties. The company has also adopted modern techniques to simulate process conditions at refineries, developing recommendations to take appropriate practical decisions.

4.4.3 Research and Development Centres

Saudi Aramco has long been considered a pioneer in the development of petroleum technology. The first phase of a new Research & Development Centre was inaugurated in Dhahran in 2002 and is expected to boost R&D in Saudi industries in general, and the petroleum industry in particular. The centre will eventually employ 350 engineering scientists during the first two phases of development.[52] The facility will expand and upgrade research equipment to support exploration, production and refining operations. Saudi Aramco reports that its scientists and researchers often develop additional value through patentable discoveries as they work to meet the challenges associated with the company's complex operations.[53] To support such endeavours, the company has an Intellectual Assets Management (IAM) team to manage and protect company-developed assets and commercially exploit those developed by company technology and research. This initiative which started in 2000 centralises the processing of patents and copyrights so that intellectual properties can be licensed and developed for marketing. This in turn has great potential to increase future revenues and generate significant cost savings, according to the company.

A major upgrade programme at Ras Tanura refinery spurred the construction of the new Ras Tanura Laboratory (RTL). The 4,500 sq m facility is connected to an advanced computer system - the Laboratory Information Management System - linking it to all refinery plants and related administrative divisions. Among the most important pieces of RTL equipment are octane engines, which measure gasoline-combustion efficiency; gas chromatographs, used to determine the components of samples; and inductively coupled plasma-mass analyzers, which determine the percentage of metals in various types of water used in refining operations and for drinking.[54] RTL also operates a miniature fractionation tower. It is used to study crude oil distillation and help determine product quantity and quality - which benefits marketing and planning.

Effective corrosion control can save Saudi Arabia in general, and Saudi Aramco, in particular, huge amounts of money in potentially lost natural resources. In its ongoing battle against corrosion in the harsh environmental conditions prevalent in the Kingdom, Saudi Aramco has turned away from metals, which have been the staple material for oil and gas industry, to hi-tech non-metallic materials. In particular, the company is installing phenolic gratings on offshore structures because of their superior corrosion resistance, strength-to-weight ratio and fire resistance.[55] Officials have stated that the company should further promote the use of non-metallic material. Accordingly, Saudi Aramco has been testing two types of non-metallic piping for oil industry application.[56]

Saudi Aramco has improved engineering capabilities in risk-based assessment and fitness-for-service determinations, and uses new technologies, which allows it to reduce the probability and consequences of certain equipment failure. To demonstrate further the company's commitment to fight against corrosion, Saudi Aramco will complete 21,000 sq m of additional laboratory and administrative facilities in 2005 at its Dhahran Research & Development Centre to house state-of-the-art corrosion testing facilities, including high pressure circulating loops to simulate field conditions.[57] The first phase of the R&D was completed in 2002. Another significant development within Saudi Aramco is the reservoir simulation Supercomputer Platform that is now used mainly to run the Company's parallel simulator called POWERS. This system was developed in-house, comprising over 180 processors that process data simultaneously.

4.4.4 Overseas joint ventures

As early as the mid 1980s the Kingdom decided that it must build strategic petroleum relations with oil consumers. These relations included entering into joint petroleum ventures with advanced countries to refine Saudi oil and distribute petroleum products. This achieved a dedicated market for Saudi oil, irrespective of the price fluctuations that occurred. It also achieved additional income for Saudi Aramco as a result of refining and distribution operations. The first project was signed with the US company, Texaco, in 1988. It was followed by similar projects in South Korea, Philippines and Greece. Saudi Aramco is currently seeking to enter into similar projects especially with countries increasing oil demand growth, such as China and India.

Several of Saudi Aramco's downstream projects have involved investments in joint venture partnerships in the US. The earlier mentioned partnership formed by Saudi Aramco and Texaco meant that Saudi Aramco acquired 50 percent of Texaco's refineries and distribution network in the US East and Gulf Coast regions. Known as the Star Enterprise project, it had a combined capacity of 615,000 bpd, and a distribution network covering 26 states in the eastern and southern US, including the District of Columbia.[58] This venture opened a downstream outlet that provided quality crude in a lucrative area over a long period. In mid-1997, agreement was reached by Saudi Aramco, Texaco, and Shell Oil to dissolve the Star Enterprise and merge the refining and marketing activities in the Eastern and Gulf Coast regions of the United States into one company, Motiva Enterprises. The merger of Star and Shell makes it one of the largest refining and marketing companies in the US.

Saudi Aramco has diversified and integrated its operations through strategic joint venture alliances with leading refining and marketing companies in the Company's principal crude oil markets. Through such alliances, Saudi Aramco benefits from the management expertise, market strength and experiences of its joint venture partners. For example, in 1991, Saudi Aramco acquired a 35 percent interest in Ssang Yong Oil Refining Company. This is South Korea's third largest refiner and leading lubricant manufacturer, having also a strong marketing presence in the Pacific Rim region. To such alliances, Saudi Aramco brings its strengths as the world's largest crude oil producer and a major international refiner.

In 1994, Saudi Aramco entered into a further joint venture. This time it was with the Philippine National Oil Company (PNOC). It purchased 40 per cent of the outstanding shares of PNOC's refining and marketing partner. Consequently Saudi Aramco committed itself to supplying at least 90 per cent of its crude requirement of 155,000 BPD.[59] Petron has more than 1,000 retail outlets and owns a 155,000 bpd refinery.[60] In March 1996, Saudi Aramco acquired a 50 percent interest in Motor Oil Hellas and Avin Oil, the refining and distribution affiliates of Greece's Vardinoyannis Group. Additionally, as at the time of writing, Saudi Aramco is engaged in negotiations with Exxon Mobil and China-Sinopec, a Chinese government-owned enterprise, for 220,000 barrels per day (bpd) joint venture oil refinery project in China. Discussions are also reported to include petrochemical plant expansion and repair of an existing refinery in China.

Saudi Aramco has already established a strong foothold in the Chinese domestic market, having renewed a crude supply agreement with the Chinese International Petroleum and Chemicals Company in Saudi Aramco's Sinopec subsidiary company. Fujian Refining and Chemicals in a joint venture with Exxon Mobil will build an integrated plant in Fujian province. It will include an eight million ton per year refinery, 600,000 tons per year ethylene facility, 300,000 tons per year polypropylene facility and 450,000 tons per year polyethylene plant.[61]

Saudi Aramco will own a 25 per cent share of these projects.[62] Saudi Aramco is committed to the long-term success of its international joint ventures as evidenced by its support for economically justifiable major improvement projects in each joint venture. The Company currently has equity participation in thirteen refineries worldwide, with total crude oil distillation capacity of 150 million tons per year or 3 million barrels per day.[63]

The details of the joint venture Refineries of the Saudi Aramco are set out in table 4.13 below with the names of the joint venture partners, the country, the products as well as the Saudi Aramco ownership percentages.

Table 4.13 : Saudi Aramco's joint venture refineries (Thousands of barrels per day)

International	Countries	Products	Saudi Aramco Ownership
Motive Enterprises	USA	840	50%
S.Oil, S.Korea	South Korea	575	35%
Petron	Philippines	180	40%
Motor oil (Hella)	Greece	100	41.9%
Domestics			
SASREF	Jubail	305	50%
SAMREF	Yanbu	365	5%

Source: Saudi Aramco, Annual Review, 2002, p. 28

The Kingdom views joint ventures with foreign partners as the most practical and efficient form of business organization to transfer technology to partners in developing countries. There are numerous benefits which partners from developed countries can reap from establishing joint ventures overseas. The most important benefits include:

- Free access to competitively priced feedstock and raw materials, thus decreasing dependence on foreign suppliers and attendant exposure to the vagaries of fluctuating market demand and the prices of raw materials

- Entry into the markets of partners that might otherwise be entirely closed, and geographical proximity to other markets, which can help to save transportation costs. The strategic geographic location of the Kingdom of Saudi Arabia for exporting products to Europe, Asia-Pacific, Africa and the Middle East is of critical importance in this regard.

- The benefits which Saudi Aramco can gain, include state-of-the-art technology; production of high quality product and systematic staff training and development in production operations, marketing and management. Joint Ventures are playing an important role in bringing change in the economic structure of Saudi Arabia, and the production of petrochemicals and other energy related manufactured products in which Saudi Arabia has a comparative advantage. JVs bring about an increased volume of national output for local consumption and export trade. Other beneficial effects on international trade include increasing the volume of trade among countries, changing their pattern and direction of trade through globalization and liberalization.

4.4.5 Diversification

Saudi Aramco plays a pivotal role in the future development of the Kingdom's gas resources, working with the international oil companies as part of a long term strategy to provide expertise and knowledge in the unique working environment of the gas industry. Central to the development of the gas sector is the establishment of an integrated industry, from exploration and production to supply lines and pipelines for primary industries, desalination units, power plants and exports. On June 3, 2001, BP Conoco, Exxon Mobil, Marathon Oil, Occidental, Phillips, Royal Dutch/Shell and Total FinaElf signed three agreements – called 'Core Ventures' – to spend at least $ 25 billion on gas exploration, production, transportation and processing, in addition to petrochemical projects, power stations and desalination plants.[64] Some $ 50 billion has been spent on joint venture refineries and petrochemical plants in the country.[65] These core projects are expected to stimulate the private sector into providing further downstream services, increasing localization, providing new jobs, transferring technology and facilitating the training of Saudi nationals.

At the upstream level, which is mainly exploration and production, involvement of international companies is not needed. The Kingdom has at its disposal, through Saudi Aramco, the expertise to develop natural gas reserves. More than sixty years of experience, backed by state-of-the-art technology, gives Saudi Aramco an edge. Since 2001, the focus of upstream Saudi Aramco investment has been the three 'Core Ventures' (CVs). These include: the South Ghawar project led by Exxon Mobil, with Shell, BP and Phillips, the Red Sea project also led by ExxonMobil but this time with an Enron/Occidental partnership; and the Shaybah venture, led by Shell with Total Fina Elf and Conoco.[66] Core Venture One is the largest of the three projects and covers exploration in the empty quarter, which has estimated gas reserves of at least 30 trillion cubic feet, plus gas processing plants and ethane crackers in both Jubail and Yanbu. The venture will also include a 2,000 MW power plant and two 150 million gallon per day desalination plants.[67] Core Venture Two includes exploration in the northern Red Sea area and the development of the Midyan and Bargan gas fields, plus power, desalination and petrochemical plants. Core Venture Three, meanwhile, includes gas exploration in the Southern part of the Empty Quarter, the development of the Kidan gas field and power, water and petrochemical plants in Jubail. Service sector companies are hoping to participate in technology transfer and many different facets of the Gas Initiative through contracts in the upstream, midstream and downstream elements of the projects, including gas processing, petrochemical, electricity and desalination plants. For the construction sector it will be very important in terms of investment in new petrochemical, desalination and industrial plants, which in turn will mean additional investment in pipelines and related services.

Mr .Al-Naimi made his view clear in a speech at the Houston Forum on October 20, 1999:

> "I am happy to tell you today that many of the proposals which we have received do fit within our needs and within the criteria we have just mentioned. We are looking into these proposals carefully, with each receiving close consideration. Equally important, we are considering other new ideas and possible projects. We expect soon, therefore, to see the commencement of negotiations with companies to formalize the needed projects. In this regard, I would like this opportunity to make it clear that the concerned companies will have an equal and fair chance. Moreover, the proposals and information supplied by each will be kept completely confidential".[68]

The Ministerial Committee for the Saudi Gas Initiative provided the following clarifications regarding Saudi Arabia's policy on foreign investment in gas:

- The Kingdom is fully committed to offering International Oil Companies (IOC) world-class rewards for their investments in world-class projects. Furthermore, we will make sure that the fiscal term to be applied to the CVs is appropriate to produce acceptable returns from exploration and production activities, as well as the midstream and downstream segments of integrated core ventures
- IOCs will be free to produce and market all gas liquids associated with natural gas discoveries – but not crude oil
- Long-term supplies of feedstock gas for the straddle plant project in CV 1 are guaranteed
- Long-term supplies of feedstock (gas and liquids) for downstream projects are guaranteed until IOCs discover their own gas resources
- Saudi Aramco will be a participant in IOC projects, not a competitor
- Some of the power, desalination, and petrochemical projects that were previously described as satellite projects, have been included in the CVs
- Additional data on CV 1 will be made available to IOCs
- Details of regulatory system, to in place by end-2001, will be officially published after approval by the Supreme Petroleum Council.[69]

This activity demonstrated Saudi Arabia's interest in foreign investment and played a key role in the creation of gas expansion (see Appendix 6 for list of Aramco's subsidary companies).

4.4.6 Human resources management and employment/ growth

Saudi Aramco management's commitment to the development of human resources is a driver in all Saudi Aramco policies for future development, particularly in the transfer, adaptation and localization of technology. The employment, training and professional development of Saudi nationals had been a guiding principle since the earliest days of the venture, and Saudi executives, professionals, and operations personnel are to be found throughout the company. Saudi Aramco also believes that human resource development is a company responsibility. In this regard, Saudi

Aramco in its efforts to employ the best available Saudi manpower, places emphasis on trainees to take over the future responsibilities of the company. Almost all the trainees come from the best universities and educational institutions in the Kingdom and the Middle East region and a healthy percentage possess US and UK qualifications.

Saudi Aramco plays a major role in creating a healthy environment to attract foreign investment in the Kingdom by working closely with foreign international companies as part of a long-term strategy to provide assistance, expertise and knowledge in the working environment. As a result of Saudi Aramco training programmes aimed at Saudisation, progress has been made from 1993 to 1999 towards increasing Saudi manpower, gradually decreasing the expatriate work force. A comparison of Saudi Aramco manpower levels after initiating the above programmes from 1993 to 2001 is set out in Table 4.14.

Table 4.14 Manpower category 1993–2001

Year	Category		Total
	Saudi	Expatriates	
2001	45,650	8,455	54,116
2000	45,620	8,445	54.076
1999	45,586	8,490	54,076
1998	46,172	9,360	55,532
1997	46,429	9,916	56,345
1996	46,133	10,347	56,480
1995	46,180	11,596	57,776
1994	44,938	12,548	57,486
1993	37,233	12,435	49,668

Sources: Saudi Aramco, Human Resources Department, 2001

The Saudi Aramco's work force by the end of 2001 totaled more than 54 thousand employees, representing more than 50 nationalities, 80 per cent of whom are Saudis.[70] Table 4.15 breaks down the employment structure still further, with a focus on total employees, Saudi nationals, supervisory and professional job percentages held by Saudis in Saudi Aramco from 1991 to 2000. The data reflect the success of human resource development and Aramco's Saudisation programmes. About 10 million hours were invested in the company's development of human resources during 2002 alone.[71]

Table 4.15 Saudi Aramco human resources development 1991-2000

Year	Total employees	Saudi nationals	% Saudis in supervisory posts	% Saudis in professional jobs
2000	54,501	46,315	85	100
1998	55,532	46,172	80	100
1997	56,345	46,629	79	-
1996	56,480	46,133	-	-
1995	57,776	46,180	-	-
1993	47,500	34,500	76	60
1992	46,023	33,847	66	42
1991	45,036	32,900	76	56

Sources: Saudi Aramco "The Arabian Sun- Special Edition Vol. LV1, No.3 November 7, 2oo1

Saudi Aramco's human resources development policy has recognised that having highly qualified people using the most appropriate technologies and business practices is the key to success. Table 4.14 clearly indicates that the company focused on developing the skills and the capabilities of its 54,501 employees. As part of these efforts, in 2002, Saudi Aramco employees submitted nearly 3,500 innovative ideas via the company's web-based Idea Management System.[72] These idea and suggestions ranged from improving the most basic work process or piece of equipment to patentable ideas. Many of these ideas will have a profound impact on Saudi Aramco's future.

4.4.7 Saudisation - roles played by Saudi Aramco

In 1949, when Harry Snyder was hired to head up the training of Saudis for Aramco, James Terry Duce, a company executive in New York, told him what was expected:

"Your task at Aramco is to train Saudis as quickly and as soundly as possible to operate the Saudi oil industry. Inevitably, the Saudi Arab Government will eventually nationalize the industry. When that occurs, we want the young Saudis to have attained the proficiency that will enable them to operate the oil industry efficiently and with goodwill toward Aramco. Thus they will be serving their country's best interests and will be protecting the interests of our parent companies".[73]

From that time, Saudisation and the development of a highly specialized and competent national workforce has been a top priority at Saudi Aramco. It has achieved an 86% Saudi workforce through a concerted process of "Saudisation". The company is implementing eight mutually supportive strategies to achieve "Saudisation" of jobs, technology transfer and productivity improvement:

1. the company provides resources, education, training and development opportunities to national employees at all levels. More than 86 percent of nearly 54,500 employees, for example, are Saudi nationals

2. Saudi nationals hold all jobs at the highest levels of management

3. state-of-the-art technologies are employed in all operations. Cutting-edge applications of the industry's latest processes flow easily across Saudi Aramco's operations

4. linking, for example, national employees with specialists at all work levels

5. employee development programmes focus on building job performance competencies and leadership skills

6. special emphasis is given to projects that provide high-level employment opportunities

7. professional training and exposure to new technology

8. Saudi Aramco is committed to improving the lives of its Saudi employees, their communities and institutions.[74]

Saudi Aramco provides its employees with a broad range of training and career development activities. Job training and educational programme participants include individuals enrolled in the apprenticeship programme. For example, in 2002 job training and educational programme Saudi participants included 1,973 individuals enrolled in the apprenticeship programme.[75] Also Saudi Aramco sponsors students, both employees and non-employees, seeking university degrees, including bachelors, masters, doctoral and advanced degrees, inside and outside the Kingdom, every year. (See section 4.4.8) Lack of Saudi educational planning in the past had led to expatriate domination of the industrial sector. And studies by the World Bank indicate that the Saudi education system is failing to educate Saudi students for future jobs adequately.[76] But the situation in Saudi Aramco has been corrected by changing the emphasis in education and training programmes. This experience confirms that the important factor for "Saudisation" in Saudi Aramco is to have in place an educational system tailored to the needs of its industry.

4.4.8 Training, education and career development

Saudi Aramco's work force by the end of 2002 totaled 54,501 employees.[77] These employees represented more than 50 nationalities, though by far the largest number, 85 per cent, are Saudis.78 Saudis hold 100 percent of the company's senior management positions and 80 percent of the company's 2,500 supervisory positions. Saudi Aramco's training and career development programme is one of the largest of its kind in the world, and is staffed by more than 2,000 full-time researchers, trainers and support personnel.[79] Its aim is to transfer technology to Saudis for the purpose of building a Saudi national work force.[80]

Saudi Aramco's T&CD has established 10 multimedia learning resource centres throughout Saudi Arabia, serving the growing needs within Saudi Aramco for professional training. The Corporate Learning Centres were originally established to meet the demand for training thousands of employees to handle basic computer functions. Today, they offer an efficient training option because the same number of employees can study the same basic courses, which are taught in the classroom at less cost and in less time, thereby providing more value. T&CD reports directly to the General Manager. This Division performs two major functions, curriculum development and testing and evaluation. An international system for planning and developing instructional programmes, Instructional Systems Development, has been adopted to ensure that instructions address the knowledge, skills and attitudes essential for successful job performance.

At Saudi Aramco, all employees, no matter how skilled, periodically upgrade their skills in specialized training courses, either in-Kingdom or overseas. Saudi Aramco has had a training programme in place since the earliest days when the Kingdom signed its first oil concession agreement in the 1930s. In the beginning, training was conducted at the worksite to accomplish a particular task, but, following the discovery of oil in 1938, a previously inexperienced workforce ballooned to meet the needs of the company. Saudi Aramco opened its first schools in 1940 and 1941 to teach English, arithmetic and the rules of industrial safety. Although primitive, these schools marked the start of a training programme, which has expanded into the world's largest.[81] The Aramco Production Training Programme, started in 1949, was the first to qualify large numbers of Saudis for jobs held by expatriates, marking the beginning of the Saudisation process. In the 1950s, Saudi Aramco built Industrial Training Centres in Abqaiq, Dhahran and Ras Tanura. In the first five years, the programme raised 12,000 Saudi employees from unskilled to skilled and semi-skilled job levels.[82] Table 4.16 lists the throughput of training programmes initiated by Saudi Aramco from 1993 to 1999, showing the steady yearly increase in participants.

Table 4.16 Training participants 1993–1999

Year	Category			Total
	Prof. development	College degree	Ind./admin. (trainee/RDP)	
1999	1,055	1,019	4,586	6,660
1998	1,104	1,035	4,931	7,070
1997	1,034	985	5,362	7,381
1996	846	857	5,540	7,243
1995	782	760	6,091	7,633
1994	811	719	6,483	8,013
1993	780	578	5,346	6,704

Sources: Saudi Aramco, internal reports, Human Resource Department, 2000

During the year 2000, there were about 3,800 participants in job-related academic courses and almost 4,800 enrolled in Job Skills and on-the-job training programme, as a part of their Saudisation drive. Maintenance new hires join Saudi Aramco as apprentices. These new hires progress from intensive classroom/shop training in industrial skills training school to eventual on-the-job qualification. Job qualification and certification are conducted in operating plants and shops as a part of routine daily work. The Company adopted a four stage maintenance training programme, consisting of one year of basic ITC/ITS core courses at the AMTC followed by 1 ½ to two years of job targeted training.[83]

Finally the trainees return to the AMTC for another 1 ½ to two years for advanced craft training classes. The duration of the training programme varies according to job target, it averaged about five years from starting out at the AMTC to qualification for an entry-level maintenance job. Several more years of work experience and specialized training classes were required to make an employee a fully qualified critical-skills craftsman. Structural development has created digital instrumentation technicians, machinists, welders, air conditioning technicians, electricians and associated support personnel. All operations candidates are hired into a two-year apprentice-training programme. After a year of basic training at the company training school, candidates are moved to special on-the-job training programmes. The Producing Training Division at operating plant sites conducts these programmes and in remote area training to systematically progress their skills and knowledge from the basic duties of the outside plant operator up through the advanced duties of the computer control system operator

Table 4.17 Saudi Aramco training expenditure - 1997 to 2001 (SR Millions)

1997	1998	1999	2000	2001
350	315	360	345	320

Source: Estimates based on different reports from Saudi Aramco, 2002

Saudi Aramco has spent a lot of money in training and human resource development as shown in Table 4.17. Saudi Aramco is seeking experienced staff to develop and manage its hydrocarbon reserves, both oil and gas. It offers a unique opportunity to work with cutting edge technology in the world's most important petroleum environment. Saudi Aramco encourages teamwork whilst promoting individual initiative and a proactive approach to the job at hand. With a quarter of the world's oil reserves and a growing role in the gas market, Saudi Aramco offers a wide spectrum of challenges to its employees of all disciplines. The sheer size of the operation demands dynamic, proactive engineers who are not afraid to back their judgment and proven experience with tough decisions. Candidates must hold a relevant academic qualification. He must have extensive skills and expertise.

We learnt from this chapter about, Saudi Aramco's experience in technology transfer. How this Company has achieved great success in the transfer of technology using different methods from Joint Venture projects to Turn Key Contracts. This success can be measured in the transfer of latest technology the knowledge, know-how and experience in the different areas of oil exploration and refining, thereby harnessing, developing, adapting and localizing the latest technologies to develop and maximize the production capacity of Saudi Aramco. The development of Saudi Aramco demonstrates the significant role it has played in the transfer, adaptation and localisation of the latest and most modern technology from the developed world to the Kingdom for the improvement of the oil industry.

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CHAPTER FIVE

DOWNSTREAM PETRO-CHEMICAL INDUSTRIALISATION AND THE ROLE OF SABIC

5.1 Introduction

Saudi Basic Industries Corporation (SABIC – see Appendix 7 for Organisational Chart) provides a good example of Saudi industrialization achievements. SABIC has made a significant impact on the Saudi industries and Saudi economy. It contributes to domestic capital formation and value added, has lent substantial support to the Kingdom's balance of payments and sold millions of tons of goods to agriculture, industry and the construction sectors. SABIC is seeking technology, management and marketing skills not available in the Kingdom. Therefore technology and technology transfer are essential elements of SABIC's strategy to help to produce top quality products to customers worldwide.

This chapter will examine the success of technology transfer as a key element for SABIC petrochemical industrial development. It focuses on the process of acquiring advanced foreign technology in the establishment of petrochemical joint venture projects. The chapter explores how technology transfer is initiated, highlighting the role of SABIC's policies for technology transfer and technology development in Saudi Arabia. It describes the scope of Saudi petrochemical technology transfer. Specifically, it explains the development of SABIC's petrochemical industry and the conditions facing this industry. It also provides a background for understanding the case study evaluation, raising issues for further analysis that will be presented in chapter 6 of this thesis.

5.2 Industrial antecedents: SABIC - the cornerstone of Saudi industry

Saudi Basic Industries Corporation was established in 1976 to expand and diversify the economic base of the Kingdom of Saudi Arabia. The Kingdom's commitment was to develop a sound economic base through industrialization to create non-oil exports, other than just relying on exporting crude oil. Emphasis on the petrochemical industry found full expression in the First Five-Year Plan (1970-1975), which called for the production of a high volume and variety of petrochemicals as well as fertilizers. However, it was only effective during the Fourth Five Year Plan when these projects came to full production. One of the more important of these projects was Al Jubail.

In the early 1970s the Saudi government saw Al Jubail as a growth pole for petrochemical and other industries because of the proximity of the Berri crude oil and gas field and the deep-water channel that makes the site suitable for international shipping. In 1973 the Bechtel Corporation was commissioned to draw up a master plan for Al Jubail that defined infrastructure requirements, located industries within the site, and set forth land use and community plans, conceptual designs of components, and environment al-control measures. When the master plan was presented to the Saudi government in 1975, it was decided to establish a Royal Commission for Jubail and Yanbu.[1]

These two centres, however, provided SABIC's industries with the necessary inputs, such as feedstock, fuel, water, electricity, manpower. There were numerous opportunities available for this modern industry including:

- development of large-scale hydrocarbon processing industries, generally in partnership with leading multinational organizations

- establishment of down-stream manufacturing enterprises using feedstock produced by larger industries

- setting-up of manufacturing concerns to create other products for export and/or local distribution

- establishment of support operations designed to offer essential goods and services to other industries and the community at large.[2]

Shortly after SABIC was established in 1976, The Minister of Industry, Dr Algosaibi, approached the leading oil and chemical corporations to interest them in establishing petrochemical joint-ventures.

These corporations had great misgivings, however. Doubts existed concerning the adequacy of the rate of return, and whether satisfactory markets could be found for petrochemical products. After negotiations in Riyadh, Houston, and other world centres, five major US corporations showed serious interest: Exxon, Mobil, Shell, Dow Chemicals, and Celanese-Texas Eastern. It was nevertheless tentatively agreed with the five US corporations to produce the petrochemicals noted in Table 5.1.

SABIC continues to work in partnership with leading international companies, utilizing the most advanced technologies and employing a highly trained workforce. SABIC's list of foreign partners includes leading international petrochemical producers from the USA, Europe, Japan, and Asia such as Shell, ExxonMobil, Celanese, Mitsubishi, Fortem Oil &Gas, Ecofuel (ENI), and Taiwan Fertilizer. People in SABIC have not found these joint ventures easy and a great deal of negotiation has had to take place. The petrochemical products and the volume of output had to be decided upon; the various processes to make these products reviewed and selected; contractors to design and construct the complexes have had to be screened and chosen; bidding documents have had to be issued and bids received; the bids have had to be reviewed with the bidders' justifying the process; and finally, the contracts have had to be drawn up, including financial arrangements.

Table 5.1 Early planning of SABIC joint-venture production, 1980 (in metric tons per year)

Product	SABIC-Mobil	SABIC-Shell	SABIC-Exxon	SABIC-DOW	SABIC-Celanese	SABIC-Japanese	SABIC PDC
Ethylene	450,000	656,000	500,000	500,000	-	-	-
Low Density Polyethylene	200,000	-	681,0000	-	-	-	130,000
High Density Polyethylene	91,000	-	-	180,000	-	-	-
Ethylene Glycol	220,000	-	-	-	-	-	300,000
Ethylene Dichloride	-	454,000	-	-	-	-	-
Caustic Soda	-	377,000	-	-	-	-	-
Styrene	-	295,000	-	-	-	-	-
Ethanol	-	281,000	-	-	-	-	-
Chlorine	-	330,000	-	-	-	-	-
Ethyl Benzene	-	327,000	-	-	-	-	-
Methanol	-	-	-	730,000	650,000	600,000	
Total	961000	2690000	1181000	1410000	650000	600000	430000

Sources: SABIC- Planning Department, Internal Reports, 1980-1985

Since the early 1980s, a succession of 18 world-scale complexes have come on stream with facilities expanded to meet domestic, regional and global demand.[3] At the start of the 21st century SABIC has become a catalyst for Saudi economic growth and development, encouraging further diversification of the Kingdom's industrial base by capitalizing on its natural, human and physical resources to promote economic progress. SABIC's manufacturing and support industries produce and market worldwide a diverse range of quality petrochemicals, plastic resins, fertilizers, metals and industrial gases. SABIC is expanding production capacity, enhancing its global marketing presence, increasing efficiency and capability as a major player in the petrochemicals industry through research and development, and investing its financial strength to improve profitability and shareholder value. Several key factors have contributed to SABIC's success. These include political stability, a strong economy, and commitment to free enterprise, open markets and the encouragement of industrial growth by the government.[4]

5.2.1 Development characteristics

SABIC's strategic goals stemmed from and have been parallel to the strategic targets of the Saudi National Development Plans. From the very beginning, SABIC has identified its goals, as follows:

- transfer modern international technologies into the Kingdom to build up an industrially oriented Saudi workforce capable of shouldering responsibility for and developing such technologies

- utlilization of the country's hydrocarbon and mineral resources, making use of the 'competitive advantage' provided by their utilization rather than exporting them as new materials

- adding value to such resources by managing the fluctuations in world market prices for primary materials; avoiding the negative impact of such fluctuations on the performance and stability of national economy

- creation of a solid base of basic products on which generations of downstream and supportive industries can be based; realizing industrial integration in the country, gradually reducing imports and motivating the national private sector to invest in industrial fields

- catching up with the industrialised world by opening new marketing outlets and channels for Saudi products; to diversify sources of national income so that dependence should not remain on oil alone.[5]

The main thrust of SABIC has been to minimize the country's dependence on a single resource for economic development, reducing dependence on the import sector, and adding value to the country's resources. Taking into consideration the advantage of abundant and cheap natural resources, as well as the firm capital base for technology transfers, emphasis has been placed upon the use of research channels to develop existing products and to create new products and new usage. SABIC has achieved growth through a well-conceived and efficiently implemented strategy of partnership, joint ventures, and technology transfer. The four most important criteria applied in the selection of partners are:

- international reputation as an industry leader

- technological expertise and willingness to share and transfer know-how

- a proven share of the global market to assist SABIC to introduce its own products

- readiness to help SABIC develop Saudi human resources by providing training and hands-on experience for Saudi citizens to shoulder operational, technological and administrative responsibilities.[6]

SABIC's joint venture partners feature prominent names from the US, Europe and Asia. Through joint ventures and a strict focus on human resource development, SABIC has managed to groom a generation of technocrats and managers to operate and manage its world scale industries. Cost reduction has traditionally been sought to survive periodic downturns in the business cycle. However, it has become harder for SABIC to squeeze costs through the supply chain. Instead, SABIC has adopted new growth strategies, technological improvements, and organizational restructuring. In the long term, the cyclical nature of the petrochemical industry will continue to be felt. Companies will increasingly adopt globalization as a strategy to achieve growth. This makes it even more important to tap into regional and global markets. SABIC needs to maintain its market share in the face of intense market competition and achieve consistent growth and stable profits despite the swings of the trade and petrochemical cycles.

SABIC's impact on major production sectors of the economy has also been very important. The most significant contribution has been in the plastic manufacturing sector where the number of plants has grown from less than ten in 1985 to over 450 plants in 2000.[7] Demand for plastic resins has grown from a few hundred tons to over 600 thousand tons, worth SR 1.6 billion during the same period.[8] SABIC has also made substantial contributions toward the Saudi economy to achieve self-sufficiency in agricultural fertilizers and various types of construction steel. For the last 25 years, SABIC has been a leading force in the development of the Kingdom's plastic industries. A recent study by SABIC and Tecnon Orbich has confirmed the objectives for the Saudi polymer industry as follows:

- increased contribution to the Seventh Development Plan – principally Saudisation
- rationalisation of the weaker industrial elements and a strengthening of technological clusters over the medium term
- improved export by encouraging such clusters to move down the 'value chain'
- improved efficiencies and profitability of clients.

5.3 Industrial status

5.3.1 Product portfolio

SABIC's comparative advantage as a petrochemical and chemical producer is founded on its abundant reserves of hydrocarbon feed stocks, multiple production sources for petrochemicals, and proximity to markets. The raw materials for most of SABIC's industries are ethane and methane. These are obtained mainly from the associated natural gas that is recovered as part of crude oil production. Natural gas and natural gas liquids are the key natural resources for the Kingdom's industrial development today. Figure 5.2 illustrates the structure of SABIC production.

Table 5.2 SABIC production, sales and domestic consumption

	1985	1990	1995	2000	2001	2002
Production (kmt)	6459	12870	21951	28080	35442	40540
Total Sales (kmt)	5155	10536	16921	21320	27371	29589
Export Sales (kmt)	3522	6845	11403	14189	18065	19946
Domestic Sales (kmt)	1633	3691	5518	7131	9306	9643
Profits (MSR) Excluding Foreign Partners	148	3030	6281	3630	1780	2849

Sources: SABIC, Operational Planning Department, Internal Reports, 1985,1990,1995, 2000-2002

Table 5.2 shows that total SABIC production has increased from 6.5 million tons in 1985 to over 40.5 million tons in the year 2002; i.e., an average growth rate of 10.3% annually.[9] Total sales grew by 10% on average annually from 5.1 million tons in 1985 to 29.5 million tons in 2002.[10] Export sales increased on average by 9.8% per annum, and SABIC domestic sales to the local market including captive use have shown the highest growth rate during the period, reaching 11%.[11] These achievements would not have been possible without transfer of technology and know-how development.

The production and capacities of SABIC core industry groups for 2002 are given in Table 5.3 below.

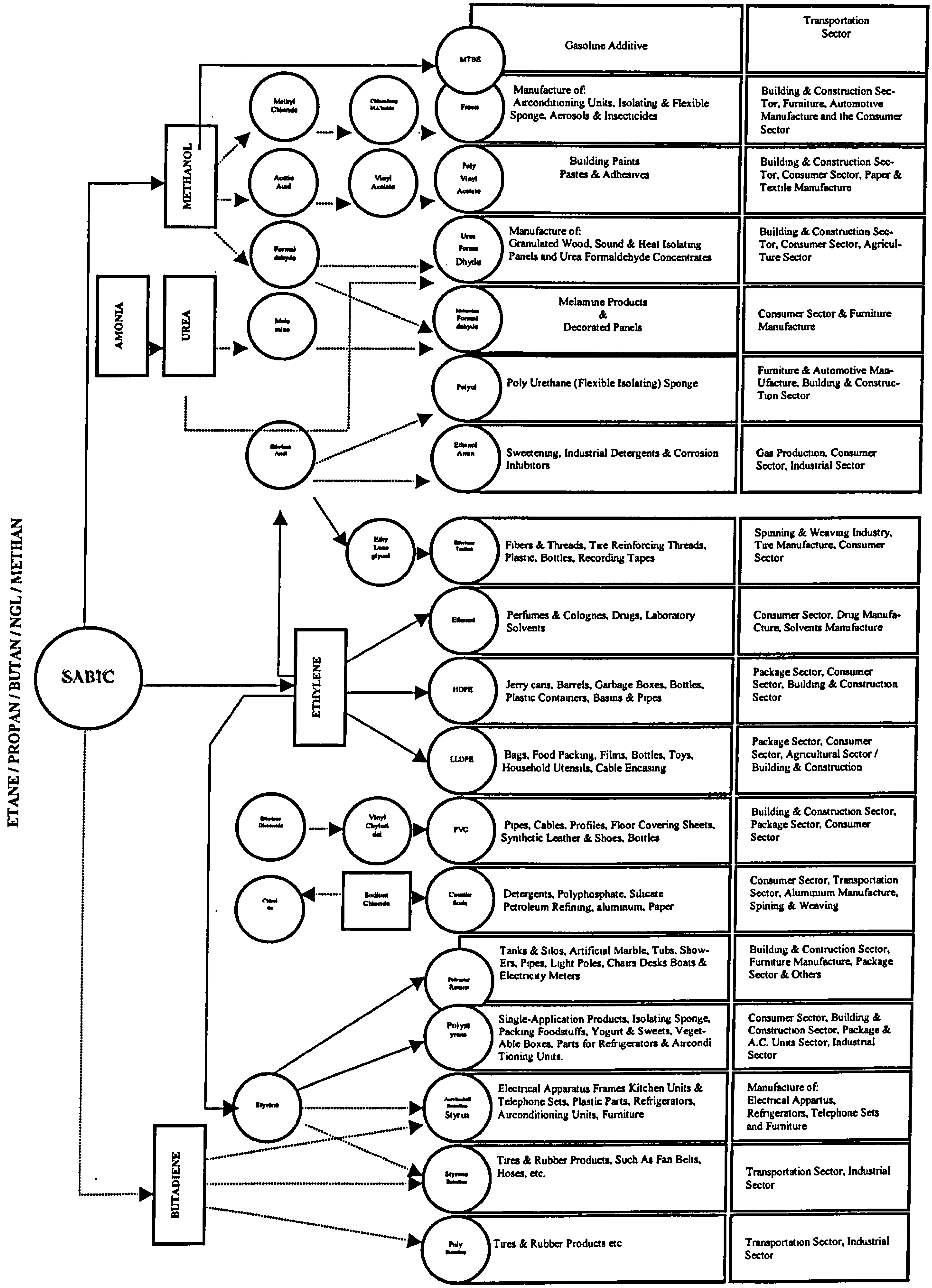
Table 5.3 SABIC's five core industrial groups, 2002

Basic Chemicals	000mt	Intermediates	000mt	Polymers	000mt	Fertilizer	000mt	Metals	**000mt**
Ethylene	5700	Ind. gas	3485	PE	2434	Ammonia	2030	Steel	**3409**
Methanol	3750	EG	1855	PP	900	Urea	2612	-	-
MTBE	2700	EDC	840	PVC	324	Phospha	810	-	-
Propylene	1105	NACH	670	Polyesters	154	Sulfuric Acid	100	-	-
Styrene	1040	VCM	990	Polyesters	135	-	-	-	-
Benzene	515	PTA	350	Melamine	20	'-	-	-	-
Xylems	375	2-E H	150	-	-	-	-	-	
CIE	300		-	-	-	-	-	-	-
Butadiene	130		-	-	-		-	-	-
Butene-1	100	-	-	-	-		-	-	-
Total Capacity	15,860	-	7460	-	6717	-	5259	-	**3409**

Sources: SABIC Annual Reports, 2002

SABIC's manufacturing base includes 18 industrial complexes operated by 17 affiliates and interests in another three industrial ventures in the Arabian Gulf.[12] SABIC through its subsidiary companies, provides the private sector with raw materials and technical expertise for producing a wide range of consumer products. Broad categories of the various products produced through five core industry groups are – Basic Chemicals, Intermediates, Polymers, Fertilizers and Metals (see Figure 5.1 overleaf).

Figure 5.1 SABIC Structures of Production and Operation



5.3.2 SABIC's growth

SABIC's current product range is heavily weighted towards basic chemicals and intermediates, and SABIC has been planning to diversify its product range and expand the volume of its existing production. SABIC production as well as sales of basic chemicals and intermediates account for around 60 per cent and 37 per cent of the total production and total sales respectively.[13] Table 5.4 gives the details of production and sales during the four years ending 2001.

Table 5.4 SABIC production and sales, 1998-2001

	Production (mmt)				Sales (SRm)			
Product groups	**1998**	**1999**	**2000**	**2001**	**1998**	**1999**	**2000**	**2001**
Basic chemicals	10954	11030	12520	14571	7142	7530	8300	9897
Intermediates	4828	4560	4880	7182	4348	4150	'4180	6532
Fertilizers	4399	4360	5120	5357	2910	2980	3460	3600
Polymers	2663	2580	2660	4202	2657	2560	2580	2575
Metals	2499	2610	2900	3110	2317	2850	2800	3385
Total	25343	27139	28080	34422	19374	20070	21320	27371

Sources: SABIC, Annual Reports, 1998,1999,2000, and 2001

Differences in production and sales are due to in-house usage for producing valued added products. Rapid growth has been a strong feature of SABIC over the past 27 years and it looks likely to remain so, as the industry aims to match its historical average of installing 1.5 million t/y of new production capacity up to 2010.[14] However, growth will not just be generated at home. In a major departure from the past, SABIC has its sights firmly set on acquisition and joint ventures overseas. Mergers and acquisitions have become a commonplace activity to enable companies to become more competitive. A number of large-scale mergers have taken place. The Chevron-Philips alliance gave birth to a world-class player, creating the largest polyethylene (HDPE) producer in North America. Dow's acquisition of Union Carbide has created the world's second largest chemical manufacturer, accounting for more than half of US polyethylene production.[15] Mitsui Chemical and Sumitomo Chemical, with combined sales of over $1.5 billion accounts for more than 30 percent of the domestic polyolefin market.[16] Consolidation has thus enabled the largest producers to dominate the market. SABIC's vision for growth is to be among these few companies and become a global leader in petrochemicals.[17]

In this direction, SABIC finalised its purchase of the Dutch DSM petrochemicals business in 2002. The move is strategically significant as it positions SABIC to become the 11th biggest player in the global field, from its previous place on the 22nd rung.[18] In 2001, DSM Petrochemicals generated sales of Euro 2.4 billion.[19] It annually sells about 2.6 million tonnes of polymers, mainly in Europe.[20] This move established SABIC as the third and fourth global player in the polyethylene and polypropylene businesses respectively. Following the acquisition of DSM Petrochemicals, the latter was renamed SABIC Euro Petrochemicals. The transaction involved the transfer of all shares of the companies that together formed DSM Petrochemicals (DPC); the associated DPC participations and sales activities, and the related technology positions, patents and trade names. The total consideration of the transaction was EUR 2.250 billion as of the effective selling date 1 January 2002.[21] Through this acquisition, SABIC took a major step forward in the implementation of its strategy, aimed at becoming a leading global player in petrochemicals. In total about 2,300 DSM employees transferred to SABIC. DPC employs 2,060 people, of whom about 1,530 are based in Geleen (Netherlands) and 530 in Gelsenkirchen (Germany).[22] DPC activities of other DSM units involve a total of about 220 people.[23] The transaction will not lead to any changes in the employer-employee relationship or the terms of employment in force. This deal will lead to a strong partnership between DSM and SABIC. At the Geleen (Netherlands) site specifically the partners will have mutual supply of feedstock and products and the provision of services and utilities. As such, this strategy represents an acceleration of SABIC's ongoing transformation and concentration on global leadership positions in high added-value activities characterized by high growth and more stable profit levels.

New products were introduced within the existing industry framework and additional manufacturing units successfully brought on stream. As a result, SABIC remains one of the most profitable chemical companies and one of the biggest and lowest cost producers in the world.[24] Its success is substantially dependent on access to cheap raw materials from Saudi Aramco. 'Most of our achievements can be attributed to our commitment to goals that were part of a national vision,' says, Mr Mohamed Al Mady, SABIC's Vice Chairman and Chief Executive Officer.

> ...'The corporation controls 5-10 percent of the global petrochemicals market and as much as 20 percent of the markets for some individual products. My aim is to see SABIC among the world's top five petrochemicals companies. It is part of SABIC strategic vision to be a global leader'.[25]

5.3.3 Expansion / diversification policy

In Saudi Arabia, SABIC has become a symbol of national industrial development. As most of its products represent raw materials for downstream industries, SABIC's growth contributed to the expansion of the Saudi industrial sector. One particular example is the plastic products industry in the Kingdom, which consumed 15,000 metric tons per year of plastic resins in the early 1980s.[26] In recent years, SABIC has been supplying more than 600,000 metric tons of resins per year to domestic industry.[27] SABIC's role as a raw material supplier is complemented by its commitment to providing technical support services and help to the domestic industry to find the right technology. It also conducts periodic project feasibility studies to help private sector industries identify new business opportunities for using its products as raw material. Financial participation in industrial ventures has been another SABIC vehicle for promoting national development. SABIC have already set a production target of 50 million tons per year to be achieved by 2010.[28] Such growth in manufacturing capacity is necessary as SABIC pushes itself to maintain and earn its position among global petrochemical industry leaders. For example, SABIC has already started a major new investment to establish its 17th world scale manufacturing affiliate in Saudi Arabia.[29] Table 5.5 lists future SABIC expansion projects.

Table 5.5 SABIC major expansion projects 2003 – 2006

Projects	Location	Capacities (millions of tons)	Year of completion
Ethlene/United	Jubail	1,0	2004
EG/United	Jubail	0,575	2004
LAO	Jobail	0.150	2005
PE/Petrokemya	Jubail	0,800	2004
PVC/Ibn Hyyan	Jubail	0,425	2005
Oxygen/Netrogen	Jubail	1,0	2004
Oxyben/Netrogen	Jubail	0,800	2004
Ethelene/Yanpet	Yanbu	0,368	2005
Amonia-Urea/SAFCO	Yanbu	1,0	2006
Acitic Acid/Ibn Rushed	Yanbu	0150	2005
PTA//Ibn Rushed	Yanbu	0.200	2005
Total	-	6.068	-

Source: SABIC, SBUs Planning, Internal Report, 2003

For instance, Jubail United Petrochemical Company (UNITED), a wholly owned affiliate of SABIC, recently awarded an engineering services, construction and procurement contract at its ethylene glycol plant to a Japanese firm, Toyo Engineering Company. The $220 million project considered to be the largest of its kind in the world, with annual capacity of 630,000 mt of ethylene glycol is likely to be completed within 28 months.[30] UNITED's other plants include ethylene, with an annual capacity of 1,000,000 million tonnes and linear alpha olefins (LAO), with an annual capacity of (150,000) million tonnes.[31] In addition, the UNITED complex possesses 50 per cent of the Petrokemya polyethylene plant having an annual capacity of 800,000 million tonnes.[32] The factory's cost has been estimated at SR 8 billion.[33] In May 2002, Linde German was selected against international competition to carry out a contract for the National Industrial Gases Company (GAS); a partly owned affiliate of SABIC.[34] GAS already has a capacity of 5,600 t/d (tonnes per day) at its Jubail and Yanbu plants, and is the Middle East's largest supplier of industrial gas.[35] Established in 1983, it is a 70:30 joint venture between SABIC and a group of local investors (see Table 5.6 for the historical profile of GAS).

Table 5.6 National Industrial Gases Company (GAS)

Product	Start-up	Capacity	Technology/ Engineering
Hydrogen	1997	120	M/Hour
Oxygen	1984	1,200 T/D	British Gas
	1993	1,200 T/D	Linde
	1999	1,200 T/D	Air Products
	1999	170 T/D	Air Products
Nitrogen	1984	500 T/D	British Gas
	1993	500 T/D	Linde
	1999	1500 T/D	Air Products
	1999	150 T/. D	Air Products
Argon	1997	7 KT/Y	-
Yanbu / Oxygen	1999	495 KTIY	Linde/Linde
	1999	495 KTIY	Linde/Linde
Nitrogen	1999	594 KTIY	Linde/Linde
	1999	594 KT/Y	Linde / Linde
Argon	1999	14 Kt/Y	Linde/Linde

Sources: Based on information from GAS, SABIC and Royal Commission.

Saudi Arabian Fertilizer Company (SAFCO) – see Table 5.7 - was established in 1969 to produce ammonia urea as a joint venture with Occidental Petroleum Corporation. In the beginning the plant was plagued by technical difficulties, management problems, and the falling world price of urea. However, the natural-gas feedstock, the water and the electricity were provided at heavily subsidized prices. In 1976 SABIC took over the exclusive management from Occidental Petroleum. Since that time SAFCO showed a profit-$35 million in 1979 and eventually, the price of urea began to rise.

Table 5.7 Saudi Arabian Fertilizer Company (SAFCO)

Product	Start-up	Capacity (000 mt)	Technology/ engineering
Ammonia	1969	189	ICI
	1993	500	Haldor Topsoe/Chiyoda
	1999	500	Technimont
Urea	1969	330 P	Cros
	1993	600 G	Stamicarbon/NSM
	1999	600	Tecnimont
Sulfuric acid	1971	100	-
Melamine	1985	20	Stamicarbon

Feed Stock	Source
Natural Gas	Saudi Aramco

Markets: All products are marketed by SABIC
Sources: Based on information from SAFCO, SABIC and Royal Commission

SABIC has three fertilizer manufacturing affiliates (SAFCO, SAMAD and IBN ALBAYTAR) and ranks as the world's second biggest producer of urea with capacity of 3 million MT/Y.[36] SABIC, moreover, is the largest urea exporter in the world.[37]

Saudi Arabian Fertilizer Company (SAFCO), will, when further expansion is completed in 2006, consist of a single train ammonia plant to produce about 1 million t/y each of urea and ammonia.[38] It will take total SAFCO capacity to 1.2 million t/y of ammonia and 1.5 million t/y of urea.[39] Estimated to cost between $400 million-500 million, the project will entail the installation of two new lines.[40] Natural gas extracted in Saudi Arabia will be used as feedstock. The Uhde group will be responsible for the entire basic and detailed engineering and procurement process as well as the project management, construction, plant commissioning and training of the operating personnel. The end product will be marketed worldwide by SABIC, which is the largest international fertilizer exporter (5.5 million tonnes per year). For Uhde, Dr. Wolfgang Essig, Chairman of Uhde's Executive Board, told the Info German Trade Review: 'With this contract we have now become a world leader in the field of high-capacity ammonia plants, and this constitutes a major step into the future of Uhde's Ammonia technology'.[41]

Acording to SABIC's plan, by the end of 2003, annual production will reach over 42 million tons of petrochemicals. But SABIC's top priority in the years ahead is to become a global leader by expanding at home and building up its presence abroad. SABIC is aware that the future growth of the global petrochemical industry is directly linked to the future growth of the world economy. Currently, Asian economies hold the best prospects for the future growth. For the period 2000-2005, China is expected to show the highest economic growth rate of 7.6 percent, followed by India with a growth rate of 6.7 percent.[42] Taiwan for the same period is likely to notch up a growth rate of 6.3 percent followed by South Korea with a growth rate of 6 percent.[43] The proximity of the Asian region to the Middle East is an important incentive for investors in this region. Major producers should invest globally to be competitive and survive in today's world market. They will have to consolidate their operational and marketing activities, restructure and search for competitive advantages. SABIC'S global chemical position has grown over time and Table 5.11 below shows the global position of SABIC's diverse product exports, especially chemical products.

Table 5. 8 Chemical company financial performance – Selected Data

	SALES & PROFIT RATIOS				INVESTMENT & COVERAGE RATIOS				PRODUCTIVITY RATIOS		
Representative Chemical Companies	Chemical Sales (US$ Millions	Profit Margins and Net Cash Flow as% Sales			Capital Expenditures		Cash as % Current Liasbilities	Equity as % Total liabilities	Per employee (US$ 000)		
		Open Profit	Net Profit	Cash Flow	US$ million	% Sales			Chemical Sales	Operating Profit	Capital Expenditure
Du Pont	24100	8%	10%	13%	10208	42%	8%	36%	246	35	104
BASF	20000	10%	9%	18%	2422	12%	29%	96%	191	28	23
Dow	19056	14%	9%	10%	1198	6%	7%	46%	444	64	28
Bayer	18471	10%	9%	18%	2533	14%	141%	79%	128	21	18
ICI	18134	4%	4%	9%	1021	6%	27%	2%	261	10	15
Hoechst	14039	7%	7%	15%	1896	13%	3%	46%	121	17	18
Mitsubishi	11671	-	0%	9%	873	7%	26%	28%	-	-	-
Akzo Nobel	9604	10%	8%	15%	696	7%	15%	73%	139	18	10
Norsk Hydro	6606	2%	11%	15%	432	7%	-	-	173	7	11
Union Carbide	6502	16%	10%	14%	755	12%	5%	51%	550	88	64
Sumitomo chemical	7583	-	2%	8%	628	8%	17%	27%	466	32	39
SABIC	6415	26%	19%	31%	2010	31%	115%	66%	452	116	142
Rhoen Poulenc	6213	-1%	-1%	8%	1063	17%	17%	45%	91	-2	16
DSM	6108	10%	7%	14%	629	10%	36%	92%	349	34	36
Solvay	5695	7%	7%	16%	811	14%	55%	71%	165	17	24
Eastman Chemical	4678	11%	6%	13%	749	16%	3%	44%	327	35	52
Monsanto	3126	7%	9%	25%	644	21%	4%	62%	143	22	29
Nova	2350	-	13%	12%	706	30%	-	-	392	39	118
Geon	1250	4%	2%	6%	51	4%	16%	35%	622	26	25
Georgia Gulf	966	15%	8%	12%	57	6%	2%	6%	928	141	55
Average Above	9642	9%	8%	14%	1469	14%	29%	50%	326	39	43
SABIC only	6415	26%	19%	31%	2010	31%	115%	66%	452	116	142

Sources: Chemical & Engineering News, Platt's, European chemical News, Asian Chemical News, Value Line, Chemical Insight, Security Analyst Data, Company Reports.

SABIC has increased its share of the international petrochemical market over the past 15–20 years.[44] According to the corporation's estimates, it meets around 5 percent of the expanding global demand for petrochemicals.[45] Its international marketing success stems from its reputation as a reliable supplier of quality products and customer-oriented support service.[46]

5.3.4 SABIC exports

SABIC has developed a global marketing network that consists of local affiliates to service respective markets. The fundamental advantages of the Kingdom and its natural hydrocarbon resources is its access to competitively priced feedstock, a geographic location mid-way between major markets in Europe and Asia, and domestic and regional markets that hold tremendous potential for growth. Despite fluctuations resulting from turbulent world trade, and especially the petrochemical cycles, exports sales have been robust with a positive trend.

SABIC's continuing goal is to provide products of world-class quality to local and diverse international markets to seek the most profitable payback possible on sales, following this up with reliable technical assistance and customer service worldwide.[47] At the same time, SABIC strives to cause minimum impact on existing markets by marketing its products in an orderly manner and pricing them at prevailing market levels. With the above marketing philosophy in mind, SABIC established SABIC Marketing Ltd, which is responsible for marketing products of SABIC affiliates, as well as other related industrial products and various services related to product sales. These services include logistics and insurance, technical assistance to customers before and after sales, plus providing customers with constructive advice to achieve maximum value from product sales. SABIC reinforced its marketing network by opening sales service offices and leasing storage facilities in various parts of the world, and by signing necessary charter transport agreements for shipping SABIC products. The Company has also established in-house workshops, laboratories and a technical service centre, staffing these facilities with technical personnel experienced with most advanced industrial applications.

5.4 Technology development levers

5.4.1 Technology strategy and policy objectives

Research and technology is an essential element of SABIC's global strategy, helping to deliver top quality products to customers worldwide. Its three pronged strategy is on:

- technology development
- technical support to customers
- improvement of manufacturing processes at SABIC plants in Jubail and Yanbu

- R&T focused towards chemicals, catalysts, polymers, fertilizers, metals and environmental management.

SABIC's R&D works in close coordination with SABIC's business units and manufacturing affiliates, consolidating research activities across all areas. The research is concentrated on applications according to the requirements of the markets. SABIC is committed to developing new technologies to strengthen the company's technological base and in-house research. As an important part of SABIC's global vision, R&D focuses on attracting home grown and international scientific talent to support these goals in Saudi Arabia, Europe, USA, Asia and the Far East, having over 500 scientists, technicians and administrative support staff to deliver its services.[48] SABIC's R&D progress has also meant that SABIC and Saudi Arabia are less dependent on foreign technology licensors. So far, several international licences have been granted. This is an important and real step on the road to scientific research and technological development, to be followed by other steps towards the development of local technology in the future. SABIC Research & Development has made solid achievements and has also played a key role in SABIC's strategy to develop its own technology. The technology quest underlines that SABIC is entering a new phase in its development. Some examples of SABIC's achievements are as follows:

- researchers at SABIC R&D, in cooperation with IFP (Institute of France du Petrol), have succeeded in developing butane-1 technology, and 'Butadiene' production technology and consequently SABIC have become a technological partner of the French Institute and shares with it the right of licensing the same. This technology is being marketed worldwide as the IFP-SABIC butene-1 process.

- developing new products in polystyrene

- improving the PVC manufacturing process

- development of a new technology, Alpha Sablin, in the area of Alpha Olefins

- several solutions for industrial problems, such as corrosion and industrial loss

- supply of SABIC R&D services to the agricultural sector. Preliminary experiments at some of the national farms in increasing productivity and reducing irrigation water quantities

- cooperation with universities and with scientific and technological centres inside and outside the Kingdom.

SABIC has developed a model of innovation strategy. SABIC's innovation strategy is based on four elements: firstly, generation of new ideas and technologies; secondly, commercialising these ideas and technology so that from a revenue point of view it is possible get maximum financial benefit; human resources is the third element, which is the development of employees with high skills through which the company benefits by way of production growth, revenue and profit margins; the final step is the SABIC industrial culture that ensures international confidence and thereby global growth. This innovation strategy has led SABIC to develop very strong R&D activities and R&D structures. However, the weakness of this strategy seems to be the lack of an information structure which is available for scientists and engineers needing to expand their horizons and to be more open to other areas where they can get information to support analysis and findings. SABIC's innovation strategy can be summarized in four elements in Box 5.1

Box. 5.1 SABIC innovation strategy

SABIC's innovation strategy:

- *knowledge infrastructure* - to ensure SABIC business is at the forefront of generating new ideas
- *commercialisation of knowledge* - to facilitate the necessary mechanisms to capture the benefits of new ideas
- *human resources* - to develop a workforce with the skills and attitudes to make new things happen, and
- *industry environment and modernisation* -to promote SABIC investment.

Sources: Different industrial and investment reports, SABIC, 2000-2002

SABIC R&D successes include a major breakthrough in the development of new technology to produce acetic acid from ethane oxidation; the first time that a modern grass root petrochemical technology has been developed in the Middle East.[49] The new process was developed after seven years of research and development work and differs fundamentally from the conventional industry practice of producing acetic acid through methanol carbonisation.[50] Acetic acid industrial applications include production of vinyl acetate monomer (VAM) and purified terephthalic acid (PTA). SABIC R&D has registered 221 patents in the development of new technologies in the technical support to affiliate manufacturing operations, and in the development of new improved products and processes (see Table 5.12).

Table 5.12 SABIC patents status 2002

Status	No. of patents	Years
Under Study	47	2000-2003
Field	169	1998-2003
Granted	05	1995-2000
Total	221	

Sources: SABIC's R&D, Internal Report, 2002

Table 5.13 shows the SABIC patent status for 2002, which indicates that SABIC has 5 patents completed and now registered with the Office of Patents in U.S.A. Under process of finalizing the necessary documentation for registration there are 169 patents while 47 projects are under study. See Table 5.14 for the list of patents granted in the US.

Table 5.13 SABIC patents registered with the Office of Patents in U.S.A

Patent No.	Title
1) 6,448,348	Process for polymerizing olefins with supported Ziegler-Natta catalyst systems
2) 6,413,901	Highly active, supported Zeigler-natta catalyst systems for olefin polymerization, methods of making and using the same.
3) 6,403,520	Catalyst compositions for polymerizing olefins to multimode molecular weight distribution polymer, processes for production and use of the catalyst
4) 6,288,182	Supported metalloocene catalyst system for olefin polymerization
5) 5,240,754	Container for photographic film cartridge

Sources: SABIC, R&D and United States Patent and Trade Mark Office, 2002

SABIC's experience in patent registration confirms that the procedures are sophisticated and need specialized people to respond to all the requirements and follow up registration procedures.[51] SABIC has learnt a lot from this experience and has been successful in completing 5 patents in the US as shown in table 5.13 upto the year 2002. These patents indicate the success of SABIC in developing technologies. The image of SABIC R&D has been enhanced after the development of SABIC's own processes for the production of Acetic Acid and Linear Alpha Olefins (LAO). SABIC announced the creation of a new technology for the production of linear alpha olefins developed jointly with Germany's Line, which will be commercially used for the first time on a 150,000 tonne a year unit that is to be built at the $1,500 million olefins complex planned by Jubail United Petrochemical Company.[52] Registering patents within and outside the Kingdom shows the possibility of growing the business through technology and investing in the right technology at the right time. R&D has also developed a new catalyst for the production of butene-1 known as SABCAT-1 that improvės product quality and reduces production costs. SABCAT-1 will benefit PETROKEMIA and other butene-1 manufacturers. The products are expected to meet the demands of local industry. The R&D reveals major breakthroughs as detailed in Box 5.2.

Box. 5.2 SABIC's successful research in catalyst developments and other various fields as follows:

- catalyst developments
- catalyst pre-activation
- process technology development project
- plant technology support projects
- product development projects
- failures and corrosion problems.

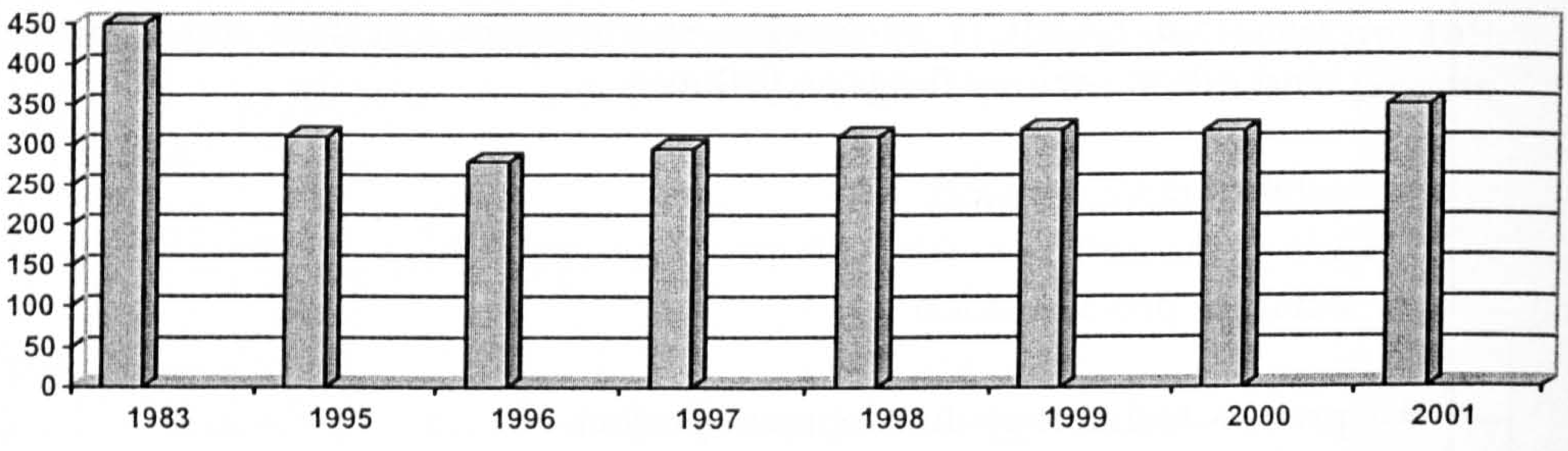
Sources: SABIC- R&T, *internal reports*, 1999-2002

SABIC's R&D Centre is contributing to the profitability and business development of SABIC, through research on various product portfolios, technical support to plants and also to customers. A project to identify high volume corrosion in Saudi Arabia has been completed and draft reports issued by King Saud University include SABIC R&D comments which identifies several potential inhibitors to be manufactured by SABIC R&D.[53] In addition, a great deal of assistance and support has been provided to the plants and customers in their fabrication runs and physical, mechanical and analytical tests.[54] At SABIC's Complex for Research and Development, work proceeds to ensure product quality and improvement as well as to diversify categories, grades and develop applications. The complex is supported by integrated relations between SABIC's industrial facilities.

5.4.2. Research and development: expenditure and trends

In spite of huge reserves, petrochemical production in the Arab world does not exceed 5% of world output.[55] One of the reasons for this weakness is the fact that Arab countries do not pay attention to R&D. The number of scientists in the Arab world is very low, equal to 1.5% of the world total, whilst Europe enjoys 21% and North America 18%, respectively.[56] Total Arab expenditures on R&D is also very low (0.7% of the world total compared with North America's 43 %).[57] Recently, the Arab world started to recognize R&D and the role it might play in developing Arab countries. Since 1985, SABIC has spent huge amounts of money in R&D as shown in Figure 5.2, placing SABIC expenditure on R&D among top of the world companies that invest heavily in R&D. SABIC has a vision of developing its own technologies and improving the quality of products to keep competitive, because the nature of petrochemical products needs a continuous improvement process.

Figure 5.2 SABIC expenditure on R&D 1995 to 2001 (SR Millions)



Sources: Based on information from SABIC R&D Internal Reports and SABIC Annual Reports 1983-2001

The need of the Saudi petrochemical industry for R&D became obvious after production began in the early 1980s. In order for SABIC to break through the dependency on foreign technology and new products/materials, it focused research on chemistry and chemical engineering to create new materials, industrial chemicals, and chemical processes. As Vice President of SABIC R&D confirmed:

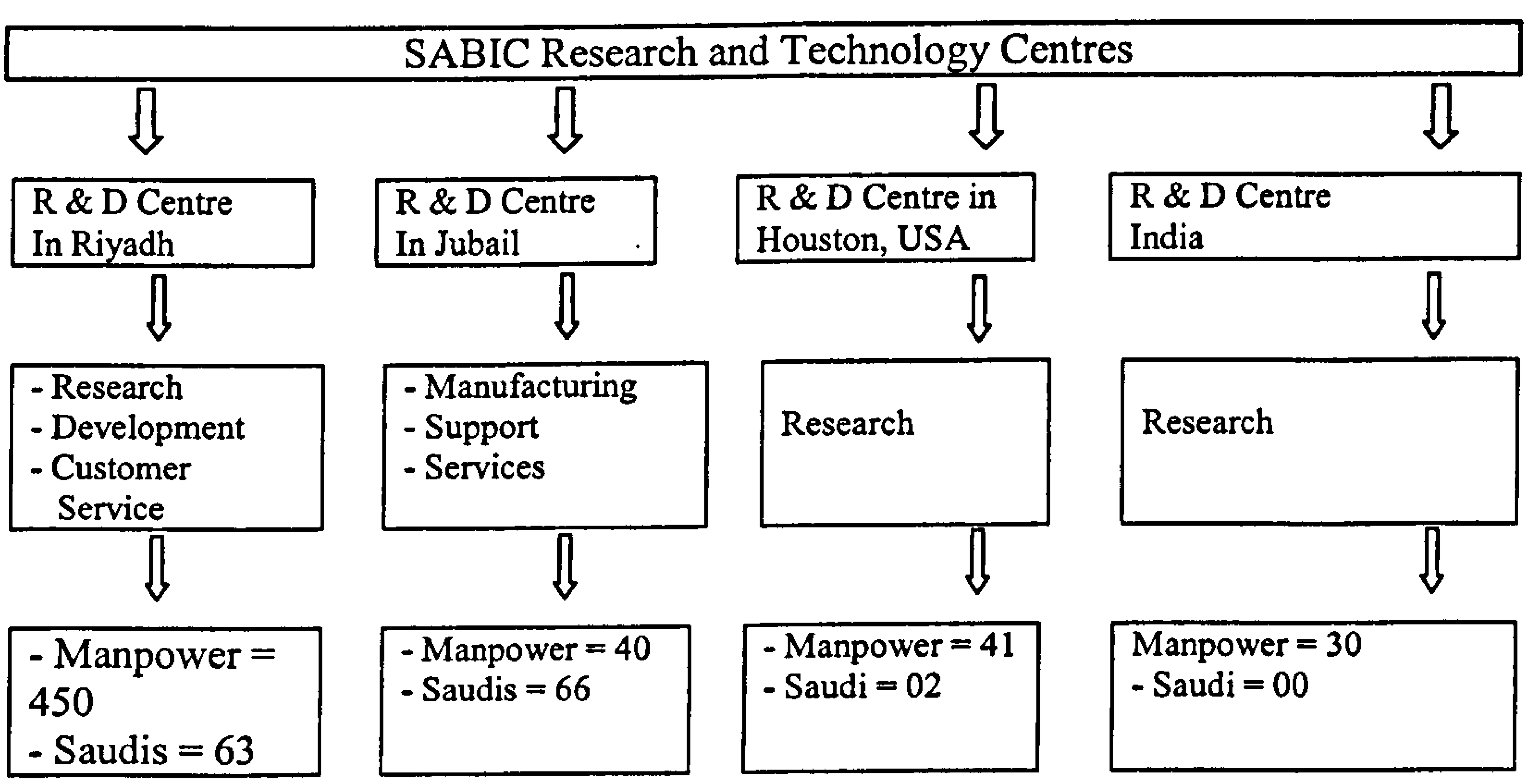
> 'SABIC R&D is mostly driven by technology rather than pure science and research for innovation knowledge, and understanding science has been replaced by product and process driven research that must meet the test of success in the competitive market place. The primary aim of almost every R&D project is to maximize return with minimum R&D expenses. Working with tighter budgets and smaller staffs, R&D managers have changed their focus and role to respond to corporate needs… by going global through overseas joint ventures or acquisition, SABIC will benefit from technical advancement and talent that will give SABIC a leading edge. The technology quest underlines that SABIC is entering a new phase in its development; no company can continue to rely on imported technology'.[58]

By concentrating on technology, SABIC can upgrade people, material assets and add value to products. Technological advancement and self-sufficiency will be the driving force behind future industrial growth.

5.4.3 Research and development centres

Technology transfer has played a major role in the development of technology in SABIC's affiliates. Reflecting on the importance of modern technology and the concept of technology transfer, SABIC has developed a dedicated technological team at the company's Industrial Complex for Research and Development. The process is a result of the importance of technology transfer and consequential research and development. SABIC's complex for research and development, which was officially opened in 1994, created a strong infrastructure framework for undertaking research. The complex is located on a 33 hectare in Riyadh. It is a modern technology centre equipped with impressive facilities. Among these are pilot plants and bench scale reactors for producing new test grades of polymer resins, catalyst development and preparation laboratories, state of the art analytical instrumentation, and a staffed technical service laboratory. This centre is committed to carrying out systematic study of industrial process application technologies for SABIC's manufacturing operations in chemicals, polymers, fertilizers, metals, and catalytic research and new product development. The R&D group also work closely with SABIC marketing operations to provide customer related technical support. One aspect of SABIC's R&D strategy is its satellite research centres outside Saudi Arabia. These centres are active in exploratory research and exploit the knowledge and technologies available in each country. SABIC has built a strong research and technology (R&T) facility, as shown in Figure 5.3, that consists of the main SABIC R&D complex in Riyadh and SABIC Technology Centres (STCs) in the US, in Al Jubail and in India.

Figure 5.3 SABIC R&D facilities



Source: SABIC, R&D, Internal Reports, 2002

It is foreseen that this type of decentralized R&D will generate increased cooperation with leading overseas universities and research organizations and provide direct local technical service support to the customers of SABIC.

According to the head of the research at SABIC R&D, these centres succeeded in developing collaborative research projects, inside and outside the Kingdom, with universities, national laboratories, consortia and academia to speed-up product and process development and achieve targeted technological objectives.[59] SABIC is steadily heading towards multi-directional growth as it pools its R&D resources with government agencies and academic centres.

Technological innovation in the petrochemical industry demands cooperation between R&D institutes and industry, and from the beginning, SABIC has developed wide cooperation with research institutes and universities outside the Kingdom. Table 5.14 shows the nature of such cooperation which covers mostly the most advanced industrial countries. These joint research projects can lead SABIC to meet its needs from technology development.

Table 5.14 SABIC 's external research cooperation with universities and institutes inside and outside the Kingdom, 2002

Country	USA	UK	Germany	France	Canada	Japan	KSA
Number of Research Institutes and Universities	3	2	2	1	2	1	5

Source: SABIC R&D, External Research, 2003

In the past, this cooperation was a new experience for SABIC, and difficulties were faced in its development. It was mostly individual efforts. However, SABIC has now gained good expertise and experience to pursue such cooperation. Cooperation mainly covers:

- technology process development
- product quality improvement
- technology improvement
- new technology, and
- cost reduction.

For example, joint research with the Japan Research Institute has developed a plan to develop new materials for green houses using SABIC polymer raw materials, taking about three years to complete. In cooperation with Saudi Universities, SABIC has developed good relations. Table 5.15 lists SABIC's joint cooperation with Saudi Universities. The aim of this cooperation is to benefit from the capability of Saudi Universities and SABIC R&D in developing technology processes and products. The experience of this cooperation is promising both for SABIC and the Universities.

SABIC's R&D strategy focuses on attracting home grown and international scientific talent to support its technology development efforts in Saudi Arabia, USA and India. Tables 5.15 and 5.16 show the number of employees in SABIC R&D Centres according to Saudi and Non-Saudi categories in all areas covering research and development activities.

Table 5.15 Number of employees in SABIC R&D Centres according to qualifications

High school	Technical college	Bachelors	Masters	PhD	Total
91	67	216	47	69	490

Sources: SABIC R&D, Internal Report, 2002

SABIC's R&D geographical spread allows it to draw on worldwide expertise and to remain close to its global customers. SABIC R&D continues to work in developing new strategies and technology alternatives to support SABIC strategy.

Table 5.16 Number of Saudi & non-Saudi employees in SABIC's R&D Centres

Saudi	Non-Saudi	Total
299	191	490

Sources: SABIC R&D, Internal Report, 2002

Another example of gaining access to the advanced technology is that of SABIC Euro Petrochemicals' acquisition of a 50% share in StaMax BV; a joint venture formed in 1999.[60] This gives SABIC full ownership of this company which produces StaMax long glass fibre polypropylene composite material. Under the arrangement, Owens Corning will be the supplier of PerforMax glass fibre. StaMax BV will use Owens Corning's unique patented process and this proprietary glass fibre to produce and sell material in the European market.

SABIC and Süd-Chemie AG have also announced a joint agreement on the acquisition of Scientific Design Company Inc. from Linde AG. Under this changed ownership, Scientific Design will remain an independent entity and continue to license its processes, provide engineering services and sell catalysts to its clients worldwide. SABIC and Süd-Chemie will manage the Scientific Design Company Inc. through a fifty-fifty joint venture. Scientific Design is based in Little Ferry, New Jersey, US; its major fields of business being catalysts and process-technology for use in the production of major chemicals such as ethylene oxide and maleic anhydride. With more than 70 employees, the company has recorded sales in the double-digit million ranges in recent years.[61]

SABIC's Quality-Lab Networking Sub committee comprises one member from each SABIC affiliate, with a view to improving quality and promoting safety awareness among the laboratory personnel. Other aims include enhancing communication and cooperation between SABIC laboratories and providing a forum to share ideas, information and technical expertise on matters of common interest.

5.4.4 SABIC's partnership/ joint ventures/ transfer

SABIC success in the area of petrochemical manufacturing has over the years been a function of three main factors, namely:

- feed stock and energy resource advantages
- technological edge
- marketing capability.

SABIC is willing to trade off some of its raw material and feedstock advantages for the advantages associated with the foreign joint venture model catering for a tripartite relationship. This model institutionalized the partnership relationship according to the features shown in Box 5.3.

Box 5.3 SABIC's joint venture arrangements

In SABIC's early joint ventures, equity was equally shared with the foreign partner. More recently different arrangements involving unequal equity shares have been tried.

- In all cases, the SABIC model has given partners equal responsibility and an equal stake in the success of the joint venture
- It also eliminated many of the conflicts that can arise between majority and minority partners
- The SABIC model also called for the setting up of an independent company to run the business
- Production is shared between the partners according to an agreed formula
- With the JV acting as a profit centre, each partner has the responsibility of marketing its own share in the world market
- Profits are distributed according to equity shares.

Sources: SABIC, " joint ventures agreements", Internal Reports, 1980-1994

The success which SABIC has achieved in collaboration with a number of American, Japanese, European, Korean and Taiwanese companies attests to the success of the SABIC model; its practical use and sustained viability. Through joint ventures and a strict focus on human resource development, SABIC has managed to groom a generation of technocrats and managers to operate and manage its world scale industries. The Company has also benefited from a strong and stable political, social and financial system that has been supportive of SABIC's industrial development programmes. The four most important issues in the selection of partners are listed in Box 5.4, below.

Box 5.4 Criteria for selection of foreign partners in SABIC joint ventures

- International reputation as an industry lead
- Technical expertise and willingness to share and transfer this know how
- Proven share of the global market that would help SABIC to introduce its own products
- Readiness to help SABIC develop Saudi human resources by providing training and hands-on experience for Saudi citizens who will shoulder the operational, technological and administrative responsibilities.

Source: SABIC, Annual Reports, 1985-1988, and SABI Planning Department

The joint venture route has helped SABIC to achieve its early objectives. Of particular importance is the Corporation's contribution to developing the Kingdom's human resources and importing modern manufacturing technologies. SABIC and its affiliates have considerably strengthened their own capabilities to provide in-house job training for the new generation of Saudi workers. A full description of SABIC's joint ventures is shown at Appendix 8.

5.4.5 Foreign joint ventures

The most important lesson that SABIC has learned from its experience regarding foreign joint ventures is the necessity of institutionalizing its relationship with foreign partners. In most SABIC's earlier partnerships, equity was equally shared with foreign partners. In all cases, however, the SABIC model has given the partner equal responsibility and a fair stake in the success of the joint business. It also has effectively resolved many of the conflicts that were likely to arise between majority and minority partners in areas such as management control, pricing and marketing policies, profit distribution and future expansion plans of the joint investment. Short-term price changes regarding feedstock, electricity and other utility services have had negative effects on the ability of the industry to compete as well as discouraging foreign investment flows to the Kingdom. To build a partnership based on trust and to protect the partners' mutual interests, transparency is essential. Comprehensive agreements were negotiated in which potential conflict areas were discussed and resolved. The SABIC Model called for setting up of an independent company to run the business. Such a company had a Board of Directors in which partners can be represented. SABIC partners who were early movers in the first wave of petrochemical manufacturing projects in the mid-1980s have had generally satisfactory financial returns on their efforts and risks over the past 15 years. Table 5.17 summarizes the cumulative financial results for eight of the major joint ventures affiliated with SABIC during the past 15 years. SABIC's partners in these eight ventures have included large oil companies, such as Exxon/Mobil and Shell, chemical companies such as Celanese, Ecofuel, Mitsubishi and Neste, and a number of local and international investors.

Table 5.17 SABIC Partner returns 1987-1999

1987 start up 8 joint ventures (11 partners) which began operations in early–mid 1980s	- Partner average annual operating income as % initial equity: 42%/year - Average cash dividends paid to partners as % initial equity: 28%/year - None of the 8 joint ventures gave SABIC partners a negative return - Cash dividends paid rate of return: 25%/year - Compound growth of partner equity value: 11%/year - Total return to partners (1987-1999) 36%/year
Sources: SABIC, Operation Planning Department, 2001 **Note: combined financials shown assume all joint ventures began in 1987 – which would tend to slightly overstate actual returns of those joint ventures with earlier start-ups.**	

Table 5.17 indicates the following performance achievements:

- cash dividends paid out to partners have averaged a rate of return of about 25% year on initial partner equity investment
- book value of partner's equity share in the eight ventures (after payment of cash dividends) has increased at a compound growth rate of approximately 11% year
- cash dividends paid (25% year) plus equity appreciation (11% year) provided a total return to investors of about 36% year
- none of the joint ventures had negative results – and all eight of these large, capital intensive, development projects paid cash dividends to partners that exceeded the initial equity invested within 5-7 years after operations began
- all eight joint ventures have elected to at least double – and in some cases, quadruple – the capacity of original facilities.

The 1987-1999 cumulative financial results for the eight joint ventures tend to overstate 'true' return, where the initial start-up of the operation occurred before 1987. Even so this can be seen as a favourable track record for SABIC since the period 1987-1999 was a volatile and sometimes difficult period for the industry. None of the eight SABIC joint ventures has experienced disappointing performance.

5.4.6 Diversification

Partially, as a result of these efforts, SABIC's net profits, excluding those of foreign partners, increased from SR 148 million in 1985 to SR 40.2 billion by the end of 2002.[62] There have been several other benefits, and one of the more important of these has been the impact on the Saudi economy from increased capital formation. Table 5.18 below summarizes the capital formation contribution of SABIC to the industrial production base during the fifteen years 1985 to 2000.

Table 5.18 SABIC's contribution to capital formation (Billion SR)

	1985	1990	1995	2000
Gross capital formation	11.6	18.9	53.9	94.7
Net capital formation	10.7	13.9	37.0	63.7

Sources: SABIC, Annual Reports, 1985,1990,1995,2000, Planning Department, 2001

Table 5.18 shows that the contribution of SABIC to Gross Capital Formation (including plant, equipment, property, and depreciation) increased on average by 15% annually during the last fifteen years.[63] Its contribution to net fixed capital formation (excluding depreciation) has increased by 12.6% annually during the same period.[64] Primary and secondary manufactured products still represent only 10% of Saudi's total exports.[65] Within the chemicals sector itself, Saudi Arabia had achieved a trade surplus of more than one billion SR by 1997.[66] Relative to oil and oil products, Saudi's petrochemical exports were still relatively small in the late 1990s. It has taken time for SABIC and other manufacturing activities to diversify the Kingdom's oil exports.

5.4.7 Human resources and Saudisation

One of the major goals in creating SABIC was to develop Saudi manpower. The first generation of SABIC's Saudi personnel received on-the-job training from joint ventures in industrial management, technical operation and administrative skills. SABIC considered human resources as the biggest challenge and the most difficult faced in the early stages of its operations due to the shortage of a skilled Saudi national work force. In order to face up to the challenge of developing a national work force capable of taking over management and technical positions in the future, SABIC started programmes for the development of human resources aimed at fulfilling this aspiration. In addition to its concern for customers, SABIC demonstrated solid commitment to the development of growing numbers of employees.[67]

Saudisation requires massive investment in human capital. At SABIC, Saudisation has been an intensive manpower development and training programme. SABIC joint venture partners have aided the realization of Saudisation efforts. They have advanced the technological skills needed to help SABIC attain its goals. These joint efforts have made it possible to achieve a majority percentage of Saudi personnel throughout SABIC's plant, supervisory, technical and administrative staffs. By the year 2002, 75% of SABIC's 12,000 workers were Saudi citizens.[68] Some SABIC affiliates have achieved Saudisation of up to 90 percent.[69] Moreover, the fact that most of the senior technical, administrative and other positions are held by Saudis deserves special mention. Tables 5.19 and 5.20 show a comparison of the manpower status in relation to the manpower development programmes in SABIC's companies, indicating how the gradual Saudisation has been implemented in SABIC.

Table 5.19 Manpower status of SABIC Affiliates, 1997

	Saudi	Expatriate	Others	Trainees	Total Manpower	Saudi %
AR-RAZI	348	7	50	-	407	86
Gas	103	1	17	-	128	86
Hadeed	1116	-	1522	424	3062	50
Ibn Al Baytar	462	-	94	14	570	84
Ibn Hayyan	1	-	-	-	1	100
Ibn Rushd	92	3	752	161	1008	25
Ibn Sina	246	7	90	-	343	72
Ibn Zahr	304	1	81	70	456	82
Kemya	269	6	70	-	345	78
Petrokemya	898	-	24-0	104	1242	81
SADAF	626	19	119	-	773	82
SAFCO	617	-	231	43	891	74
SAMAD	382	-	128	28	528	76
SHARQ	531	7	106	25	669	83
Yanpet	798	20	294	62	1174	73
TOTAL	6793	71	3794	949	11607	1132

Sources: SABIC/ Human Resources Department, Internal report, 1997

In co-operation with its joint venture partners, SABIC has conducted training programmes inside and outside the Kingdom which have produced an industrially oriented generation of Saudi citizens.

Table 5.20 Manpower status of SABIC Affiliates -2001

	Saudi	Secondees	Others	Trainees	Total Manpower	Saudi %
AR-RAZI	373	2	40	-	415	90
Gas	164	3	22	-	189	86
Hadeed	2023	-	1276	66	3365	62
Ibn Al Baytar	0	0	-	0	0	0
Ibn Hayyan	-	-	-	-	-	-
Ibn Rushd	467	-	606	21	1094	45
Ibn Sina	248	1	22	-	271	92
IbnZahr	409	1	38	12	460	92
Kemya	465	46	82	-	597	79
Petrokemya	1107	-	145	63	1315	89
SADAF	633	10	48	33	724	92
SAFCO	886	-	96	-	982	90
SAMAD	385	8	41	-	434	89
SHARQ	635	1	45	-	684	93
Yanpet	1214	22	323	16	1575	78
TOTAL	9009	94	2784	218	12105	75

Sources: SABIC/ Human Resources Department, 2002

5.4.8 Training, education and career development

Although SABIC has had its own successes and drawbacks in its efforts to develop a local work force, early success of these programmes were reflected in the comparison of figures for the period 1980 to 1985. During the years 1980 and 1981 only 1,400 trainees were involved in the training programmes. However, this marginal early success had its impact on the young generation, whereby more and more young Saudis were attracted to the programmes of SABIC. This increased the number of trainees and consequently much needed qualified and skilled employees for SABIC. The figure of 6,659 high calibre technical and management trainees that came out of these training programmes in 1985, as against 1,400 four years earlier, to take up responsible positions in SABIC, provides proof of the success of SABIC's human resource development policies.[70] With this early success, SABIC policy makers stressed the need to include provision in the joint venture agreements for the joint venture partners to provide training to SABIC employees. SABIC approached this early vision, mapping out a strategy to ensure success.

The strategy included the hiring of graduates from universities and sending them to be trained with the foreign partners, in engineering, operation, management and marketing, for periods ranging from six months to three years. SABIC also started an English training programme vital to proper communication between foreign workers and Saudi trainees. SABIC sent its employees to the UK and USA for English training programmes of six to 18 months, helping to narrow the language barrier thereby helping Saudi employees to understand technological and operational theories. Moreover, as part of its employee-training scheme, SABIC entered into agreements with universities and institutions in the Kingdom to conduct training programmes for its employees for one to two years. The main aim of SABIC's training programmes has been to give its employees an opportunity to gain wider knowledge and know-how and achieve the maximum benefits from joint venture partnerships within a limited space of time. Another important objective is to give all SABIC employees in general, and especially engineers and supervisory level staff, on-the-job training within the joint venture. In marketing, SABIC had the belief that experience in marketing cannot be easily achieved without actual participation of the people involved in marketing in day-to-day marketing activities. Therefore, SABIC introduced a marketing programme through which they buy products similar to that of their own products and re-sell them to give them experience in the market itself. The aim is to make them ready to take over stiff challenges in marketing their own products when joint venture production commences. SABIC also placed special emphasis on petrochemical recycling and marketing research issues when SABIC sends employees to marketing consultants for higher training. SABIC pre-production marketing activities include domestic re-selling of products similar to those that would be produced in their plants. The re-sale programme was intended to study the market in the Kingdom, to identify its needs and requirements, to establish a close relationship between SABIC and the market and to build up a national staff trained in marketing and related technical services. While the above programmes were on going, SABIC conducted worldwide intensive market research. It also participated in specialized international conferences and symposiums, established working agreements with shoppers, carriers and insurers and opened branch offices in various cities in the world. The objective was to strengthen relations with foreign markets to develop marketing, capability, supporting SABIC s manufacturing projects.[71]

When SABIC chose the joint-venture method for technology transfer and for implementation of its projects, the reasons were varied. The aims were to construct a strong bridge that would give SABIC's industries permanent access to new technologies and to ensure a fair share of SABIC products on world markets through distribution and marketing agreements with overseas partners.

However, SABIC's fundamental objective in using the joint venture approach, was to accommodate the development of Saudi nationals, to make them capable of shouldering the responsibilities of industrialization. This required the preparation of training programmes for Saudi workers so that sufficient trained manpower required for management and operation would be available at the time of start-up. Table 5.21 details SABIC's expenditure on worker training over the period 1985-2001. Also in the 1980's, SABIC started successive qualifying and training programmes within the Kingdom, followed by on-the-job training inside and outside the country at its plants and plants of its partners. These training programmes received large numbers of secondary and intermediate school graduates as prospective trainees.

Table 5.21 SABIC annual expenditure on training 1985 to 2001 (SR. millions)

1985	1997	1998	1999	2000	2001
55	77	86	73	88	79

Sources: Based on information from SABIC Reports 1985, 1997,1998,2000 and 2001

The number of Saudi employees in the areas of direct management and maintenance at SABIC's industrial complexes by the end of 1984 reached 3,280 out of a total of 6,953.[72] Employees at SABIC Marketing Companies at the end of the year reached 314; 81% of whom were Saudi universities graduates, holding a B.A, B.Sc, M.A or a PhD degree.[73] As for the Saudi employees at SABIC plants, engineers, skilled workers and technical foremen constitute the majority.[74] For the years 1985-2001, Table 5.22 shows SABIC manpower to local/non-local status and also qualification.

Table 5.22 SABIC's manpower qualifications according to nationality (Year 2001)

Qualification	Saudi	Non Saudi	Total	Saudi %
PhD	07	89	96	07
Masters Degree	112	229	341	33
High Diploma	08	06	14	-
Bachelors Degree	1,900	1,856	3,756	51
High School	3,806	1,049	4,855	78
Technical (Industrial)	1,474	195	1,669	88
High School Commerce	204	30	234	87
Vocational Training	52	16	68	76
Secondary School	2,345	95	2440	96
Total	11,088	4,357	15,445	72

Sources: SABIC, Human Resources Department, Internal Report, 2002

SABIC's intention was to have Saudi workers representing at least 60-70% of the total manpower during the first years of a plant's operation. This percentage was planned to gradually increase in favour of Saudi nationals in subsequent years. The training plans covered the period 1980-1985 and the period 1985-1990. The preparation, qualifying and training elements of the plan include manpower programmes for direct management and operations staff of the first generation of SABIC industries, totalling about 7,000 persons. Total manpower requirements for the second generation of SABIC's industries was estimated to be approximately 5,400 employees of all categories. In general SABIC training for affiliated companies aimed to achieve at least 75% of Saudis in their total manpower requirements. According to a recent study of Human Resources development in

SABIC, the company considered development of manpower, especially a national work force, as one of the most important elements for industrial development.[75]

Finally, Table 5.23, below, indicates how successful SABIC has been in reducing expatriates in all areas of production, maintenance, marketing and management. In 2002, there were 11 companies exceeding 90% Saudisation; one company had 70% Saudisation and another had 65% Saudisation. The average Saudisation is 78%.

Table 5.23 Saudisation change, by SABIC's Affiliates for years 1985 and 2002

Company	1985			2002			
	Total	Saudi	Non-Saudi	Total manpower	Saudi	Saudisation %	Contractor employees
SABIC				2297	1603	-	473
HADEED	2359	740	1512	3037	1967	65	0
ARRAZI	254	200	54	412	371	90	51
SAMAD	432	232	200	406	367	90	181
YANPET	1191	600	591	1516	1222	99	263
KEMYA	358	310	48	584	495	85	483
SADAF	1249	590	659	713	649	91	381
IBN SINA	203	170	33	276	257	93	110
PETROKEMYA	458	250	208	1436	1300	91	513
SHARQ	407	350	57	689	648	94	108
SAFCO	594	310	284	930	844	91	171
GAS	88	70	18	189	164	98	31
HAYYAN	286	160	126				
IBN ZAHR	62	50	10	460	422	92	128
IBN AL Bayatar	60	45	15	-	-	-	-
SAPTANK	-			142	129	91	52
TAIF	-			105	74	70	79
Total	8001	3814	4167	14,108	1098 1	78	3500

Sources: SABIC, Human Resources Department, Internal Reports, 1985 and 2002

5.5 Summary

Analysis from Chapter 5 clearly shows the success of SABIC in technology transfer from partners to employees. On the job training has been the key to transfer of knowledge and experience to Saudis. Also SABIC and partners together share the challenge of educating people and transferring knowledge, expertise and technology to Saudi Arabia. SABIC cannot achieve this success without partner support.

In a broad sense the local shaping of technology in Saudi industry can be seen as the adoption and further elaboration of technology development on the basis of technology transfer from abroad. From the viewpoint of SABIC's experience, it also shows the way for other Saudi firms to acquire technology capability by managing transfer of foreign technology. The seeming success of SABIC's technology transfer has made it possible for the company to increase production and quality using new technology. Success in petrochemical manufacturing is the function of three main factors. A feedstock and energy resource advantage, a technological edge, and a marketing capability. A good fit between SABIC and a foreign partner, is where SABIC offers competitive feedstock and the foreign partner, technology and marketing expertise. A direct result of implementing SABIC's joint venture model, is that the share of foreign assets constitutes 33% of SABIC's total assets.[76]

SABIC and its partners are today marketing their products in over 100 different regional and international countries across the world.[77] From the preceding analysis, SABIC has pursued a strategy of technology development and technology transfer as the key to future modernization, relying on an intensive, rather than extensive, developmental strategy. SABIC is enjoying development in which diversification of the Saudi economic base and expansion of infrastructures facilities requires the material and experience of the industrialized world. Ultimately, transfer of technology will prove to be the critical key to the continued development of petrochemical industry. Therefore, the primary thrust of development is to achieve a self-sustaining and diversified industry. This chapter suggests that, with the help of several factors, such as raw materials and the cooperation of international companies, SABIC is involved in what appears a successful strategy of technology acquisition. However, SABIC is likely to remain dependent upon external sources of technological development for the foreseeable future.

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CHAPTER SIX

CASE STUDY ANALYSIS OF THE EFFECTIVENESS OF TECHNOLOGY TRANSFER IN SAUDI ARABIA'S ENERGY AND DOWNSTREAM PETROCHEMICAL SECTORS

6.0 Introduction

As highlighted in Chapter one's study framework, this study explores how Saudi Arabia can accumulate technological capabilities and contribute to advanced industry technology transfer. The key for success is effective utilisation of technological competencies. Various strategies and choices are available in selecting particular types of technology transactions. These choices may also depend on the objectives and requirements of a company. For example, what level and type of competence are needed? Is innovation and competence required as well as productive capacity? Is there a difference between long and short-term goals?

This chapter examines these questions in detail through a comparative analysis of the research data gleaned from the questionnaire appended as Appendix 1 which was sent to the companies and other affiliates of the two case-study organizations indicated in Appendix 2. This Chapter is the core of the thesis. It aims to examine the survey's questions in detail. It also measures the responses to the questionnaire related to the achievements of both these companies. This analysis shows how Saudi Arabia has acquired oil and petrochemical technological capabilities by utilising advanced foreign technologies in the two cases, Saudi Aramco and SABIC. From the survey analysis, this chapter comprises five sections. Section 6.1 analyses the results of the survey on the different strategies represented and different development methods adopted by Aramco and SABIC, and contrasts their strengths and weaknesses. This analysis mainly focuses on how the characteristics of the different technologies and the type of transfer processes affect the possibility for both Saudi Aramco and SABIC to gain access to appropriate foreign advanced technologies.

In light of the analysis of these two cases, section 6.2 analyses technological learning and adaption activities in Saudi Aramco and SABIC affiliates, relating to various formal and informal means of technology transfer. It also stresses the importance of wider industrial development and its impact on the effectiveness of the technology transfer activities.

Section 6.3 examines the outcome of the experiences of Saudi Aramco and SABIC in technology transfer. This is done in relation to technological learning, technological capabilities and the contribution to the Saudi oil and petrochemical industry. It distinguishes technological capabilities at the firm level from those at the national level, highlighting the gap between the technological capabilities of individual firms like Aramco and SABIC for innovating oil and petrochemical technologies in Saudi Arabia.

In light of the two cases, section 6.3 seeks to examine the links between players involved in technological activities and the incentives to explore technological opportunities and engage in technological learning, ultimately to build up the technological capabilities of these companies. This section explores how Aramco and SABIC enabled new links to be developed between technology R&D institutions for adopting technological changes.

Section 6.4 draws the survey analysis in the preceding sections together in order to reach concluding points. In particular, it seeks to answer the research questions raised in chapter 1, relating to indigenous industrial development of Saudi Arabia, driven by oil and petrochemical technological development. It also discusses the scope for local participation in technological development, and how this strategy has worked in different circumstances for Saudi industrial development.

6.1 Technology absorption in Saudi Arabia

This study has shown how Saudi oil and petrochemical development has successfully utilised advanced foreign technology through technology transfer to fulfill national objectives in both technological and economic development. In less than thirty years, the Kingdom has managed to expand its oil and petrochemical capacity. It has also modernized its plants with high technology systems. At the same time, Saudi Arabia has built up oil and petrochemical technological capabilities not only in production, operation, maintenance, but also in innovation of new technological knowledge.

As noted in the theoretical critique of Chapter 2, technological learning is the means by which technological capabilities are created. This section analyses how technological learning took place in the two cases. It looks to the means of technological learning, i.e. formal learning activities and informal technological information flows. It explores the importance of involving a wide range and number of players in technological learning, and the different roles that technology manufacturers, designers, users and suppliers can play in technological learning. In addition, the discussion emphasizes the importance of the wider social and economic environment in encouraging technological learning activities

To a large extent, this study has found that Saudi technology transfer from abroad has been effective in respect of the acquisition of technological capabilities. The oil and petrochemical technology transfer process has provided avenues for technological information inflows and a wide range of means for technological learning. This also indirectly provides the basis for technology cooperation and technological learning by using, operating, producing, adapting, designing, creating and innovating to achieve accumulation of indigenous technological capabilities. The study highlights the importance of informal as well as formal links and knowledge. Chapters 4 and 5 discussed the close relationships between technology transfer, sharing and technological development through learning. The findings verify the presumption indicated in Chapter 3 that technology transfer is necessary for Saudi industry to build up absorptive capabilities for progression towards indigenisation. The key for ultimately acquiring technological competencies is to select and adapt imported technology.

In respect of the concept of technological capabilities, distinctions have been drawn between the capabilities of production, operation, maintenance, resource allocation and marketing management and the capabilities of innovation and technological capabilities at basic and advanced levels. The initial presumption prioritised the advanced technological capabilities of innovation. The two case studies demonstrate the pressing need of developing and strengthening basic technological capabilities. These are two reasons for this: firstly, basic technological capabilities create the basis for wider advances in economic growth and provide the foundation for the development of more advanced technological capabilities; for example, through the effective use of foreign advanced technological competencies. The fact is that in most Saudi industries these capabilities in general are weak. And this is particularly true for individual firms that lack these basic capabilities. Secondly, the development of basic technological capabilities requires mass involvement in technological learning.

The findings of this study confirm that in Saudi industry, technological capability at the national level can be much stronger than that at the level of the firm, and it depends on effective technological collaboration between organizations. For example, only SABIC and Aramco have sizeable R&D capacity and, having cooperated with R&D institutes, they can develop and produce more petrochemical processes. This highlights one of the major issues of this study, the role of institutional linkages and government policies in supporting technological cooperation and in fully utilizing existing technological competencies across the country.

There is in principle a range of strategies available for Saudi industry to adopt, in accordance with domestic requirements and existing technological capabilities and external opportunities. The cases studies demonstrate how different strategies have been successfully applied in Saudi technology. The survey analyzed and compared the two strategies presented by the cases of SABIC and Saudi Aramco.

6.1.1 Technological capabilities and development

Saudi Arabia, as with most developing countries, lacks technological resources. However, while making this comparison at the national and the firm level, this study shows that the country as a whole acquired considerable technological capabilities not only in production, operation and services, but also in innovation.

This study distinguishes basic level technological capabilities, such as, production, operation, maintenance, marketing and resource allocation, from the higher-level capabilities of innovating new technologies. It also stresses differences in technological capabilities between the firm level and the national level. The two case studies demonstrate that:

- both companies now possess a wide range of technological capabilities, from production, operation and maintenance

- as shown by the survey responses, both SABIC and Aramco have sought to master new technologies to improve production and revenues

- both companies' technological activities, such as technology adaptation, domestication of component production, were selectively chosen, in order to pursue their benefits

- learning of managerial methods was not a simple copying of processes as the companies developed a style of management between partners and local suppliers through which they achieved high productivity from involvement in technological learning and collaboration

- the concept of an innovative system conveys an image of a process that is systematic, ordered and stable.

The findings of this study point to the nature of Saudi industrial transactions, suggesting that it is helpful to search for the best model of the nation's system to promote innovation in changing Saudi industrial and technological development. Just as important, there may be no single best national system for the country as a whole, not just because of regional differences, but also because the features of different national systems of innovation for different industries and different technologies may well need to be different. The findings from this study indicate that there are differences between firm level and national level in terms of technological capabilities.

In light of both case studies, this study shows that both companies have obtained considerable technological capabilities in a range of areas from production, engineering, operation, marketing, management, to services. Acquisition of technological capabilities needed to produce technologies. These capabilities are associated with not only a few extremely highly skilled and creative engineers and technologists, but rather involve a wide range of players including technological specialists. Development of technological capabilities in production, operation and services in Aramco and SABIC as a whole have been successful, via advanced technology transfer from industrialised countries and in particular, joint venture technology transfer. In the case of Aramco, production capacity had expanded rapidly, from 1980 to 2002, during twenty years of production (Sections 4.3.1 and 5.3.1). Production capabilities have also been gradually established and upgraded. As was seen in both case studies in chapters 4 and 5, the technology was good, especially in production, quality and production management. Since 1985, SABIC and Aramco's production capacity had been increasing rapidly compared to its designed annual capacity (Table 4.9.5). SABIC's actual output in 1989, 1995, 2000, 2002, has produced ten times more than what was anticipated.[1] With average growth of 1.3 million metric tons per year this is an impressive growth.[2] Furthermore, production volume continued to increase at about 32% per year.[3] According to the

SABIC plan, at the end of 2005, after the completion of new expansions, the annual production volume will be 47 million metric tons.[4] As has been explained in chapter 5, SABIC expects to be one of the largest petrochemical producers in the world by that time. This study demonstrates that the firms involved in both case studies have capabilities such as marketing, including recognition or the importance of users requirements, production, management and an understanding of all human resource issued.

6.1.2 Learning methods adopted by Saudi Aramco and SABIC

Technological learning took place in both case studies. The range of learning activities includes formally organized learning such as staff and employee training courses arranged by both companies to obtain technological competencies, training and technical assistance from experts and management participation. Through these formalized means, the engineers in the companies have systematically obtained skills for manufacturing, installation and maintenance, as well as engineering technologies.

Advanced managerial methods and values were also introduced to the engineers. This helped both Saudi Aramco and SABIC to develop their own strategies, policies, resource allocation and management. It allowed their affiliates to achieve high productivity. As production quality is one of the most common problems in the industry, the help of foreign technology and specialists to gradually achieve production quality at world levels was critical. This study has found that new technology allowed Aramco and SABIC to cut cost. At the moment Aramco invests more in improving the success of exploration, in new ways to image oil and gas reservoirs, in improving drilling technology, in automating plants and equipments, and in implementing manufacturing processes.

Technological learning has been widely spread through both informal and formal channels. This study shows that learning is the responsibility of everybody in the company. In order to achieve this, Aramco and SABIC have a number of techniques and tools that help to promote learning. The companies have established their own R&D centres and cooperation with universities in order to provide the means for transfer of technological information across the companies. Many of the engineers and researchers who gathered at the company, later returned to their original department, and thereafter, used their knowledge to carry out technological projects. Some of them also contributed to the improvement of technology when they were involved in technical approval.

Informal and formal learning activities in Aramco and SABIC have taken place at almost all levels, involving not only those involved indirectly in technology transfer and development projects, but also via installation engineering teams (Questions 3.08 and 6.03). Achievement of company production capabilities have required the involvement of a wide range of players within the company to inculcate not only understanding of manufacturing processes but also wider recognition of the importance of industry.

As noted in chapter 3, a supportive industry and economic environment is crucial in providing incentives for technological learning. Without it, even formalized technological learning may be inefficient and incomplete. This was demonstrated in the cases of affiliates. Both Aramco and SABIC have sought cooperation opportunities in technological learning to improve their technological capabilities. The case studies of the two companies show the importance of technological learning through which the Saudi firms could adapt foreign advanced technologies and create indigenous systems. Four elements are essential in this process.

First, formalized means are needed e.g. technological training operating with technical assistance

Second, technological learning through the market to compare different products and therefore learn what quality can be expected

Third, mass involvement in technological learning is crucial, particularly for improving technological capabilities in operation and production

Fourth, a supportive environment is crucial for technological learning.

Oil and petrochemical companies are famous for applying and adapting existing technology to their needs. Aramco and SABIC like other leading companies have adopted this approach. Table 6.1 provides a summary of what has so far been attained in Aramco and SABIC in the transfer and implementation of new technology. A good example of this transfer is the work on automated process controls that monitor safety, efficiency and plant operations. To meet these business goals, Saudi Aramco has established a strategy based on good corporate citizenship, a principle that guides the business to invest only in those technologies which contribute to regulatory compliance in all respects. Good examples are emissions controls, industrial wastewater treatment and bioremediation. Table 6.1 also highlights that Saudi Aramco and SABIC are dependent mainly on contractors in building new plants and maintenance. However, the table indicates the weaknesses of both companies and the need to develop their own technology with more national participation in these two areas.

Table 6.1 Summary of the extent of technology transfer in Aramco and SABIC

Industrial sectors	Aramco SABIC ownership	Aramco SABIC participation in operation	Contractors	National participation (Saudisation)	Technology and know-how
Upstream operation (Aramco):					
- Oil exploration	**100%**	**100%**	**Mainly foreigners**	**67%**	**Still foreigners**
- Oil production	**100%**	**100%**	**Mainly foreigners**	**70%**	**Still foreigners**
- Oil operation	**100%**	**100%**	**Mainly foreigners -**	**75%**	**Still foreigners**
-Gas operation	**100%**	**100%**	**Mainly foreigners**	**75%**	**Still foreigners**
- Crude transportation:					
- Pipeline network	**100%**	**100%**	**Mainly local**	**78%**	**Mainly foreigners**
- Tanker fleet of crude oil	**55%**	**65%**	**Mainly foreigners**	**65%**	**Foreigners**
Down stream operation (Aramco):					
- Refining:					
- Local refineries (in KSA)	**100%**	**100%**	**Foreigners**	**86%**	**Foreigners**
- Export refineries (in KSA)	**50/50 jv**	**50/50 jv**	**Foreigners**	**84%**	**Foreigners**
- Domestic marketing distribution	**100%**	**100%**	**Foreigners**	**90%**	**Mainly foreigners**
- International marketing distribution	**100%**	**100%**	**Foreigners**	**70%**	**Still foreigners**
Petrochemicals (SABIC):					
- First generation plants (1980s)	**50/50jv**	**50/50%jv**	**Foreigners**	**74%**	**Still foreigners**
- Second generation plants (1990s)	**100%**	**100%**	**Mainly foreign**	**74%**	**Foreigners**

Sources: Saudi Aramco annual review 1995-2002 and SABIC annual reports 1990-2002

However the companies, as discussed in chapters 4 and 5, have been successful in national participation through education and training. Aramco shows more success in Saudisation of most oil sectors achieving close to 90%. SABIC's success in Saudisation is close to 80%. Table 6.1 also highlights the fact that technology and know-how are still dominated by foreigners in Aramco and SABIC. This confirms the need of both companies to consider long term planning in research and development (discussed further in section 6.2).

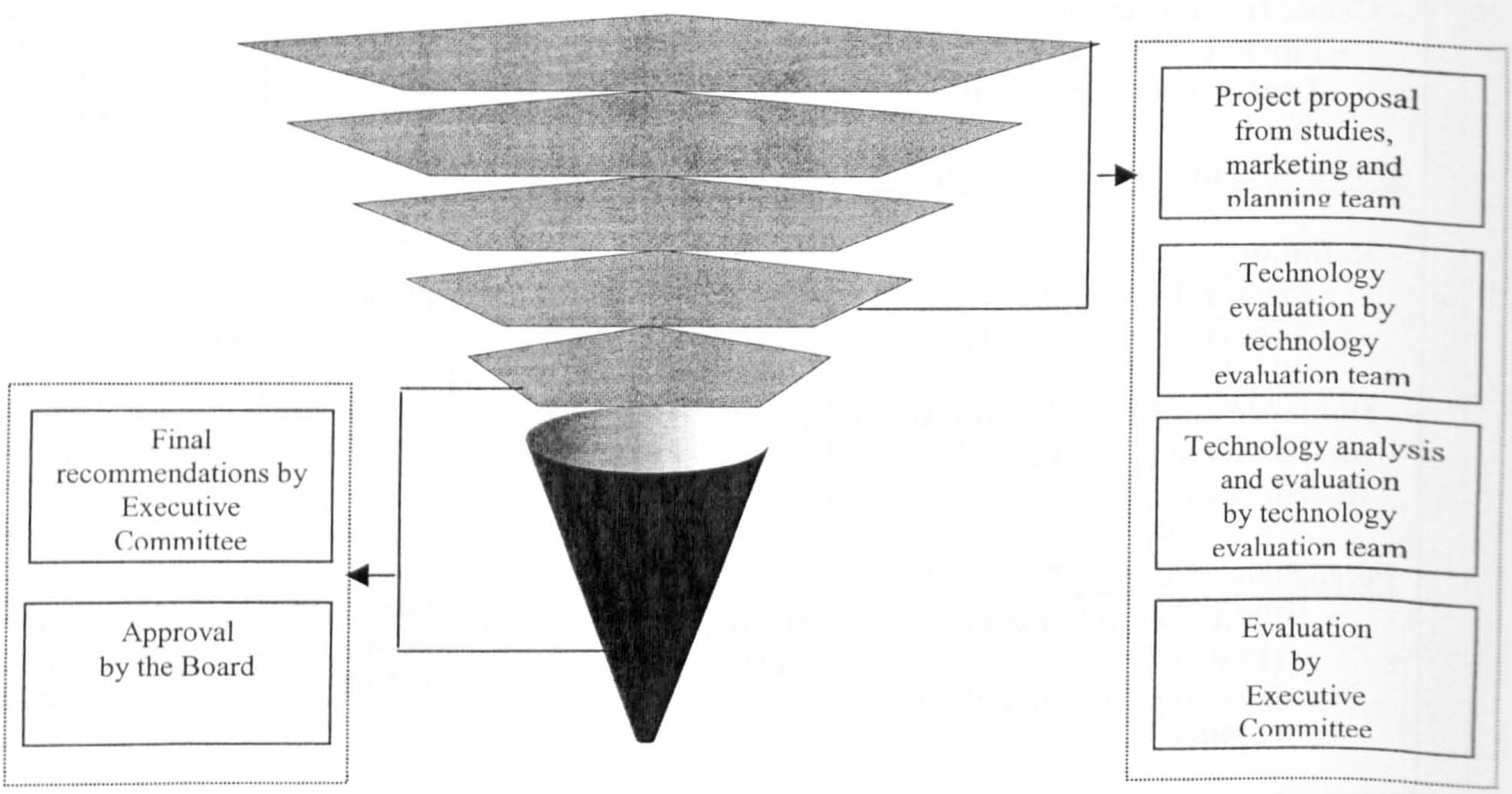
6.1.3 Elements of technology evaluation and selection

While Aramco and SABIC apply similar methods in technology search and selection for most projects, whether oil or petrochemical, the relative procedures remain as:

- Selection of licensor
- Evaluation of technology
- Revision of terms and conditions for technology licensing
- Engineering
- Construction process
- Operation

Figure 6.1 demonstrates the technology evaluation and selection procedures in Aramco and SABIC as follows:

Figure 6.1 Technology evaluation and selection procedures in Aramco and SABIC



The procedure applied by Aramco and SABIC for technology evaluation can be summarized as follows:

- Studies, marketing and planning team of the company conducts research to determine the suitability of the proposed product

- Recommendation by the technology evaluation team of the proposal prepared by the marketing and planning team is sought and a detailed questionnaire is sent to the prospective licensors regarding their specific technology

- technology evaluation team then analyzes the responses of prospective licensors and makes recommendations

- the Technology evaluation team members make inspection tours of the technology and its ramifications.

This process, which takes as long as nine months, finally comes to an end with the recommendation of the technologies to be licensed. Technical, economic, legal and marketing considerations are the four primary important elements from the data collected during visits and meetings with the technology supplier. Technical considerations contain information regarding product quality, commercial viability, complexity, reliability, flexibility, environmental impact and safety and security considerations.

Economic considerations mainly relate to the cost of the license/services provided by the licensor including initial cost, cost of expansion, plant cost and production cost. Scope of grant, right of use, selling rights, scope of indemnity, guarantees and applicable law mostly form the legal considerations.

Marketing considerations comprise quality of product range, market possibility, area limitations and technical services back up and market presence for product distribution. With these methods gleaned from the questionnaire appended as Appendix 1 which was sent to the companies and other affiliates of the two case-study organizations indicated in Appendix 2, Saudi Aramco and SABIC have been able to transfer technology directly from licensors to their industrial complexes. In the survey, SABIC considers importation of technology to suit customers needs and conditions as the most important factor in its decision making process. Table 6.2 lists the six criteria for selection of technology that were reflected in the answers received from SABIC and Saudi Aramco affiliates listed in Appendix 1 and 2.

Table 6.2 Saudi Aramco and SABIC: factors in the selection of new technology

	Not Important	Slightly Important	Very Important	Not Applicable	Highest % response	
					Aramco	SABIC
Financial condition		A	S		76	75
Contract condition			A/S		75	74
Mode of payment & facilities		A	S		85	72
Complexity of technology		S	A		70	78
Reputation of supplier		A	S		68	76
Latest & proven technology			A/S		75	70
% Response to Question 4.05					68	72

Note: A = Saudi Aramco S = SABIC A/S = Saudi Aramco and SABIC

Petrochemical plants emphasize the need for the latest and proven technology and the reputation of the supplier as the first priority when it comes to the selection of new technology. Whereas the refineries, in Aramco, place more focus on the financial condition to be considered in the selection of technology. Differences in the criteria of selection technology for petrochemical plants and refineries are mainly because of the nature of industries where petrochemical industries need to consider the world market competitive conditions through using the latest technology and reputation of the supplier.

In the area of technology selection most of the answers from the affiliates of SABIC and Aramco demonstrate that both companies depend heavily on partner recommendations.

Table 6.3 Technology selection in Aramco and SABIC

Technology selection by :	Highest % response	
	Aramco	SABIC
- Chairman of the firm - Foreign consulting companies - Local consulting companies - Your own technical committee A S - Educational institutions - Others.	76	70
% Response to question 4.03	68	65

A = Aramco S = SABIC

The responses indicate that Aramco and SABIC may be constrained in developing criteria to select and evaluate technology. They still need outside sources to develop recommendations about technology selection. This weakness is clearly confirmed in Table 6.3 where most of the answers confirmed the use of the company technical committeesfor selection of technologies. Some answers to this question mentioned foreign consulting companies

However, in most cases, these committees practically depend on foreign consultant and partner recommendations that leave very little choice for the companies own decisions. As such, Saudi Aramco and SABIC need to consider developing their own capability for evaluation and selection of technology. **Since all answers have not mentioned their capabilities in technology selection,** the survey confirms some weaknesses, which affect mainly the technology transfer process and technological learning.

6.1.4 Types of technology transaction and technological learning

As discussed in chapter 2, the nature of imported technology and the type of technology transaction together determine both the availability technological competencies embodied in imported technologies and the scope for local shaping of these imported technologies. Aramco and SABIC use different strategies for utilizing foreign advanced technology to meet domestic requirements. This includes selecting a different range and type of technology, e.g. between 'oil industry' and 'petrochemical industry'.

This section compares the two strategies: the one involved in transferring a comprehensive package of technology; the other involving purchase of standardized technologies. This section analyses the weaknesses and strengths of these different strategies, examining how these strategies have helped to develop technological capabilities and meet companies' requirements. The two case studies demonstrate how to exploit foreign advanced technologies. However, these cases are very different in the following respects:

First, from the theoretical framework developed, this study shows that these two companies have different strategic characteristics. SABIC's strategy can be characterized as technology transfer that is subject to local configuration. Aramco industry, by contrast, involves a wide range of foreign technology, which has been configured into a particular architecture before being transferred to the company. This adaption and maintenance of technological knowledge reflects their respective technological competencies, which have been accumulated over time.

Second, the two case studies have adopted similar technology transfer transactions in a turnkey project approach, which includes the manufacturing and engineering, as well as the skills of management. A highly formal and carefully planned process of technology transfer was adopted to ensure the transfer of all the skills needed to create productive capability.

Wholesale technology transfer provides access to a wide range of technological capabilities spanning from knowledge to production and management techniques. It provides much better means for the companies to gain access to advanced foreign technologies, which was carefully planned, negotiated and formalized in a written contract.

This study, on the other hand, found that the wholesale technology transaction 'model' allowed very limited technology innovating capacities. As shown in Table 6.4, the form and channel of technology transfer used in SABIC and Saudi Aramco show that there has been little participation from the affiliates.

Table 6.4 Forms and channels through which technology has been transferred to Aramco and SABIC

	Not Important	Slightly Important	Very Important	Not Applicable	Highest % response: Aramco	Highest % response: SAB
Technology supply		S	A		73	70
Machinery supply				A/S	80	70
Education		A/S			56	72
Training			S/A		80	75
License agreements			A/S		86	80
Turnkey contracts			S/A		85	87
Direct foreign investment		A			64	76
Employment of foreign experts		A	S		74	75
Joint venture		A	S		65	85
Technical assistance/consultants		A/S			70	76
Management participation					75	76
% Response to question 4.02					55	71

Note : A = Aramco S = SABIC

The two companies under consideration mostly use turnkey contracts as the most important channel of transfer followed by license agreements. Aramco has limited uses of technology transfer through joint ventures. In the two case studies, the turnkey approach may limit company participation and may affect the level of employee learning.

It may be useful for SABIC and Aramco to complete the project on time; however from a learning point of view, both companies should consider implementing new strategies whereby they allow more Saudis to be involved in the projects from an early stage. One of the most important areas in technology transfer, which oil and petrochemical companies should consider, is the design of the plant. However, the survey indicates that most of the SABIC and Aramco affiliates depended heavily on foreign consulting companies or on firms who supply the technology. Only two companies indicated that they have some participation from their own engineering departments.

Designing the plant is an important stage where the company should give consideration to a detailed designing and engineering study. The survey clearly highlights that the process and policy of the two companies need to be evaluated and revised to raise national participation in the early stage of designing the plant. **This is because early involvement of Saudis will provide a greater opportunity for**

learning about the characteristics of technology, its use and its appropriateness to local conditions. This is one of the most important findings of the study.

6.1.5 Partners and joint venture cooperation

In chapter 3, this study argued that oil resources and economic stability in the Kingdom have given Aramco and SABIC a great boost in their direct contacts with well known foreign oil companies. These relations created confidence with foreign companies. The results are that joint venture cooperation focused on developing successful long-term partnerships. This has benefited the Kingdom immensely, mainly in the areas of technology transfer and know how. This study clearly shows that the methods adopted by SABIC in selecting joint venture partners impose strict terms and conditions on their partners to train Saudi youths operate SABIC's factories in the future.

Another reason behind the success of technology transfer in both companies has regard to the rules governing time schedules and the strict deadlines they set for all projects. This covers the provisions in the agreements with the technology providing companies regarding the complete and successful implementation of technology transfer, as well as the passing of knowledge to Saudi nationals. Both companies have successfully built plants with the latest technologies in very short periods using the turnkey approach, where the contractor builds the plant, passing it to locals only at the time of start-up.

Table 6.5 indicates that for SABIC and Aramco, as with other oil and petrochemical companies in the world, is accorded a high priority. A high level of responses from both companies supported this view.

Table 6.5 Continuous innovations plays a major role in generating revenue

	Highest % response	
	Aramco	SAB IC
In the company, does continuous innovation plays a major role in generating revenue	Yes	Yes
% Response to question 3.01	62	68

However, in the response to question 3.02 in Table 6.6, more than 90% of the answers indicate that innovations originate from another country. Few answers indicate that innovations have originated within their own firms without any foreign involvement.

All SABIC and all Aramco affiliates, in sections B and C in Table 6.6, confirm that the source of most innovations came through joint venture partners mainly from the United States of America. This shows strong and deep-rooted domination by

American technology and American investment in both oil and petrochemical industries in Saudi Arabia.

Table 6.6 Sources of innovation for Aramco and SABIC

In the last five years, did the company introduce a new product or service, or did it substantially change its method of production?	Highest % response	
	Aramco	SAB IC
A - If yes, this innovation originated from - Within the firm A S - Another source in your country %. - Another country	Yes 65	Yes 78
B - If the innovation was from another country, which of the following was involved? - It was part of foreign direct investment operation A S - You obtained a license or otherwise compensated foreign company for the innovation - It was a direct import of foreign machinery, equipment or technology with no further contact - You simply adapted the innovation to your needs, with none of the above	76	78
C - Please specify the country source of most innovation whether licensed or through joint venture partnership: the company source of most innovation / through licensed / thorough JV partnership - USA AS A S - EU - Japan - Other …………	60	70
% Response to question 3.02	65	75

Note : A = Aramco S = SABIC AS = Aramco and SABIC

All answers from SABIC and Aramco affiliates strongly suggest joint ventures are an important source of obtaining and transferring new technology. The survey clearly identifies that SABIC and Aramco mainly depend on the joint venture approach as the method of technology transfer. This method has been very successfully implemented in the early plants. The main attraction for partners to work with SABIC and Aramco in joint ventures at that time was mainly the availability of raw materials and financial flexibility.

Table 6.7 Advantages to partner companies from JVs

Advantages to Aramco and SABIC	Advantages to foreigner partners:
• State -of –the- art technology producing high quality products • economies of scale • establishing modern production and marketing operations • conducting systematic training for management and labour • serving vital development objectives of the host country.	• Free access to competitively priced feedstock • entry into protected markets of partners, specially EC, NAFTA and Japan • an alternative to costly acquisition • meet more closely customer needs and services.

Table 6.7 lists the joint venture advantages for Saudi Aramco and SABIC and their partners. From this table, and the discussions in chapters 4 and 5, this study confirms that JVs are suitable for the oil and petrochemical industries. JV arrangements have offered Aramco and SABIC an important mechanism for the transfer of technology and technical know-how. Partners in these joints ventures have been able to achieve the following:

1. Allowing partners to share the risk of large investment and the benefits of economies of scale

2. allowing restructuring among partners during cyclical production surpluses, which are endemic to the industry

3. saving transportation and shipment costs

4. providing the necessary funds for building new capacity.

Based on the discussions in chapter 3, the Saudi joint venture experience has revealed the vital role which JVs played in the development and growth of Saudi industry. It shows that the Americans have been by far the most important JV partners in the Kingdom. This is not surprising, because the oil and petrochemical industry in the Kingdom has been historically dominated by pioneering American firms. Box 6.1 addresses SABIC's model in joint ventures with foreign partners. It shows that joint ventures are mutually agreed upon arrangements to share capital, resources, feedstock, management skills and marketing expertise.

Box 6.1 Characteristics of SABIC's joint venture model

- Setting up an independent company to run the business
- Production is shared according to an agreed formula
- Each partner markets his share with the joint venture acting as profit centre
- Profits are distributed according to equity shares
- Expansions are financed from profits according to an agreed formula.

Sources: SABIC's joint venture agreements, internal summary, 1990

However, in recent years, SABIC and Saudi Aramco started using different methods of technology transfer to implement the creation of new plants with 100% ownership, using the turnkey approach and license agreements. The result of this change has affected the cost of construction and also the profitability of the plant. SABIC and Aramco can easily use this approach because they have knowledge and expertise about sources of technology, project management and contracting.

In the area of human resource development with partners and in examining early annual reports of the affiliates of SABIC and Aramco, this study shows that large expatriate work forces from partner firms were involved in operations and management.

Affiliates now have few expatriates in management and operation. Between 80 to 90% of expatriate jobs have now been transferred to Saudis. An example of this change is SHARQ, a joint venture between SABIC and Mitsubishi, which started operations in the early 80s with a 300 Japanese work force, but today has only 2 Japanese workers.[5] Evidently, the Saudisation policy as applied to the Aramco and SABIC affiliates, as discussed in Chapters 4 and 5, have been successful in SABIC and Aramco. Both SABIC and Aramco, have achieved between 75% and 80% Saudisation in most of their plants.

The success of SABIC in human resources development can be also confirmed in a recent study by the European Chemical News, which examined the top world petrochemical performers based on the Reed survey. Table 6.8 shows SABIC's labour productivity among other world largest companies. In this study, SABIC ranked 16 in sales, 13 in profits and scored the top rank in sales per employee and enjoyed the highest capital intensity per employee, exceeding the 2nd best DOW by almost two fold.

Table 6.8 SABIC ranking in sales, profits and assets per employee

Company	Sales / Employees (000) $	Profits / Employees (000) $	Assets/Employees (000) $
Lyondell Chemical	2331	(30)	2031
MITSUI Chemical	559	4.5	761
SABIC	536	33.1	1661
Dow Chemical	528	(7.3)	674
Mitsubishi Chemical	347	(8.8)	438
Bayer	330	7	282
Du Pont	321	54.5	510
BASF	313	56	355
Solvay	264	12.2	333
I C I	242	5	237
Degussa	216	7	302
AKZO Nobel	189	9	174

Sources: European Chemical News, April 2003

6.1.6 Revision of SABIC and Aramco models of technology license agreements

Technology licensing is the most common form of technology transfer vehicle. Discussed in section 2.3.6, the survey aimed to find if there is an article in the licensed agreements, which requires the supplier to provide different requirements, (see Tables 6.9 and 6.10). The response of the affiliates, from both SABIC and Aramco, confirms that education, training and technical services are the most important applications provided by the licensor.

Table 6.9 Obligations in technology license agreements

In the company, is there any article in the technology license agreement, which obligates the supplier to provide the following?	Highest % response	
	Aramco	SABIC
Education courses	No	No
Training services	Yes	Yes
Components and parts	No	No
Specialized technical services	No	No
Transfer some technical instructions	No	No
Specialized research	No	No
Local participation in R & D	No	No
Local participation in design & construction	No	No
Local participation in management	No	No
% Response to question 5.01	62	74

However, most companies have not participated in design and construction of the plants, thereby depriving themselves of the important opportunity to make insights into the design and construction process of a new project. With the obvious intention of protecting its stock of valuable technical knowledge and know how, at times, the technology suppliers prefer to appoint their own top management staff, especially if the licensee is in a joint venture partnership with the technology supplier. The supplier by using its own expatriate staff in the highest technical and engineering positions, can protect its market position in the face of competition from other firms, limiting the diffusion of its know how.

Table 6.10 Restrictions in license agreements

Did the license agreement restrict the use of?	Highest% response	
	Aramco	SAB IC
Local Material Resources	No	No
Outside Material Resources	No	No
Local Machines & Equipment	No	No
Outside Machines & Equipment	No	No
Development of Machines & Equipment	Yes	Yes
Local Manpower	No	No
Local Market	No	No
Regional Market	No	No
Outside Market	No	No
% Response to question 5.02	65	75

The results of Table 6.10 is a clear reflection of the supplier's intention of maintaining control over foreign operations, relating to everything affecting the technology and its application. It is imperative that in order to ensure the correct implementation of technology transfer on a long term basis, there is a need to hire a greater proportion of local staff at all levels. This involves pride and accomplishment in being part of a domestic organisation which is laying a solid foundation for the nation's economic and social advancement.

The findings of this study on national participation in the stage of engineering and construction, emphasizes the need for SABIC and Aramco to revise their models of technical license agreements to include more national participation in engineering, designing and also in R&D. It is important for the two companies and their affiliates to strengthen their position in the technology transfer process. For SABIC and its affiliates and for some products, SABIC should also develop new methods in the negotiation process with the technology licensor in order to reduce limitations in market share, mainly in highly specialized products where SABIC can have more flexibility in the market area. This is because SABIC and Aramco need to develop new plants to produce new products to support their positions in the international market. Nothing has been found in the questionnaire about limitations in the market share for most of SABIC and Aramco products because most of these products are considered as raw materials and commodities and have no restrictions in market share.

6.2 National human resources development to absorb and learn new technology

This study found that Saudi Arabia has successfully developed 5-year plans since 1970, with a special emphasis in these plans on the development of national human resources. As presented in chapter 3, these plans considered national human development as the most important part of this programmes. The vision was encouraged by the Saudi Government to develop and expand the educational infrastructure, including schools, technical and vocational training and higher educational institutes, college universities.

This study also found that the Kingdom, from the beginning, faced a difficult task in educating its nationals. Therefore, Saudi Arabia decided to send Saudi nationals abroad, mainly to the USA and Europe to pursue studies in different areas and fields such as engineering, science, technology, management and finance. Aramco and SABIC stand ahead as pioneering firms which implemented and developed close cooperation with the USA and European countries to educate and train their employees. During that time, Aramco and SABIC were implementing sophisticated project developments through technical cooperation and direct joint ventures with large oil companies such as Exxon Mobil, Shell and other well-known international oil producers. This vision allowed the Saudi oil and petrochemical industries to develop and gain a prominent place amongst the world's producing countries.

In the beginning the two case study companies faced problems in finding enough Saudi nationals willing to join these programmes, because they were new and also because both companies operated in remote areas away from the main cities. This required implementation of motivation programmes to attract Saudi nationals and hence both companies were able to attract a reasonable percentage of Saudis to join in the initial stages. This study found differences between Aramco and SABIC in their respective human resources development programmes:

1. Aramco successfully developed long programmes with the universities in the Kingdom as well as universities in the USA and Europe

2. SABIC, by contrast, selected short programmes to develop its human resources by sending them to its partners to work and gain experience in similar plants in the USA, Europe and Japan

3. During this time SABIC and its partners finalized the construction of new plants and when the plants were ready for operation, normally 2-3 years, the

employees under training in partner facilities were ready to take charge of the new plants in the Kingdom

4. Aramco and SABIC sought to engage their employees in similar partners plants to get them familiar with the engineering and construction aspects.

These programmes have been the main source of qualified employees in Aramco and SABIC. The approach is arguably a good strategy to be considered in the development of human resources for other Saudi companies. **However, the recruitment of foreign employees by the contractors to carry out all the early work in turnkey projects is a minus point, because it deprives Saudi nationals of participation in building and construction work.**

Human resources, as was discussed in sections 4.4.7 and 5.3.7 are important elements in technology transfer. Recruitment and training of Saudi nationals to perform at high levels of skill by acquiring technology is one of the most important aspects of technology transfer as the organization takes in more locals. According to the industry involved, the skills of the work force, and also the qualifications required for the job, training policies can take different forms. When the skill levels of the technical and administrative hierarchy become higher, the recruiting and training become more difficult and complex. These positions suffer scarcity in most developing countries due to the inadequacy of local education systems to produce efficiently the talent industry requires.

Aramco and SABIC depend heavily on expatriate workers in spite of the heavy cost involved in recruitments. This is due to the better salaries offered and the cost of moving them and their families to the employer country, for periods ranging from 2 to 5 years until the local recruits are ready to take over.

Most SABIC projects begin the training of local personnel immediately after the technology is acquired. With the help of training staff provided by the technology supplier, SABIC avoids hiring expatriate workers on excessive salaries in the initial periods of project start-ups. Instead SABIC makes every effort to upgrade employee knowledge by placing emphasis on technical personnel, providing them with on-the-job practical training, thereby helping projects to advance with new techniques and products. The two options available to the licensee in the training of its staff are, either to send them to the technology supplier or to allow them to attend training courses in local training centres outside the company with more emphasis on English language familiarization.

Table 6.11 Company interest in absorbing new technology

	Highest% response	
	Aramco	SABIC
People in the company are aggressive in absorbing new technology world's best	Yes	Yes
response to question 8.03	62	74

As shown in Table 6.11 the two companies (SABIC and Saudi Aramco) confirm their aggressive approach in absorbing best new technology in the world. This approach is due to the fact that oil and petrochemical industry needs to obtain the best new technological inventions in the world to improve and maintain high standards of production capability and the quality of production to meet the ever increasing demand for high quality product, which is not possible without the best new technology.

Responses to Question 8.03 in the questionnaire are shown in Table 6.11. It highlights the way SABIC and Aramco provide their employees with opportunities to observe technology developments and to gain professional skills. The questions also measure the investment of SABIC and Aramco affiliates in the areas of recruitment and training to motivate people to learn. The response of most of the companies show the success of both SABIC and Aramco in attracting highly skilled people, training them are educating them in the latest technology. However, geographically, the three companies from Yanbu area in the West of Saudi Arabia are far behind the other regions in the area of training and development.

Arguably, the reason for this is the location of these plants which are far away from the main operational headquarters of both SABIC and Aramco. This study confirms that it may be the responsibility of the management of these companies to consider training as an important element in human resource development strategies. As detailed in chapters 4 and 5, both SABIC and Aramco invest heavily in human resource development mainly in training. However, in the Yanbu area the companies should make a concerted effort to benefit from the human resource training and develop strategies to ensure that all employees are exposed to these training programmes acquiring the required skills equal to their colleagues in other parts of the country.

Two other areas of concern highlighted in the survey are about cooperation strategies and coordination with the corporate departments. Responses suggest that there is a lack of strategy cooperation and information. Therefore, SABIC and Aramco corporate strategy departments should consider detailed and clear strategies for all affiliates, developing a simple process to help affiliates in developing their own strategies. Company management should also consider wider participation of employees, and communicate clearly with them the details about corporate strategy.

This study also confirms that the two case study companies need to develop training programmes about corporate strategy and its implementation.

Another area which this study's survey highlights concerns individuals who have no knowledge whatsoever about corporate activities in the R&D field. This places a responsibility on SABIC and Aramco to develop a model for cooperation and communication with their affiliates, where they can enjoy involvement in corporate activities. Newsletters and conferences are good methods for both SABIC and Aramco to use for effective communications with their affiliates. The need is to encourage a flow of information between employees and companies to create a kind of technology group to facilitate communications between all affiliates in SABIC and Aramco.

6.2.1 Aramco and SABIC: Saudisation process and methodology

Aramco and SABIC have both pursued Saudisation policy enthusiastically. The only difference is on the methodology that they have followed. The points of differences are as follows:

- By taking advantage of the Saudi Government policy of developing national manpower to run the industry, SABIC devised a programme for high school graduates; orienting them at local institutes and sending them abroad to the partner's plants to get on-the-job training

- At the start of the 5th Five-year development plan, as discussed in chapter 3, the Saudi government was conscious of the problem of national manpower and to cope with the situation, the Saudi government put great emphasis on the development of a national cadre of local workers to operate industries envisaged to be developed in the Kingdom. Encouraged by government policy and patronage, SABIC took the lead in developing its own manpower to run its plants by hiring high school graduates, orienting them at local institutes and sending them abroad to partners plants to get the required training

- At the start, SABIC faced with a scarcity of required graduates, sought to attract graduates from Aramco and other industrial concerns.

This study shows that both SABIC and Aramco have successfully achieved high levels of Saudisation e.g. 80% during the last two years. This is an example of the success of their policy.

Responses to the survey have also identified that SABIC took both short and long-term steps to develop its own national manpower by hiring high school graduates, orienting them at the local institutes and sending them abroad at partner facilities to prepare them for running SABIC plants once they were complete. This crash programme of on-the-job training for its recruits at the partners' plants paid off and once the plants were ready for operation, the recruits were ready to run the plants. SABIC also devised long-term programmes to continually develop manpower needs.

This, they did, by sending employees to universities, institutes and other relevant institutions to prepare these employees to take up higher positions. As a result, SABIC achieved 75% Saudisation at its plants and this percentage is gradually increasing.

By contrast, Aramco has from the very beginning cultivated contacts with foreign partners, including oil giants like Shell and Exxon, who provided training facilities to Aramco employees. Aramco devised long-term programmes based on these contacts and sent employees for long periods to be fully equipped with the necessary skills required by Aramco to run its operations. As a result of this long-term programme, the Saudisation percentage reached more than 80%, as has been discussed in Chapter 4.

6.2.2 Principal technology sharing problems

The survey, especially question 6.02 (Table 6.12), has provided more detail about technology problems in production and operation. Two of SABIC's affiliates and one of Aramco's affiliates have listed several problems, mainly related to three areas, namely:

- quality of design,
- quality of manufacturing and
- quality of materials.

These problems have arisen principally because SABIC and Aramco plants are constructed and maintained by contractors. Both case studies indicate little involvement from their affiliates in these two important areas.

Table 6.12 Technology problems

	Highest% response	
	Aramco	SABIC
Has the firm faced any technology problems in production or operation?	Yes	Yes
% response to question 6.02	63	76

Non-participation in construction and maintenance activities in the two case study firms are due to the fact that:

1. construction and maintenance work mainly involves heavy labour forces

2. companies believe it is better to do both maintenance and plant construction through contractors not only because of the higher number of manpower required, but to save cost

3. the responsibility for completing the project on time lies with the contractor

4. these activities rest with project management, which is also done mostly through contractors.

Discussions undertaken in the fieldwork survey emphasize the need for both SABIC and Saudi Aramco to consider increasing their participation in construction and maintenance through promoting their own engineering and labours. This study recommends strong involvement from both companies because these two areas, construction and maintenance, are a great source of knowledge and expertise. They will add skills to SABIC engineers and labourers, as a part of the technology transfer objectives, discussed in chapter 2 (sections 2.1.2 and 2.2). Such involvement will help the company to limit technology transfer problems.

In the evaluation of the organization chart of both SABIC and Aramco in appendices 3 and 4, this study has noted that two activities (maintenance and construction) do not have important and clear positions in the organization charts. The focus in the organizational charts for both Aramco and SABIC is mainly on management, operations, sales, marketing and general services. The construction and maintenance functions in both SABIC and Aramco are so important that they should have strong representation in the organizational chart.

Most of the SABIC and Aramco affiliates have confirmed their experience of principal technology sharing problems that have arisen with foreign partnerships. And this confirms the importance of keeping close relations with partner firms and sharing with them the development of plants. This is important as can be seen by reference to Table 6.13 in the transfer of technology between the receiver and the provider.

Table 6.13 Case Study experience with regard to principal technology-sharing problems with foreign partners

	Highest% response	
	Aramco	SABIC
Did the firm experience any technology-sharing problems that have arisen with a foreign partner ?	Yes	Yes
response to question 6.03	66	70

Both receiver and provider of technology should honour their responsibilities in running the plants smoothly, providing all assistance, and helping to increase the transfer of learning skills to Saudi manpower. However, on the national level, the Saudi government should develop a technology transfer mechanism and criteria for local technology development based on an appropriate technology transfer model, as explained in chapter 1 (Figure 1.2). This model will provide Saudi industries with the opportunity to develop their own technology transfer process, to secure know-how and experience to be transferred to Saudis.

6.2.3 Importance of technology modification

In the area of important technology modifications, Table 6.14 indicates the success of SABIC and Aramco in such modifications based on the experience of their engineering teams. Modifications through innovation have created inventive products from ideas. For example, Aramco has developed a novel analytical tool for evaluating reservoir rock properties called POPI, which is now in the process of being commercialized.[6] This technology promises to be a powerful tool helping to reduce oil production costs.

Table 6.14 Existence of modifications of the imported technology in the company

	Highest% response	
	Aramco	SABIC
Please state whether there have been any modifications of the imported technology in the company?	Yes	Yes
response to question 6.01	61	73

However, the survey could not provide further examples of such achievements. As discussed in chapters 4 and 5, both SABIC and Aramco have exhibited successful technology development and modification processes in their plants. The list of Aramco and SABIC patents listed in chapters 4 and 5 confirms this fact. The survey aimed to discover an estimate of local participation in different areas, mainly in project designing, project construction, services, supervision, operation, inspection and research and development. The responses from most of SABIC and Aramco affiliates have shown very low local participation in these areas. However, few companies, mainly Aramco affiliates, showed high local participation in the areas of supervision and operation. **This study raises important questions about the responsibility of SABIC and Aramco in developing methods and models for local participation because this is a very crucial area that plays an important role in gaining experience, either directly or through local contractors.** The objectives are:

1. To increase the capability of local sources

2. To assist SABIC and Aramco to raise the quality and capability of national participation

3. At the national level the Saudi government should develop a system to encourage SABIC and Aramco to consider local participation in all areas of activity.

Question 7.06 (Table 6.15) highlights the degree in local participation in selected areas within the case study companies.

Table 6.15 Local participation in Aramco and SABIC projects

	(Participation)			Highest % responose	
	Low	Medium	High	Aramco	SABIC
Projects design		AS		65	60
Projects construction	AS			70	75
Principal services	AS			50	60
Supervision			AS	75	70
Operation			AS	80	70
Testing and inspection			AS	85	75
Research and development		AS		50	60
% response to question 7.06				57	72

NOTE : A = Aramco S = SABIC AS = Aramco and SABIC

Table 6.16 focused on the importance of the companies' efforts in 7 areas and rates the company's (Saudi Aramco and SABIC) position versus other companies. It shows that:

- Aramco and SABIC have different achievements as a result of following different methods of technology and management strategies
- one of SABIC affiliates highlighted strongly that its weak positions in the areas of skilled workers and services contrast with the quality of production which is equal to the best in the world. In the same area, Aramco affiliates have highlighted that they are equal to the best in the world
- most of the answers rank the companies' position high and or equal to the best in the world. Only two answers from two companies indicate that they are equal only to the best in the region
- the answers from all companies have different views regarding the position of technology, but most of them still believe that they are close to the best in the world. A number of answers from some companies indicate that they may have better technology than other companies.

Table 6.16 Relative position of Aramco and SABIC versus other companies

	Behind other local companies	Similar to other local companies	Equal to the best in the region	Equal to the best in the world	Highest % response	
					Aramco	SABIC
- Product design & quality				AS	80	74
- Manufacturing process				AS	80	79
- Safety			S	A	71	70
- Management		S	A		76	73
- Technology				AS	64	50
- Skilled workers			AS		70	65
- Services offered		S	A		75	76
% Response to question 1.08					62	74

NOTE : A = Aramco S = SABIC AS = Aramco and SABIC

The issue of technology-related goals is revealed by the answers to question 2.02 in the survey. They indicate that one of SABIC affiliates has difficulty with technology to achieve anticipated profits, production quality and capacities. The survey shows that this company was facing difficulties in achieving its goals in technology transfer due to the quality of technology not reaching required standards.

However, the same company rates its position in product design, quality and technology equal to the best in the world, while indicating a very low rating for skilled workers. The survey results (Aramco 62% and SABIC 69% response) suggest that:

1. this company was successful in the transfer of technology and hardware, but faced problems in transferring the knowledge and know-how to its workers

2. reflect the problems encountered a low level of skilled worker performance

3. this company also has difficulty in management and management strategies rather than the manufacturing process.

6.3 Innovation, R&D and company policy

Chapter 2 has already pointed out the increasing interest in innovation within technology studies, addressing the links between technological dynamism and institutional structures and incentives for innovation. The case studies analysis shows that state intervention has greatly contributed to oil and petrochemical technological development. The concept of innovation may be helpful for a country to catch up with technologically advanced and dynamic industries.

In the area of R&D facilities, the survey shows that SABIC has extensive experience with R&D. This could not have happened without the support of the joint venture partners to SABIC. SABIC has been very successful in developing good relations with partners in R&D. SABIC considers that all joint ventures and affiliates act as partners in R&D activities. Chapter 5, section 5.3.1, indicates that SABIC has developed agreements with all its partners to support R&D activities and using SABIC R&D centres for their needs in solving their technology problems. These agreements are cost-based on a percentage of total sales. Both SABIC and partners gain benefits from this deal. However, Saudi Aramco has not developed this kind of mechanism and has not learned the way of sharing with its partners in R&D, still depending on outside sources for R&D. Table 6.17 nevertheless shows that 62% of the Aramco and 74% of SABIC respondents possessed R&D facilities.

Table 6.17 Companies' R&D facilities

	Highest% response	
	Aramco	SABIC
Does the company have R&D facilities?	Yes	Yes
response to question 6.05	62	74

SABIC has had differing experiences with its partners in research and development, and has introduced strategies to invent and develop own-technologies. The cost is normally shared by SABIC and its partners. SABIC partners are fully confident of the capabilities of SABIC R&D centres in the following areas:

1. Solving problems such as sudden shut downs and interruptions in plants
2. provision of valuable technical assistance to all joint venture partners
3. joint technology development, yielding results neither group could have achieved alone.

Relations between SABIC and its partners in the R&D area should be evaluated and studied by Aramco, so as to benefit from this experience, because the development of joint ventures is the responsibility of both Aramco and its partners. This will direct Aramco in a more viable direction in developing close relations with its partners to develop their plants.

Table 6.18, details the responses from primarily question 3.07, **showing all SABIC and Aramco affiliates' annual expenditure on R&D is less than 10% of their total annual revenue.** This is a small investment in respect of the huge oil and petrochemical industry in the Kingdom, which needs to continue development of technology capability and introduce new products to enhance product quality and profit margins.

Table 6.18 Research and development in the companies

Conducting research and development R&D in the company	Highest % response	
	Aramco	SAB IC
A. Direct government subsidies to company Never occur	Never occurs	Never occurs
A. The company's annual expenditure on R&D, as a percentage of revenues - Less than 10% - 21-30% - 41-50% - 11-20% - 31-40% - greater than 51%	Less than 10%	Less than 10%
% Response to question 3.07	62	74

Discussion with respondents raises another issue in which both SABIC and Aramco need to cooperate; that investments in R&D for Saudi petrochemicals to increase natural resources in line with early government objectives to make better use of local natural resources (discussed in chapter 3). Specifically this study strongly emphasises the need for more cooperation between SABIC and Saudi Aramco to develop and expand the Saudi petrochemical industry through provision of more feedstock alternatives.

6.3.1 Innovation and technological capability

Whilst expansion in production capacity has had the most obvious immediate economic importance for SABIC, the indigenous capabilities to create and innovate technologies have been seen as more strategic and long term in allowing SABIC to avoid technological dependence on foreign firms. At the firm level, SABIC and Aramco in the beginning were weak in terms of technology innovating capabilities.

Even Aramco, the most powerful and successful of the two case study firms, has had limited activities in technology innovation. This is due partly to the model of technology innovating capabilities. Moreover, Aramco and SABIC were both at the stage of rapid expansion of production facilities, and their products were in constant high demand, thus they had little interest in pursuing major technological changes. Although Saudi Aramco is one of world's most modern producers, and one of the key developers in Saudi Arabia, it apparently could not carry out any undertakings in R&D or design.

However, Saudi Aramco has recently attempted to develop its own technical capabilities through cooperation with R&D institutions. SABIC, on the other hand, is the best example of how technological cooperation has fostered local technological capabilities in innovation. The SABIC case study displays technological capabilities that were able to combine foreign and local technological elements to create local innovation. The Saudi Aramco development took advantage of technological collaboration between R&D institutes and industries, with the result that local technological capabilities in Aramco are still low. In the Saudi industrial development case, continued technological cooperation between Aramco and SABIC was not evident even at the end of the study. This is a reminder of how the strategies of the two big players may inhibit the collaboration and knowledge flows needed for developing new technologies.

Although Aramco and SABIC technology transfers were not designed to deliver technology innovation, they did lead to the dissemination of technological knowledge across industries and research institutes. They provided the basis for further technology development work in Saudi industry. The comparative analysis of these two case studies to develop Saudi industrial competence suggests that there is not a rigid division between importing production competence (the focus of Saudi Aramco technology transfer) and indigenous technology innovation capacity (the focus of SABIC technology transfer). The two cases suggest that there are different routes to achieving technological capabilities. However, this should not prevent important local innovation effort adapting to country circumstances. The Saudi Aramco development model has been extremely successful in the way that it has made selective use of imported technological elements, allowing local development to concentrate on those areas in which they were most advantageous to indigenous development.

The case studies have thrown light on the rapid changes in R&D activity:

First, it brought about new types of collaboration between R&D centres and manufacturing firms. As shown in chapter 4, Aramco initiated technological co-operation with local universities and R&D institutes on quite a few occasions. Equally SABIC was itself a successful product of technological collaboration between R&D institutes and universities

Second, the need to change attitudes of firms and employers towards technological activities

Third, and perhaps most importantly, the creation of incentives in the system for technological learning, leading to technological capabilities

Fourth, firms like Saudi Aramco and SABIC have been forced by the market to master new technologies, to improve production, to establish technological skills, and to allocate resources by themselves.

In the area of innovation and research and development, survey responses confirm the importance of new innovations in all companies play a major role in revenue generation. Examples (section 6.1.5) show that workers in Aramco and SABIC are more challenging in this area. In the case of Aramco, perhaps a good measure of its position in research and technology efforts is its growing portfolio of 17 patents granted, 3 pending and an additional 90 in the pipeline.[7] This study confirms that by gaining know-how through the licensing of intellectual property, Aramco and SABIC can add additional value to their operations and industries.

6.3.2 Technology collaboration with education institutions

In the area of relations between affiliates of both SABIC and Aramco with universities and research institutes, some strong relationships with universities in the Kingdom is shown. Aramco, especially, indicates stronger relations with universities (discussed in chapter 5). Aramco from an early stage has had close links with universities outside the Kingdom because of the nature of the business.

The Aramco case study demonstrates a new process of collaboration with research institutes of the local university, King Fahd University of Petroleum and Minerals (KFUPM) and the Japanese Cooperation Centre for Petroleum (JCCP).

Some of the research ventures are quite new to Aramco but people in Aramco need to be prepared to learn from others, particularly in regard to:

- Sharing of knowledge
- Setting mutually compatible goals
- And choosing partners.

By contrast, SABIC is dependent on its own research and development activities and this confirms what was discussed in chapter 5 (section on SABIC research centres). SABIC boasts of one of the biggest R&D activities not only in the Kingdom but in the region as well. In this direction, Aramco recently started to develop and expand its local research and development centre. But SABIC is way ahead of Aramco and has invested more (Chapter 5). **Because of their close relations, integrated industries, and the nature of the business, this study believes that it is important and beneficial for both SABIC and Aramco to develop a close relationship in research and development activities.** This will help expand research and development activities by sharing knowledge and resources to support oil and petrochemical industry in the Kingdom.

Both companies are great leaders in industry, and will achieve not only fast success if they coordinate their efforts in this area but also will become a valuable source of R&D for other industrial sectors in the Kingdom. This study strongly recommends that SABIC and Aramco develop a joint venture in R&D. In the same direction, the Saudi government should be involved directly in developing policy for research and development, investing to develop a national system for innovations. This will serve industries and provide assistance to achieve national objectives.

King Abdul Aziz City for Science and Technology (KCAST) has in recent years led the development of the Saudi science and technology plan. However (as discussed in chapter 3), this plan has not shown any clear direction to develop Saudi national science and technology. This study identifies the need to develop a system for innovation in the Kingdom. The system should include a clear vision, method and objectives in order to support local innovation and technical capability within Saudi industry.

In this study, there is no single model of how collaborative research has been pursued in the cases of Aramco and SABIC. Rather, there is a range of frameworks and mechanisms for establishing research objectives, which vary from company to company. However some universities in the UK have developed different approaches to collaboration with industry, which can be summarized as follows:

- **The objectives** must be in line with the business strategies and research capabilities of the partners

- **The plan** should take advantage of, not suffer from, the cultural differences of partners and their environments

- **Close communication** is critical to ensure effective feedback mechanisms

- **Projects should** leverage capabilities and minimize the time from concept to commercialization

- **Projects should** contribute to basic knowledge creation and to the rapid achievement of technologies that can be commercialized.

This study suggests that these factors can be used as guideline for Saudi industry in their relations with educational institutes and universities. Here, for example, Table 6.19 shows that Aramco and SABIC have broad and long-term relationships with universities inside and outside the Kingdom.

Table 6.19 Relationships between the companies and scientific research institutions

	Highest% response	
	Aramco	SABIC
Does your company have relationships with scientific research institutions (e.g. university laboratories, government laboratories) ?	Yes	Yes
response to question 3.05	58	72

This study confirms that it is important for both companies (Aramco and SABIC) to keep wide and deep relationships with universities inside and outside the Kingdom. Chapters 4 and 5 (sections 4.4.3 and 5.3.3) have discussed, with examples, this approach and how successful the development of good relations with educational institutes and universities can be.

6.3.3 Experiences of Aramco and SABIC in granting patents at national level

As a result of the relative success of both SABIC and Saudi Aramco in research and development, either through direct facilities in the case of SABIC or through universities and institutes as in the case of Saudi Aramco, both case studies have shown this as an important development in achieving patents (see Table 6.20). In technology transfer, this evidences the capability of both companies to observe and develop local technologies.

These achievements can be considered as an indicator of the success of technology transfer to Saudi Arabia. Saudi industry should evaluate both experiences of SABIC and Saudi Aramco in granting patents (discussed in Chapters 4 and 5). At the national level, both SABIC and Saudi Aramco are facing difficulties in registering patents in the Kingdom, because the complex processes require detailed experience, and this is absent with respect to the government agent, King Abdul Aziz City for Science and Technology. This study identifies this difficulty which affects both SABIC and Aramco in the granting of patents inside Saudi Arabia.

Table 6.20 Process of registering and granting patents in Saudi Arabia

	Highest % response	
	Aramco	SABIC
Does the company have any patent registrations?	Yes	Yes
response to question 6.07	65	70

Box number 3.8 in chapter 3 summarized the needs and objectives of Saudi science and technology; however this section highlights the weaknesses of Saudi Arabia in the process of registering and granting patents at the national level. As has been mentioned in chapter 3, section 3.5, King Abdul Aziz City for Science and Technology (KACST) is the leading governmental authority for R&D at national level and should provide all assistance to the industry mainly in R&D and specifically in patent registration procedures. **This study strongly recommends that King Abdul Aziz City for Science and Technology expands its activities and imparts its experience and knowledge to others in order to build a dependable base for patent activities.** This may include developing detailed strategies, policies and procedures. It is important for KACST to develop the capability to encourage innovation for the benefit of the national industrial sector.

6.4 Aramco and SABIC strategies in acquiring technology

During the last three decades of Saudi economic reforms (1970 – 2002), Saudi Aramco has succeeded in both modernizing oil technologies and increasing capacity dramatically. This study confirms that it would not be possible to achieve such a quantum jump without introducing advanced foreign technologies along side those directly imported. The two case studies of Saudi Aramco and SABIC show that transferring foreign advanced technologies has made a crucially important contribution to technology development.

Taking a broad view, that Saudi Arabia should have acquired sufficient foreign technologies over the years to develop its local capabilities aimed at sustaining and maintaining some elements of technological independence. As was reviewed in section 2.2, the most important part of technology transfer is the transmission of know-how through education and training combined with practical experience. In the cases of both Aramco and SABIC, two elements are essential:

- the type of technology
- and the type of technology transaction.

These two elements determine the availability of technological competencies, embodied in the imported technologies. They also have an impact on the scope for local development of imported technologies. There exist several means for the transmission of know-how, formal local training programmes, training programmes abroad, in-plant courses, on-the-job training, education abroad, circulation of books and periodicals. The strategy used in the Aramco and SABIC case studies can be seen as involving acquisition of technology, embodying a wide range of advanced technologies from the industrialized world, plus foreign developer's technological, industrial and economic knowledge. This strategy established technology transfer through various formalized channels to allow Aramco and SABIC to gain access to these technologies.

Table 6.21 indicates that these companies have learned by implementing sophisticated technology. It summarises their strengths, weaknesses and opportunities. The Table shows that Aramco and SABIC's foreign collaborations are an economical and commercial success. It indicates that joint ventures in Saudi Arabia can be profitable. **This study has found that it may be useful for the Saudi government to encourage both companies to expand their knowledge and technical-know how to other countries, mainly to GCC countries, especially in technology development and joint ventures.**

From the survey (questions 7.02, 7.03 and 7.04), weaknesses of SABIC and Aramco are identified in the areas of obtaining technology and product design. After many years of experience, SABIC and Aramco have not yet been capable of developing their own technology and improving their product development. All answers indicate that both companies still depend 100% on foreign sources. The responses show the need for SABIC and Aramco to invest heavily in R&D, in order to build capabilities for developing their own technology and in meeting technical development needs.

In chapter 3 (section 3.6.2), this study showed that it is feasible for Saudi Arabia to benefit from advanced technologies and technology transfer. While transferring advanced foreign technologies Saudi Arabia may also be able to avoid some of the mistakes that may have been made in the earlier technological development and/or technology transfer. However, technology transfer is not a simple linear process of transporting geographically a technology from one place to another.

As pointed out in chapter 2, technology transfer requires knowledge, experience and skill. In the process of technology transfer, Table 2.1 shows that the success of technology transfer is bound up with the behaviour of both suppliers and recipients, involving a significant degree of uncertainty. Whether the results of technology transfer favour recipients, depends greatly on how the processes are carried out. This study raises important questions about technology transfer projects that are strategically planned.

Table 6.21 Strengths, weaknesses, and opportunities for Aramco and SABIC

ARAMCO	SABIC
Strengths:	**Strengths:**
• Biggest producer in the world • Huge oil reserves • Modern technology base • Experienced management	• Huge commercial success • High quality products • Modern technology base • Well established JVs
Weaknesses:	**Weaknesses:**
• R&D infrastructure • Innovation system • Human resources system • Policy coordination and evaluation	• Innovation management • Information system • Human resources system • Policy coordination and evaluation
Opportunities:	**Opportunities:**
• Diversification of products • Linkages with domestic firms • Promote innovation • Responding to globalisation	• Improving policy making • Linkages with domestic firms • Support professional education • New joint ventures

Based on the evidence of the Aramco and SABIC case studies, this study indicates that there is a need for effective strategies to use available domestic resources as well as to identify opportunities emerging in the global economy. In this respect, this study confirms that the structural approach is useful for Saudi industry to understand the potential pitfalls in development. However, it provides little practical advice about how to avoid these hazards and further to actively make use of the emerging opportunities. It is a challenge for Saudi Arabia to strengthen its technological capacity through local development of imported technologies. The case studies presented provide clear examples of this.

Saudi Aramco has the stewardship and responsibility for one-fourth of the world's proven crude oil reserves and is ranked as the number one oil company in the world for the 14th year by industry analysts.[8] This company realizes that the global challenges can only be met by local initiatives that foster the reliability of supply and maintain the cost competitiveness of oil through innovative approaches. In fact (as has been demonstrated in chapter 4), one of Aramco's strongest commercial attributes is that its facilities can quickly increase crude oil production from about seven to ten million barrels a day, that no other company anywhere can match.[9] This is a major commitment of considerable effort to world oil supply stability. Aramco's flexibility is strengthened by the fact that it consistently replaces annual crude production, year after year, with new reserves through field discoveries and enhanced production methods. But most of all, reliability depends on building local strategic depth by mining the talents of its people and by honing skills through broad-based training programmes which are probably the largest and most comprehensive corporate programmes in the world. In the area of national participation, Table 6.1, Aramco has shown leadership in the Saudisation of the workforce - over 85 percent of Saudi Armco's employees are Saudi nationals while oil and gas operations are fully Saudised.[10]

This study confirms that Aramco is a good example of successful transfer of technology. It has not only incorporated the latest upstream and downstream technologies in its work, but has also advanced those technologies locally, finding new applications through innovative thinking. For example, a number of innovative production techniques was used in 2002 to improve performance, reduce costs and help protect the environment:

- Extended reach horizontal wells which increase the reservoir contact area without drilling additional wells
- use of a rotary steerable system drilling tools improving drilling penetration rates
- batch drilling used offshore to save time and improve material handling logistics
- multilateral well completions, including fishbone multilaterals, maximizing production from a single well
- seismic inversion technology is used to measure indirectly the presence of gas
- slimming designs for well-casing that results in reduced rig time and casing costs

An aspect of development studies, is whether a foreign company's experiences are relevant to firms in other developing countries. The case studies confirm that, although their circumstances may be rather different, lessons drawn from foreign company experiences are useful. For example, foreign companies may not only acquire the capacity to produce their technologies, but perhaps also innovational competencies, as in the case of SABIC. The key question for Saudi Arabia is how to achieve technological dynamism. The Saudi government can play a complementary role in providing an environment for technological development.

From the experiences of Saudi Aramco and SABIC, the Saudi government needs to adopt a technology policy directed at:

- **Managing technology transfer** to deal with issues connected with the search and selection of the most appropriate technical systems
- **Managing technological development** to ensure and adopt the technical system and, in the long run, to foster innovation based on such technology

- **Developing local technological capacity** to develop human resources, R&D infrastructure and dynamic industrial infrastructure.

However, there may be limits in which it is possible to generalise from the Saudi experiences in oil and petrochemical development. Saudi Arabia is a large country and has a special position amongst the world's energy suppliers. Its huge natural resources make it an extremely attractive target for foreign companies across the world. For the same reason, it makes sense for Saudi Arabia to develop its own technology, which can best suit Saudi industry conditions, and to compete in the huge world market.

In the survey, neither SABIC nor Aramco affiliates have encountered any difficulty with government agencies in acquiring technology. This is an important factor in limiting government involvement in acquiring of technologies and technology transfer. In the two case studies the full responsibility of acquiring technologies is placed on the company. The important question is why SABIC and Aramco have not learnt from their long experiences in building their own petrochemical and refinery plants. There are similarities in production process and technology, requiring an urgent need for the development strategies of both companies to be reevaluated in this area. **However, this study confirms that the Saudi government should play a flexible role in helping the companies to acquire the right technology.** It may be useful for the government to work with Aramco and SABIC to develop a technology transfer system, with the objective focused on local technology development to create a scientific technology base. In this area the Saudi government may seek the opportunity to develop this system by evaluating the experiences of both SABIC and Aramco to develop criteria for attracting technology into the Kingdom.

6.5 Summary

The results of the questionnaire analysis have been discussed in detail in Chapter.6, This analysis mainly cover the areas that have been included in the questionnaire clarifying the position of technology transfer in both SABIC and Saudi Aramco. From the questionnaire, this Chapter has drawn different conclusions relating to the technology learning and capabilities and the need for the two companies to focus on the technology transfer process.

In the case of Saudi oil and petrochemical industries, efficiency is often the result of investments in new equipment. The Saudi firm's policy is to transfer modern technology and processes that lead to high productivity and quality products. However innovation and technology transfer are an interactive and iterative process, involving many different parties. The effective process to transfer technology requires interactivity between various users, producers and adaptors of technology.

From the results of this study, it is clear that Aramco and SABIC's technology transfer policy objectives should not just be to build the companies' capabilities, but also to facilitate the whole process of technological innovation by modifying the form of technology network. From the survey of this study it can be confirmed that it is necessary, for Aramco and SABIC, to have a clear policy framework with respect to technology transfer and policy cooperation.

Table 6.21 demonstrates that successful technology transfer includes transfer of technological capabilities, which may be beneficial to both the supplier and user. Aramco and SABIC as technology users, need to give attention to adaptation as an essential and integral part of technology procurement. As shown in Table 6.22, the introduction and diffusion of technologies in the industrial sector needs a sound environmental and economic policy, stressing the need for long-term goals and commitment by policymakers. This also means that technology transfer needs to be incorporated into R&D strategies. A possible framework is shown in Table 6.22, and may assist Aramco and SABIC to develop their own innovative concepts for technology assessment, adaptation and development, improving policy practices of technology transfer in their industries. The case studies confirm that the interactive and dynamic character of technology transfer stresses the need for innovative and flexible approaches, through long-term partnerships. The policymakers in Aramco and SABIC should be responsible for developing such a comprehensive framework for technology transfer policy. The framework for Saudi Aramco and SABIC with 5 different theme. The first theme "securing appropriate frame work conditions", is rightly devoted to developing human resources in Science and Technology with increased support from the government and the industry sector for professional training. Likewise, all other themes "building an innovation culture", and "improving policy making", identify the policy aims to help both SABIC and Aramco in developing policies to further enhance and improve technology transfer capabilities. These themes, policy aims, and means show that the Saudi government can play a complimentary role in providing an environment for technological development.

Table 6.22 Technology transfer policies for the Saudi oil and petrochemical industry

Theme	*Policy aim*	*Means*
Securing appropriate framework conditions	To develop human resources in S&T	Increased government and industry support for professional education.
Building an innovation culture	To diffuse best practices in innovation management To promote the creation of innovative firms.	Internet-based business information networks. Funding greater use of benchmarking and diagnostic tools
Enhancing technology diffusion	To increase firms' absorptive capacity To improve linkages and public research	Co-financing of consultants to upgrade firms' organisational ability. Co-financing of technology uptake via public/private partnerships
Promoting networking and clustering	To stimulate the formation of innovative clusters of firms To ensure a better match between the S&T infrastructure and industry needs.	Competition among regions for funding of cluster initiatives. Co-funding of centres of excellence to facilitate university-industry interactions. Building networks between public research actors and firms.
Leveraging research and development	Sustain techno logical opportunities in the long run. To increase economic return from research	Increased spending on basic R&D Increased support to R&D. Public-private partnerships Technology foresight for policy setting. Regulatory reform (university-industry interface).
Responding to globalization	To increase linkages between domestic and foreign firms To increase country's attractiveness as a location for knowledge-based activities.	Building networks of competitive domestic firms. Building innovative clusters (see above). Systemic upgrading of the S&T infrastructure
Improving policy making	To enhance policy coordination. To improve policy evaluation	Raising the coordination function to the highest policy level. Making evaluation obligatory. Developing new methodologies

Source: Organisation for Economic Co-operation and Development (OECD), *"Innovation and Technology "*, 1999,Paris, p.70

The two case studies and the literature demonstrate clearly that there are strong needs to develop the capacity to assess and select technologies. Various innovative policy concepts, including networking and joint research organisations, were found to be successful. To increase the likelihood of success, long-term support is essential, stressing the needs of Aramco and SABIC for capacity-building and the cooperation of technology suppliers and users as partners. They need to be committed to achieving their goals and committed to achieving the goals of the partners. This approach can make it possible to transfer technology relationships into a successful alliance, meeting the objectives of both partners. In addition to the contents of Table 6.22 this study suggests that the Saudi industrial innovation strategy should address the following:

- **Knowledge infrastructure**- to ensure that Saudi industry is at the forefront of generating new ideas

- **Commercialization of knowledge** - to facilitate the necessary partnerships and mechanisms to capture the benefits of new ideas

- **Human resources** - to develop a workforce with the skills and attitudes to make new things happen

- **Business and industrial environment** - to improve the Saudi investment climate in the global knowledge-based economy.

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CHAPTER SEVEN

LESSONS LEARNED: POLICY OPTIONS FOR SAUDI INDUSTRY

7.0 Introduction

The preceding chapter 6 analysed issues related to the two cases studies (Saudi Aramco and SABIC) and related to the main research question posed in chapter 1. This final chapter seeks to offer conclusions from the research results. It also considers the extent to which these findings may be specific to Saudi industry and particularly to the oil and petrochemical industry. It further examines how relevant these findings are to the main policy issues and concerns of the Kingdom of Saudi Arabia. Finally it reflects on the study suggesting some implications and opportunities for further research.

This chapter is arranged in six sections. Section 7.1 addresses the fundamental theoretical issues, which emerged from the review of literature. It reviews the Saudi Aramco and SABIC experiences in oil and petrochemical technology development.

The next two sections focus on the areas of technology transfer, technological capabilities and the learning process. Section 7.2 relates the empirical findings to the perspective of local technology and technological capabilities to analyze the strategies available for Saudi oil and petrochemical industry to selectively utilize foreign technology in order to meet Saudi industrial needs. Section 7.3 reviews the SABIC and Saudi Aramco approaches towards human resource development to establish linkages between technology transfer and manpower development. Section 7.4 confirms the need for technological collaboration between Aramco and SABIC. It reviews Saudi joint ventures and the criteria for partner selection. It also looks at the role of partnerships in speeding up the transfer process. It confirms the need to establish institutions to formulate and implement these policies and nurture a national S&T capacity. Such institutions would implement the various technology policies suggested in this chapter. It argues that Saudi industry needs to have a technology policy aimed at enhancing its industrial development process. Technology policies need to be advocated as an integral part of industrial and economic development. Section 7.5, provides the concluding points and proposes policy recommendations in order to make it possible for Saudi industry to improve the process of technology transfer. It is recommended that Saudi industry initiate steps to achieve a more beneficial and constructive technological transfer process. The final section 7.6 proposes areas for further research.

7.1 Saudi oil and petrochemical technology transfer

Technology transfer is necessary for Saudi industry to build up technological capabilities. The key for ultimately acquiring technological competence is to select and to adapt imported technology. The literature in chapter 2 examined the terms and conditions of technology transfer, identifying the principal problems encountered. For the effectiveness of transfer, technology must be transferred in all its required parts. This depends on how the transfer mechanism is organized; there is a particularly high risk that transfer may be incomplete when in its unpackaged form via independent dealers. The most important part of technology transfer is the transmission of know-how through education and training combined with practical experience. There exists several means for the transmission of know-how, formal local training programmes, training programmes abroad, in-plant courses, on-the-job training, education abroad, circulation of books and periodicals. In the first stage of government-sponsored technology development, Saudi industry imported foreign technologies, which solved its urgent demands, helped the construction of the infrastructure and forever provided a window for Saudi industry to learn about advanced technologies. This helped the second stage transferring complete technologies. This step successfully built up production capacities and also greatly contributed to the modernization of industry infrastructure, as noted in chapter 3. Subsequent stages provided technological resources for technological development and technological learning.

The experience of Aramco and SABIC confirm that the purchase of technology via licenses covering designs or patents cannot in itself be considered as a complete transfer of technology, unless, it is accompanied by the following:

- the undertaking of a thorough market survey including economic and technical planning, taking global and domestic factors into consideration
- a bias towards capital-intensive projects, such as upstream and basic industries, including the appropriate infrastructure
- an emphasis on integration, maintenance and operation of utilities
- the upgrade and development of transplanted technology processes.

This illustrates the criteria applied by Aramco and SABIC in selecting and transferring advanced technologies for their industries in the Kingdom. While SABIC apply similar methods in its technology search and selection for its projects, technical, economic, legal and marketing considerations are the four primary elements of its technology evaluation process. Technical considerations contain information regarding product quality, commercial viability, complexity, reliability, flexibility, environmental impact and safety and security considerations. Economic considerations relate to the cost of license/services provided by the licensor including initial cost, cost of expansion, plant cost and production cost. Scope of grant, right of use, selling rights, scope of indemnity, guarantees and applicable law, forms the legal considerations. Finally, marketing considerations comprise quality of product range, market possibility, area limitations and technical services back up. With these proven methods, SABIC has been able to transfer technology directly from the licensors to industrial plants.

7.2 Technology transfer and technological capabilities

As indicated in the preceding chapters technology transfer is a desirable process. Saudi industry constantly wants more of the technology to be acquired or transferred. The source of foreign technology to Saudi oil and petrochemical industry has remained strong over the years, because multinationals still invest and operate in the country. This study confirms that the joint venture strategy is the main Saudi government technology transfer policy in the oil and petrochemical industry. However, it appears the authorities have been unable to make maximum use of the opportunities available for acquiring technology. Government policy towards the petroleum industry emphasizes that financial return from exploitation of resources is preferred to setting out a more effective strategy of acquiring technology.

In chapter 6, it was noted that the promotion of technological learning is crucial for improving the technological capabilities of Aramco and SABIC. Technological learning is not only associated with those directly involved in the process of technology creation and design, but also with the producers and users. With respect to the case study analysis, it is evident that Saudi industrial development has brought about three important changes:

- new types of technological collaboration have emerged between R&D institutes and manufacturing firms (Aramco and SABIC)

- the attitudes of the companies, including R&D centres, manufacturing and other bodies, towards technology have changed, with a more positive approach now being adopted

- technological learning has been encouraged and has involved more people and a wider range organisations, helping the accumulation of technological capabilities at both the firm and national level.

In some Saudi Aramco projects, acquisition of technology through a licensing agreement provides cheaper technology, not only under the control of the supplier but also more amenable to local adaptation and subsequent development. However, this analysis is valid only in certain circumstances. In the Aramco case study with stable and mature technologies, it has done better by licensing the needed technology.

The SABIC case study, by contrast, confirms that effective transfer of know-how requires a strong personal relationship between sender and receiver. The strength of the relationship between SABIC and its partners are two functions of the amount of contact between the personnel of the two firms, and the degree of commitment on the part of the technology-supplying firm to ensure that real learning takes place.

From the results of the questionnaire analysis as shown in Chapter 6, the two companies (SABIC and Saudi Aramco) have built plants with the latest technologies in very short periods using a turnkey approach where the contractor builds the plant and hands over the 'key' at the start-up. However, both companies think it is necessary for them to push the contractors to complete the work on time, because they consider that time is important from the revenue and profit point of view. The contractor gives a lot of attention to the time factor in order not to delay the completion of the project to avoid losing money. However, the recruitment of foreign employees by the contractor to carry out the work from the beginning to the start-up is a minus point, because it deprives Saudi nationals of participation in building and construction work.

7.3 Human resource development in Saudi Aramco and SABIC

The Saudi government has sought to establish linkages between industrial development and manpower development. The industrialisation concept is not only limited by technical and economic aspects, but also has a connection with organization and managerial pressures. These come from the need to qualify and train Saudi labour to participate in the production process and acquire industrial behaviour. For this reason the Saudi government has initiated a number of policy measures, as listed in Box 3.7. High rates of investment in human resources by Aramco and SABIC have resulted in an impressive improvement in human and social indicators over the past three decades.

SABIC and Aramco are companies of two contrasting styles when it comes to the development human resources. Aramco which was inaugurated in 1933 as a company fully managed and operated by Americans took a long time to focus its attention on the development of an efficient and qualified national work force capable of taking over the leadership of the company from the Americans. By comparison, SABIC from its inception had a different philosophy whereby the company trained and developed Saudi nationals from the beginning to gain skills and know how in a very short period of time. Although the approaches of the two companies have been entirely different, it is not possible to say that one method is better than the other because both methods have their unique characteristics as well as disadvantages.

Although slower in its transition from an American managed company to a fully Saudi-managed company, Aramco used to its advantage the training of nationals through their working alongside highly skilled Americans. However, although the SABIC approach was quicker in the training of a national work force, it is definitely a more time consuming and costly method. But SABIC was quickly compensated for its heavy investment in human resource development by creating a local skilled workforce in a very short time. While Aramco had the advantage of minimizing cost and effort in the training of employees, through American expertise, the company suffered from being a company fully managed by foreign nationals for a long period.

The successful experience of Aramco and SABIC make it possible for the Saudi government to create a plan to develop local capability to generate technological know how and to use indigenous manpower for the benefit of the country. It is necessary for Saudi industry to create professional training schemes that will enable Saudis to develop local capabilities aimed at reducing dependence on foreign expatriates. Saudi industry should also establish effective training and development programmes for Saudis to be trained for technical and managerial jobs. It is clear from chapter 2 that recipient firms should be given the opportunity for local participation in the various stages.

In light of the Kingdom's drive for privatization, future development plans emphasise expanding the work scope of Saudi private sector to ensure its effective contribution in the achievement of the strategic objective of diversifying the economic base and upgrading performance and economic efficiency. The most significant future challenges facing Saudi industry is the need to employ national manpower and to strengthen policies of saudisation and replacement. Along with this, programmes for on-going training should be expanded to improve the ability of national manpower to gain employment in Saudi industry.

7.4 Conclusions

Employing the conceptual framework of technology transfer outlined in Chapter One, this study has through Chapters 4-6 analysed the major issues associated with technology transfer sharing development and indigenisation applied to the Saudi oil and petrochemical sectors. The key conclusions to be drawn from the results of this analysis are as follows:

1. This study indicates (section 6.2.2) little involvement from Aramco and SABIC in the three important areas of:

    - Quality of design,
    - Quality of manufacturing and
    - Quality of materials.

    One reason for these problems is that the plants are constructed and maintained by foreign contractors. The companies believe it is better to do their maintenance and construction through contractors, not only because of the higher numbers of manpower required, but also to pass on the responsibility of completing the project on time to the contractor. Part of this policy is because project management is also done through contractors. The study emphasizes that SABIC and Aramco need to increase their participation in construction and maintenance through their own engineering and labour effort. This is because construction and maintenance are great sources of knowledge and expertise and will enhance experience to Aramco and SABIC engineers and labourers, as part of the technology transfer objectives. This process will help the companies to limit technology transfer problems.

2. Saudi industry has been successful in, firstly, attracting foreign companies and, secondly, through participation in developing their own plants. Aramco and SABIC have learnt from the experience of joint ventures the advantages of technical cooperation in constructing huge plants profitably and successfully. Aramco and SABIC are of the opinion that technology transfer cannot be successfully undertaken without direct cooperation with companies in the USA, Western Europe and Japan. The joint ventures focus on developing

successful long-term partnerships, with the joint venture partners considering their employees as joint venture employees irrespective of whether they are Saudi or non-Saudis. This fact has benefited the Kingdom immensely, mainly in the areas of technology transfer and know-how. Success in technology transfer for Aramco and SABIC derives from the following factors:

- very clear strategies regarding the reasonable prices companies negotiate with full guarantee and warranty, and the manner in which they implement transfers of technology

- the rules governing time schedules and the strict deadlines they set for all projects including provisions in the agreements with the technology providing companies regarding complete and successful implementation of technology transfer as well as the passing of knowledge to Saudi nationals

- maintenance of good business relations with the biggest oil and petrochemical companies in the world, from management to engineering and technical levels

- the similarity of plants in the Kingdom with those outside the Kingdom, making it easy for partners to link their strategies between the local plants and the plants outside in sharing assistance and knowledge in solving problems

- both companies and their partners always aim at de-bottlenecking and looking for improvements in cost reduction and raising production capacities with a minimum of investments. Therefore, all foreign partners develop technology and implement technology transfer and growth capacity locally, sharing with Saudi partners

- that the methods adopted by SABIC in selecting joint venture partners and the strict terms and conditions that partners should train Saudi youth to shoulder administrative responsibilities and operate factories in the future

- SABIC has chosen outside partners to share risks and the profits. This approach has benefited the economy of Saudi Arabia so much that today every other newly established company is a joint venture. This study confirms the fact that joint ventures allow for expansion of the petrochemical industry, facilitate the transfer of technology to Saudi industry, and enhance the status of Saudi products in the international market

- SABIC has adopted a policy of establishing joint ventures with foreign firms as the principal means of providing technology and development support to manufacturers of petrochemical industries. American companies realize that joint ventures with the Saudis is a means to gain better access to the Middle East petrochemical market and reduce production costs by using relatively cheap Saudi petroleum. Aramco's equity participation in the foreign oil companies has given the corporation a majority at the board level and accordingly can influence investment and production policies. These corporations have been involved with Aramco and SABIC in joint ventures; however, the Saudi side is generally not looking for capital investment when entering a joint venture, but rather wants technology, management and marketing skills.

3. In the area of relations with universities and research institutes, evidence of a strong relationship mainly with universities in the Kingdom is shown. Aramco, especially, indicates stronger relations with universities and from an early stage it had close links with universities outside the Kingdom because of the nature of the oil industry. The Aramco case demonstrates a new process in collaboration with universities. This study raises the importance of the Saudi government to encourage Saudi universities to establish units to extend support, assistance and cooperation to the industry. This study suggests that it is important for Saudi Arabia to consider these units as a government scheme, which helps companies access the knowledge and skills within Saudi Arabia's 'Knowledge Base'. Through these units, partnerships are formed between Saudi companies and groups of staff, often from different disciplines, in Saudi knowledge base organizations. These partnerships are at the heart of innovation projects that are central to the strategic development of the company partners. The mission of these units is to strengthen the competitiveness of industry by stimulation of innovation in industry through collaborative partnerships between the science, engineering and technology base and industry. Their objectives are to:

- facilitate the transfer of technology and the spread of technical and management skills, and to encourage industrial investment in training, research and development

- provide industry-based training supervised jointly by personnel in the science, engineering and technology base, for high calibre graduates intending to pursue careers in industry

- enhance the levels of research and training in the science, engineering and technology base that is relevant to industry by stimulating collaborative research and development projects and forging partnerships between the science, engineering and technology base and industry

- part-fund Saudi government grants to knowledge-base organizations to contribute to the costs incurred in participating

Through participating in these programmes, universities effectively link with Saudi industry for the transfer of their knowledge to drive productivity and competitiveness. These programmes involve high quality graduates working in companies on technology and knowledge transfer, and jointly supervised by personnel in the 'knowledge base' and in business in order to create an environment in which academics and businesses are partners in developing industry.

4. As research and development is the most important factor for the oil and petrochemical industry to develop technical know how, Aramco recently started to develop and expand its local research and development centre. But SABIC is way ahead of Aramco and has invested more. This study points out that SABIC's Research and Development Centre is considered to be one of the most modern facilities and plays an important role in developing products and applications. The results of the case study analysis suggests that there is a need to develop cooperation between Saudi Aramco and SABIC in the following areas:

    - the two companies need to cooperate in fields, such as the environment, maintenance and safety and security for the betterment of both companies in particular and the Kingdom in general

    - both companies need to work together in cooperation with universities, mainly in the areas of research and development to support efforts to learn more about technology transfer and know how

    - cooperation on recruiting intelligent undergraduates from universities

    - provide universities with laboratory equipment that is necessary to upgrade the level of education in these institutions, essential as an investment for the future of the oil gas and petrochemical industries

    - Aramco and SABIC have been able to transfer technology directly from licensors to their industries. SABIC considers importation of technology to suit its needs and its industry conditions as the most important factor in its decision making process. However, this study indicates that SABIC and Aramco may be limited in developing criteria to select and evaluate technology. They still need outside sources to develop recommendations about technology selection. This weakness is confirmed, as most of the projects have used foreign consulting companies for the selection of technologies. Company technical committees, depend on the foreign consultant and partner recommendations, leaving little choice for the company's own decisions. Aramco and SABIC should consider developing their own capability in the evaluation and selection of technology.

    - SABIC has been successful in developing good relations with its partners in R&D and considers that all joint venture partners share R&D activities. SABIC has developed agreements with all its partners to support R&D activities, using R&D Centres for their needs in solving technology problems. These agreements are cost-based on the percentage of total sales. Both SABIC and its partners gain benefits from this deal. However, Aramco has not developed this kind of mechanism and has not learned the way of sharing with its partners in R&D in the Kingdom, still depending on outside sources for R&D.

- Another aspect of technology transfer and technology sharing is the establishment of off-shore R&D centres with partners. Although the economics of R&D location dictate that basic design and development work by firms be highly centralised in the home country, they do perform R&D in host countries. Furthermore, global R&D is positively linked to the extent to which foreign markets are served by their subsidiary's local production. SABIC has established different types of R&D units abroad for the adaptation of existing technology and the generation of new knowledge.

5. In some projects SABIC and Aramco have not included employee participation in design and construction of plants. The findings of this study, about national participation in the stage of engineering and construction, emphasize the need for SABIC and Aramco to revise their models of technical license agreements to include more national participation in engineering, designing and also R&D. It is important for the two companies to strengthen their position in the technology transfer process.

6. Little has been found about limitations in the market access for most of SABIC and Aramco products because most of these products are considered as raw materials and commodities with limited restrictions imposed. However, SABIC should revise its strategies and methods in the negotiation process with technology licensors in order to reduce any limitations in market share, this mainly relates to highly specialized products where SABIC can have more flexibility in the market area. This is important because SABIC needs more flexibility in negotiations to be able to produce new products to reinforce its position in the international market.

7. There is evidence that SABIC and Aramco have undertaken successful development and modification of their technology processes in their plants. The list of Aramco and SABIC patents confirms this fact. However, with regard to technology modification, responses from SABIC and Aramco affiliates suggest very low local participation. This study raises important questions about the responsibility of SABIC and Aramco in developing methods. Local participation is crucial, playing an important role in gaining experience, either directly or through local contractors. At the national levels, the Saudi government should develop a system to encourage SABIC, Aramco and other Saudi firms to consider local participation in all areas of activity.

8. At the national level, Saudi industry should develop a technology transfer mechanism and criteria for local technology development based on the technology transfer model, outlined in chapter 1, Figure 1.2. This model provides Saudi industry with the opportunity to develop its own technology.

9. At the firm level, SABIC and Aramco were weak in the beginning in terms of technology innovating capabilities. This is due partly to the fact that Aramco and SABIC were in the stage of rapidly expanding production facilities, and as their products were in constant high demand, they had little interest in pursuing major technological change.

10. Although Aramco is a major enterprise in Saudi Arabia, it has only pursued limited R&D and design on its own. SABIC, on the other hand, provides an example of a Saudi company able to combine foreign and local technological elements to create innovation.

11. Aramco and SABIC technology transfer was designed to deliver technology innovation, and it did lead to the dissemination of technological knowledge across industries and research institutes. Comparative analysis of these two case studies suggests that there is not a rigid division between importing 'production' competence (the focus of Aramco technology transfer) and indigenous technology innovation capacity (the focus of SABIC). The two case studies indicate that there are different routes to achieving technological capabilities. However, this has not prevented an important local adaptive innovation occurring (sections 6.1.4 and 6.1.5).

12. At the national level, the Saudi government should be involved directly in developing a policy for research and development, serving industry and providing assistance to achieve national objectives. This policy should include a clear vision, as well as methods and objectives in order to support local innovation and technical capability within Saudi industry.

The development of technological capabilities in production, operation and services in Aramco and SABIC as a whole was successful, through advanced technology transfer from industrialized countries, particularly joint venture technology transfer. However, in general, technological capabilities of Saudi firms are still weak. To some extent, acquisition of technological capabilities needed to produce technologies are more essential than capabilities in innovation. These capabilities are associated with not only a few highly skilled and creative engineers and technologists, but involve a wide range of players including technological specialists. Saudi Aramco shows more success in Saudisation where most oil sectors have achieved close to 90% Saudisation. SABIC also shows success in Saudisation, close to 80%. However Table 6.1 highlights the fact that technology and know-how are still alien concepts in Aramco and SABIC.

7.5 Policy recommendations: national technology policy

Whilst research and development is an important aspect of industrial development in any developing or industrialized country, Saudi industry's progress in this direction has been minimal. No Saudi government policy emphasised R&D development until the 7th National Development Plan. Significantly the contributions of SABIC and Saudi Aramco have been the main stay in research and development to date.

Industry is a critical factor in Saudi economic development, yet the perceptions of industrial development in Saudi Arabia have not considered the critical role of technology policy. As a result, Saudi industrial development strategy is concerned more with the production of locally generated raw materials than indigenous technological development. Technology policies need to be advocated as an integral part of industrial and economic development. Saudi national economic plans need to consider the fact that the economy in general and industrial development strategy specifically can sponsor technical innovation. This study argues that Saudi industry needs to have a technology policy aimed at enhancing its industrial development process. The policy would comprise the following components:

- Scientific research and experimental-design work
- Enhancement of material and technological aspects of scientific work to ensure that such advances increase mechanization and automation of production
- Financing of S&T research
- Capital investment in the development of S&T
- Training of S&T personnel.

This study confirms that Saudi Arabia has made statements declaring the importance of technology in its development efforts. However, these statements do not amount to an industrial technology policy. The limited technology policies that do exist have been ineffectually implemented, largely because of:

- weaknesses in understanding the relationship between technology and industrial development
- weaknesses in understanding of the nature of 'dynamic' industrial and technological change
- the absence of a strategic indigenous programme of action for industrial development.

Saudi Arabia needs to adopt an industrial technology policy focusing on the:

- ***management of technology transfer:*** policies for managing international technology transfer deal with issues connected with the search and selection of the most appropriate technical system, as well as negotiation of the best terms for the relocation of imported technical systems

- ***management of technical change:*** policies for managing technical change to ensure that once the technical system is relocated, the industry, or firm, is able to assimilate and adopt the technical system and, in the long run, introduce innovations based on such technology

- ***development of local technological capacity:*** policies for developing local technological capacity intended to develop human resources, an S&T infrastructure, and a dynamic industrial infrastructure.

The Saudi government should formulate policies that will nurture these critical areas. It should be emphasised that these recommendations are not intended as a comprehensive industrial technology policy package. Rather it is an attempt to outline an industrial technology policy that will create the conditions for industrial development. These policies require an institutional framework. Without institutions, any planning or policy will remain a dream.

At the national level, there is a need to formulate national technology policies to put technology at the centre of development planning. This study confirms the need to establish institutions to formulate and implement these policies and nurture a national S&T capacity. Such institutions would implement the various technology policies suggested in this chapter to be responsible for:

- planning S&T inputs for other sectors of the economy
- planning and developing human resources
- planning and developing a national S&T infrastructure
- planning and strengthening a dynamic industrial infrastructure
- coordinating national and international factors affecting S&T.

A national technology institute in King Abdul Aziz City for Science and Technology should be established to deal with these issues. A dynamic industrial infrastructure would largely supplement the sectoral policies relating to industrial development. However, many 'strategic' industries contribute not only to industrial growth but also to S&T. Specific policies aimed at strengthening the industrial infrastructure should be administered by the Ministry of Industry. The Industrial Technology Institute should have both national and international functions. On the national front, the centre would concern itself more with the dissemination of technological information among different sectors of the economy as well as the mobilisation of funds to support domestic S&T activities. On the international front, the centre should be charged with ensuring scientific and technical cooperation, coordinating technological policies at regional and sub regional levels, and managing and monitoring technology transfer.

The Saudi Offset Programme is another method of technology transfer to Saudi industry. In this scheme, Saudi Arabia being conscious of its leverage in having huge defence contracts, obliges the seller to invest a certain percentage of the defence contract into associated transfer of technology into the Kingdom. The Saudi offset programme covers military as well as some major civilian contracts and encourages firms from the US, Britain and France to set up local high tech plants in joint ventures with Saudi companies. The programme creates newly diversified industries, increases training and productivity, facilitates technology transfers and stimulates economic growth. This study confirms that the programme has provided opportunities for Saudi national companies to transfer several technologies in aviation, space, petrochemicals, electronics, computer systems and medical operations.

Reference to the Saudi British Offset Programme (Al Yamamah), this study recommends the establishment of a Saudi British Technology Management Office

(SBTMO) to assist Saudi industry to learn relevant issues from British industry concerning the management of technology. This mission can be accomplished through research projects on strategic and organisational aspects of technology management, dissemination of that research to practicing engineers and managers, and the education of engineering and management students. The programme would seek to answer key questions regarding Saudi industrial management methods for the creative use of science and technology, such as:

- How can Saudi companies develop product technology that meets market demands?

- How can Saudi industry move rapidly from a position of technological followers to technological leaders?

- How can Saudi industry succeed in absorbing technology from foreign industry?

- How can the learning process be improved?

In its first two years, SBTMO needs to carry out research projects on Saudi product design, manufacturing, supplier relations, research and development, and relevant topics.

Saudi Aramco and SABIC should organise a world-wide conference in petrochemicals and oil, annually. This conference will be open to all petrochemical and oil producers in the world in order to set the technological development agenda for the petrochemical and oil industries and to enhance the position of the Kingdom as the premier petrochemical and oil producer in the world. This study suggests that the conference should be sponsored and organized jointly by Aramco and SABIC. This conference will provide the opportunity for technical presentations to be delivered by leading experts from across the world, focusing on new products, applications and industry-specific issues.

7.6 Proposals for further research

The issues involved in this study of technology transfer have necessarily been narrowly focused. In a more detailed research project the following areas need to be investigated:

- The interrelationship between Aramco and the private sector needs to be studied in detail, so as to ascertain the prospects and constraints in the relationship. The multiplier effect of the presence of the private sector has not been adequately assessed in this study. It would require a detailed study of Aramco, government institutions and private entrepreneurs in Saudi industry.

- The limited manpower capacity of Aramco and SABIC particularly Saudis, limits the country being able to engage in a more aggressive technology acquisition strategy. A further study may provide important information on this issue.

- The apparently differing results in joint ventures between SABIC and the multinational companies may be attributable to the contract agreements. In a further study, it might be appropriate to investigate these contracts in detail to ascertain their adequacy in ensuring the realization of the government's policies on the industry.

Further research is necessary on the type of technology transfer to Saudi industry. It is evident that local service and consulting organizations were not involved in important areas of technology transfer to Saudi industry. Without local involvement, it is difficult for local capabilities (e.g. technical) to be developed to the level required for Saudi Arabia to create its own technology. It will be of policy relevance to study Saudi government plans for eradicating or minimizing dependence on foreign consultants. Research undertaken in this area would help both existing and prospective new technology recipients to formulate future strategies with more confidence.

It is vital to research modernization through technology, and the impact that culture has on this process. There is a need to explore whether certain culture or beliefs are barriers to modernization, economic development and success in international competition.

The method of selecting case studies of firms has revealed interesting and policy significant examples of problems in the transfer of technology from foreign companies to local firms. Future research could use more sophisticated forms of analysis. A focus on specific aspects is also possible, in that there could be studies of, for instance, management decision-making, production techniques, and the role of marketing. The crucial problem of synthesis of different aspects remains and this study has been able to demonstrate how technology transfer could help Saudi industry to develop its local capabilities aimed at sustaining and maintaining technological independence.

7.7 Non-technology issues requiring attention

Due to the heavy dependence of the national economy of Saudi Arabia on a single national resource, oil, the economy is exposed to wide fluctuations of the world oil markets, over which the Kingdom has very little control.

Although the solid gains made by Saudi Aramco and SABIC in the upstream development of oil into higher value added products are outstanding examples of achievements in this area, still the Saudi economy remains almost as un-diversified as it was in the early 70s. The Saudi economy needs to move away from heavy dependence on oil and instead move towards domestic and export-biased productive industries based on sustainable high value added production.

To make this possible, a strategy for establishing a competitive infrastructure needs to be implemented. The current lack of well established clusters of firms deprive Saudi industries of a competitive advantage. Saudi industrial structures typically are fragmented and weakly linked, if at all. There have been some successful attempts to promote clusters in large industrial cities, e.g. Yanbu and Jubail, but much more is needed beyond simply building on raw material supply relationships.

7.8 Complementary Studies

At the heart of globalization, is the balanced entry into the world arena of emerging economies. The Kingdom should thus guide legitimate national interests to embark upon opening up its economy and transforming institutions and people to take their place in the new global economy.

To achieve this, it is imperative that more emphasis be given to science and technology. Also, a massive literacy campaign should be implemented to overhaul the Kingdom's education system. The really important strategic industry for the next century is going to be knowledge, and the key to knowledge is education. The upside potential for improved educational capabilities is huge.

Although the private sector entrepreneurs and businessmen of the Kingdom are capable world contenders, the present corporate structures, relative strengths, technological capabilities and resources are not. The latter needs to be addressed by the Kingdom's policymakers.

Low levels of research, development and technological diffusion are other factors. There has been a perverse tendency to pursue 'turnkey' technological projects with limited or no potential for the transfer of technical knowledge to the local labour market. Saudi industries have also been very slow to adopt new technologies on their own volition. Under- investment in training and slow adoption of flexible workplace practices exist in the Kingdom compared to other more advanced developing countries. Inadequate financing for technology and export-oriented companies is another draw-back. There is no equivalent of OPIC or ECGD.

Small firms are seldom capable of significant efforts in R&D and are too financially fragile to compete on the increasingly globalized world markets. Therefore, Saudi Arabia needs to establish an adequate science and technology system. Whilst there are some consulting and contracting firms in Saudi Arabia, these remain small and specialized only in the areas of civil engineering.

Therefore the main policymakers of Saudi Aramco and SABIC must work with the government, to implement the reforms necessary to create an environment that can raise the level of knowledge and know-how in both private and public sectors, by:

- Raising skill levels through learning by doing, abandoning turnkey projects and implementing widely accessible training programmes that can absorb and train Saudis, on the factory or office floor. Increasing domestic technological capabilities through University Centres of Excellence and developing linkages within each state and among Gulf and Arab states.

- Increasing participation in the new world economy and the knowledge economy for which Saudis need a viable and efficient informational infrastructure.

The implementation of the aforesaid strategies and continuous innovation through national and regional policies and the dismantling of any barriers that preclude the full support and participation of as many Saudis as possible, are essential. Such strategies are needed to meet the needs of the Kingdom and to bring the economically viable and technically relevant capabilities of Saudi industries into the twenty first century as full members of the world community.

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APPENDIX 1: Questionnaire

Company……………………………………………………………………………………
Name………………………………………………………………………………………
Position / Department……………………………………………………………………
Postal Code…………………………………………………………………………………
City…………………………………………………………………………………………
Phone………………………………………………………………………………………

The aim of the questionnaire:

This questionnaire is administered to the managers, directors, advisors and engineers who have been involved in the development of Saudi industry. The questions were designed to collect data about technological and industrial development within Saudi industrial companies. Your expert opinion is therefore essential in bringing to light technology development issues in your company that are important for The Kingdom of Saudi Arabia.

Given the importance of the information contained in each questionnaire response, I thank you for taking the time to complete this questionnaire and appreciate that it represents a major contribution on your part.

You may rest assured that by giving your perspective, you are providing an invaluable service to the development of Saudi industry and all replies will be treated in the utmost confidence.

Instruction:

Most of the questions in this questionnaire ask you to check a box or circle a number according to your opinion. Many questions are in the follow forms:

In your company, products designs are
Copied or licensed from abroad 1 2 3 4 5 developed locally

Circling 1 means you largely agree with the left-hand side
Circling 2 means you agree somewhat with the left-hand side
Circling 3 means your opinion is indifferent between the two answers
Circling 4 means you agree somewhat with the right-hand side
Circling 5 means you largely agree with the right-hand side
Note: Please circle only one number per question!!

I realize that some of the questions ask for potentially sensitive information. **All responses will be treated as confidential.**

Sections covered in this questionnaire:

I. About your company
II. Technology
III. Innovation and research and development(R&D)
IV. Technology selection
V. Foreign technology licensing agreement
VI. Technology modification
VII. Company operations & strategy
VIII. Human resources
IX. Final comment

The results of the questionnaire:

The Chapter 6 which is the core chapter for this research has discussed the results of the questionnaire in detail through a comparative analysis of the research data gleaned from the questionnaire which was sent to the companies and other affiliates of two case-study organizations indicated in Appendix 2. This Chapter aims to examine the survey's questions in detail. It also measure the response to the questionnaire related to the achievements of the two cases, Saudi Aramco and SABIC.

Kindly return as soon as possible
Return address: P.O. Box 50748 Riyadh 11533 Kingdom of Saudi Arabia

I. About your company

Please note that in all questions asking about your firm (your branch or subsidiary)

1.01 Which of the following best describes your company or your unit (check all that apply)

- O Plant production
- O Management
- O Maintenance
- O Research and development
- O Accounting
- O Sales office
- O Others.......................

1.02 Your company's approximate number of employees

- O Under 250
- O 250-500
- O 500- 1000
- O More than 1000

1.03 Please estimate the proportions of your company's workforce according to level of education attained. Please include all workers - production, maintenance, management, accounting, and so forth.

Less than primary school	... %
Secondary school	... %
High school completed	... %
Vocational school completed	... %
University degree completed	...%
TOTAL OF ALL WORKERS =	100 %

1.04 Approximate percentage of employees in your company involved in the

Management	..... %
Operation	......%
Maintenance.	...... %
R&D	......%

1.05 Your company's average annual revenue growth over the past five years

O Negative	O 11-20%	O 41-50%
O 0%	O 21-30%	O 51-60%

O 1-10% O 31-40% O greater than 60%

1.06 Your company's annual expenditure on new technology costs, as a percentage of revenues

O Less than 10%	O 21-30%	O 41-50%
O 11- 20%	O 31-40%	O greater than 51%

1.07 Your company's competitive strategy in its principal business is (choose the most applicable answer)

O based on natural resource availability
O based on favourable costs of skilled workers
O based on product or process technology

1.08 For each of the following categories, please rate your company's position versus other companies. (Again note: you should respond from the perspective of your subsidiary.)

	Behind other local companies	**Similar to other local companies**	**Equal to the best in the region**	**Equal to the best in the world**
Product design and quality	O	O	O	O
Manufacturing process	O	O	O	O
Safety	O	O	O	O
Management strategy	O	O	O	O
Technology	O	O	O	O
Skilled workers	O	O	O	O
Services offered	O	O	O	O

II. Technology

2.01 Your company's position in technology

Generally lags behind 1 2 3 4 5 is among the world leaders most other companies

2.02 In your company, does the technology achieve the following? (check all that apply)

	Yes	No
More profit	O	O
More production	O	O
More export	O	O
Use of local resources	O	O
Reducing foreign expertise and experts	O	O
Others		

III. Innovation and research and development (R&D)

3.01 In your company, continuous innovation plays a major role in generating revenue

Not true 1 2 3 4 5 true

3.02 In the last five years, did your company introduce a new product or service, or did it substantially change its method of production?

Yes 1 2 3 4 5 No

A - If yes, this innovation originated from

- O Within the firm
- O Another source in your country
- O Another country

B - If the innovation was from another country, which of the following was involved?

- O It was part of foreign direct investment operation
- O You obtained a license or otherwise compensated a foreign company for the innovation
- O It was a direct import of foreign machinery, equipment or technology with no further contact
- O You simply adapted the innovation to your needs, with none of the above.

C - Please specify the country source of most innovation whether licensed or through joint venture partnership:

the country source of most innovation	through licensed	through JV partnership
O USA	()	()
O EU	()	()
O Japan	()	()
O Other	()	()

3.03 Licensing of foreign technology is

Uncommon in your company 1 2 3 4 5 a common means of acquiring new technology

3.04 Joint venture in your company

Brings little new technology 1 2 3 4 5 is an important source of new technology

3.05 Relation between your company and scientific research institution (e.g. university laboratories, government laboratories) are

Non-existence 1 2 3 4 5 the best in their fields

3.06 Your company

Does not spend money on R&D 1 2 3 4 5 spends heavily on R&D

3.07 Conducting research and development (R&D) in your company

A. Direct government subsidies to company

Never occur 1 2 3 4 5 are widespread and large

B. Government R&D tax credits

Never occur 1 2 3 4 5 are widespread and large

C. Your company's annual expenditure on R&D costs, as a percentage of revenues

O Less than 10%	O 21-30%	O 41-50%
O 11- 20%	O 31-40%	O greater than 51%

3.08 In your company, how are the following inputs obtained?

A. Components and parts

Almost always imported 1 2 3 4 5 almost always sourced locally

B. Process machinery

Almost always imported 1 2 3 4 5 almost always sourced locally

C. Specialized research and training services are

Not available in the country 1 2 3 4 5 available from world-class Institutions

D. Specialized technology services are

Not available in the country 1 2 3 4 5 available from world-class institutions

IV. Technology selection

4.01 Which of the following sources of information have been used for selection of new technology in your company? (choose the most applicable answer)

O Periodicals
O Catalogues
O Consulting
O Visiting exhibitions
O Partners
O Others...............

4.02 There are many forms and channels through which technology transfer can be transferred from industrialized countries to other countries, according to their importance, which of the following forms of technology transfer were used in your company? (Please do not select more than five forms as "extremely important").

	Not important	Slightly important	Very important	Not applicable
Technology supply	O	O	O	O
Machinery supply	O	O	O	O
Education	O	O	O	O
Training	O	O	O	O
License agreements	O	O	O	O
Turnkey contracts	O	O	O	O
Direct foreign investment	O	O	O	O
Employment of foreign experts	O	O	O	O
Joint venture	O	O	O	O
Technical assistance/consultants	O	O	O	O
Management participation	O	O	O	O
Others........................	O	O	O	O

4.03 Technology in your company selected by (choose the most applicable answer)

O Chairman of the firm
O Foreign consulting companies
O Local consulting companies
O Your own technical committee
O Educational institutions
O Others..............................

4.04 Design the plant in your company by (choose the most applicable answer)

O The firm acquiring the technology
O Foreign consulting companies
O Local consulting companies
O Your own engineering department
O Educational institutions
O Others ....

4.05 Please rank judge on a four-point scale how important these different factors are to your decisions in the selection new technology?

	Not important	Slightly important	Very important	Not applicable
Financial condition	O	O	O	O
Contract condition	O	O	O	O
Mode of payment & facilities	O	O	O	O
Complexity of technology	O	O	O	O
Reputation of supplier	O	O	O	O
Latest & proven technology	O	O	O	O

V. Foreign technology license agreement

5.01 In your company, is there any article in the technology license agreement, which obligates the supplier to provide the following?

	Yes	No
Education courses	O	O
Training services	O	O
Components and parts	O	O
Specialized technical services	O	O
Transfer some technical instructions	O	O
Specialized research	O	O
Local participation in R&D	O	O
Local participation in design & construction	O	O
Local participation in management	O	O
Others..	O	O

5.02 Did the license agreement restrict the use of?

	Yes	No
Local material resources	O	O
Outside material resources	O	O
Local machines & equipment	O	O
Outside machines & equipment	O	O
Development of machines & equipment	O	O
Local manpower	O	O
Local market	O	O
Regional market	O	O
Outside market	O	O
Other.......................................	O	O

VI. Technology modification

6.01 Please state whether there have been any modifications of the imported technology in your company?

Yes O No O

If yes, please give example and indicate the source responsible:

....

....

6.02 Has your firm faced any technology problems in production or operation?

Yes O No O

If yes, please give example:

....

....

6.03 Did your firm experience the principal technology-sharing problems that have arisen with a foreign partner

Yes O No O

If yes, please give example:

....

....

6.04 Did your firm experience difficulty with government sector in the acquiring of technology?

Yes O No O

If yes, please give example:

....

....

6.05 Does your company have R&D facilities?

Yes O No O

If no, please state the reasons:

....

....

6.05 Does your company have any relations with educational institutions such as universities?

Yes O No O

If yes, please give example:

....

6.07 Does your company have any patent registrations?

Yes O No O

If yes, please give example and indicate when acquired, where the registration is lodged and the nature of the technology patented

....

....

....

VII. Company operations & strategy

Note: the following questions seek your assessment of the typical company or subsidiary that competes internationally.

7.01 Competitive advantage of your company in international markets is

Due to low cost labour or Natural resources	1 2 3 4 5	due to unique products and processes

7.02 Your company obtains technology

Exclusively from foreign companies	1 2 3 4 5	by pioneering their own new products or processes

7.03 In your company, products designs are

Copied or licensed from abroad	1 2 3 4 5	developed locally

7.04 In your company, production processes

Generally use obsolete technology	1 2 3 4 5	generally employ the world's best and most efficient technology

7.05 To what extent has the imported technology your firm's ability to coordinate with customers and suppliers?

No change	1 2 3 4 5	huge improvement

7.06 In your company, please estimate local participation in

	Low Participation	Medium participation	High participation
Projects design	O	O	O
Projects construction	O	O	O
Principal services	O	O	O
Supervision	O	O	O
Operation	O	O	O
Testing and inspection	O	O	O
Research and development	O	O	O

VIII. Human resources

8.01 The general approach of your company to human resources is

To invest little in training and development	1 2 3 4 5	to invest heavily to employee attract, train and retain staff

8.02 Management training program in your company

Limited and poor quality	1 2 3 4 5	go only to skilled professionals among the

8.03 People in your company are

Not interested in absorbing new technology	1 2 3 4 5	aggressive in absorbing new technology world's best

IX. Final comment

9.01 Please give here any comment, idea or suggestion that you feel may be relevant to this study?

....
....
....
....
....

(Thank you for your cooperation and kindly return as soon as possible)

APPENDIX 2:

2-1: List of Saudi Aramco and SABIC Affiliates in Survey

The following box describes units or departments who replied to the survey:

- Plant operation and planning
- Research and development
- Finance and accounting
- Sales and marketing
- Human resources
- Production
- Management
- Maintenance

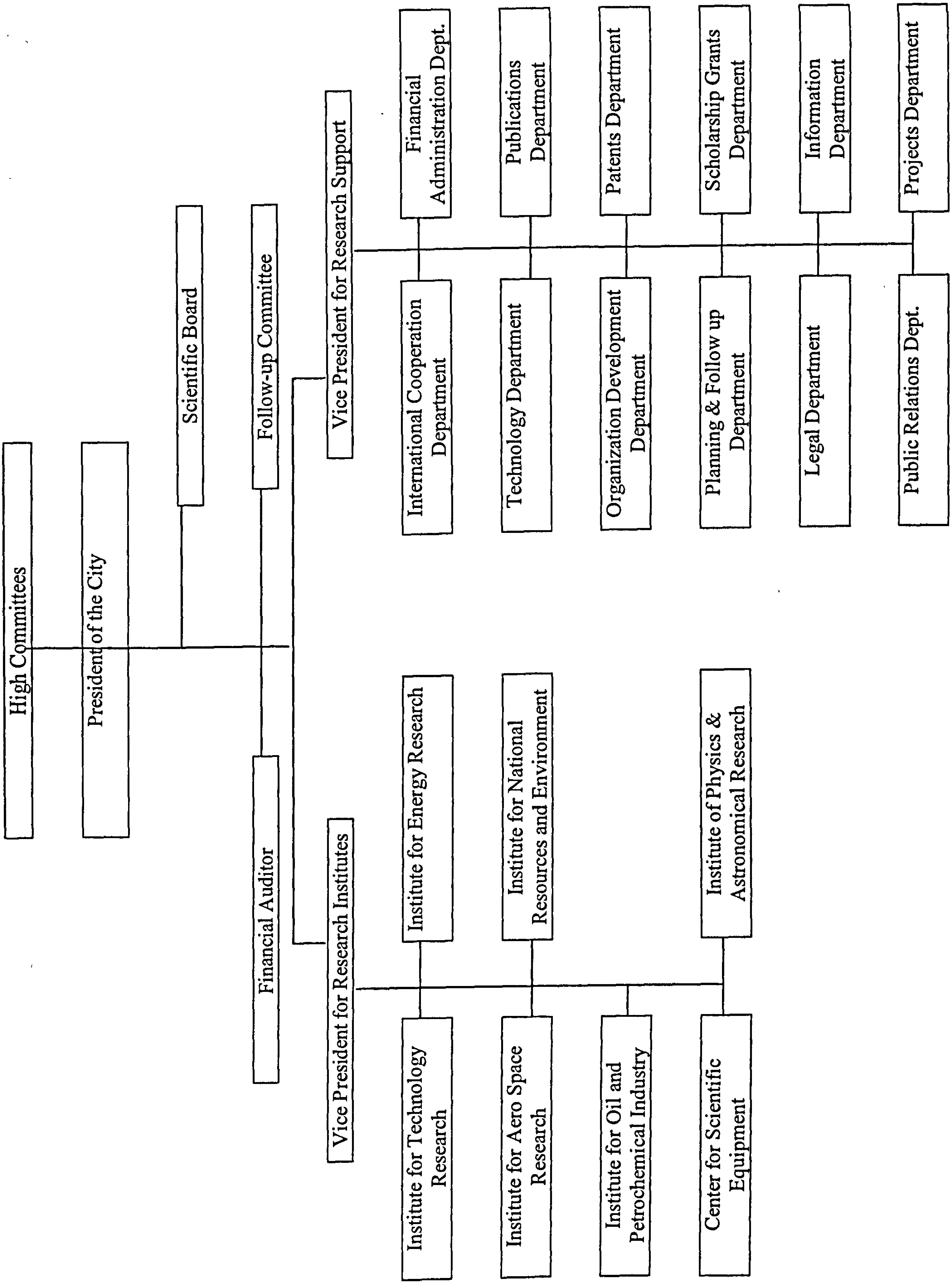
2-2: List of Saudi Aramco Affiliates in KSA were chosen as a focus through the case study survey

Company	No. of survey	No. of reply
Saudi Arabian Oil Company (Saudi Aramco)	15	07
Aramco Ras Tannurah Refinery	05	04
Saudi Aramco Mobil Refinery Co. (SAMREF)	05	08
Aramco Riyadh Oil Refinery	05	04
Saudi Aramco Shell Refinery Co. (SASREF)	10	05
Jeddah Oil Refinery	05	02
Aramco Yanbu Refinery	05	04
TOTAL	**50**	**34**

2-3: List of SABIC's Affiliates in the Kingdom of Saudi Arabia were chosen as a focus through the case study survey

Company	No. of survey	No. of reply
Sudi Basic Industries Corporation (SABIC) / HQ	10	05
Saudi Methanol Co. (AR-RAZI)	05	02
National Industries Gases Co (GAS)	03	03
Saudi European Petrochemical Co (IBN_ZAHR)	05	02
Arabian Industrial Fibers Co (IBN-RUSHD)	05	04
National Methanol Co. (IBN-SINA)	05	01
Saudi Petrochemical Co. (SADAF)	05	03
AL-Jubail Fertilizer Co. (SAMAD)	03	02
Saudi Iron & Steel Co. (HADEED)	--	
Eastern Petrochemical Co. (SHARQ)	05	02
AL-Jubail Petrochemical Co. (KEMYA)	05	05
Saudi Yanbu Petrochemical Co. (YANPET	05	05
Ibn-Hayyan Plastic Products Co. (TAYF)	--	
National Plastic Co. (IBN-HAYYAN)	--	
Arabian Petrochemical Co. (PETROKEMYA)	05	02
National Chemical Fertilizer Co. (IBN AL-BAYTAR)	03	01
Saudi Arabian Fertilizer Co. (SAFCO)	03	02
SABIC Terminal Services Co. (SABTANK)	--	
TOTAL	62	39

APPENDIX 3:
ORGANIZATIONAL CHART OF KING ABDUL AZIZ CITY FOR SCIENCE AND TECHNOLOGY



King Abdul Aziz City for Science and Technology is an independent scientific organisation, established in 1977, for the purpose of implementing a national policy for the advancement of science and technology and to formulate the strategies.

The City was primarily responsible for the introduction of scientific research programmes for development in the Kingdom, it also pioneered in the enhancement of various research programmes between the Kingdom and the international scientific research institutions. While the offering of scholarships and training courses in scientific research was one of its major projects, it also coordinated with departments, scientific institutions and research centre in the Kingdom for the purpose of research and data exchange.

As research projects are carried out in different institutions throughout the Kingdom, the King Abdul Aziz City for Science and Technology (KACST) was vested with the responsibility of administration and supervision of all research projects in various scientific areas. KACST conducts ongoing research comparing solar-powered alternatives to diesel fuel. One experiment, HYSOLAR, is testing hydrogen as a fuel in rebuilt automobile engines, using internal combustion to convert the hydrogen. KACSTis also conducting a solar-cooling experiment and has designed a solar thermal cooker. It has also implemented solar-powered highway signs and lighting. Energy generated from wind and the peaceful uses of atomic energy are other possibilities being researched by KACST scientists.

Another division of KACST, the Institute of Astronomical Research, signed an agreement with the National Aeronautics and Space Administration(NASA) of the United States to track sand drifting, develop mapping and detect underground water. The highlight of this cooperative project came on June 24, 1985 at Edwards Air Force Base in California. The U.S. SpaceShuttle Discovery landed after finishing a successful space mission with a crew that included Prince Sultan Bin Salman Bin Abdul Aziz, the first Arab and Muslim astronaut. (*)

(*) Sources: ***King Abdul Aziz City for Science and Technology, Annual Reports 2001-2002*****, KACST , Riyadh ,Kingdom of Saudi Arabia, 2002**

APPENDIX 4: List of Saudi Aramco patents (2002 to1976)

Patent No.	Title
6,180,888	Pulsed voltage surge resistant magent wire
6,156,827	Bituminous compositions prepared from thermoplatic polyolefins and their uses
6,060,162	Pulsed voltage mirge resistant magnet wire
6,056,995	Method of coating electrical conductors with corona resistant multi layer insulation
5,861,578	Electrical conductors coated with corona resistant, multiplayer insulation system
5,654,095	Pulsed Voltage surge resistant magnet wire
5,476,681	Rigid polyurethane/polyisocyanurate of foams containing paraffinic based oils
5,405,885	Rigid polyurethane/polyiosocyanate foams containing paraffinic based oils
5,256,740	Amino substituted polymers and their use as additives for modifying the cold properties of middle hydrocarbon distillates
5,112,937	Polymers derived from unsaturated polyesters by addition of compounds with a thiol function and their use as additives modifying the properties of petroleum middle distillates when cold
5,106,515	Polymers derived from unsaturated polyesters by addition of compounds with a thiol function and their use as additives modifying the properties of petroleum middle distillates when cold
5,037,945	Polymers derived from unsaturated polyesters by addition of compounds with an armine function and their use as additives modifying the properties of petroleum middle distillates when cold
5,001,202	Polymers derived from unsaturated polyesters by addition of compounds with an amine function and their use as additives modifying the properties of petroleum middle distillates when cold
4,956,492	Dialkyl fumarate, vinyl acetate copolymers useful as dewaxing aids

4,900,332	Nitrogenous copolymers, their preparation and use as additives for improving the pour properties of hydrocarbon middle distillates
4,837,338	Removal of impurities from n methyl pyrolidone using highly pure water washed activated alumina
4,832,821	Catalyst reforming process
4,813,027	Method and apparatus for enhancing seismic data
4,766,099	Catalyst for oil hydrorefining or mild hydrocracking of heavy oil charges to produce middle distillates
4,731,095	Nitrogen containing copolymers useful as additives for lowering thye cloud point of hydrocarbon middle distillates and compositions containing them
4,695,363	Crystal modification using dewaxing aids under agitated conditions
4,678,555	Preparation of cellulose acertate membrane and its use for polar solvent oil separation
4,670,130	The use of dailyyl furnarate vinyl acetate copolymers as dewaxing aids
4,652,273	Hydrocarbon middle distillates composition containing nitrogen containing additives for decreasing its cloud point
4,584,093	Process for the hydrotreatment of hydrocarbon oil employing catalysts based on alumina, silica or silica alumina
4,549,955	Process for stabilizing hydroprocessed lubricating oil stocks by the addition of hydrogen sulfide
4,541,972	Prerparation of cellulose acetate membrane and its use for polar solvent oil separation
4,537,875	Crushed catalysts containing alumina silica or silica alumina and process for their manufacture
4,514,280	Dewaxing waxy oil by dilution chilling employing static mixing means
4,511,369	Copolymers with nitrogen groups, useful as additives for decreasing the cloud point of hydrocarbon middle distillates and compositions containing them.

4,510,255	Process for manufacturing a supported catalyst for the hydrotreatment of hydrocarbon oils
4,503,182	Copolymers useful as additives for lowering the cloud point of middle hydrocarbon distillates, and compositions of middle hydrocarbon distillates comprising them
4,502,787	Agitated heat exchanger to chill solvent oil and wax slurry to wax filtration temperature
4,496,456	Method for preparing thin regenerated cellulose membranes of high flux and selectivity for organic liquids separations
4,464,494	Adhesive system for production of spiral wound membrane elements for use in organic fluid mixture seperations
4,461,698	Solvent dewaxing waxy hydrocarbon distillate oils using a combination wax naphthalene condensate poly dialky furmarate/vinyl acetate copolymer dewaxing aid
4,451,353	Solvent dewaxing waxy hydrocarbon distillates using a combination poly acrylate polymer and polymethacrylate polymer dewaxing aid
4,444,648	Solvent dewaxing with methyl tertiary butyl ether
4,441,987	Dewaxing process using agitated heat exchanger to chill solvent oil and wax slurry to wax filtration temperature
4,422,924	Solvent dewaxing waxy hydrocarbons using an alpha olefin polymer olefin vinyl acetate copoloymer composite dewaxing aid
4,421,634	Catalytic dewaxing with a hydrogen form zeolite L catlyst
4,406,771	Solvent dewaxing waxy hydrocarbon oil distillates using a combination poly dialkyl furmarate vinyl acetate copolymer having pendent carbon side chain length of predominantly C. sub 22 and polyalky (meth-) acrylate polymer dewaxing aid
4,396,492	Method for retarding corrosion in petroleum processing operation using N-methy pyrrolidone
4,377,467	Solvent dewaxing waxy hydrocarbon oils using dewaxing aid
4,371,641	Bitumehn containing extended compositions
4,368,112	Solvent recovery from foots oil using modified regenerated cellulose membranes
4,367,074	Novel filter aid compositions for improving the limiting

	filterability temperature and inhibition of n-paraffin crystal formation during low temperature of middle distillates
4,361,502	Catalyst for the pyrolysis of hydrocarbons
4,359,325	Copolymedrs from acrylate dicarboxylic compounds and disobutylene as oil additives
4,354,003	Solvent dewaxing waxy hydrocarbons using an alpha-olefin polyer olefin vinyl acetate copolymer composite dewaxing aid
4,334,978	Dewaxing and wax filterability by reducing scraper speed in scraped surface chilling units
4,319,962	Continous autorefrigerative dewaxing apparatus
4,285,804	Process for hydrotreating heavy hydrocarbons in liquid phase in the presence of a dispersed catalyst
4,264,334	Heavy fuel-oil compositions having an improved stability under storage conditions
4,217,203	Continous autorefrigerative dewaxing process and apparatus
4,216,075	Combination dewaxing process
4,181,597	Polyvinylpyrolidone dewaxing aid for bright stocks
4,176,044	Residual oil desulfurization in multiple zones without concomitant increase in hydrogen consumption
4,172,816	Solvent dewaxing waxy hydrocarbon oils using dewaxing aid
4,171,259	Method of stabilizing lube oils
4,169,785	Process for alkylating waxy hydrocarbons with C.sub.3-C.Sub.5 carbon atom secondary alcohols as catalyst
4,169,039	Catalytic process for preparing olefins by hydrocarbon pyrolysis
4,149,991	Reforming with multimetiallic catalysts
4,148,758	Reforming with multimetallic catalysts
4,146,461	Dilution chilling dewaxing by modification of tower temperature profile
4,145,275	Dilchill dewaxing using wash filtrate solvent dilution
4,125,458	Simultaneous deasphalting-extraction process

4,124,489	Production of transformer oil feed stocks from waxy crudes
4,11,790	Dilution chilling dewaxing solvent
4,081,352	Combination of extraction-dewaxing of waxy petroleum oils
4,076,613	Combined disulfurization and conversion with alkali metals
4,057,491	Solvent recovery process for N-methyl-2-pyrrolidone in hydrocarbon extraction
4,052,294	Method of solvent recovery in autorefrigerant/ketone dewaxing processes
4,032,431	Shape selective naphtha processing
4,021,207	Liquid hydrocarbon compositions of improved behaviour in the cold and containing diene polymers
4,018,866	Process for producing low pour point transformer oils from parafrfinic crudes
4,015, 952	Liquid hydrocarbon compositions of improved behavior in the cold and containing diene polymers
4,013,549	Lube extraction with NMP/Phenol/water mixtures
4,013,542	Partial pre-dilution dilution chilling
4,007,112	Method of controlling a distillation column for topping crude petroleum
3,989,616	Production of lubricating oils blending stocks and selected components for asphalt production
3,984,687	Shielded magnetic lens and deflection yoke structure for electron beam column
3,979,279	Treatment of lube stock for improvement of oxidative stability
3,975,396	Deasphalting process
3,969,221	Iridium-containing reforming catalyst and process
3,956,107	Nickel-containing reforming catalyst and process
3,933,622	Trimetallic hydrocarbon conversion catalyst

Source: ***USA Patents Office*, 2002**

APPENDIX 5: Subsidiary companies owned by Saudi Aramco

Aramco Services Company

Aramco Services Company ASC is a U.S. corporation headquartered in Houston, Texas to provide a wide range of services to the parent company Saudi Aramco. ASC also recruits talented people from North America for Saudi Aramco and assists in relocating those people to Saudi Arabia. Aramco Services Company's Engineering Services is made up of four teams. The Engineering Unit provides engineering support to North America-based Project Management Teams and to Saudi Aramco. The Quality Systems Unit provides inspection support to Saudi Aramco's procurement and vendor inspection activities in North America and to PMTs. The New Technology Team seeks out the best new science and engineering. The Information and Image Services Unit operates the Corporate Information Centre, which provides the Drawing Management System and computer graphics support.

These services include, but are not limited to, purchasing, expediting, and export shipping of materials in excess of over $100 million annually to support the operations of Saudi Aramco. In addition, P&T supports Saudi Aramco's Project Management Teams with logistic services, systems, procedures and training services as required. P&T also supports ASC's domestic purchasing and travel needs, as well as the sale of surplus materials of ASC and its affiliates.

Saudi Aramco Shell Refinery Company (SASREF)

Saudi Aramco and Shell are equal partners in SASREF. The refinery is located in Jubail City. The Refinery operations started in 1985 and its intake is 305 MBD Arabian Light crude oil. The main products are Chemical Feed Naphtha, Dual Purpose Kerosene, 0.5% Sulfur Gas oil and Fuel Oil (380 Cst) and their main destination is Asia. SASREF has recently boosted its competitive ability by building an advanced thermal cracking unit that enables the refinery to produce lighter more valuable products. The refinery currently employs about 616 employee which consist of 84% Saudis. A Saudi Aramco executive serves as SASREF's President & Managing Director.

Saudi Aramco Mobil Refinery Company (SAMREF)

Saudi Aramco and ExxonMobil are equal Partners in Samref, which owns and operates a refinery at Yanbu. The Yanbu facility refines 365 MBD of Arabian Light crude oil and was designed for maximizing gasoline production. Its product slate also includes kerosene, jet fuel, diesel and fuel oil. Samref products are sold in the Kingdom and exported. The Samref refinery operations began in 1984 and has current workforce of 877 employees, with a Saudisation rate of 84%. A Saudi Aramco executive serves as SAMREF's President & CEO.

Saudi Aramco Lubrication Oil Refining Company (LUBEREF)

Luberef was established in 1968 as a joint venture between Petromin (70%) and Exxon Mobil (30%). In 1996 Petromin's interest in Luberef was assumed by Saudi Aramco. Its first refinery, Luberef -I was constructed next to the Jeddah Oil Refinery and has maximum capacity of 1.8 million barrels per year and which receives straight-run fuel oil from the Jeddah Oil Refinery and refines it into four base oils products.

With combined capacity of 3.8 million barrels per year, Luberef is able to meet both domestic and overseas market demand. Key target markets for Luberef include the Middle East, Africa and Asia. Luberef-II was built in 1997 at Yanbu and has a capacity of 2 million barrels per year. With the completion of Luberef-II, Saudi Arabia became self sufficient in its production of base oils, no longer having to import them to meet domestic demand. Luberef is a joint venture with Mobil in which Saudi Aramco holds a 70 per cent stake. When the Jeddah facility opened in 1978, it was the first lubricant refinery in the Middle East. Luberef's current workforce is 408, with a Saudisation rate of 83%.

Aramco Gulf Operation Company (AGOC)

The Aramco Gulf Operations Company ("AGOC") was established in February 2000 as a Saudi Aramco wholly owned subsidiary. AGOC successfully took control of the Saudi Government interest in the former Neutral Zone. AGOC is located in al-Khafji at the Eastern Province of Saudi Arabia and engaged in activities relating to all phases of the oil industry and its other associate complementary industries in any area within the Kingdom or abroad, as may be authorized by the Government of the Kingdom from time to time.

These activities include prospecting, exploring, manufacturing, refining, transporting, storing, exporting, marketing, purchasing, exchanging, trading and dealing in any way with hydrocarbon substances, including crude oil, natural gas, liquefied gas, asphalt, sulfur and any or all other hydrocarbon substance products, by products. Crude oil production is estimated around 150 MBD. AGOC current manpower is 1181, with a 100% Saudization rate.

A Saudi Aramco executive serves as President and CEO of AGOC. Saudi Aramco monitors world markets very closely for opportunities of joint ventures in refining and marketing. Up to date about Three billion barrels of Saudi oil have been marketed through the following overseas Saudi Aramco joint venture projects:

Motiva Enterprise Companies in the United States

In 1997, an agreement was signed to merge two Shell International refineries with the Star Enterprise project, which was established in 1988 and is jointly owned by Saudi Aramco and Texaco of USA. This project formed a strong partnership for refining and marketing in 26 American states in the eastern and the Gulf of Mexico costs. The Company assets include four refineries with a capacity of 820,000 bpd, over 53 product distribution terminals and 14,000 service stations with total sale of 600,000 bpd of motor fuel. Saudi Aramco owns through its Saudi Refining affiliate a 32.5% share in Motiva while Texaco and Shell own 32.5% and 35%, respectively.

Sang Yong Oil Corporation in the Republic of South Korea

South Korean refiner S-Oil, in which Saudi Aramco holds a 35 per cent stake, exports extra-low sulphur gas oil to Japan and Hong Kong ahead of stricter emissions requirements in Japan, according to reports. S-Oil has the capacity to produce 10,000 to 20,000 barrels per day (bpd Saudi Aramco bought its 35 per cent interest in the S-Oil Corporation - formerly known as Ssangyong - in 1991. The Korean company operates a 525,000 bpd refinery in Onsan, and has established a strong marketing position in the Pacific Rim region. The capacity of the plant was raised to its current level in 1994, while a $1.2 billion facility to convert heavy oil residue into higher value products was completed in 1997.

Saudi Aramco is a leading foreign investor in South Korea, and the S-Oil refinery sources at least 70 per cent of its crude oil needs from the Kingdom, thus almost guaranteeing a ready market for Saudi oil.

SIn 1999 Saudi Aramco owns a 35% of S-Oil Corporation's shares. It is the biggest shareholder in this Company which has advanced petroleum refining installations with a production capacity of about 525,000 bpd, 90% of which is supplied by Saudi Aramco. Saudi Aramco's total crude oil sales in South Korea increased to more than 720,000 bpd, nearly six times sales since the turn of the current decade.

Petron Corporation in Philippines

Saudi Aramco has, since 1994, had a 40 per cent interest in the Philippines' largest refiner, Petron. Petron operates 180,000 barrels per day (bpd) refinery at Bataan and markets products through more than 1,000 retail outlets. The company is one of the top three oil retailers in the Philippines. Saudi Aramco supplies the refinery with the majority of its crude oil needs, under a flexible crude purchases agreement with Petron. The agreement gives Petron wider latitude in its crude purchas5 in aggressive environments. Saudi Aramco owns a 40% share in Petron of the Philippines, which has a refining capacity of 160,000 bpd. The Company is seeking to increase this capacity to 180,000 bpd.

Motor Oil (Hellas) in Greece

Saudi Aramco signed an agreement with Fardioyanis Industrial Group in Greece to acquire a 50% share in Motor Oil (Hellas) Corinth Refineries and Avinoil Industrial Commercial and Maritime in March 1996. Saudi Aramco became the major supplier of the Company's crude oil requirements. Hellas is the largest private refining company in Greece and runs a conversion refinery with a capacity of 100,000 bpd.

Arab Pipeline Company (SUMED)

In Mid 1997, Saudi Aramco assumed Petromin's 15% share in Sumed in Egypt which is jointly owned and run by Saudi Arabia, Egypt, Abu Dhabi, Kuwait and Qatar. Saudi Aramco is the largest user of Sumed Pipelines, which have a capacity of 2.4 million bpd, and carries crude oil from the Gulf of Suez to the Mediterranean coast, thereby serving as a short cut to ports on the Mediterranean and in North Europe.

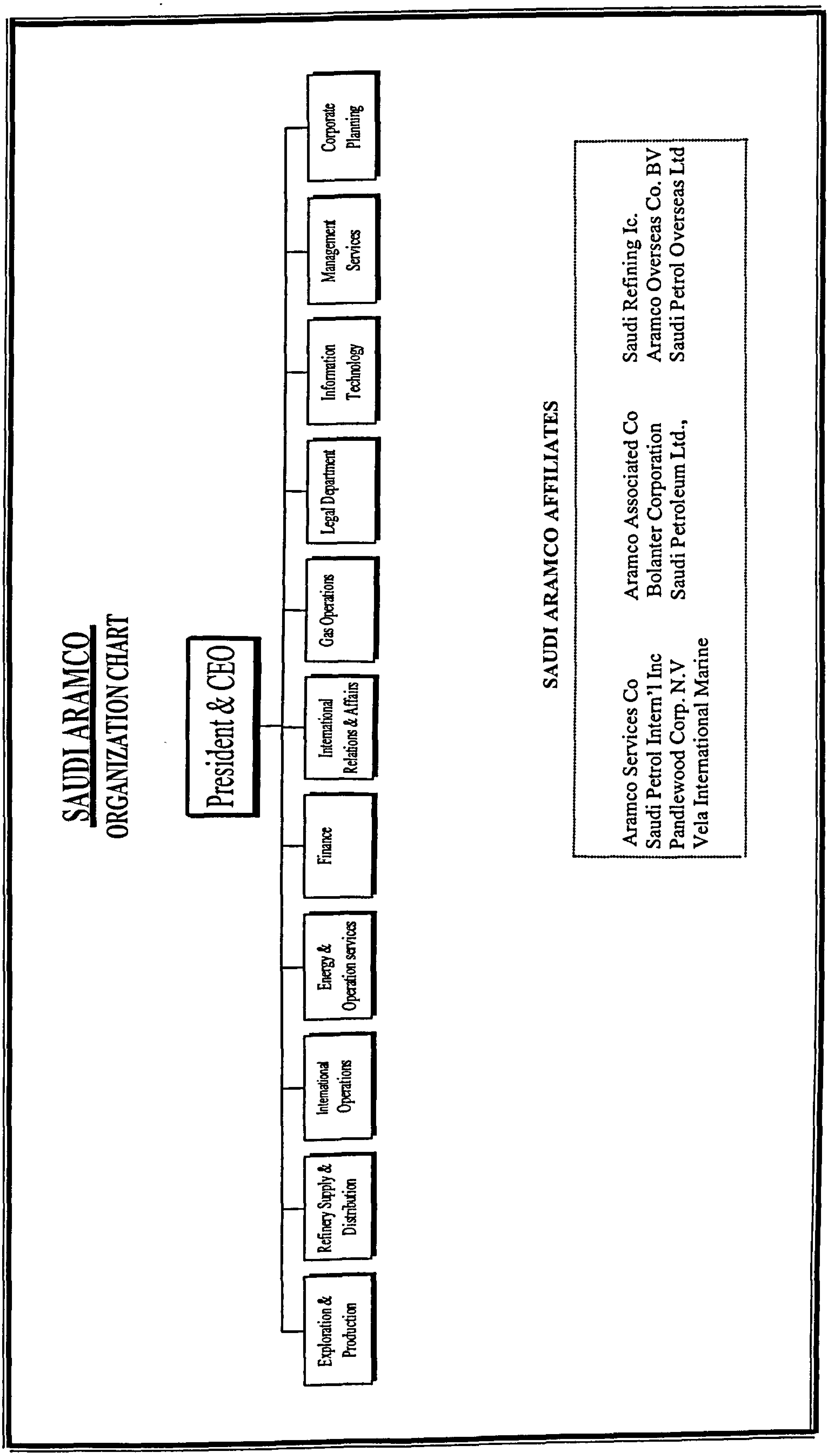
Vela International Marine

Vela's global shipping business complies with the highest international standards outlined by the International Maritime Organization (IMO). Because the shipping industry is diverse and subject to many local as well as global regulations, the International Safety Management (ISM) code is designed for broad applications. But its focus is on the safe operation and handling of vessels and the prevention of environmental damage. Saudi Aramco crude transport subsidiary Vela International Marine is preparing for the future with a fleet upgrade, which includes four new very large crude carriers (VLCCs). The 300,000 deadweight ton vessels are due for delivery next year and 2003, and will complement Vela's current fleet of 21 VLCCs and Ultra Large Crude Carriers (ULCCs), and two petroleum product carriers. Each new VLCC will have the capacity to transport two million barrels of crude oil. Vela provides dependable crude delivery to customers in North America, Europe and the Far East. The economies of scale offered by the company's supertankers enables the company to maintain competitive rates for its crude oil. However, transporting more than a quarter of Saudi Aramco's annual crude oil exports is a mammoth job and one which requires the most stringent safety standards to be observed.

A number of issues are taken into consideration with regards to safety at Vela, through its Marine Operations Department. Reconditioning of the fleet is a vital aspect of operations, according to the company, allowing a more thorough inspection of the ship's hull, propeller and rudder. Periodic dry-docking is a requirement of all carriers expecting to maintain international government and industry certification. In the interest of accident-free operations, these requirements impose strict standards or codes with which the owners and operators must comply.

APPENDIX 6

Organisational Chart for Saudi Aramco



APPENDIX 7: SABIC's joint ventures

I . SABIC's joint ventures with the United States:

SABIC/Mobil joint venture / Saudi Yanbu Petrochemical Company (Yanpet)

As far back as 1946 Mobil came to the Kingdom to produce and distribute oil as a partner with Saudi Aramco. In August 1976 an agreement was signed between Mobil and SABIC to establish a joint-venture Saudi Yanbu Petrochemical Co. (Yanpet). On April 19, 1980, the final agreement was signed by Chairman of Mobil Saudi Arabia (the wholly owned subsidiary of Mobil Oil Corporation), and SABIC.

Profile of Saudi Yanbu Petrochemical Company (YANPET)
Location: Yanbu Industrial City, Saudi Arabia
Partnership: 50/50 Joint venture between SABIC and MobilExxon.
Capital investment: SR 7 billion (US$ 1.8 billion)
Established: 1981
Employees: 1575 (1214 Saudi, 361 non Saudi)

Products	Start-up	Capacities	Technology/Engineering
Ethylene	1984	1,600,000	Lummus/Bechtel
Propylene	1984	350,000	Lummus/Bechtel
Ethylene glycol (EG)	1984	800,000	SD/Bechtel
LLDPE/HDPE	1984	1,200,000	UCC/Bechtel, MHI
Propylene	2000	260,000	UCC/MHI
Pyrolysis gasoline	2000	116,000	Lummus/Lummus

Feedstock	Source
Ethane	Saudi Aramco
Propane	Saudi Aramco
Light Naphtha	Saudi Aramco
Oxygen	GAS
Butene-1	

Markets: Mobil and SABIC Marketing Ltd market all products
Source: based on information from YANPET, SABIC and Royal Commission for Jubail and Yanbu, October 2001.

At this time, Minister of Industry Dr. Algosaibi identified this agreement as a major landmark in the Kingdom's industrial development history.(Joint Venture Agreement, 1980)

The SABIC-Mobil plant came on stream in 1985 to produce: 1,600,000 tons annually of ethylene using the Mobil process and Bechtel engineering; 1,200,000 tons of low-density polyethylene (LDPE) using the Union Carbide process; 800,000 tons of ethylene glycol again using the Mobil process; and 150,000 tons of high density polyethylene (HDPE) once again using the Mobil process. The capital investment of this project was about SR 7 billion ($1.8 billion). Mobil and SABIC became partners, each holding 50 percent of the equity. Each partner provided 15 percent of the capital cost in cash. The remaining 60 percent was provided by Public Investment Fund of Saudi Arabia and 10 percent by private banks . A crude-oil entitlement was also being made available by Saudi Arabia to Mobil as an added inducement to invest. About 3,000 people were needed to staff this complex. 77 percent of the employees are Saudis and 23 percent expatriates.

Yanbu started to market its products in Europe, along the eastern seaboard of the United States, in the Arab world, in Africa, and in Saudi Arabia itself. Three quarters of the sales were handled by Mobil. (Joint Venture Agreement, 1980)

SABIC/Shell joint venture / Saudi Petrochemical Company (SADAF)

Saudi Petrochemical Co.(SADAF), was established in 1980 in a 50-50 joint venture with Shell Oil Co., U.S.A. to build one of the largest petrochemical complexes in the world-a "mega project.". Using ethane and methane, this complex annually produced: 1,100,000 tons of ethylene using the C.F. Braun of California process and engineering; 1,100,000 tons of styrene using the Mobile-Badger process and Badger engineering; 840,000 tons of ethylene dichloride using the Stauffer process and Dravo Corporation engineering; 300,000 tons of crude industrial ethanol using the Shell Development Company process and C.F. Braun engineering; 670,000 tons of caustic soda and 330,000 tons of chlorine using the Diamong Shamrock process and Davro for the engineering; and finally, 700,000 tons of MTBE using UOP,CD Tech & Sinamprogetti.

This company began production of ethylene in 1984. Additional production units came on-stream in 1985. SABIC and Shell International Chemical, believed these ventures would be successful both for the Kingdom and for their partners. The capital investment of this complex reached SR14.2 billion ($3,800 million). SABIC and Shell each invested 12.5% in this venture. The balance was funded by the Public Investment Fund of the Saudi Ministry of Finance, which was prepared to make available 60 percent of the total cost of the complex with a grace period of five years and at a rate of interest between 3 and 6 percent. Commercial banks were being brought into the financing as well. The return on equity for this complex was some 15 to 20 percent. This return depended on the price of such inputs as feedstock, fuel, electricity, and water as well as the world price of the products and the volume of sales.

It was expected that the costs of the feedstock and the fuel would be much lower than in the industrialized countries and that the other variable costs would be at least comparable.

Profile of Saudi Petrochemical Company (SADAF)

Location:	Al-Jubail Industrial City, Saudi Arabia
Partnership:	A 50/50 SABIC Joint Venture with Pacten Arabian Company (subsidiary of Shell)
Capital investment:	SR 14.2 billion (US$ 3.8 billion)
Commercial operation:	1986
Employees:	717 (663 Saudi, 54 Non-Saudi)

Product	Start-up	Capacity	Technology/Engineering
Ethylene	1985	1,200,000	C.F.Braun/Flour,BRB
Crude Ethanol	1985	300,000	Shell/Flour
EDC	1985	560,000	Stauffer/DRAVO
	1997	280,000	EVC/Flour-BRB
Ethylbenzene	1985	390,000	Badger/Flour
	1997	195,000	Badger/Flour
Styrene	1985	360,000	UCC-Cosden-Badger/Flour
	1997	190,000	UCC-Cosden-Badger/Flour
	2000	500,000	ABB Lummus/Daelim
MTBE/ETBE	1997	700,000	CD Tech/M.W.Kellogg-BRB
NaOH	1985	450,000	Diamond Shamrock/DRAVO
	1997	225,000	Uhde/Flour/BRB
Chlorine	1985	394,000	Diamond Shamrock/DRAVO
	1997	197,000	Uhde/Flour/BRB
Feedstock	Capacity		Source
Ethane	1,300		Saudi Aramco
Salt	1,100		Salt Mine Jubail
Benzene	450		SASREF
Methanol	200		IB SINA
Butane	400		Saudi Aramco
Markets	KSA		World
	(21%)		(79%)

Sources : Based on information from SADAF, SABIC and Royal Commission for Jubail and Yanbu, October 2001.

SABIC/Exxon joint venture / Al-Jubail Petrochemical Company (KEMYA)

Exxon, the world's largest company, first came to Saudi Arabia in 1946 as a partner with Saudi Aramco and the Kingdom soon became a major source of oil for Exxon. In the 1970s the possibility was raised by SABIC of a joint venture Al-Jubail Petrochemical Co. (KEMYA) to produce low-density polyethylene (LDPE). After an agreement was signed in March of 1977, a number of feasibility studies were undertaken. A final agreement was signed on April 26, 1980, between SABIC and Exxon Chemical Company of USA.

This complex, used ethylene as a feedstock, which came from a cracker to be shared with the SABIC Shell joint venture /Saudi Petrochemical Co (SADAF). Using Union Carbide's new Unipol process to produce some 850,000 tons of LLDPE and using Exxon Chemical process to produce 220,000 tons of LDPE annually. The engineering was done by the Fluor Corporation. The investment of this project had been put as $ SR14,2 billion (US$ 3.8 billion), with the equity being shared equally. As an additional incentive, Exxon received a commitment from Saudi Arabia to provide crude oil for the invested in the complex. From the beginning of the project, promising and qualified Saudis joined the team during the detailed engineering phase and during the construction and precommissioning phase. Each one of them was given a specific task and responsibility. Another aspect was to maximize the use of local materials and contractors, more than 50% was executed by local suppliers and contractors. The total personnel of this plant was about 350. When the plant started up, 30% of the personnel were Saudis. A number of Saudis then were with Exxon in the United States for training, and their number gradually increased. Most of the production was marketed by Exxon. Abdulaziz Al-Zamil, former SABIC's Vice Chairman and the Managing Director, emphasized that the transfer of technology and management expertise was important what he deemed critical was the responsibility for marketing the products. Feeding the plants' production into Exxon's marketing network was the most significant portion of the agreement. The output of exports were channelled into world markets, including Europe. SABIC initially marketed the remaining of the production in Saudi Arabia and abroad. The proportion marketed by SABIC gradually increased.

Profile of Al-Jubail Petrochemical Company (KEMYA)
Location: Al-Jubail Industrial City, Saudi Arabia
Partnership: A 50/50 SABIC joint venture with MobilExxon.
Capital investment: SR 7.87 billion (US$ 2.1 bill.)
Commercial operation: 1984
Employees: 585 (470 Saudi, 115 Non-Saudi)

Product	Start-up	Capacity	Technology/Enginerering
Ethylene	1985	700,000	Lummus/Lummus
Propylene	2000	200,000	Lummus/Lummus
LLDPE/HDPE	1985	850,000	UCC/Flour
LDPE	2000	220,000	Exxon/Tecnimont

Feed Stock	Capacity	Source
Ethylene	--	SADAF &PETROKEMYA
Butene-1	--	PETROKEMYA
Ethane, Propane	--	Saudi Aramco
Hydrogen, Oxygen	--	GAS

MARKETS	KSA	GCC	WORLD
	3%	8%	89%

Source : based on information from Royal Commission for Jubail and Yanbu ,October 2001.

SABIC/Celanese-Texas Eastern joint venture/ National Methanol Company (IBN SINA)

The Celanese Corporation and Texas Eastern of the United States and SABIC agreed to launch a joint-venture methanol plant in Jubail each holding 25 percent. National Methanol Co. (IBN SINA) was formed in 1981 at Al-Jubail and came on-stream in 1984. Considerable progress was made since that time. It was decided to establish a world scale complex-one that would use local methane to produce 730,000 tons of methanol a year employing the Imperial Chemical Industries process. The engineering was done by C.F. Braun and Company. The investment of this plant was estimated at SR 4.2 billion ($1120 million). This venture seemed to have particularly good prospects. Methanol was becoming a key product for SABIC. Total demand in the United States, as expected by Celanese tripled over the next decade and production of the plant in Saudi Arabia was absorbed in the United States. Actual production levels increased 50 percent currently. (Feasibility Study of the joint venture 1981)

Profile of National Methanol Company (IBN SINA)

Location:	Al-Jubail Industrial City, Saudi Arabia
Partnership:	(SABIC) 50% Celanese – USA 25% Duke Energy International – USA 25%
Capital investment :	SR 4.2 billion (US$ 1120 mil.)
Commercial operation:	1984
Employee:	274 (255 Saudi,19 non Saudi)

Products	Start-up	Capacities	Technology/Engineering
Methanol	1984	1,050,000	ICI/C.F.Braun
MTBE	1994	850,000	CID Tech/Flour Houdry/UOP
Feedstock	Capacity		Source
Methanol Plant : Methane	-		Saudi Aramco
CO2	-		IBN Al-BAYTAR
MTBE Plant: Butane	695,000 TPY		Saudi Aramco
Methanol	324.000 TPY		IBN SINA
Markets	KSA	GCC	World
Methanol	22%	3%	76%
MTBE	24%	3%	73%

Source: based on information from IBN SINA, SABIC and Royal Commission for Jubail and Yanbu, October 2001.

II. SABIC joint ventures with European Countries

Saudi European Petrochemical Company (IBN ZAHR), SABIC's first joint venture company with European partners, began production of methyl teritiary butyl either (MTBE) in the second quarter of 1988 at Al Jubail. The company owned 70 percent by SABIC and 10 percent each by Fortum of Finland and Ecofuel of Italy. A third joint venture partner was the Arab Petroleum Investment Corp. (APICORP), with a 10 percent share. IBN ZAHR had a production capacity of 1,500,000 mt/y. This is one of the largest MTBE complexes in the world. Methanol feedstock was supplied from other SABIC methanol producing affiliates. MTBE is a non-polluting, high-octane, oxygenated gasoline additive intended to replace tetraethyl lead in motor fuels. Consumption of MTBE was expected to increase dramatically in the next few years as the developed world particularly implements new environment protection policies to remove lead from gasoline in order to reduce lead emissions from automotive exhausts. (Feasibility Study of the joint venture 1984)

Profile of Saudi European Petrochemical Company (IBN ZAHR)

Location:	Al-Jubail Industrial City , Saudi Arabia
Partnership:	SABIC 70% Fortum (Finland) 10% Ecofuel (Italy)10% APICORP (Arab Petroleum Investment Corporation)10%
Capital investment:	SR 5.2 Billion (US$ 1386 mil.)
Commercial operation:	1989
Employees:	599 (435 Saudi, 164 non-Saudi)

Products	Start-up	Capacities	Technology/Engineering
MTBE	1989	1,500,000	Snamprogetti/Snamprogetti
Polypropylene	1995	640,000	UCC/Parsons
Feedstock	Capacity (TPY)		Source
Butane	1,150,000		Saudi Aramco
Methanol	550.000		SABIC (IBN SINA)
Propylene	720,000		Petrokemya / Kemya
Markets	KSA	GCC	World
MTBE	13%	5%	74.50%
PP	40%	10%	50%

Source: based on information from Royal Commission for Jubail and Yanbu, October 2001.

III. SABIC joint ventures with Asian Countries

Asia, which rapidly became a major economic region in the world, accounted for many of the most dynamic economies: Taiwan, Japan, and South Korea. With their lack of natural resources, these countries made outward-looking policies central to their overall economic strategy. These Asian states play a key role in Saudi Arabia's petrochemical industry as Japan, the most industrially advanced country, provides technology and markets. Taiwan and South Korea provide technicians and markets. SABIC has arranged three joint-venture agreements with Asian countries, one of which is Taiwanese and the other, Japanese as follow:

SABIC/ joint venture with Taiwan / Al -Jubail Fertilizer Company (SAMAD)

Taiwan has virtually no oil and the most important source is Saudi Arabia. The close links between Saudi Arabia and Taiwan found a concrete expression in an agreement signed on December 4,1979, between SABIC and the Taiwan Fertilizer Company Limited (TFC) to establish the Al-Jubail Fertilizer Company (SAMAD) located in Jubail.

This joint venture used methane to produce 500,000 mt/y of urea began in 1983. De-bottlenecking increased urea production by 20 percent to 630,000 mt/y. The total investment was estimated at SR 2.5 billion ($693 million). SABIC and the Taiwan Fertilizer Company each subscribed 50 percent of the shares of the Al-Jubail Fertilizer Company, putting up $100 million, with the balance being loaned by the Saudi Public Investment Fund (PIF). Some 60 percent of the output was marketed by the Taiwan Fertilizer Company in Taiwan and other places in the Far East. The other 40 percent was marketed jointly by the Taiwan Fertilizer Company and SABIC elsewhere. Ammonia, being a source of nitrogen -fertilizer, was closely linked to agricultural production. (The Feasibility Study of the JV 1979)

While Taiwan had highly skilled engineers, technicians, and labor, they relied on U.S., European, and Japanese technology in petrochemicals. Thus, with the Al-Jubail Fertilizer Company (SAMAD), the Pullman Kellogg and Stamicarbon BV processes were being used while the construction-management services were the responsibility of Bakhsh-Pullman Kellogg. Design and engineering was partly carried out in the US offices of Pullman Kellogg. The actual construction on the site in Jubail started in June of 1980, and the plant went on stream in 1984. (SAMAD Reports 1980-1985)

Profile of Al-Jubail Fertilizer Company (SAMAD)

Location:	Al-Jubail Industrial City, Saudi Arabia
Partnership:	A 50/50 SABIC joint venture with Taiwan Fertilizer (TFC)
Capital investment :	SR 2.5 billion (US$ 693 mil.)
Commercial operation:	1984
Employees :	429 (380 Saudi, 49 non-Saudi)

Products	Start-up	Capacities	Technology/Engineering
Ammonia	1983	391,000	M.W. Kellog
Urea	1983	650,000	Stamicarbon
2-Ethyl hexanol	1995	150,000	Davy-UCC/John Brown
Dioctyl phthalate DOP	1997	50,000	Mitsubishi Gas Chemical /MKK
Feedstock	Capacity		Source
Methane	30,500 MMSFY		Saudi Aramco
Ammonia	365		SAMAD
Propylene	125		Petrokemya
PA	17		Imported
2-EH	33,500		SAMAD
Markets	KSA		World
Urea	15%		85%
DOP	25%		75%
2-EH	-		100%

Source : based on information from Royal Commission for Jubail and Yanbu, October 2001.

SABIC/ joint ventures with Japan

Saudi economic relations with Japan developed rapidly. In December of 1973 the International Trade and Industry Minister, Yasuhiro Miko, visited the Kingdom. This visit led to the signing in 1975 of a Japan-Saudi Arabia economic and technological agreement, consisting of five articles:

1. promotion of economic and technological cooperation;
2. establishment of joint ventures and the contents of technological cooperation;
3. supply of required services and facilities;
4. encouragement of economic and technological cooperation between the peoples of the two nations;
5. and encouragement of Japanese capital investment.

The following year, joint committee offices were established in Riyadh. Saudi Arabia and Japan had much to gain from a close association. The Vice Chairman of Mitsubishi Corporation, Keizaturo Yamada, had observed that the Kingdom was interested in securing technology and complete turnkey projects in exchange for the export of Saudi oil. The Japanese technology for the petrochemical industry was almost on a par with the best in the United States and Europe. To secure Japanese technology and the much-needed channels, Saudi Arabia had recourse to the "sogo shosha" (general trading companies). These giant business owed their strength to close business connections. They were active in marketing, distribution, financing, and organizing large-scale plant construction. Mitsubishi realized that a chemical company's success depended almost entirely on whether it had a solid link with a major feedstock supplier. This has led Mitsubishi and various other Japanese firms to look with increasing favour on joint ventures in the Kingdom. SABIC, and Mitsubishi both had strong mutual interests in strengthening cooperation in the development of the petrochemical industry in Saudi Arabia. (The Feasibility Study of the JV 1979)

SABIC/Mitsubishi Gas joint venture

SABIC/Mitsubishi Gas joint venture /Saudi Methanol Company (AR RAZI), formed in 1979, was the first of the SABIC Petrochemicals Companies to be created in a 50-50 joint venture partnership with a group of Japanese companies headed by Mitsubishi Gas Chemical Co. On April 14, 1980, Kisako Hori, the general manager of the Mitsubishi Heavy Industries Limited, signed the agreement with SABIC to build the plant to produce methanol with design capacity of 600,000 mt/y using natural gas as a feedstock. Actual production levels increased 20 percent to 3,000,000 mt/y currently. This was the first venture by Japanese firms in methanol production outside of Japan. (Evaluation of SABIC- Japames Methanol Project 1979)

Profile of Saudi Methanol Company (AR-RAZI)
Location: Al-Jubail Industrial City, Saudi Arabia
Partnership: 50/50 Joint venture between SABIC and JSMC (Japan Saudi Arabia Methanol Co.) A consortium of Japanese companies headed by Mitsubishi Gas Chemicals
Capital investment: SR 3.6 Billion
Commercial operation: 1983
Employees: 509 (459 Saudi, 50 non saudi)

Product	Start-up	Capacity	Technology/Engineering
Methanol	1983	3,000,000	MGC/MHI
Feedstock	Capacity		Source
Methane	2.4		Saudi Aramco
Markets	KSA		WORLD
	(20%)		(80%)

Source: based on information from Royal Commission for Jubail and Yanbu, October 2001.

SABIC/Mitsubishi Corporation joint venture/ Eastern Petrochemical Company (SHARAQ)

The most important joint venture with the Japanese is the giant petrochemical complex, SABIC/Mitsubishi Corporation 50-50 joint venture/ Eastern Petrochemical Co. (SHARAQ), located in Jubail. Using ethane as a feedstock, the plant had an annual capacity of 450,000 tons of ethylene, 250,000 tons of low-density polyethylene (LDPE), 450,000 tons of ethylene glycol, and 80,000 tons of high-density polyethylene (HDPE), according to tentative agreements. A great deal of capital was required-possibly some SR 8 Billion ($2 billion). Funding was by SABIC and a consortium of Japanese firms, grouped in the Saudi Petrochemical Development Corporation (SPDC), which was formed in 1979. The consortium was led by the Mitsubishi Corporation and fourteen other Mitsubishi companies as well as thirteen oil companies, nine power companies, eleven petrochemical companies, four banks, and two gas companies.

Profile of Eastern Petrochemical Company (SHARAQ)
Location: Al-Jubail Industrial City, Saudi Arabia,
Partnership: 50/50 Joint venture between SABIC and SPDC Ltd
(A consortium of Japanese companies headed by Mitsubishi)
Capital investment: SR 7.6 billion (US$2026 million)
Commercial operation: 1987
Employees: 819 (Saudi 638, 181 non Saudi)

Products	Start-up	Capacities	Technology/Engineering
EG	1985	1,500,000	SHELL/Chiyoda Petrostar (CPL)
LLDPE	1985	750,000	UCC/CPL /Mitsubishi Ind. (MHI)
Feedstock	Capacity		Source
Ethylene	10.30		Petrokemya (Joint Ownership)
Hydrogen	0.1		Petrokemya
Methane	7		Petrokemya
Oxygen	760		NIGC (GAS)
Butene-1	46		Petrokemya
Markets	KSA	GCC	World
EG	1%	-	99%
LLDPE	11%	3%	86%

Source : based on information from Royal Commission for Jubail and Yanbu ,October 2001.

The Japanese corporate commitment was 7.5 percent of the capital investment. Another 7.5 percent came from the OECF, which classifies as "national." This undertaking was the largest economic cooperation agreement yet between Japan and Saudi Arabia and that the Japanese government holds the realization of this project is of vital importance. Sharaq was formed in 1981 and came on-stream in 1987. De-bottlenecking and adjust plant operations to achieve maximum production capacity had increased output of LLDPE up 10 percent, and the output of EG up 15 percent.

SABIC/ S. Korea joint venture /National Plastics Company (IBN HAYYAN)

National Plastics Co. (IBN HAYYAN) was the first of SABIC's downstream industries to enter production. It was formed in 1984 in a joint venture with the Lucky-Gold Star Group of South Korea. On-stream production of polyvinyl chloride (PVC) and vinyl chloride monomer (VCM) began in 1986. During 1987, the first complete year of operation, IBN HAYYAN's production reached design capacity of 200,000 mt/y of PVC, destined mainly for domestic use.

Profile of National Plastic Company (IBN HAYYAN)
Location: Al-Jubail Industrial City, Saudi Arabia
Partnership: Saudi Basic Industries Corporation (SABIC) 86.5%
National Industrialization Co. (NIC) 10.0%
Saudi Plastic Product Co. Ltd. (SAPPCO) 2.0%
Arabian Plastic Manufacturing Co. (APLACO) 1.5%
Capital investment: SR 1.65 Billion (US$ 440 million)
Commercial operation: 1986

Products	Start-up	Capacities	Technology/Engineering
VCM	1986	400,000	Geon/Uhde, John Brown
PVC	1986	3,00,000	Geon/Uhde, Budger
PVC Paste	1995	24,000	EVC/TPL
Feedstock	Capacity		Source
Ethylene	93		Petrokemya
Etylene dichloride	328		SADAF
Markets	KSA	GCC	World
VCM	87%	-	13%
PVC	51%	21%	28%
PVC Paste	4%	1%	95%

Source: based on information from Royal Commission for Jubail and Yanbu, October 2001.

Profile of National Chemical Fertilizer Company (IBN AL-BAYTAR)

Location:	Al-Jubail, Saudi Arabia
Partnership:	Saudi Basic Industries Corporation (SABIC) 50%
	Saudi Arabian Fertilizer Company (SAFCO) 50%
Capital investment:	SR 2 billion (US$ 533 million)
Established:	1985
Employees:	645 (580 Saudi, 56 non Saudi)

Product	Start-up	Capacity	Technology/Engineering
Ammonia	1987	500,000	M.W. Kellogg / TEC
Granual Urea		500,000	Snamprogetti / NSM / TEC
NPK fertilizer	1991	500,000	Cros / TPL-Shinwha E&C
GTSP	1991	200,000	Jacobs / TPL-Shinwha E&C
DAP	1991	100,000	Cros TPL-Shinwha E&C
Liquid NPK	1991	10,000	Cros TPL-Shinwha E&C

Feedstock	Capacity	Source
Natural gas		Saudi Aramco
Phosphoric acid	200	Imported from Morocco/Tunisia
Potassium sulphate	15	Imported from Europe
Sulfuric acid	12	SAFCO

Markets: All products are marketed by SABIC.

	KSA	GCC	World
Urea	15 %	-	85%
NPK fertilizer	87 %	13%	-
DAP	80 %	20%	-
Liquid NPK	100%	-	-

Source: based on information from Royal Commission for Jubail and Yanbu, October, 2001.

Arabian Petrochemical Company (PETROKEMY)

Arabian Petrochemical Company (PETROKEMY) was formed in May 1981 as the first company a wholly owned by SABIC. The company initially went into production with support one ethylene plant with a design capacity of 500,000 MTPY, along with support facilities necessary for such a plant. This plant has design capacity of 50,000 mtpy, and is considered to be the largest plant in the world. It was built with production technology of IFP of France. Soon after, polystyrene plants with design capacity 100,000 MTPY were built and started production in the first quarter of 1988. In addition, the ethylene plant was expanded by adding two more furnaces for a total of eight furnaces which increased the design capacity to 650,000 mtpy. In 1985 the total manpower was 443 employees. Since then the number of employees increased to over 600 to meet the requirement for the new project. PETROKEMYA also successfully increased the Saudization rate from 56% at the end of 1985 to 65% 2003.

Profile of Arabian Petrochemical Company (PETROKEMYA)

Location:	AI-Jubail Industrial City, Saudi Arabia
Partnership:	A wholly-owned by SABIC (Dow Chemical withdraw in December 1982)
Capital investment:	SR 9.3 billion (US$ 2.48 billion)
Commercial operation:	1985
Employees :	1305 (1162 Saudi, 143 non Saudi)

Product	Start-up	Capacity	Technology/Engineering
Ethylene	1985	2,400,000	C.F. Braun/ Kellogg / MES /Chiyoda
Propylene	1993	520,000	Kellogg/MES
Butadiene	1993	130,000	BASF/MES
Benzene	1993	150,000	Lummus-Houdry/MES
Butene-1	1987	100,000	IFP/ SABIC-IFP / MES/ Chiyoda
Polystyrene	1985	165,000	Fina/Chiyoda
EPS	1985	25,000	CdF Chemie-CosderVChiyoda
LLDPE/HDPE	2003	800,000	UCC (Unipol)

Feedstocks	Source
Ethane	Saudi Aramco
Natural gasoline	Saudi Aramco
Butane	Saudi Aramco
Propane	Saudi Aramco
SM	SADAF

Markets	KSA	GCC	World
Ethylene	83%	-	17%
Propylene	84%	-	16%
Butadiene	5%	-	95%
Benzene	100%	-	-
Polystyrene	45%	13%	42%

Source: based on information from Royal Commission for Jubail and Yanbu, October, 2001.

The Arabian Industrial Fibres Company (IBN RUSHD)

The Arabian Industrial Fibres Company (IBN RUSHD) is one of SABIC's joint ventures with the Saudi private sector established in Yanbu. In early operation, this company has a technical problems which affected the operation. In this regard SABIC signed a team from SABIC R&D and the licensor of the technology to examine the quality of the product and all the factors to increase the production. The cooperation between SABIC and UOP was facing the challenge to achieve targets for more than 2 years. Today, improvements in production have reached more than 90% of capacity but the aim is to reach 100% capacity

Profile of Arabian Industrial Fibres Company (IBN RUSHD)

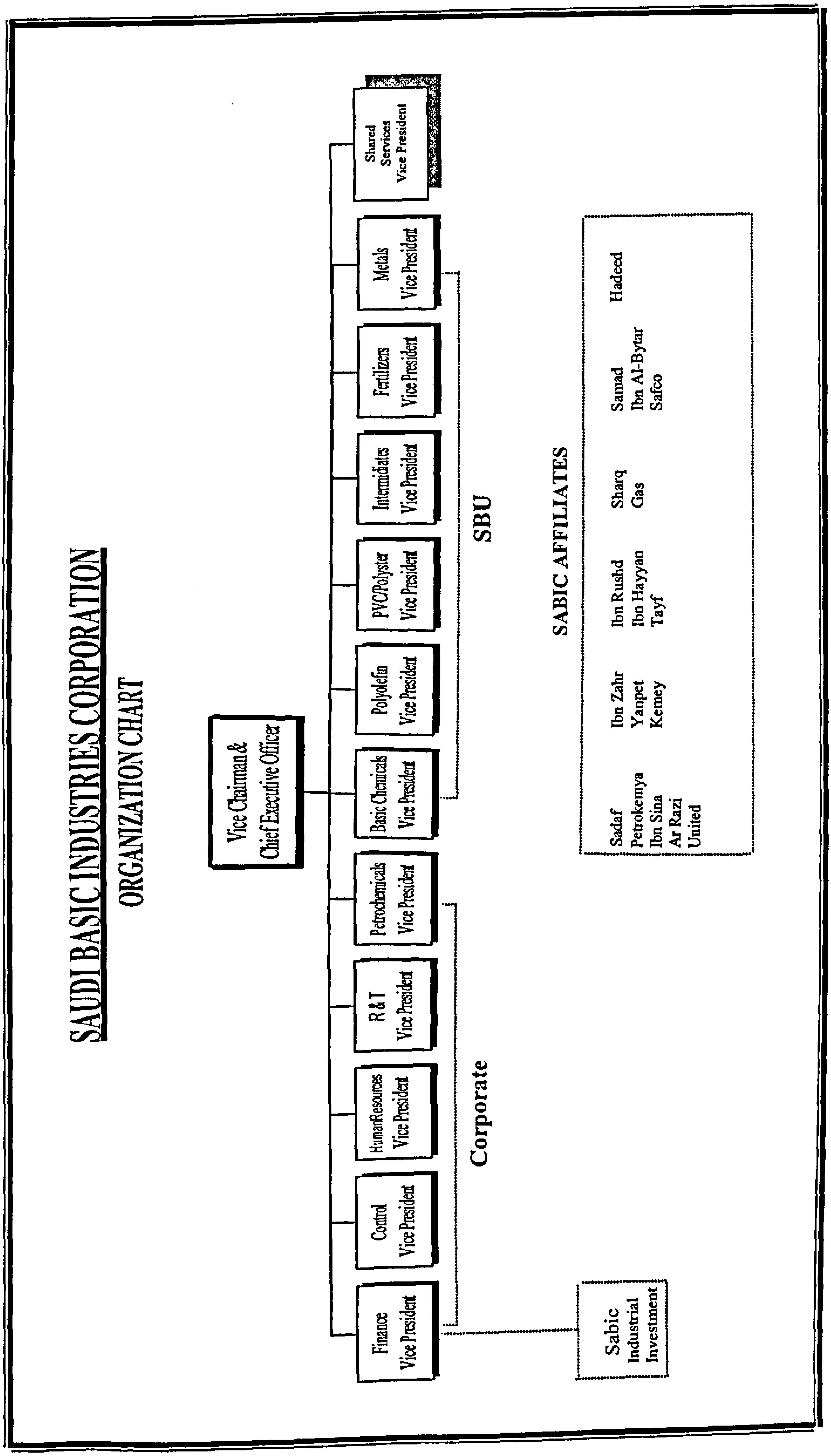
Location:	Yanbu Industrial City, SAUDI ARABIA
Partnership:	SABIC (51.7%) and Saudi Private Sectors (48.3%)
Capital investment:	SR 3,550 million (US$ 947 million)
Established:	1993
Employees:	1094 (467 Saudi, 627 non Saudi)

Product	Start-up	Capacity	Technology/Engineering
Polyester total	1997	140,000	Zimmer/Bechtel
Staple fiber	1997	48,000	Zimmer/Bechtel
POY	1997	32,000	Zimmer/Bechtel
Carpet fiber	1997	20,000	Zimmer/Bechtel
Bottle grade (chip)	1997	40,000	Zimmer/Bechtel
Textile chip	1997	10,000	Zimmer/Bechtel
PTA	1999	350,000	Enichem/Tecnimont
Benzene	1999	350,000	UOP, BP(Cyclao/Chiyoda
p-Xylene	1999	375,000	UOP, BP(Cyclao/Chiyoda
o-Xylene	1999	45,000	UOP, BP(Cyclao/Chiyoda
m-Xylene	1998	36,000	Planning stage

Feedstock	Source
PTA	IBN RUSHD
MEG	YANPET
PX (235,000tly)	IBN RUSHD
LPG	Saudi Aramco

Source: Based on information from Royal Commission Jubail and Yanbu, October, 2001.

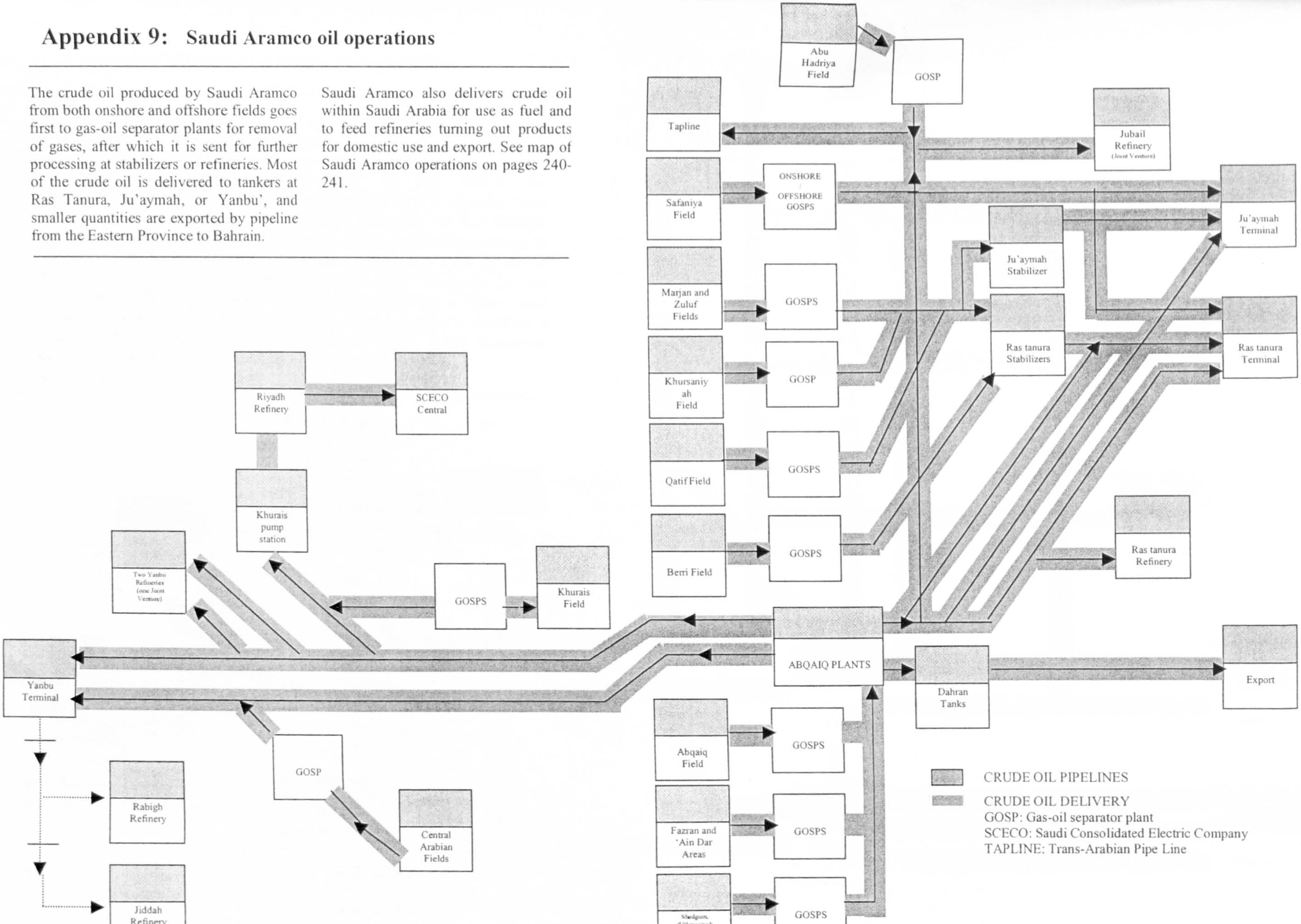
Appendix 8
Organisational Chart for SABIC



Appendix 9: Saudi Aramco oil operations

The crude oil produced by Saudi Aramco from both onshore and offshore fields goes first to gas-oil separator plants for removal of gases, after which it is sent for further processing at stabilizers or refineries. Most of the crude oil is delivered to tankers at Ras Tanura, Ju'aymah, or Yanbu', and smaller quantities are exported by pipeline from the Eastern Province to Bahrain.

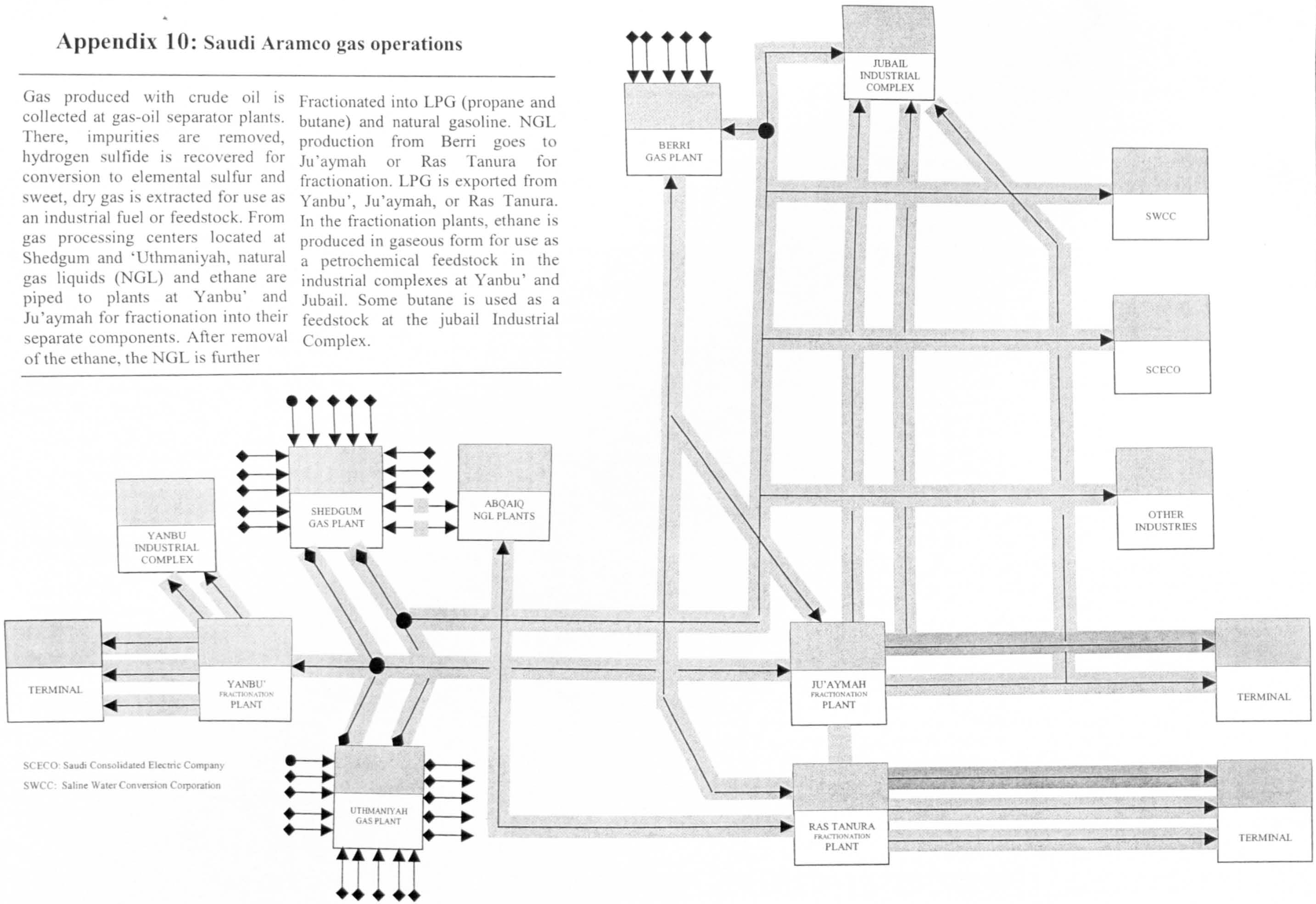
Saudi Aramco also delivers crude oil within Saudi Arabia for use as fuel and to feed refineries turning out products for domestic use and export. See map of Saudi Aramco operations on pages 240-241.



Sources: Saudi Aramco, "Saudi Aramco and its words", Edited by: Ismail Nawab, Peter Speers and Baw'l Hoye, Saudi Aramco, Dahran, Saudi Arabia, 1995

Appendix 10: Saudi Aramco gas operations

Gas produced with crude oil is collected at gas-oil separator plants. There, impurities are removed, hydrogen sulfide is recovered for conversion to elemental sulfur and sweet, dry gas is extracted for use as an industrial fuel or feedstock. From gas processing centers located at Shedgum and 'Uthmaniyah, natural gas liquids (NGL) and ethane are piped to plants at Yanbu' and Ju'aymah for fractionation into their separate components. After removal of the ethane, the NGL is further Fractionated into LPG (propane and butane) and natural gasoline. NGL production from Berri goes to Ju'aymah or Ras Tanura for fractionation. LPG is exported from Yanbu', Ju'aymah, or Ras Tanura. In the fractionation plants, ethane is produced in gaseous form for use as a petrochemical feedstock in the industrial complexes at Yanbu' and Jubail. Some butane is used as a feedstock at the jubail Industrial Complex.



SCECO: Saudi Consolidated Electric Company

SWCC: Saline Water Conversion Corporation

Sources: Saudi Aramco, "Saudi Aramco and its words", Edited by: Ismail Nawab, Peter Spears and Bawl Hoye, Saudi Aramco, Dahran, Saudi Arabia, 1995