DEVELOPING MODEL AND METHODOLOGY FOR GLOBALIZATION STRATEGY FOR INDIAN CRUDE OIL SECURITY

A THESIS

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by

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **DEVELOPING MODEL AND METHODOLOGY FOR GLOBALIZATION STRATEGY FOR INDIAN CRUDE OIL SECURITY** in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy and submitted in the Department of Management Studies of the Indian Institute of Technology Roorkee, Roorkee is an authentic record of my own work carried out during a period from July 2005 to February 2009 under the supervision of Dr. Zillur Rahman, Assistant Professor, Department of Management Studies, Indian Institute of Technology Roorkee, Roorkee.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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(RATAN KUMAR MISHRA)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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Supervisor

Dated 13.02.2009

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Signature of Supervisor

Signature of External Examiner

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(Ratan Kumar Mishra)

ABSTRACT

Crude oil continues to dominate as energy source and is envisaged to meet more than 80% of the projected increase in primary energy demand. India, an emerging economy is the world's fifth-largest energy consumer and a net oil-gas importer. The share of crude oil and natural gas in the primary commercial energy source of the country has been increasing over the years. It is projected that India's consumption of crude oil and natural gas will rise sharply over the next few years.

India has insufficient established oil and gas reserves. There has been meager domestic crude oil reserve addition in the past and declining production from existing oil fields. The domestic production and consumption pattern of crude oil and natural gas suggests widening gap. The convergence of factors like widening demand-supply and meager domestic reserve accretion and will lead to increased import dependency over the years. It poses a serious threat to sustenance of Indian economy.

For an import dependent country like India, the issue of crude oil security would depend significantly on the supply of crude oil on a stable and reliable basis from domestic and overseas. The strategies adopted by nations for crude oil security include intensive exploration of domestic exploration activities by national players, import of crude oil, attract foreign investments for exploration activities, and secure equity oil from overseas. India resorted to restructuring of the petroleum sector. It deregulated upstream and downstream petroleum activities, created favorable environment for foreign and private investments, and removed monopoly. Several

policy decisions have been implemented by the Government of India during the last decades for extensive exploration of Indian province. India resorted to allowing hundred percent Foreign Direct Investment (FDI) with attractive fiscal provisions to attract foreign companies to invest in upstream (i.e. exploration and production) and downstream (i.e. refining and petrochemical) to supplement the efforts made by Indian companies. These were aimed to create a level playing field for both domestic and global players to participate in petroleum business. Acquisition of overseas acreage for equity oil has been another strategy. Indian petroleum sector has taken globalization initiatives by way of investments in overseas equity and there has been phenomenal increment in overseas oil-gas equity.

The study reveals that the various drivers have fostered multiplication in overseas activities by companies to carry out petroleum exploration and exploitation business to secure overseas oil-gas equity. India witnessed the emergence of facilitating drivers by virtue of liberalization initiatives allowing increasing participation of India in the global economy, decline in role of governments by denationalization of many industries, increased privatization in previously state-dominated E&P business, and shift to open market economies from closed systems. Added to these has been the competitive environment leading to continuing increase in level of world trade, several countries becoming key competitors for oil-gas exploration and production acreages, growth of global networks making countries interdependent in petroleum exploration and exploitation, and rise of new competitors intent upon becoming global competitors. These factors have led Indian government owned enterprises as well as private players to secure oil-gas opportunities overseas.

Several countries resort to secure supply from overseas by acquiring equity crude oil. Globally firms resort to strategic and tactical investment decisions in overseas Exploration and Production (E&P) opportunities of crude oil involving significant capital diversification investment. Selection of overseas investment opportunities are critical for a firm because of uncertainty in identifying and quantifying the attendant risk- geological, commercial, social and political as well as return on investment. There is a growing concern to screen and rank overseas investment opportunities. Profitability, risk and growth guide overseas investment decisions. The resolution to opt for overseas E&P investment opportunity depend on the technical prospectivity, the ease of doing business in that country, fiscal system, as well as country risk. We describe such decision for resolving overseas venture by a numerical rank called Globalization Index as a function of these factors. We have applied nonparametric approach to obtain Globalization Index. Some methodology and model is desirable for the scouting, scanning and screening of country (ies) for entering in to global business for crude oil. This resarch is an attempt to conceptualize and develop a model encompassing the parameters which has bearing of the global business pertaining to upstream crude oil.

The thesis has brought forward methodology and model for globalization strategy which an enterprise will find useful for scouting, scanning and screening of global opportnities in upstream petroleum business for crude oil security for India. The model leads to a mathematical construct which is able to provide a ranking of countries (response) in terms of the employed variables (predictors). The ranks are reasonable as well as acceptable when examined in terms of the impacting factors normally expected to affect the upstream petroleum business. The thesis has suggested the strategy to be adopted by India to achieve crude oil security by entering into overseas upstream business.

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CHAPTER 1

INTRODUCTION

Energy is the prime mover for economic development, vital to the sustenance of economy, and holds the key in accelerating the economic growth. The future economic growth depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly. Plentiful, reliable, and affordable energy supplies are essential to economic development. The growing economies and rising personal incomes will drive energy demand up by 50 percent, and developing economies will account for over 60 percent of world energy demand by 2030 (Energy Outlook To 2030). Energy consumption depends on economy and population of the region (Figures 1.1 and 1.2).

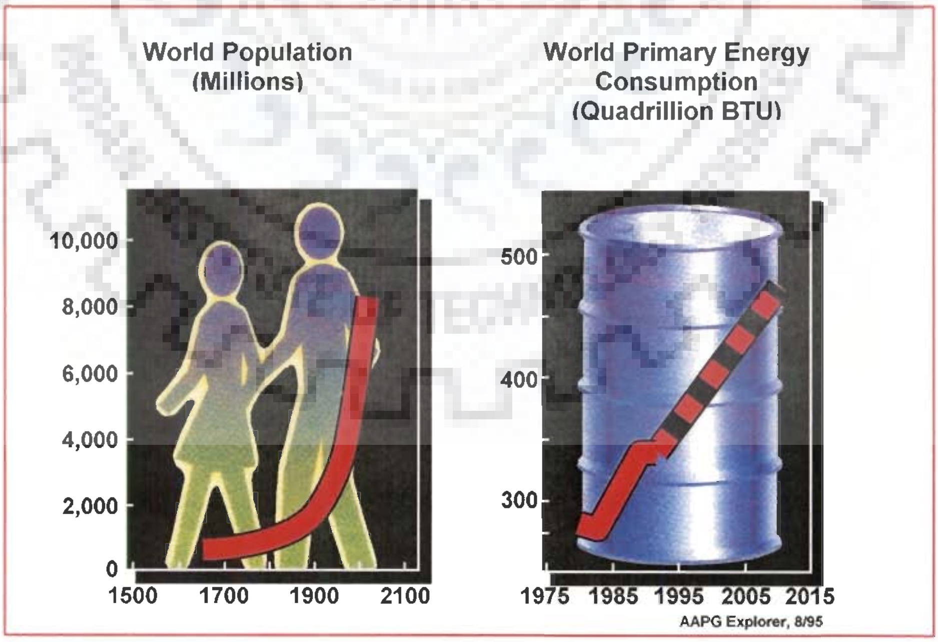


Figure1.1 Relationship between global energy demand and population,

Source: American Association of Petroleum Geologist Explorer, 8/95

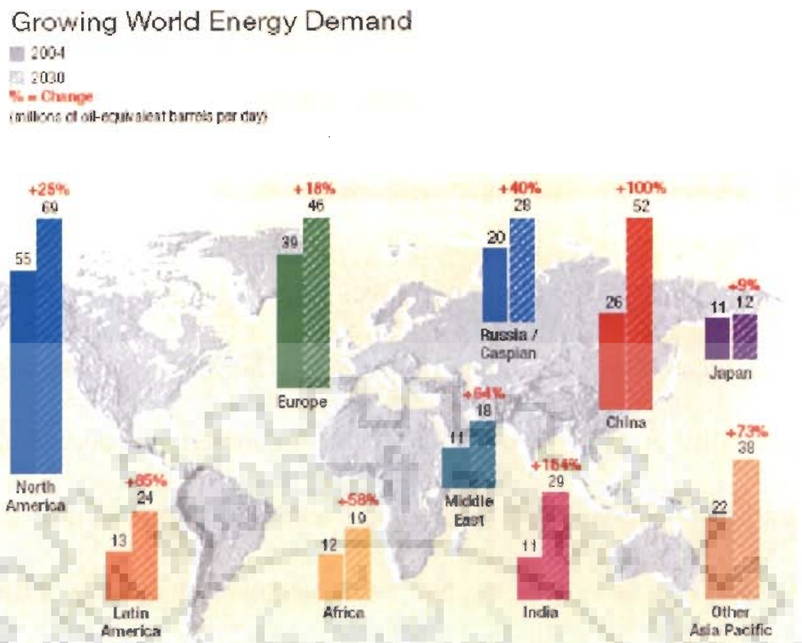


Figure1.2 Growing World Energy Demand (ExxonMobil, 2005)

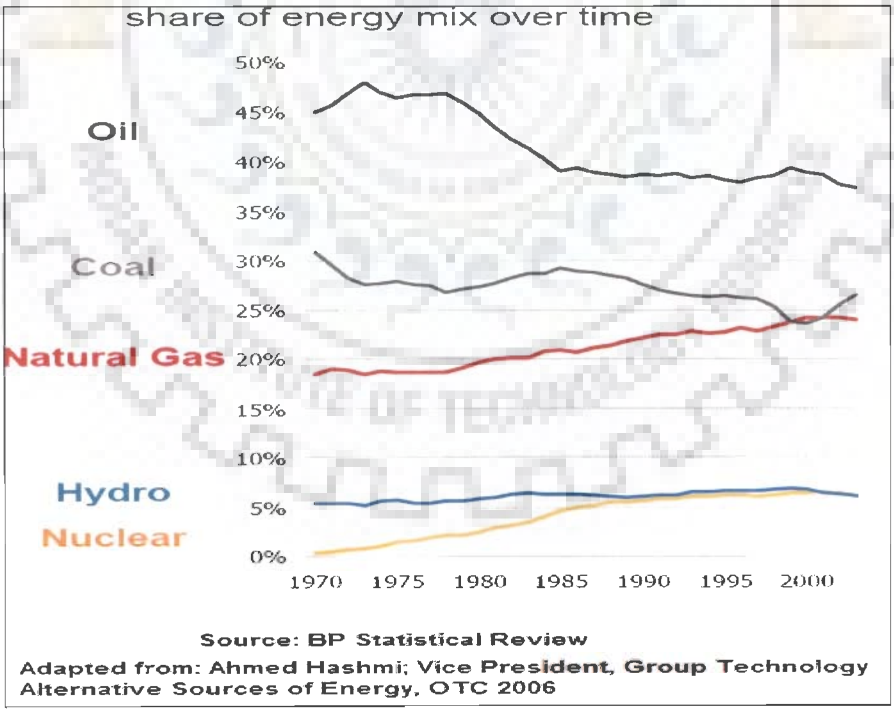


Fig. 1.3 Changing Pattern of energy mix

Globally energy is characterized by changing pattern of energy mix, dominance of oil and gas, and increasing share of natural gas (Figure 1.3). Both oil and gas are referred to as hydrocarbons, which are composed of carbon and hydrogen. The more carbon atoms in a row, the larger and heavier the hydrocarbon. The simplest gas is generally pure methane, which is a single carbon atom with four hydrogen atoms attached to it.

The importance of energy need no explanation. At the World Summit on Sustainable Development (WSSD) (Johannesburg; August/September 2002) the then U.N. Secretary General Kofi Annan, introduced "WEHAB Energy Framework", emphasizing the linkage and interdependence of Water, Energy, Health, Agriculture, and Biodiversity (WEHAB) (Figure 1.4) (WEA, 2000). It was realized that the development goals in the areas of water, health, agriculture, and biodiversity often cannot be met without energy inputs, and the policies adopted in these sectors similarly impact the availability and reliability of energy services.

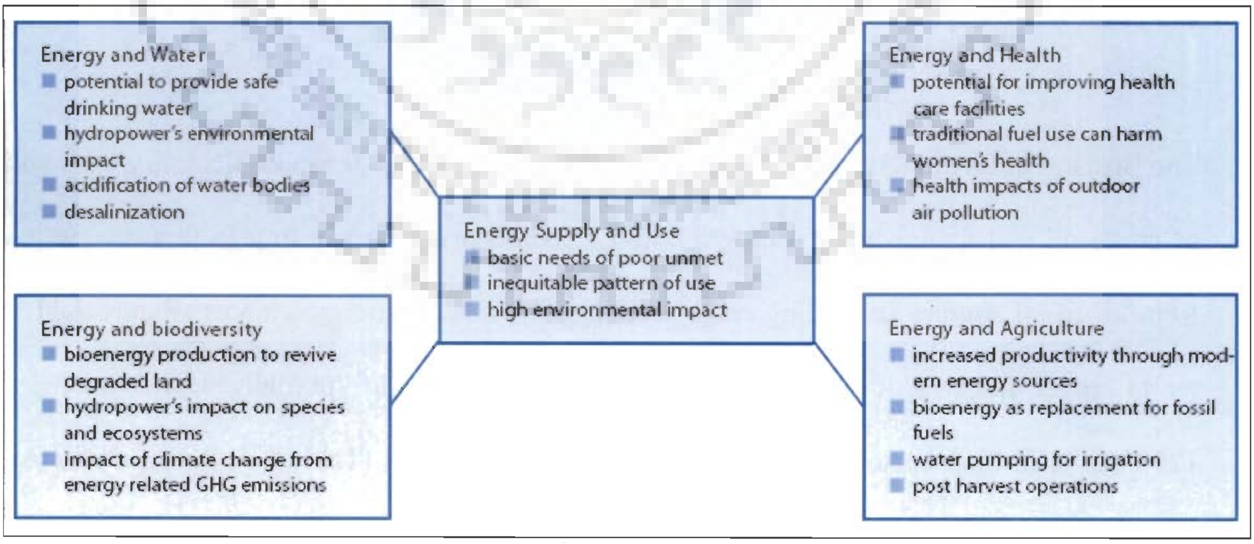


Figure 1.4 Examples of The Critical Role Of Energy (Source: World Energy Assessment Overview: 2004 Update) Part I. Energy at the World Summit for Sustainable Development

The energy security issue has been firmly reiterated at The World Summit on Sustainable Development (2002) which urged the international community to: *"take joint actions and improve efforts to work together rat all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the millennium development goals, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty*".(WEA, 2004)

Recently the term "Energy System" has been introduced which constitutes an energy supply sector and energy end-use technologies with an objective to deliver to consumers the benefits that energy use offers to household e.g. illumination, cooked food, comfortable indoor temperatures, refrigeration, telecommunications; as well as to virtually every commercial and industrial activity. It begins with the collection or extraction of primary energy (say crude oil or natural gas) that may be converted to energy such as electricity or diesel oil that are suitable for end uses (WEA, 2004).

The British Petroleum (BP) statistical review provides a detailed account of country wise volume of crude oil and natural gas (Tables 1.1 to 1.3, Annexure i). According to this review energy from all fossil sources (including coal) accounts for 88% of energy sources (Figure 1.5). The world proved reserves of oil and oil equivalent gas at the end of 2006 has been estimated to be 1208355.91 million barrels as per BP Statistical Review 2008 (Table 1.3, Annexure-i). As per United States Geological Survey (2006), the mean estimates of undiscovered resources of crude oil is about 724 billion barrels and of natural gas 5196388 trillion cubic feet (Table 1.4, Table

1.5, and Table 1.6, Annexure-i). These resources are likely to provide energy to the world for coming several decades (Figure.1.6).

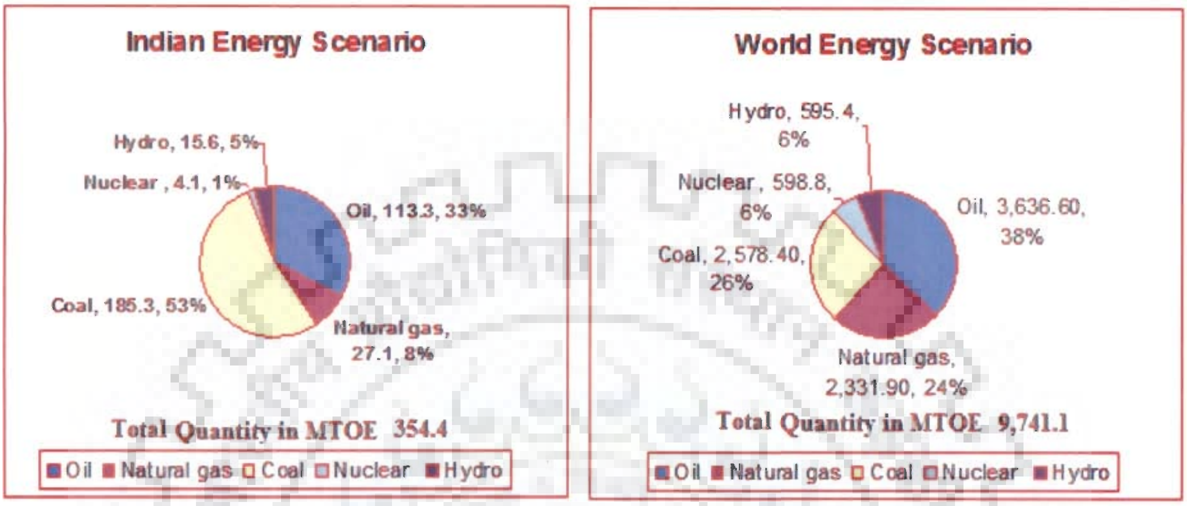


Figure 1.5 Global and Indian energy scenario (Source: BP Statistical Review 2005)

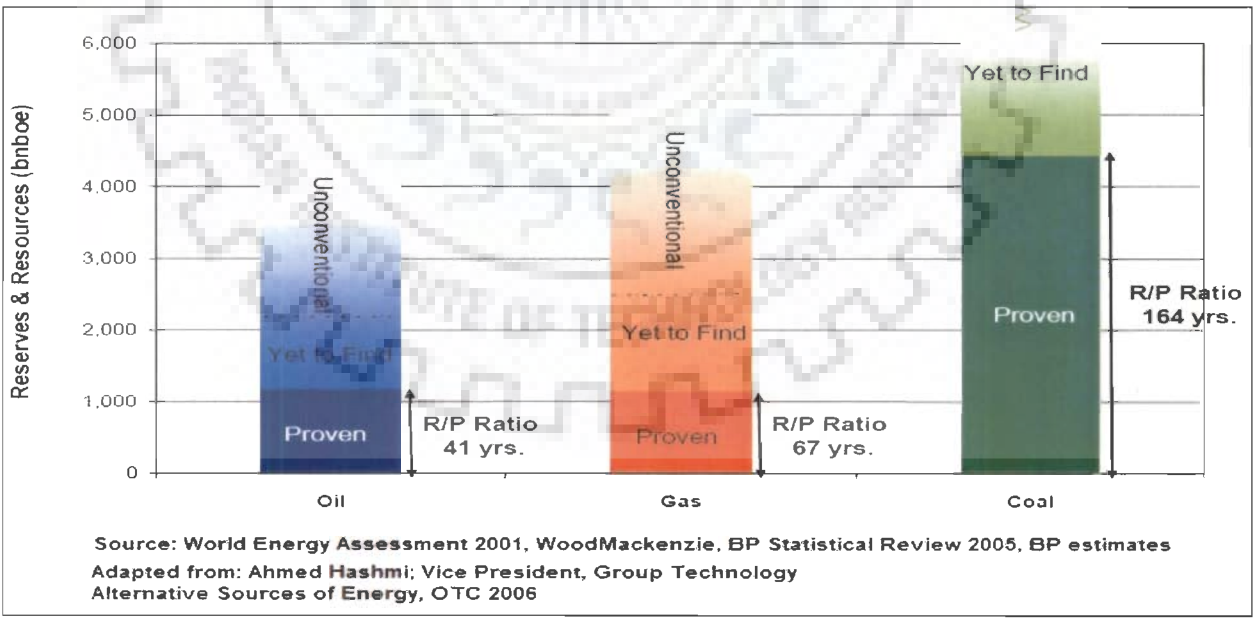


Figure 1.6 Reserves and Resources for Oil, gas and coal

Oil and gas are the fuel for the engine of modern society (Figure 1.7). Crude oil is the dominant energy form (Finizza, 1996). Without oil, industrial society would be impossible.

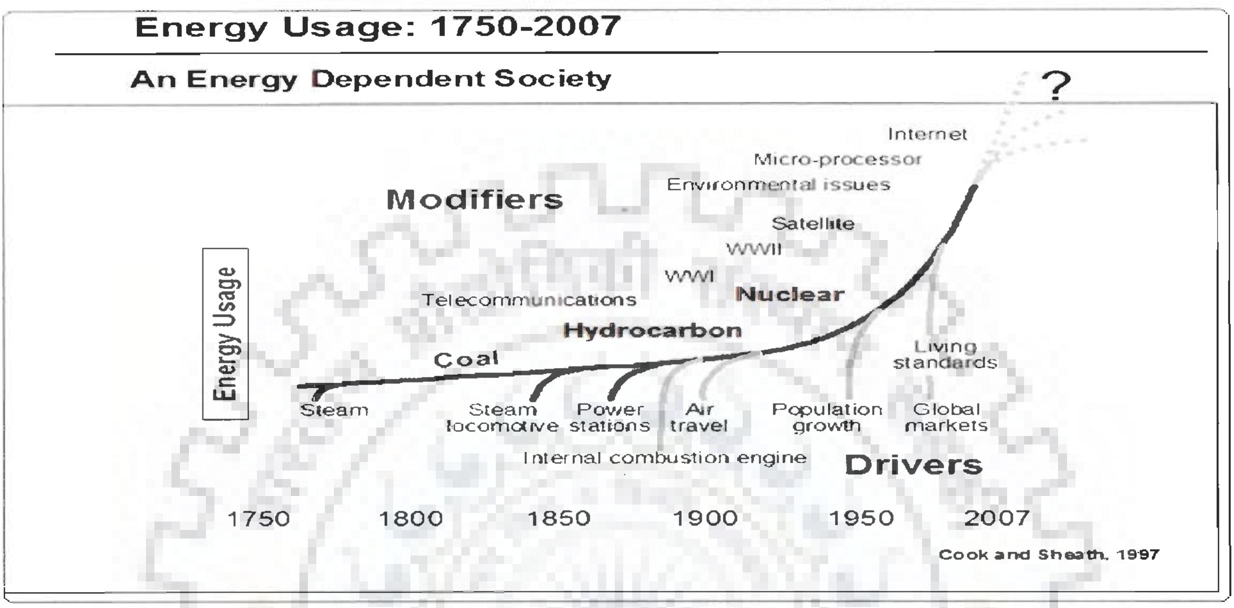


Figure 1.7 Crude oil – Dominant source of energy

Crude oil and gas meet more than 80 percent of the world's energy needs, and this trend is expected to continue through 2030. Oil and gas will remain predominant among forms of energy supply (Energy Outlook To 2030). Crude oil and gas are integrated into the production of many products. Crude oil and gas make up 65 to 70 percent of all the energy consumed by the three largest economies in the world - U.S., Japan, and the European Union. Many of the industrializing countries of the Third World, such as South Korea, China, Brazil, India, and Mexico, have skyrocketing oil and gas consumption. There has been substantial rise in share of crude oil (Nakicenovic et al, 1998), (Grubler, 1998). According to International Energy Agency (2006); crude oil is the single largest fuel (Figure 1.8).

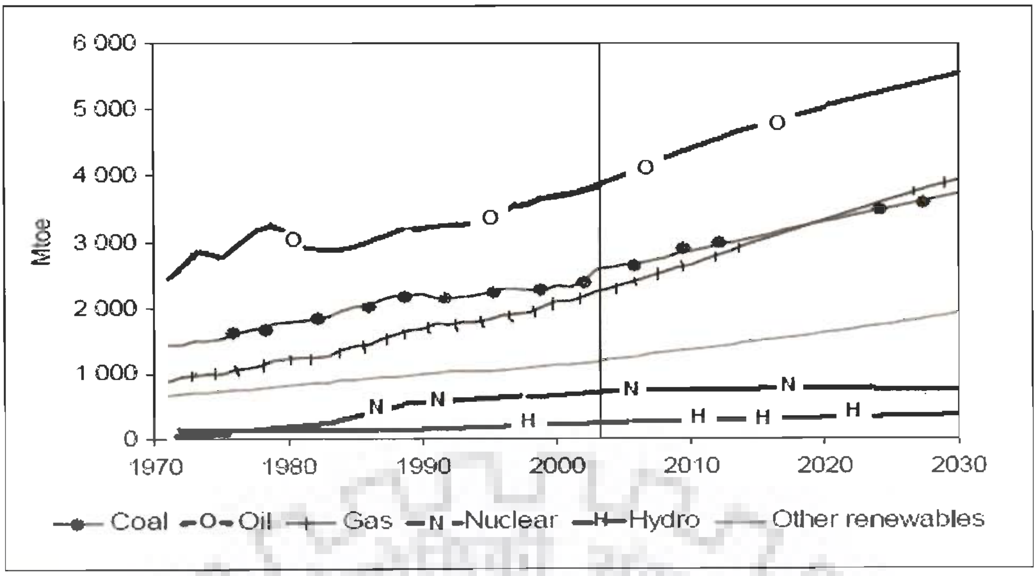


Figure 1.8 World Primary Energy Demand by Fuel

Adapted from International Energy Agency, 2006

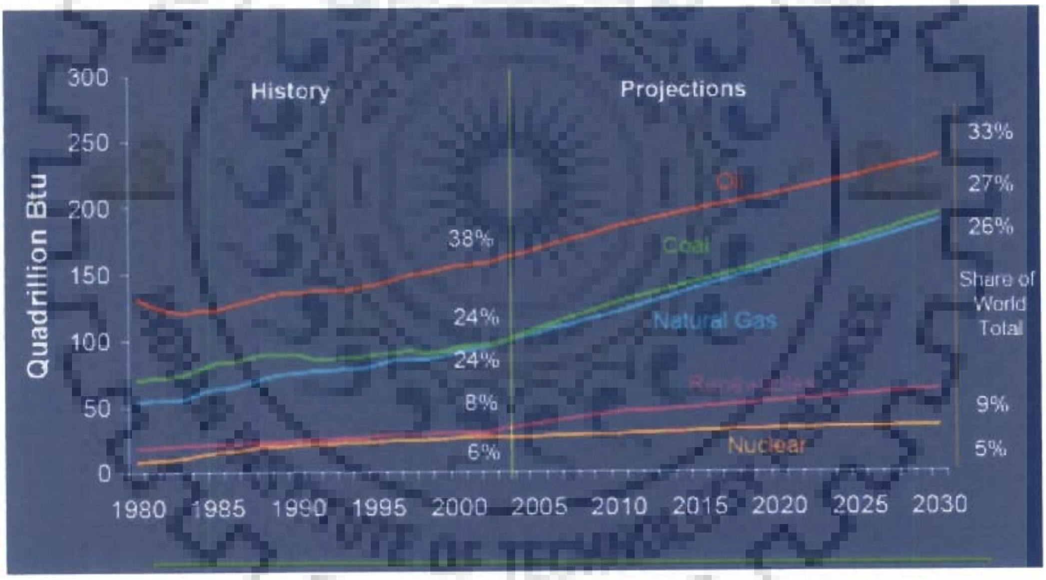


Figure 1.9 World Marketed Energy use by Fuel Type, 1980-2030

Source: Energy Information Administration

Crude oil will continue to dominate global energy requirements (Figure 1.9) (Dorian et al, 2006, Finizza, 1996) and a major object for global business. Presently, it accounts for 10% of world trade, which is the largest single commodity traded globally. The issue is – while global proven reserves of oil are ample, supply is not guaranteed. As per the G-8 summit on global energy security; St. Petersburg, July 16, 2006 "Uninterrupted, sufficient, reliable and secure supply of energy at prices, reflecting economic fundamentals and market principles and with minimum damage to the environment is one of the key development factors for our countries and a mankind as a whole. There is a direct relationship between well-being, way and quality of life of a great number of people and their secure access to energy. The system of energy supply and demand has become truly global. This situation requires the strengthening of partnership between producing and consuming countries through continuous and constructive dialogue with common objective to enhance global energy security." Energy security and the role of crude oil and natural gas have been a concern for India. Policy concerns starting in the late fifties and continuing until 1973 focused on protecting the domestic oil industry. Following the energy crises of the seventies, policy focused on reducing the economic impacts of oil by diversifying domestic energy sources, increasing energy efficiency, and establishing the Strategic Petroleum Reserve. Deregulation of domestic energy prices in the early eighties and the increasingly flexible nature of the world oil market have further changed policy concerns. Concerns today deal mostly with vulnerability of the economy to large oil price fluctuations.

Beyond doubt oil-gas will retain its position as the single largest source of energy. Energy demand growth will be focused on oil and gas because there are no ready alternatives. At least for the present, there is no alternative to crude oil and gas. The issue of energy security (as well as crude oil security), hinges around what should be done to secure supply as per growing demand. There have been several discoveries in past decade leading to added supply of crude oil, but the demand has also increased globally, including India leading to widening gap in demand-supply scenario. The concern for oil security is due to the continued growth in demand, which according to the International Energy Agency, will grow by 32 percent by 2020, mainly due to population growth and economy. India along with other major global economies like the United States, Europe, Japan, and China are dependent on imported crude oil and this dependency is likely to increase form the supplies from West Africa, Russia, and the Middle East. But, the global trade in oil and natural gas is plagued with insecurity – especially geopolitical leading to supply disruption hampering long-term energy security.

The realistic step to endure crude oil supply will be to diversify the sources of supply to the world market to the maximum extent. The Indian oil-gas industry has been taking such initiatives since decades by making investment overseas to secure equity crude oil and gas from global provinces and thus making effort towards energy security.

India needs to make sustained, committed and designed investment in the countries where the petroleum resources are available, and where the needs of both partners can be profitably fulfilled. Such an effort will forge the development of a strong and enduring relationship of mutual advantage between the economies. The issue thus hinges on designing a strategy for long term overseas investment in the crude oil business and it is a burning issue which needs attention to which the present research work is intended.

This chapter formulates a general background for the present research investigation on the development of methodology and model for globalization strategy for Indian crude oil security. The general understanding and broad classification of energy resources has also been presented in this chapter. The broad outline of global scenario of crude oil is also given. The end, need and the objectives of the present research work have been described. In the end the methodology and model for globalization strategy for crude oil security has been discussed.

1.1 GENERAL BACKGROUND

Energy can be broadly classified as non-renewable and renewable. The former has limited supplies and they cannot be replenished, or made again, in a short period of time. Crude oil, Natural gas, and Coal are non-renewable energy sources. Oil, natural gas and coal are called "fossil fuels" because they have been formed from the organic remains of plants and animals. Renewable energy are those that can be replenished naturally in a short period of time like Solar, Wind, Ethanol, Geothermal, Biomass, and Hydropower.

“Although oil, natural gas, and coal will remain the primary energy sources for the foreseeable future, a variety of resources will be needed to meet the world’s growing demand. All energy sources have benefits, as well as challenges to overcome to produce, deliver, and use them on a wide-scale and efficient basis. Costs are an important consideration. How much will the capital/set-up costs be, and what are the ongoing operating costs? Will the final product be too expensive for the average consumer? Does the energy source require storage or other additional infrastructure? Is it possible to produce it on a large scale? Also, think about how its production will impact the environment.

Oil and natural gas are essential for our daily lives; provide fuel for transportation, and generation of electricity. Crude oil is expected to be the dominant energy source for decades to come. The challenge is how to meet rising world energy consumption that is projected to increase 71% by 2030.

1.2 GLOBAL SOURCES OF CRUDE OIL

The oil and natural gas are produced in more than 100 countries around the world. Most of those countries produce both oil and natural gas; a few produce only natural gas. The ten largest oil producing countries are: Saudi Arabia, United States, Russia, Iran, Mexico, Norway, China, Venezuela, Canada, and the United Arab Emirates (Table-1.1-Annexure i and Figure 1.10). Russia, United States, Canada, United Kingdom, Algeria, Netherlands, Indonesia, Iran, Norway, and Malaysia are the ten largest natural gas producing (Table 1.2- Annexure i). A growing percentage of the world's production is from offshore areas, such as the Gulf of Mexico, the North Sea, western Africa (Angola, Nigeria), and Asia (China, Vietnam, and Australia). The BP Statistical Review of World Energy provides yearly data of global reserves, production, consumption, trade and prices of crude oil and natural gas (Table 1.1 and 1.2- Annexure i).

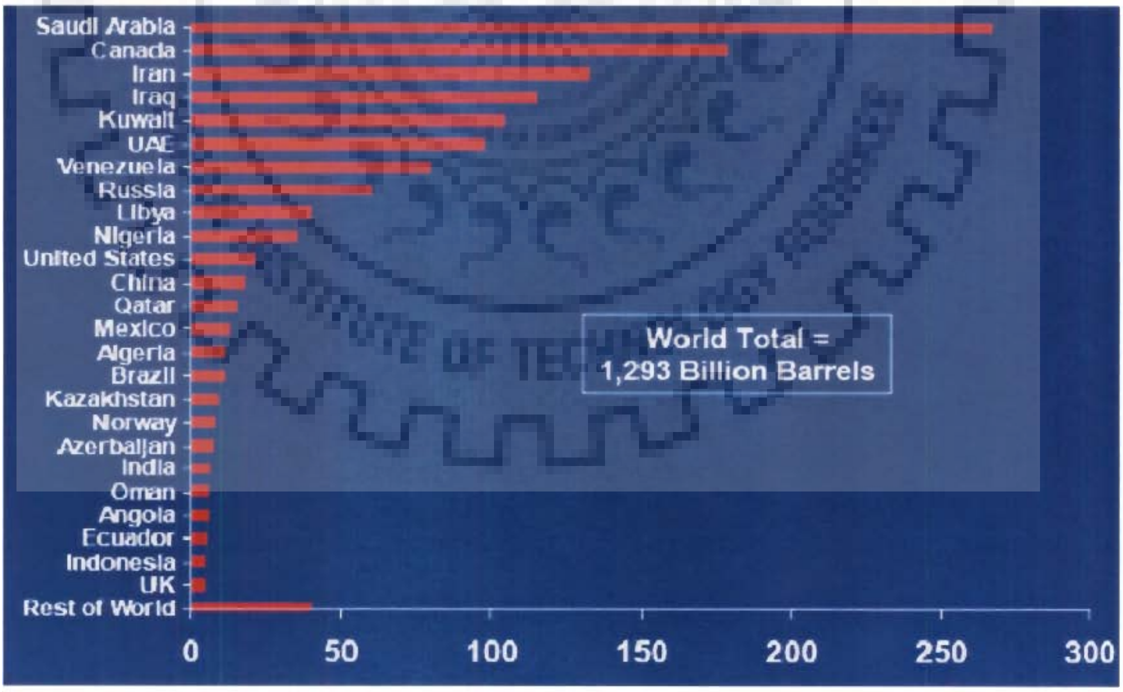


Figure 1.10 World Oil Reserves by Country, as of January 1, 2006 (billion barrels)

Source: Oil & Gas Journal, Vol. 103, No. 47 (December 19, 2005)

1.3 NEED OF THE PRESENT STUDY

Crude oil business is a global business. While coal and gas are internationally traded, they are small relative to the trade in oil. Globally 3V's – Value (of crude oil), Volume (of crude oil) and Vulnerability to crude oil supply is a cause of concern. Crude oil exploration, production, refining and marketing, has progressively happened to be more global and countries resort to entering in to various kinds of arrangements for security of oil supply.

As mentioned earlier crude oil in probability will remain the dominant source of energy and will continue to be a major object for global business. India faces serious crude oil crisis. It imports about two-third of its consumption leading to serious financial burden, dependence on the foreign suppliers, and threat of supply disruption. The demand for oil is expected to increase leading to widening of demand-supply scenario.

The convergence of energy requirements for economic growth, obligation to reduce import dependence, and myriads of global opportunities are key driving forces subjecting countries to globalize petroleum sourcing, and India is no exception.

The investment options in global destinations calls for scrutiny by investor countries so as to secure uninterrupted crude oil supply. It necessitates development of a scenario where importing and producing countries feel mutually interdependent – the importer by the flow of crude oil and producers by flow of investment requirements necessary for exploration and production of crude oil. Importing countries these days often resort to diversification of crude oil supply source and signing long-term contracts with overseas producers to minimize and mitigate supply disruption.

But, diversification of overseas supply source calls for sizable investments involving billions of dollars.

In order to harvest the long-term crude oil security for India, and reap economic risk-free return in terms of uninterrupted crude oil supply to the country from global sources calls for judicious selection of global investment opportunities among alternative crude oil exploration and production ventures. Developing an energy security framework will involve assessment of alternative energy supply options, both in terms of resources and regions.

1.4 OBJECTIVES OF THE PRESENT STUDY

The present investigation is proposed to be carried out to study the globalization strategy for Indian crude oil security with the following objectives:

1. To identify approach to globalization strategy by Indian petroleum industry for securing crude oil exploration and production opportunities overseas for sourcing crude oil supply to the country.

2. To critically examine and integrate the issues like fiscal system, economic elements, various risk, and globally available volume of crude oil to derive crude oil sourcing options.

3. To develop a model crude oil security management system (COSMS) for India, which will address the overall control functionality of crude oil sourcing from overseas and will be the integrating element for oil security, economic aspects and fiscal issues. COSMS is aimed to provide rational selection of global crude oil sourcing options for India subject to prevailing parameters. The model may be based on other similar model(s) attempted earlier with requisite modifications and adaptation to suit requirements of Indian situation. The critical issue is to create a functional and modular system model where all critical components are suitably represented.

1.5 METHODLOLOGY AND THE MODEL

Selection of overseas petroleum exploration and production investment opportunities is critical because of uncertainty in identifying and quantifying the attendant risk- geological, commercial, social and political as well as return on investment. It leads to growing concern to screen and rank overseas investment opportunities. Profitability, risk and growth guide overseas investment decisions.

Globally firms resort to strategic and tactical investment decisions in overseas E&P opportunities involving significant investment. Petroleum potential and prospectivity, country risk (political and business), economic system; financial, taxation and fiscal terms; social, and political milieu; markets; and infrastructure etc for countries are factors which steer any business entity to decide the overseas destination for venturing in to the business of exploration and exploitation of crude oil.

The decision to opt for overseas exploration and production investment opportunity depend on the technical prospectivity (TP), the ease of doing business in that country (EODB), fiscal rank/ index (FI), Global Competitiveness Index (GCI) as well as country risk (CR). I have used the term "Globalization Index" (GI) to numerically rank countries which will facilitate in making decision in selection of overseas venture. In general terms, a decision for resolution of an overseas venture can be quantitatively related to Globalization Index (GI) in following functional form

$$GI = f\,(TP, EODB, FI, GCI, \text{and } CR).$$

Most commonly, "Globalization Index" can be estimated from different parameters impacting it using either empirical relationship or some form of statistical regression: parametric or non parametric. The empirical models may not be applicable in regions having environments endowed with different kinds of risk categories and risk elements, without making adjustments to exponents in the model. Statistical regression has been proposed as a versatile solution to the problem of estimation. Conventional statistical regression has generally been done parametrically using multiple linear or nonlinear models that require a priori assumptions regarding functional forms. In recent years, nonparametric regression techniques such as Alternating Conditional Expectation (ACE) (Xue et al, 1997); hybrid soft computing systems viz. Artificial Neural Networks (ANN) (Kosko, 1999) and Group Method of Data Handling (GMDH) (Farlow, 1989) have been introduced to overcome the limitations of conventional regression methods. ACE algorithm has been extensively used for petrophysical parameter estimation by Verma (2005 and 2008). Further ACE algorithm has been employed by several investigators in variety of domain, e.g. for exchange rate analysis, (Chinn, 1991), Material Requirement Planning (Sum, et al, 1995) and IS planning (Ang, et al 1999). Negi and Prasad (2006) have applied Artificial Neural Networks (ANN) to predict lithofacies. The technique has been applied by several investigators in variety of domain, e.g. weather modeling and forecasting (Abdel-Aal, 1997), classification of medical data (Abdel-Aal, 1995), and credit evaluation (Summers, 1996).

In parametric approach to regression, a model is fitted to data by assuming a functional relationship. However, it is always not possible to identify the underlying functional form amongst dependent and independent variables. Nonparametric regression technique offer much more flexible data analysis tools for exploring the underlying relationships between dependent and independent variables. It does not require knowledge of the functional relationship between dependent and independent variables and the optimal transformations are derived solely based on data set.

In this work, I have applied the alternating conditional expectation (ACE) algorithm of Breiman and Friedman (1985) as well as a refined form of GMDH known as Autonet for estimation of Globalization Index from the different parameters impacting it. ACE generates an optimal correlation between a response (dependent) variable (Globalization Index) and multiple predictors (independent) variables through non-parametric transformations. It leads to an optimal correlation derived solely based on the data set. The final correlation is obtained by plotting the transformed dependent variable against the sum of the transformed independent variables. The description of ACE algorithm and Autonet/ GMDH and their application to construct a model has also been described in chapter 7.

1.6 ORGANIZATION OF THESIS

Chapter wise summary of the thesis is as follows.

Chapter 1 provides general understanding and the importance of crude oil as an energy source. The global sources of crude oil as well as concern of crude oil security are discussed. The chapter provides the rational for present study and its objective. The parameters affecting globalization strategy for crude oil security has been discussed. The approach to modeling these parameters to rank global opportunities for crude oil security has been discussed.

Chapter 2 incorporates the review of literature.

Chapter 3 describes the global energy scenario and issues as well as concern for energy and crude oil security. It deals with the importance of crude oil as an energy source.

Description of the Indian energy scenario and India's concern for crude oil security is provided in chapter 4. Broad understanding of efforts towards crude oil security by India, both within and outside the country has been discussed.

Chapter 5 describes the various modes of entry in to overseas upstream business. Description of various factors which affect the strategy to enter in to overseas business for crude oil exploration and production is provided.

Chapter 6 describes various technical and non-technical uncertainties that may impact the degree of attractiveness of crude oil assets to an overseas investor. Business environment, petroleum regulations and fiscal terms, availability of infrastructures, currency and credit risks, likelihood of strikes, acts of terrorism; fear of expropriation, and risks to the health, safety, and environment etc. are factors which are taken in to consideration for assessments of E&P assets. These elements have critical importance because they affect the economic viability and thus attractiveness of crude oil and gas assets to global investors.

Chapter 7 deals with the development of model of factors affecting business decisions for entering overseas upstream business. This model is aimed to rank the crude oil bearing countries in order of attractiveness for overseas business and is envisaged to facilitate the decision makers in deciding a strategy for selection of global opportunities.

Because of the widespread need for conceptualization and development of model and methodology to steer globalization strategy for entering in to overseas business of crude oil exploration and exploitation, the objective of this research has been to develop a methodology and model that can incorporate the above mentioned uncertainties. An attempt has been made in chapter 8 to incorporating the factors to develop a methodology for globalization strategy.

Chapter 9 finally presents the summary and finding of research work.

The organization of the research work is represented in Figure 1.11.

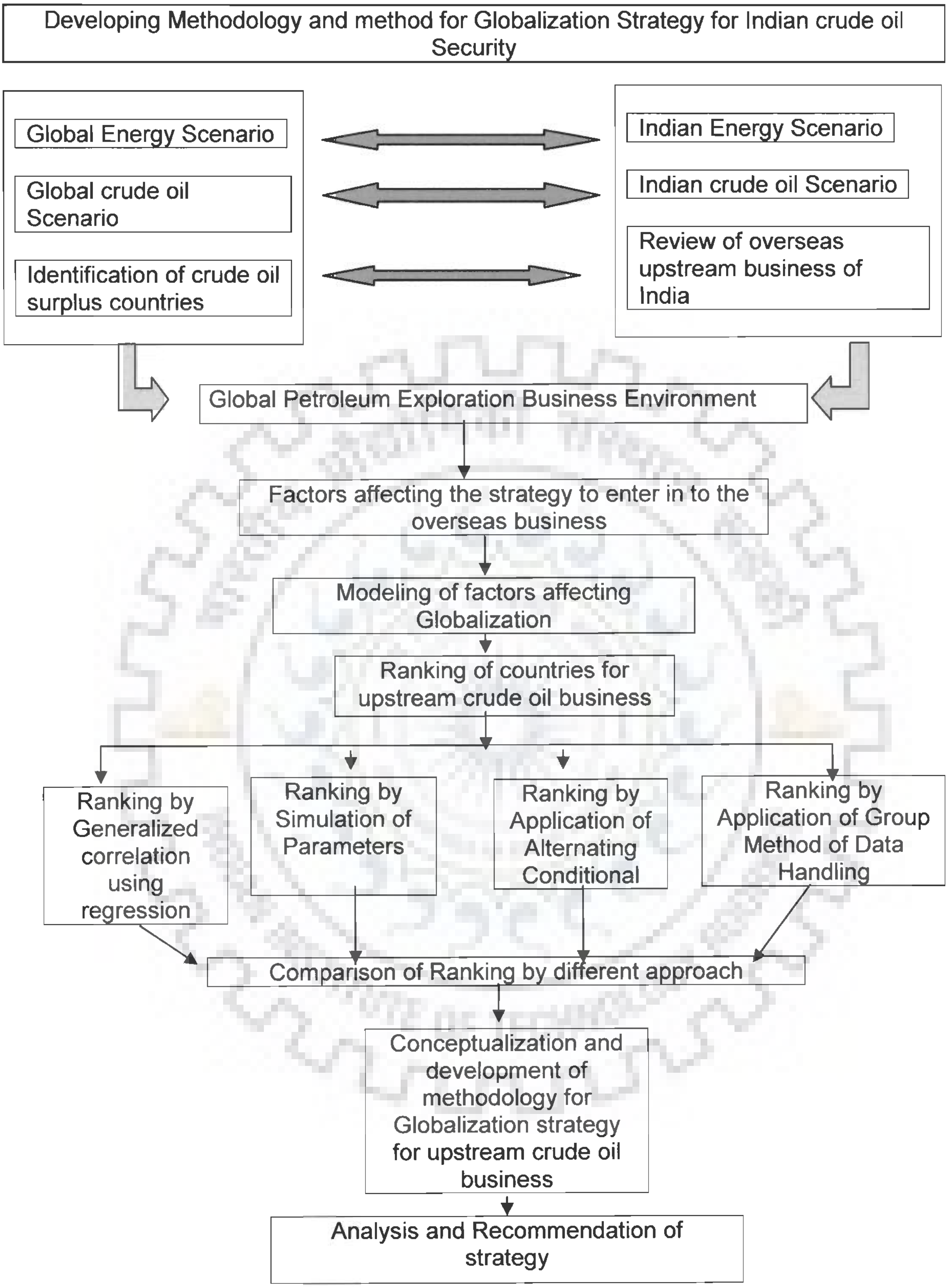


Figure 1.11 Organization of the present research work

1.7 CONCLUDING REMARKS

The background for the present research work has been prepared and some vital aspects of the globalization strategies have been covered. The selection criteria for global destination to secure crude oil for India and its influence on crude oil security have also been discussed. It has been observed that few global destinations are favorable for sourcing crude oil. The requirement of undertaking present research work and the objectives of the present study has also been discussed. Finally, a chart is presented to depict how the present thesis is organized.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Comprehensive and extensive literature has been referred from wide range of available sources and the review of the scouted, scanned and studied literature is being presented in this chapter in four sections. First a comprehensive review of literature related to energy security, global energy issues and key factors affecting energy security is presented. Next section focus on the comprehensive account of work carried out by several researchers in the field of energy security. Subsequent sections provide the literature review of some of the research methods for globalization strategy, methodology and modeling for globalization strategy.

2.2 ENERGY SECURITY

"Energy is a modern necessity" (Gluck, 1990). It constitutes basic ingredient of many services that improves quality of life and enable economic and social development. A secure, adequate, affordable and reliable supply of energy is a necessary precondition for sustainable development.

2.2.1 Concept of Energy Security

The concept of energy security emerged in 1970's. It is a broad and evolving concept and an element of global focus these days. During the 1970s and 1980s, energy security meant reducing the level of import of crude oil and managing the risks associated with those imports. Energy security persists as a policy driver of great rhetorical and practical importance (Gluck, 1990).

- U.N. Economic Commission for Europe (UNECE) Energy Security Forum defines energy security as "The availability of usable energy supplies, at the point of final consumption, in sufficient quantity and timeliness so that, given due regard for encouraging energy efficiency, the economic and social development of the country is not materially constrained."(SARI/ENERGY, Jan 2008)

- According to Asia Pacific Energy Research Centre (APERC), energy security refers to securing adequate energy supplies at reasonable and stable prices in order to sustain economic performance and growth.

- According to the World Bank Group (2005), energy security refers to establishing that countries can sustainably produce and use energy at reasonable cost in order to facilitate economic growth and improve the quality of life of peoples by augmentation of access to modern energy services.

The subject of energy security carries different connotation to different entities and different countries interpret what "energy security" mean to the term differently (Daniel, 2006 and the World Bank Group, 2005). In the developed world the energy security is simply the availability of sufficient supplies at affordable prices, and for the developing countries it is how changes in energy prices affect their balance of payments. Importing nations have been resorting to measures and initiatives since century to ensure a continuing flow of energy to fuel their economies (Gluck, 1990). The consuming countries want "security of supply" – that is reliability and availability of energy at reasonable prices. Exporting countries like Russia or in the Middle

East are concerned about maintaining of "security of demand" i.e. sufficient access to markets and consumers for their export (Daniel, 2006).

The global energy challenges have been discussed by several authors. Dorian et al (2006), discuss about global challenges in energy. According to him oil will continue to dominate global energy requirements. Eventually in long-run the transition to other energy source will take place, necessitating the concomitant change in environmental measures. Brown (1981), provides the global energy challenges and responses. According to him, there has been intentional and unintentional decline in consumption of oil and gas. Less developed countries has experienced balance of payment problems. Diversification of fuel types as well as geographic supply sources have been suggested as alternative solution.

2.2.2 Definition of Energy Security

The World Energy Assessment, 2000 defines energy security as "a term that applies to the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices, without unacceptable or irreversible impact on the environment." According to this assessment whether the energy resources will be available in the marketplace at affordable prices depends on how markets perform, on government taxation and regulation, and on the role of policies such as electrification or subsidies. Security of supply has taken a higher place on the global agenda recently for a number of reasons: the shift in oil and gas prices from very low levels in the 1990s to higher, more sustained levels today, changes in contracts and other aspects of market reform, deregulation and the establishment of new forms of regulation, protocols to reduce greenhouse gas emissions, and political instability in some main supplier countries. The potential for conflict, sabotage, disruption of production and trade, and reduction in strategic reserves cannot be dismissed. A range of actions can be taken to improve energy security. One important measure is to avoid excessive dependence on fossil fuel imports. This involves diversifying supply – both geographically and among various primary energy sources. Another measure is fostering greater political stability among energy-importing countries and between importing and exporting countries. Examples might include wider adoption – and more effective implementation – of the Energy Charter Treaty as well as increased sharing of infrastructure for transporting natural gas. This assessment suggests some additional measures to enhance energy security

- encouraging technology transfers to developing countries so they can develop local resources and improve energy production and efficiencies;
- increasing national and regional strategic reserves of crude oil and oil products through increased investment and advanced exploration technologies; and
- promoting sustainable international markets for biofuels (e.g., ethanol) and international trade between producers and consumers of such fuels.

The interdependence between industrialized countries and oil exporters is another important feature which enhances energy security. Importer is anxious about security of supply and exporters about security of demand. According to the World Bank Group (2005),

- "For energy producers, it is the ability to secure, long term and attractive markets for their natural resources that often underpin their economies.
- For the major industrialized economies, it is the continuing supply of energy that drives their economies and supports a high and growing quality of life.

- For poor countries, it is a vital ingredient in their paths out of poverty.
- For all countries, though, there is a vital common interest, between producers and consumers and between rich and poor, in ensuring that the global economy finds the energy it needs to grow in a sustainable way."

Supply disruption due to human intervention (terrorism, sabotage, war etc) is another concern.

2.2.3 Objective of energy security

The objective of energy security, according to Yergin (2006) is to assure adequate, reliable supplies of energy at reasonable prices and in ways that do not jeopardize major national values and objectives. But, finding secure and economic sources of energy to grow has always been a challenge. The World Bank Group (2005) in the briefing paper on energy security issue provides an overview on global energy security issues and challenges in the short and long run. It suggests areas of focus where consistent approaches and global actions will help improve energy security. According to Asia Pacific Energy Research Centre (2003), many economies are looking at the energy security policies and measures with a view to shielding their economies from energy supply disruptions and to improve the resilience of their economies to supply and price shocks in both sort-term and long-term. The principles and policies that underpin "energy security" includes besides taking care of international relations, creation of strategic reserves, diversification of sources of supply, and increased use of other energy sources (Zobaa, 2005).

2.2.4 Importance of crude oil

Oil dethroned coal in 1950s (Carmoy, 1986). In spite of sky-rocketing prices, it did not abdicate to other energy sources in the 1970s. Oil remains the dominant fuel in the primary energy mix with a share of around 40%, and there is an increasing for oil supply on a decreasing number of sources (IEA, 2006). According to the Tenth Five Year Plan of India, "The world energy consumption pattern has been changing over the years. Presently, the share of oil in the world energy mix is 40 per cent and that of gas is 23 per cent. The international energy outlook projections indicate that the hydrocarbons will continue to cater to 68 per cent of the total commercial world energy demand over the next two decades. The share of oil may remain the same whereas that of natural gas may go up as the latter is emerging as the preferred feedstock and fuel since it is more environment friendly." The price of oil is a price leader for the other primary energy sources (Caromy, 1986). The oil market is not free. It is dominated on the supply side by a relatively small number of producing countries that try to manipulate the crude flows according to a changing mix of political and commercial motives.

2.2.5 Growth in demand of crude oil

As per the projections of IEA the world energy demand increases by 57% between 1997 and 2020 at an average rate of 2%. Crude oil remains the dominant fuel in the primary energy mix, and the volume of world oil demand is projected at close to 115 million barrels per day in 2020, compared with 75 mb/day in 1997.

2.2.6 Issue of crude oil security

Crude oil is the principal source of energy and provides critical energy for transportation. The internal combustion will remain the prime driver of transportation and crude oil will remain its significant source of fuel. The effective link between growth in energy consumption and economy, crucial role of crude oil in mechanized warfare, and its uneven distribution across the glove have lead leaders to pay close attention to available energy supplies and consider it as a strategic commodity (Gluck, 1990).

The soaring oil prices, exceedingly tight oil market, terrorism, geopolitical disagreement, instability in some exploring nations, fear of scramble for supplies, and nation's requirement of energy for economic growth leads towards attention on energy security (Daniel, 2006). Crude oil price rise has affected economies and it has been detrimental to the economic performance of oil importing nations, but, provided windfall gains for oil exporters. While oil is essential to fuel economic growth, its supply is volatile, subject to short-term interruptions as well as long-term lapses in the rate of supply development. As a consequence, any lapse carry with them substantial economic costs and give rise to concern over "oil security" (Voropai, 2000). The increase of oil prices to record levels has attracted the attention of the international community towards the issue of energy security, because rising and volatile energy prices pose a risk to the world economy and to all countries, but the poorer importing countries are less able to cope with increased prices Whereas, oil and gas exporters have been able to generate windfall profits from high oil and gas price levels, the importers generally are concerned about the meaning of short term price shocks for longer term secure supply of reasonably priced energy (The World Bank Group,2005)."

The global crude oil resources are limited. Estimates of volume of available crude oil has been attempted by several individuals and institutions notably British Petroleum (BP). The BP annual statistical review of energy resources provides detailed information about the country wise energy scenario, trade etc. Edwards J.D (2001) has narrated the risks, challenges and opportunities in twenty first century due to decline in production of crude oil and increase of renewable, non polluting energy sources. Salameh (2000) discusses about global oil outlook. The paper focuses on the concept on dwindling of gap between demand and production capacity of global oil and its impact on the global oil supplies, the price of oil and the global economy. Hall (1992) has provided an insight into the estimates of oil imports expenditure for national security. The issue of the strategic petroleum reserve has been discussed by Katz (1981).

Import reduction and reducing dependence of importers for crude oil supplies is a major concern. It has importance not only from energy security point of view, but also from the point of view of supply disruption as well as economic considerations to have protection from oil price shocks. Kline et al (1982), discussed a number of oil import reduction measures to reduce the cost of oil supply interruptions. The options suggested are – taking measures to promote domestic oil production, provide subsidy to produce more domestic energy, fixing oil import quota, rationalizing tariffs. Looney (2002) has attempted to find a relationship between oil price movement and globalization and observed that increased globalization appears to be strengthening the impact of oil price shocks in the advanced industrial countries, but to a much lesser extent in the newly industrializing countries.

The concept of energy security in regional or country specific context has been discussed by some authors. Zobaa (2005), discusses the way to regional version of IEA to achieve regional cooperation and avoid future disruption in supply. Birol (2005) provides an account of global energy scenario during 2005-2030. Middle East and North Africa have been considered as focal centers to meet the global energy requirement, based on regions remaining reserves. There are vast areas which are prospective from hydrocarbon point of view e.g. global deep offshore province, West Africa offshore, etc. Thus, to derive any conclusion taking the Middle East and North Africa as future source leaves a gap in study. Fereidun Fesharaki (1999) discusses the issues and aspects pertaining to the energy security of Asia, especially the energy security concern, and the options available to the region. In this study, Middle East has been considered as sole oil-source for Asia. Exploration during last decade has added new oil-producing regions endowed with rich reserves as potential supply source for Asia. These regions may provide viable alternate option to Asia for oil supply and this aspect need critical review.

Voropai (2002) has discussed in detail the main threats to Russia's energy security and reasoning for as well as against the issues pertaining to energy cooperation. The study focuses on some aspects of energy security of Russia, and its East Siberian and Far-Eastern regions as a factor of the common energy cooperation in East Asia. It deals with the main threats to the energy security of Russia with regard to economic, socio-political, technological and legal factors. The authors have suggested that there are positive as well as negative aspects to the Energy security issue of Russia. The positive aspects refer to the inflow of funds for development, maintenance of Russian energy facilities, and regional co-operation facilitating Russian economic security. But, there are certain negative issues as well. The first and foremost being the limitation of some projects in solving the Russian domestic energy requirements, especially under the condition when these projects are funded and financed by other nations. Another issues of concern are fast depletion of Russian reserves, interference by foreign investors/ stake-holders, and technological dependence of Russia on foreign firms. These negative issues which pose threat to Russian energy security may hold true for other nations as well and needs to be addressed.

Kemp (1992), while discussing petroleum policy issues in developing countries suggests that petroleum holds importance for both importing and exporting countries. Both are exposed to fluctuations in oil price. Exporting countries should focus on profit related fiscal instrument and importers should look in to the aspect of opportunity cost. The taxation of petroleum products should take in to cognizance the aspects of energy security.

2.2.7 Indian crude oil Scenario

According to the Tenth Five Year Plan of India "Against a 63 per cent supply of primary commercial energy through hydrocarbons in the world, in the case of India it is 44.9 per cent (36.0 per cent for oil and 8.9 per cent for natural gas). The demand for oil in the country over the next five years is expected to grow at an annual average rate of 3.6 per cent which will be higher than the average growth of around 2 per cent in the world energy demand."

Muneer (2005) provides an overview of the current and projected energy scene. It quantifies the period of exhaustion of the current major energy sources like coal, oil, gas and projected demand for energy. But, with vast unexplored and under-explored province, sustained global efforts in exploration coupled with successes the quantification may not hold true. Moreover, with vast unexplored and under-explored province it cannot be said with certainty that India's fossil fuel resources are limited compared to global reserves. Such issue needs critical analysis in light of new E&P efforts and discoveries. The rational to quantify that India will continue to experience the energy supply shortfall for at least another 15 years needs further analysis. According to Muneer (2005), the net importers (China, India, UK, USA) are facing decline of fossil fuel reserve and are heavily dependent on fossil fuel to meet the energy requirements. The paper suggests a switch over from fossil fuel to renewable energy sources. The way forward to switch from fossil fuel to renewable energy sources and related technological preparedness as well as economic impact needs attention.

Pachauri et al. (2004) has provided a comprehensive overview of Indian energy scenario. The issue of Indian energy security has been discussed in detail by Jokhan Ram (2007) and Nanda et al (1990). Jokhan Ram (1997, 2002, and 2005), has stressed about the petroleum exploration in frontier and deep water basins of India. Thukral (1990) weighs up the option for India to import crude or products.

2.3. GLOBALIZATION STRATEGY

The review of top twenty management journals to elucidate the recent developments in international management research by Werner (2002) provided a comprehensive overview about the growing research in the field of International Management (IM), the mythologies for IM research and future areas for research has been a source of inspiration for the present thesis. Chng (2000) has provided a detailed review on works in the area of global strategy and identified areas for future research. Gluck (1990) deals with the climate of international business in 1980s, especially under dynamics of changes in oil market, fluctuations in currency markets, shifts in labor markets, aggressive competition, and globalization of market.

The emergence of a new filed called “Global Strategic Management” is now accepted fact, which is a blend of international business and strategic management. Several new events have taken place in global arena like birth of EU, collapse of communism, information revolution and environmental awareness. The study by Halal (1993) focuses on the global strategic management encompassing these issues. A review of present day globalization is given in the work of Reid (2000) and provides an analysis how the economist’s analysis of free trade is related to the forces behind the globalization of competition.

According to Daniel (2006), tight oil-market, high oil prices, terrorism, etc. are some of the emerging issues which have renewed focus on energy security and countries must diversify their energy supply sources to have energy security.

Cueille et al (2003), has discussed about the growth and globalization strategies of large independent petroleum companies especially the edge these companies derive against the major players by targeting certain specific market sector or geographical location and offer a viable alternative to host country by providing an opportunity to monetize geopolitically risky acreage which may be unattractive to major players.

Several factors may influence the degree of globalization/adaptation practices of organization. The various environmental variables as well as organizational and marketing variables that influence the level of marketing adaptation practices of exporting companies has been analyzed by Wong (2004). Priem (2001) has provided a some concepts on Resource Based View. Rugman(1985) puts forward that competing globally is more complex than competing domestically.

The role of new information about key environmental parameters like political risk, foreign exchange risk, government policy changes etc. as well as activities of other multinational enterprises to plan, implement and succeed in global business has been discussed by Rugman (1985).

Bryan et al (2005) proposed to exploit the size and scope, the pool of talented human resource to combine tangible and intangible assets for developing a new model of competitive advantage, based on the premise that there is a relationship between the growth and profitability of the organization and the talented professionals it possess. The strategy should be to develop and mobilize the unique intangibles, which may help in business especially in global environment. The account of restructuring among the world's leading oil companies has been discussed in detail by Cibin et al (1996). Cebin has analyzed the corporate restructuring of the international oil majors during 1980-92.

2.3.1 Strategic Planning Process and Mode For Foreign Entry

There are several ways to enter a foreign market – exporting, licensing, joint venture, wholly owned foreign investment, acquisition and Greenfield investment. Buckley (1998) has provided an approach for firming up foreign market entry strategy by applying internalization approach.

The framework or threads of strategic fabric have been discussed by Hambrick et al (2005). This work suggests that the strategy comprises of an 'arena' i.e. where the firm will be active, a 'vehicle', meaning thereby how the form will reach there, 'differentiators' which means how the firm will win in market place, 'staging' which refers to the speed and sequence of moves and economic logic which means how it will obtain returns.

Quick et al (1983a), discuss the strategic planning process in oil exploration and raise the issue that narrowing business opportunities warrants the oil industry to change their approach toward exploration and crude oil exploration need to be considered as a business, not just as a function. According to them in the strategic planning process, the risk analysis is not sufficient to provide a method for comparing exploration programs with other businesses and instead the portfolio theory be applied for this purpose. Such analysis, as per these authors, has been used successfully in the strategic planning process to compare various business opportunities and to set corporate strategies. Portfolio analysis reviews the petroleum exploration industry as a portfolio of investment opportunities. Coyne et al (1996) has suggested that firms must recognize the dynamics inherent in every situation and manage building blocks of strategy effectively over time. The firms need to manage the way strategy unfolds with time.

Peter et al (2003), discusses about the equity alliances and why major corporations are opting it to stimulate growth and increase corporate wealth. But, no specific focus of energy/petroleum sector, which constitute the business with high risk and reward. Successful cases of alliances in petroleum sector turning out to be acquisitions and mergers.

Elmuti et al (2001) has emphasized the role of strategic alliance and emerging scenario of multi-company alliance. An account of strategic alliance and its practical implementation in development of an oil filed is exemplified by Austin et al (1995). The theoretical model of relationship between the international strategic alliance relationships within the foreign investment decision process has been discussed by Robson et al (2005). The preference of joint venture over wholly owned subsidiary and performance of joint venture in developing countries is available in the wark of Beamish et al (1986). McDougall et al (1993) discusses about the necessary and sufficient elements for the existence of international new ventures. The work also describes the formation of international organization or international new ventures within the framework of international business, entrepreneurship, and strategic management.

Sullivan (2000), has given a detailed account of strategic initiatives, policy reforms, rules and regulation for survival and prospering in the global economy. Comprehensive evaluation of FDI with special reference to India is also given. Svensson (1998) has provided three empirical models for the choice of making foreign direct investment which includes completely refrain from entry and Greenfield investments.

Pandit (2008) has described in detail about the fate of mergers and acquisitions in terms of their performance to create value to shareholders. According to his study active boards, stronger governance structures and external monitors are associated with value-enhancing acquisitions. In contrast, weak boards, dominant management and the absence of external monitoring appear to allow bad acquisitions to occur.

The interrelationships among the different internal tensions and their impact on different types of strategic alliances as well as termination of alliances through mergers and acquisition and dissolution has been provided by Das (2000).

2.4 METHODOLOGY AND MODEL FOR STRATEGY

2.4.1 Methodology

Strategy to enter a foreign market needs methodology and model. The country specific exploration scenario, frontier areas of exploration, availability of crude oil resources and reserves, past successes, acreage available for future exploration and expected field sizes in any province dictate the exploration strategy. Dave (2002) has provided the exploration strategies to be adopted by any company to assess exploration opportunities and improve exploration results, especially in the light of end of an era when easy oil can be found.

Assessment of potential oil and gas exploration investments is a crucial initial step for petroleum companies to ensure the success of the investments. The issue becomes more crucial and critical if the project is in foreign country. Therefore thorough understanding of decision-making processes in assessing potential oil and gas exploration investment employed by the firms is very crucial. A detailed discussion about the concepts of risk in petroleum exploration and fiscal system has been provided by Kjemperud (2001) and Johnston (1994). These provide knowledge and judgmental skill to assess potential oil and gas exploration investments. These authors have also provided about the decision-making processes of the upstream investments by the petroleum companies. The result of the study established and empirically described the management view of the current practices of assessing oil and gas exploration investments. Suslick (2004) has discussed some contributions and developments of risk analysis applied to petroleum exploration, field appraisal and development, production forecast under uncertainty, decision making process, portfolio management, and real options approach.

The factors which drive an explorer in deciding their exploration destination include country risk, fiscal or country terms, tax systems, good geology, markets, and infrastructure. Company enters foreign country for exploration of petroleum on the basis of concessions, leases, or contracts granted by governments. Khelil (1995) has provided an account for fiscal Systems for oil. A comprehensive account of global fiscal system has been provided by Van Meurs (1989). A ranking of global fiscal system has been provided.

Harvey et al (1996) has given a great deal of information about country risk. The authors have emphasized the importance of country risk in global business, which has three elements – political risk, economic risk and financial risk. The study has devised an index of these risk based by time series analysis. Dreher (2003) has provide an index of globalization taking into consideration three main dimensions – economic, social and political. It has taken into consideration data of three decades for 123 countries.

The rank of countries which may facilitate the firm to opt for business requires evaluation of potential candidates. The process requires screening of countries based on some criteria which may be based on limited data. But, it can be left to random decision making process and thus a screening methodology to reduce the potential sites to a meaningful number which can be subjected to thorough analysis may be considered. Veugelers (2001) has proposed a methodology based on some criteria which contribute to a global ranking of each country and assigning weights to these criteria. Bagge et al (2005) has proposed a framework for securing partners for international farm-outs.

2.4.2 The Model

Coping with uncertainty and risk for complex decision-making situation is a complex process. There is a wealth of knowledge and experience that can contribute to rational risk management. Due to success for modeling in problem solving, various modeling paradigms have been intensively developed over in last few decades. Makowski (2005), has dealt in detail about the mathematical modeling for coping with uncertainty and risk. A detailed discussion on the complex problem of coping with uncertainty, and rational risk management for complex decision- making situation has been discussed. Besides this the authors has provided an extensive list of reference for further reading. Surya (2008) has provided a country entry risk assessment model for global petroleum investments using a matrix of weighted risk factors. Hybrid soft computing systems viz. Artificial Neural Networks (ANN) and Group Method of Data Handling (GMDH) have been introduced by several researchers to overcome the imitations of conventional regression methods.

Wang et al (2004) has discussed the Alternating Conditional Expectation (ACE) algorithm of Breiman and Friedman (1985) for estimating the transformations of a response and a set of predictor variables in multiple regression that produce the maximum linear effect between the (transformed) independent variables and the (transformed) response variable. The authors suggest that these transformations can give the data analyst insight into the relationships between these variables so that relationship between them can be best described and non-linear relationships can be uncovered. Furthermore, the authors have discussed the power and usefulness of ACE guided transformation in multivariate analysis. The study demonstrates that ACE is able to identify the correct functional forms, to reveal more accurate relationships, and to improve the model fit considerably compared to the conventional linear model.

Plethora of literature is available employing ACE algorithm in diverse areas. It has been extensively used in petroleum industry for parameter estimation by Xue et al (1997), Verma and Prasad (2005, 2008), Negi and Prasad (2005), and Kukreja (2005 and 2009). Further ACE algorithm has been employed by several investigators in variety of domains e.g. for exchange rate analysis, Material Requirement Planning (MRP), and IS planning.

Although the ACE algorithm has been favored by several authors for understanding complicated relationships and it provides a largely automated approach to estimating optimal transformations, it does not mean that the *ACE* results should be trusted blindly. Additional information and experience of the data analyst remain important. It should be emphasized that the success of the *ACE* algorithm, like other modern statistical methods, relies on the quality of the data and underlying association between the response and independent variables Wang et al (2004).

Sum et al has attempted to model the effects of a service guarantee on perceived service quality using ACE. This work examine the moderating effects of a service guarantee on perceived service quality, by modeling the relationship between service quality and service guarantee and employee variables such as employee motivation/vision and learning through service failure. In fact the nature and form of the relationships between these variables is not clear and if such relationship could be established it can assist service managers to allocate resources more judiciously, avoid pitfalls, and establish more realistic expectations. The work leads to provide new approach into the management of service guarantees and perceived service quality.

GMDH has been recognized as well proven optimization criteria for automatically determining the network size and connectivity, and coefficients for network model. Osman (2002) has provided an account of this modeling technique and its application in oil and gas industry. Negi and Prasad (2006) have applied Artificial Neural Networks (ANN) to predict lithofacies. The technique has been applied by several investigators in variety of domain, e.g. weather modeling and forecasting (Abdel -Aal et al, 1995), classification of medical data (Abdel-Aal et al 1997), credit evaluation (Summetrs, 1996), rental value of residential properties (Kim et al, 1966).

The development of model requires data. The published literatures (Harvey et al 1996; Dreher, 2006) provide detail account of country risk elements. The public domain data of BP Statistical Review, 2008 and EIA has country wise extensive time series information about the potential reserves, resources, trade statistics of renewable and non-renewable energy sources. The data pertaining to Corruption Perception Index, Global Competitive Index, Ease of doing Business, are being published respectively by Transparency International, World Economic Forum, www.doingbusiness.org . The work of Van Meurs(1998) and Khelil (1995) provides data for country fiscal rank.

2.5 GAPS IDENTIFIED FROM EXISTING LITERATURE

The identified gaps in literature provide a guideline for further research in globalization strategy for crude oil security. The continued and ubiquitous dependence of world on crude oil for energy provide tremendous scope of research for technologist, strategist, economist etc. The literature review led the authors to comprehend that the research has mostly been focused to some other specific topic or are too general. The review of the literiature has revealed that little work has been done on the development of methodology focusing on global business strategy for entering in to global crude oil exploration business. Investigation further revealed that there is no documented work addressing the issue of conceptualization and development of any model encompassing the parameters which has bearing of the global business pertaining to crude oil exploration. The issue has drawn not enough attention by researchers. Hence this research is envisaged to develop a methodology and model for globalization strategy which an enterprise will find useful for scouting, scanning and screening of global opportnities in crude oil exploration and production business for crude oil. The implemetation of findings of the study may help India to achieve energy security. The study has identified following gaps.

No.	AUTHOR	THEME OF STUDY	GAP
1.	James P. Dorian et al, Global challenges in energy; Energy Policy, Vol.34, Issue 15, October 2006, Pages 1984-1991	Dominance of oil in near future.	Initiatives/ actions taken to explore and exploit petroleum resources in difficult, hostile and inaccessible regions.
2.	Dr. Faith Birol, World Energy prospects and	Provides an account of global energy scenario	Any conclusion taking the Middle East and North Africa

	challenges, International Energy Agency, 2006.	during 2005-2030.	as future source leaves a gap in study.
3.	Yergin, Daniel, Ensuring Energy Security; Foreign Affairs; Mar/ Apr2006, Vol. 85 Issue 2, p 69-82.	Countries must diversify their energy supply sources to have energy security.	How and where to diversify for the energy supply sources?
7.	Zobaa, Energy Security in the Asia-Pacific Region, IEEE.2005	Overview of the energy security in the Asia-Pacific.	Way to regional version of IEA
10.	Peter Pekar Jr and Marc S Maegulis, Equity alliance take centre stage; Business Strategy Review, 2003, vol. 14 issue 2, pp 50-62	Importance of equity alliances to stimulate growth and increase corporate wealth.	Specific focus of energy/petroleum sector, which constitute the business with high risk and reward.
11.	Jean-Philippe Cueille and Jesus E de Miguel Rodriguez, Large US independent petroleum firms emerging as viable competitors to majors; Oil and Gas Journal, Feb.24, 2003.	Growth and globalization strategies of large independent petroleum companies	No explicit focus on the aspects like which areas are geopolitically or politically too risky or too mature.
16.	Finizza, Anthony J., The future of oil; Business Economics, Oct 96, Vol. 31 Issue 4.	Outlook of petroleum industry in 21st century and importance of oil market in international economy.	Analysis of other entry modes vis-à-vis strategic alliance

17.	Alexander G. Kemp, Petroleum policy issues in developing countries; Energy Policy, Feb. 1992.	Deals with the petroleum policy issues for importing and exporting countries,	Policy framework for taxation for different products vis-à-vis issues like energy security, balance of payments and socio-economic issues need attention.
18.	Kapil Thukral, India's oil policy To import crudes or products? Energy Policy, May 1990.	Weighs up the economic options for India to import refined petroleum products as against crude oil.	Economic implications for importing refined petroleum products.
19.	David Kline and John P. Weyant, India's oil policy To import crudes or products?; Energy Policy, May 1990.	Considers a number of oil import reduction measures	Analysis for oil importing developing countries like India need focus
20.	Harrison Brown, Opening address: Energy challenges and responses; Energy, Vol. 8. No.1, pp 1-6, 1981.	Diversification of fuel supply sources have been suggested as alternative solution.	Strategy for diversification and geopolitical risk as well as economic issues require consideration.
21	Surya Ranjan (2008): " Simplified Country entry risk assessment model for global petroleum investments," SPE paper no. 112932	Provide a country entry risk assessment model for global petroleum investments using a matrix of weighted risk factors	Issue to define the assigned weights needs consideration

Table 2.1 Some Identified gaps from the existing literature

2.6 CONCLUSION

In this chapter various facets pertaining to global energy scenario and related issues has been discussed. The literature was classified into various categories such as dealing with basic concept of energy security, global energy issues, and key factors affecting energy security. Next section provided an account of work carried out by several researchers in the field of energy security. Literature review for globalization strategy, methodology and modeling for crude oil security has been provided. From the literature certain gaps are identified and these gaps provided a direction to conduct the present research efforts. An effort has been made in this research, which contribute to the body of knowledge in these gap areas identified. Subsequent chapters of this thesis report these developments and analyze the effectiveness and validity of these new approaches proposed in the context of globalization strategy for Indian crude oil security.

CHAPTER 3

GLOBAL ENERGY SCENARIO

Crude oil is an important commodity and without it, industrial society would be impossible. Crude oil and natural gas are the fuel for the engine of modern capitalism. The dependence for crude oil is not simply a matter of concern for the volume and value of crude oil a nation imports, but, also other issues that together create economic, political and other problems. There is concentration of the world's oil supply in a small group of oil producing states that may exercise monopoly power, together with the demand-side vulnerability of the Indian economy to soaring crude oil prices. Rising crude oil prices, gradual decline in established reserves, and few new finds raise concern for crude oil supply security. The present global distribution of crude oil reserves leads to a scenario of mutual dependence between nations- the importers upon exporting nations to get the requisite supply and exporters to find market for their surplus. Therefore, an in-depth understanding of petroleum bearing provinces, their established potential and prospectivity of crude oil and natural gas (technically referred to as reserves, and resources respectively), production-consumption pattern, and demand-supply scenario on global, regional, national-scale is imperative. The understanding of global distribution of resource will help in consolidating a global business strategy for scouting, scanning, and screening of overseas opportunities for oil – gas exploration and production business.

The purpose of this chapter is to examine the factors that impact the oil and gas exploration and production business. We begin with a general overview of the global oil and gas industry and product demand and supply, production and consumption pattern and provide background information on oil and gas resources, as well as description of characteristics of exploration and production business. The factors that impact supply and demand, investment decisions, and country competitiveness are then reviewed. We conclude with a summary of the observations about the factors influencing overseas crude oil exploration business.

3.1 GENERAL BACKGROUND

3.1.1 Brief idea about petroleum business

Petroleum is the world's major source of energy and is a key factor in the continued development. Crude oil and Natural gas are abundant fossil fuels, found throughout the world in reservoirs deep beneath the surface of the earth and floor of the oceans. It forms as pockets of oil and gas deposits or is trapped in porous rock formations. They are the product of the subsurface sub-aerial decay of organic residuals (animals, plants, etc.) during geological past. The remains of dead plants and animals were deposited in sedimentary basins and were eventually covered by sediments. The high pressures, high temperatures and chemical action converted these remains into oil and gas. The oil and gas were then squeezed out and expelled of the host rocks also called source rocks (mostly shale) in which they were generated, by overburden pressure and other physico-chemical factors and from there it migrated into porous sedimentary rocks. Oil and gas migrates upward through the porous rock, as it is less dense than the water, which fills the pores and gets trapped in the structures called "traps" created by geological processes. The exploration for petroleum started since 1860's and has led to establishment of oil and gas reserves in several countries.

3.1.2 The functions of petroleum industry

The petroleum business encompasses three segments – upstream, midstream and downstream, (Kaiser et al 2006) each segment having spectrum of functions as in table below:

Segment →	Upstream	Midstream	Downstream
Functions →	Exploration, development, and production, (E&P)	Transportation	Refining, Marketing and distribution

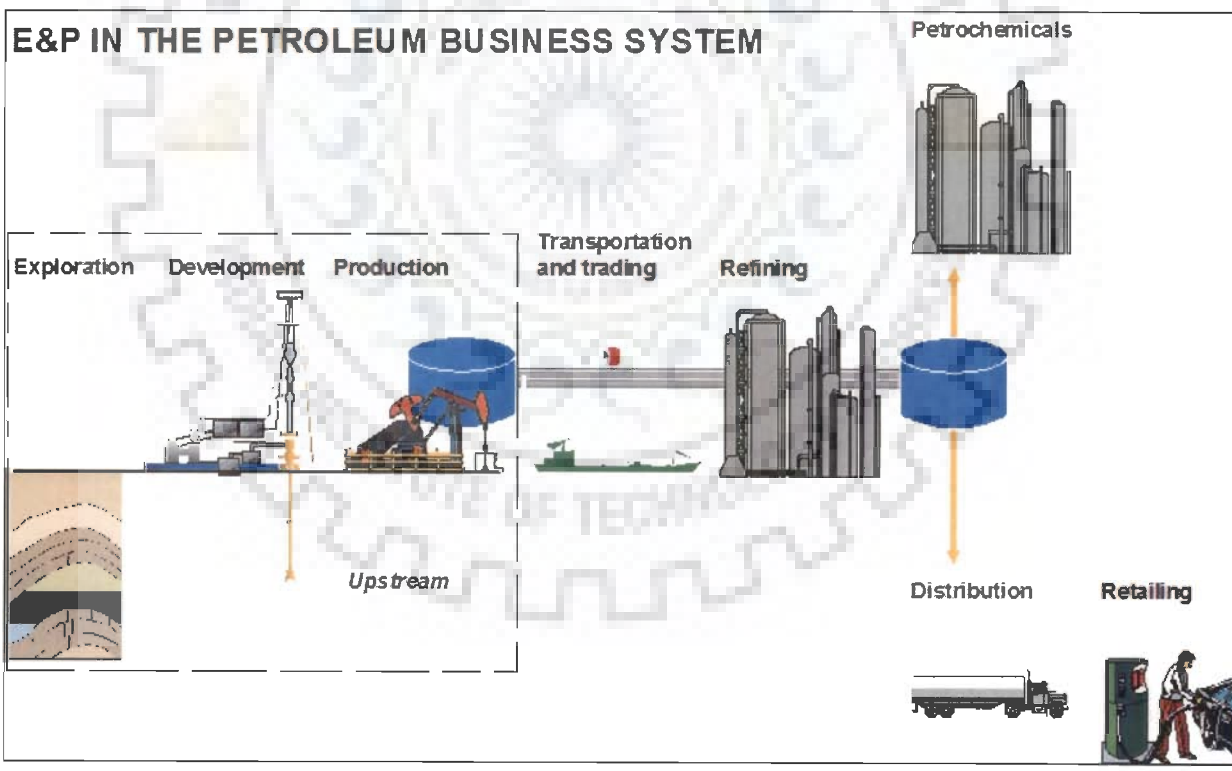


Figure 3.1 The Petroleum Value Chain

The players in the E&P industry can be divided into three groups

Exploration and production industry

- Resource holders
  - Governments
  - National oil companies (NOCs)
  - Private landowners
- Operators
  - Majors
  - Independents
- Service companies

Thus, the petroleum business comprises upstream activities that take place before the oil goes into a pipeline or tanker (i.e. exploration, development, and production); transportation and trading; refining; and fuel distribution and retailing.

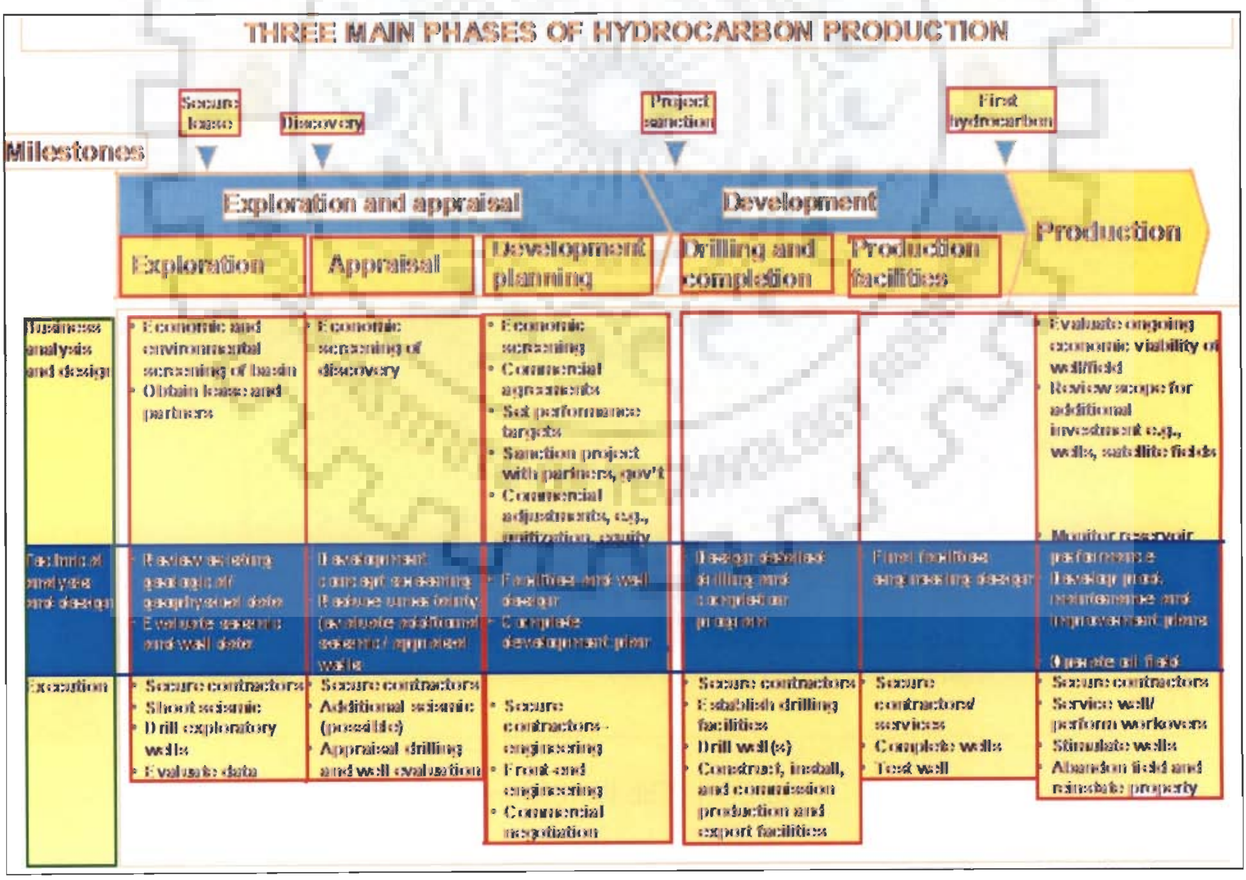


Figure 3.2 Phases in Petroleum Upstream Business

There are many sub-businesses within exploration and production. Exploration, development, and production can each be thought of as a separate business, and a particular oil field pass through each stage. When the exploration commences, the field is just a concept with the geologist. A commercial discovery provides incentive for development, when structures and pipelines are built and the majority of wells for production are drilled. During the production phase operations and maintenance of the facilities installed during development is regularly carried out, and production is enhanced by drilling development wells and improved recovery processes.

3.1.2.1 Phases of upstream activity

The upstream activity is divided different phases and these phases are in real life of overlapping or occur concurrently and are rarely in sequential order. It is really difficult to determine with precision the phase during which an event occurred or a particular cost is incurred. Moreover, there are certain services the requirement of which spills in to several phases. Following are the different phases in which upstream activities may be divided:

a. Prospecting
b. Acquisition of oil and gas rights
c. Exploration
d. Appraisal or evaluation
e. Development
f. Production and
g. Closure-site restoration, abandonment and dismantling.

The above sequence of the phases may not be identical for all the enterprise or projects. Various combinations are possible. The brief description of the various phases is as follows.

3.1.2.2.1 Prospecting

It is basically carried out to narrow down the area of interest for exploration. The program generally targets a very large area. Eventually by doing research and analysis as well as various kinds of mapping and synthesizing the information thus gathered, structures which may be locale of oil and gas are identified which then is referred to as the area of interest for the company. It is mostly carried out before acquiring the oil and gas rights. If the results of prospecting are negative than the area is considered not interesting and oil and gas rights are not taken. Prospecting is occasionally conducted after taking oil and gas rights.

During this phase the costs are occasionally incurred in activities that are not part of the specific project for exploring oil and gas but, are of general nature. For example the expenditure towards purchasing of geological and geophysical data. Even the reconnaissance survey prior to obtaining the rights, the expenditure towards obtaining sub-surface geological and geophysical data from operators, purchase of aerial photographs, satellite imageries etc. amount to significant value in this phase.

3.1.2.1.2 Acquisition of Oil and Gas Rights

It refers to obtaining legal rights to explore, develop and produce resources. It may be acquired by:

a. Purchasing of oil and gas outright ownership

b. Obtaining a lease or concession

c. Entering in to:

- Production-sharing contract
- Joint venture or farm-out agreement
- Service contract
- Risk-service contract
- Technical assistance contract etc.

The acquisition of oil and gas rights provides a company with the right and obligation to operate the property. It includes the right to explore, develop and produce oil and gas. In some contracts the operator may be entitled to a part of the specified costs directly from production (cost oil). The typical oil and gas lease usually calls for:

- Signature bonus: It is the amount paid by the lessee to the lessor at the time the contract is signed,
- Dead rent: It is annual payments made by the lessee to the lessor until drilling has started and,
- A royalty equal to a specified percentage of sales percentage or of value oil and gas produced during each period.

In India any oil company wishing to undertake exploration activities has to initially apply and obtain Petroleum Exploration License (PEL). For carrying out development and production Miming Lease is to be obtained. Requisite fees need to be paid for obtaining PEL and ML.

3.1.2.1.3 Exploration

It involves detailed examinations of a specific area to search for oil and gas. It may involve activities as those in prospecting phase but a narrowly focused area and the scale of investigation is very small. Generally exploration is done after obtaining the oil and gas rights. The topographical, geological, geochemical and geophysical surveys are carried out and geological structures are identified. Once few locations are firmed up for drilling based on these studied the rig is deployed and exploratory drilling is carried out. The cost involved in this phase is very high. It will include cost of the following:

- Reconnaissance survey
- Topographical survey
- Geological field mapping
- Gravity-Magnetic survey
- Seismic (2D and 3D) surveys
- Geochemical surveys
- Drilling of exploration wells and their completion along with civil works required prior to drilling these wells.

If any enterprise plans to drill a well in the near vicinity of explored prospect, it may obtain subsurface information from the owner of the drilled prospect by making a bottom-hole contribution or dry hole contribution. Both these payments represent exploration costs. Occasionally prospecting costs and costs incurred in acquiring oil and gas rights are added to the cost of exploration phase because they are considered as being part of the exploration phase.

3.1.2.1.4 Evaluation or Appraisal Phase

Once exploration phase has confirmed the presence of oil and gas in a structure the appraisal starts. It refers to determining the technical feasibility and commercial viability of the prospect. The appraisal wells are drilled to delineate the reservoir, which has been identified by exploration phase. It aims at knowing about the size (aerial extent), characteristics etc. to assess its commercial potential and to get an idea of recoverable reserves. During this phase detailed engineering studies are carried out to design the development plan of the field, plan for the transportation of oil and gas is made, and detailed economic evaluation of the prospect is carried out to know about the techno-economic viability of the prospect.

The cost involve in this phase will be significant. It will include cost of drilling of appraisal wells, development of infrastructures for drilling these wells, cost of engineering studies, and cost of feasibility studies which includes techno-economic analysis, analysis for development of infrastructure for transportation of oil and gas. If the infrastructure facility exists for a nearby prospect and the resources can be pooled to transport the product than the appraisal well production can be taken and the development cost will be less. But, if the prospect which is being evaluated by appraisal wells have no approach to any infrastructure than the cost of development of these facilities will be considerable and production may not start till these facilities are crated.

3.1.2.1.5 Development Phase

It refers to the commercial production of discovered oil and gas. In general following are the major activities carried out in this phase:

- Preparing well locations and their approach for drilling
- Carrying out civil works which includes building roads, power lines, constructing platforms or drill site foundations from where wells will be drilled
- Drilling of development wells as per development plan
- Installation of necessary equipment for taking production, storing of oil and gas, its transportation etc.

The cost involved in this phase will depend upon the number of wells to be drilled and their cumulative cost, cost of civil works, cost of production and transportation equipments and facilities.

3.1.2.1.6 Production

It involves the extraction of the oil and gas from the prospect and the allied processes, which are required to make it marketable. It includes the following activities:

- Lifting the oil or gas to the surface
- Gathering production of individual wells to a common point
- Treating and processing of oil and gas (to remove impurities and separation of the phases)
- Storage in the field production tanks

The terminating of oil and gas production at the outlet valve of the field production storage system normally marks the end of production phase. But, occasionally based on the operating circumstances, the production stage is deemed to be complete at the first point of sale of the oil and natural gas. It may be when oil and gas are delivered to a main pipeline or to other means of transportation, to a marine terminal or to a refinery. With this also comes the end of the upstream activities. The cost involved in this phase is due to the cost of production equipment, separators, pipelines, treaters, storage tanks, gathering stations, handling devices etc.

3.1.2.2 Closure

When the field ceases/fail to produce than the equipment is removed and facilities, which were created are demolished. The site is restored to appropriate condition and finally abandoned. In the process the wells are plugged. The degree of removal and restoration depends on the government regulation, geographical location of the field, policy of the enterprise. The cost involved in this stage includes well abandonment cost, site-restoration cost and cost in removing equipment, surface facilities etc.

3.1.3 Petroleum resources

The global petroleum resources are plentiful, but unevenly distributed (Thomas S. Ahlbrandt, 2002) in the subsurface traps, can be viewed as a pyramid with a small amount of high quality resource that is cheap to extract, and with increasing amounts of lower quality resource that cost more to extract (Figure 3.3). The upper part of the pyramid is well defined, as these resources are mostly known and are generally considered "conventional." The lower part of the pyramid is less understood and the amount of petroleum in accumulations that are now largely uneconomic — such as gas hydrates or basin-centered gas — is highly speculative. If we draw a slice through the pyramid then the upper part will define the economic resource of oil or gas.

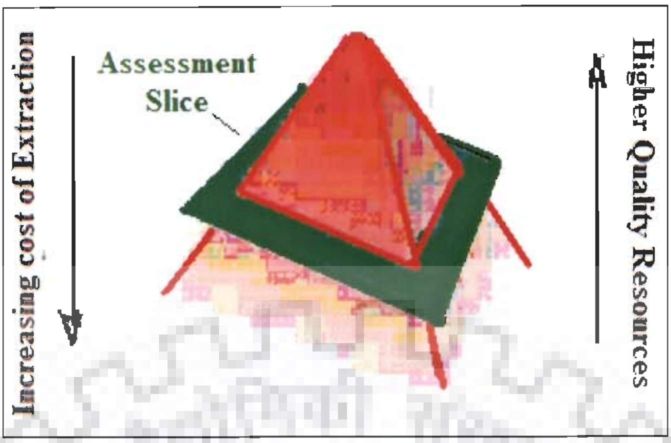


Figure 3.3 Resource Pyramid (Source: USGS)

Thus, the resource pyramid depicts the economic feasibility of an area's petroleum reserves

3.1.3.1 Concept of resources and reserves

Oil and gas reserves are commonly quantified by the petroleum industry into three categories (Table 3.1).

a. Proved,

b. b. Probable and

c. c. Possible

Given below are definitions as agreed upon by joint committee constituted for the purpose by SPE, WPC and AAPG. The joint offer was done in six years and the reserves definitions were approved in 1997 and the resources definitions in 2000.

<table>
<tr><td rowspan="10">PETROLEUM INITIALLY IN - PLACE</td><td rowspan="7">Discovered Petroleum-Initially-In-Place</td><td rowspan="3">COMMERCIAL</td><td colspan="3">PRODUCTION</td><td></td></tr>
<tr><td colspan="3">RESERVES</td><td>Producing</td></tr>
<tr><td>Proved (1P)</td><td>Proved+ probable (2P)</td><td>Proved+ Probable+ Possible (3P)</td><td>Being Developed
Development Planned</td></tr>
<tr><td rowspan="4">SUB COMERCIAL</td><td colspan="3" rowspan="2">CONTINGENT RESOURCES</td><td>Technology Proved</td></tr>
<tr><td>Technology Not Proved</td></tr>
<tr><td>Low Estimate</td><td>Best Estimate</td><td>High Estimate</td><td>Non Commercial</td></tr>
<tr><td colspan="3">Unrecoverable</td><td></td></tr>
<tr><td colspan="2" rowspan="3">Undiscovered Petroleum-Initially-In-Place</td><td colspan="3">PROSPECTIVE RESOURCES</td><td>PROSPECT
LEAD</td></tr>
<tr><td>Low Estimate</td><td>Best Estimate</td><td>High Estimate</td><td>PLAY</td></tr>
<tr><td colspan="3">Unrecoverable</td><td></td></tr>
</table>

Table 3.1 SPE/WPC/AAPG Joint Definitions of Resources and Reserves
Source: A.R. Martinez EEC Geneva 2002

A. Proved reserves

Proved reserves of petroleum are the quantities of petroleum which by analysis of geological and engineering data can be estimated with reasonable certainty to be commercially recoverable from a given data forward, from known reservoirs and under current economic conditions.

- Besides current economic conditions, operating methods and government regulations are also to be taken into considerations. There should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate.
- Reservoirs are considered proved if economic producibilty is supported by actual production or formation tests or if core analysis and/ or log interpretation demonstrates economic producibilty with reasonable certainty.
- The term proved refers to the estimated volume of reserves and not just to the productivity of the well or reservoirs.
- In certain instances, proved reserves may be assigned on the basis of electrical and other types of logs and/ or core analysis that indicates that the subject reservoirs is hydrocarbon bearing and is analogous to reservoirs in the same area that are producing, or have demonstrated the ability to produce on a formation test.
- The area of a reservoir considered proved includes
    - (i) that portion delineated by fluid contacts, if any,
    - (ii) the adjoining portions not yet drilled that can be reasonably judged as economically productive on the basis of available geologic and engineering.

In the absence of data on fluid contacts, the lowest known structural occurrence of hydrocarbons controls the lower proven limit of reservoir. Proven reservoirs are estimates of hydrocarbon to be recovered from a given data forward. They are expected to be revised as hydrocarbons are produced and additional data become available.

- Proven natural gas reserves comprise non associated gas and associated dissolved gas.

- Reserves that can be produced economically through the application of established improved recovery techniques are included in the proven classification when these qualifications are met:

  (i) successful testing by a pilot project or the operation of an installed program in that reservoir or one with similar rock and fluid properties provides support for the engineering analysis on which the project or program was based, and

  (ii) it is reasonably certain the project will proceed.

- Reserves to be recovered by improved recovery techniques that is yet to be established through repeated economically successful applications will be included in the proved category only

  (i) after successful testing by a pilot project, or

  (ii) after the operation of an installed program in the reservoir provides support for the engineering analysis on which the project or program was based and it is reasonably certain that the project will proceed.

- Estimated of proved reserves do not include crude oil, natural gas, or natural gas liquids being held in underground storage.
- There are two broad categories of proved reserves:
  - Proved Development Reserves- are those reserves that can be expected to be recovered through existing wells (including reserves behind pipe) with proved equipment and operating methods. Improved recovery reserves can be considered developed only after improved recovery projects have been installed.

- Proved undeveloped Reserves – are those additional proved reserves that are expected to be recovered from
  - Future drilling wells,
  - Deepening of existing wells to a different reservoir , or
  - The installation of an improved recovery project

In general, proved undeveloped reserves are assigned to undrilled locations that satisfy the following conditions:

- The locations are direct offsets to wells that have indicated commercial production in the objectives formation ,
- It is reasonably certain that the locations are within the known proved productive limits of the objective formation ,
- The location conform to existing well spacing regulation s, if any ,and
- It is reasonably certain that the locations will be developed.

Reserves for other undrilled locations are classified as proved undeveloped only in those cases where interpretation of data from wells indicates that the objective formation is laterally continuous and contains commercially recoverable hydrocarbons at locations beyond direct offsets.

B. Unproved Reserve

The unproved reserves are based on geologic and / or engineering data similar to that used in estimates of proved reserves; but technical, economic, or regulatory uncertainties preclude such reserves being classified as proved. They may be estimated assuming future economic conditions different from those prevailing at the time of estimate. Estimates of unproved reserves may be made for internal planning or special evaluations, but are not routinely compiled. unproved reserves are not to be added to proved reserve because of different levels of uncertainty. unproved reserves may be divided into two sub-classifications: probable and possible.

C. Probable Reserves

Probable reserves of petroleum are the quantities of petroleum which analysis of geological and engineering data suggests are likely than not to be commercially recoverable.

In general, probable reserves may include

- Reserves attributable to improved recovery methods that have been established by repeated commercially successful applications,
- Increment reserves in proved producing reservoirs where an alternate interpretation of performance or volumetric data indicates more reserves than can be classified as proved. There should be at least a 50% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable reserves.
- Reserves anticipated to be proved by normal step-out drilling where subsurface control is inadequate to classify these as proved,
- Reserves information that appear to be productive based on log characteristics but there is lack of core data or definitive test and which are not analogous to producing or proved reservoirs in the area,
- Reserves in an area of a formation that has been proved productive in other areas of the field, but, subject area appears to be separated from the proved area by faulting

and geologic interpretations indicates subject area is structurally higher than the proved area.

– Reserves attributable to a successful work over, treatment, change of equipment, or other mechanical procedures, where such procedure has not been proved successful in wells exhibiting similar behavior in analogous reservoirs.

D. Possible Reserves

Possible reserves of petroleum are the quantities of petroleum which analysis of geological and engineering data suggest are likely to be commercially recoverable than probable reserves.

- Possible reserves are unproved reserves. There should be at least a 10% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable plus possible reserves.
- In general possible reserves may include
  - Reserves suggested by structural and/ or stratigraphic extrapolation beyond areas classified as probable, based on geologic and or geophysical interpretation,
  - Reserves in information that appear to be hydrocarbon bearing based on logs or cores but that may not be productive at commercial rates,
  - Incremental reserves attributable to infill drilling that are subjected to technical uncertainty,
  - Reserves attributable to an improved recovery method when a project or pilot is planned, but, not in operation and rock fluid, and reservoir characteristics are such that a reasonable doubt exists that the project will be commercial, and

- Reserves in an area of formation that has been proved productive in other area of the field, but, subject area appears to be separated from the proved area by faulting and geologic interpretation indicates subject area is structurally lower than the proved area.

E. Commercial Reserves

The proven and probable oil and gas reserves or proved developed and undeveloped oil and gas reserves may be takes as the commercial reserves by any company as per their discretion. The alternative definitions are mutually exclusive and the chosen option needs to be applied consistently.

(a) Proven and probable reserves

These are the estimated quantities of crude oil, natural gas and natural gas liquids which geological and engineering data demonstrates with a specific degree of certainty to be recoverable in future years from known reservoirs and which are considered commercially producible.

(b) Proved developed and undeveloped oil and natural gas reserves

The estimated qualities of crude oil, natural gas and natural gas liquids which geological data demonstrates with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions.

As per the United Nations Framework Classification (UNFC), the total resources initially in-place of naturally occurring energy and mineral resources, are described in terms of three quantities - Produced, Remaining recoverable, and Additional quantities remaining in-place (Figure 3.4).

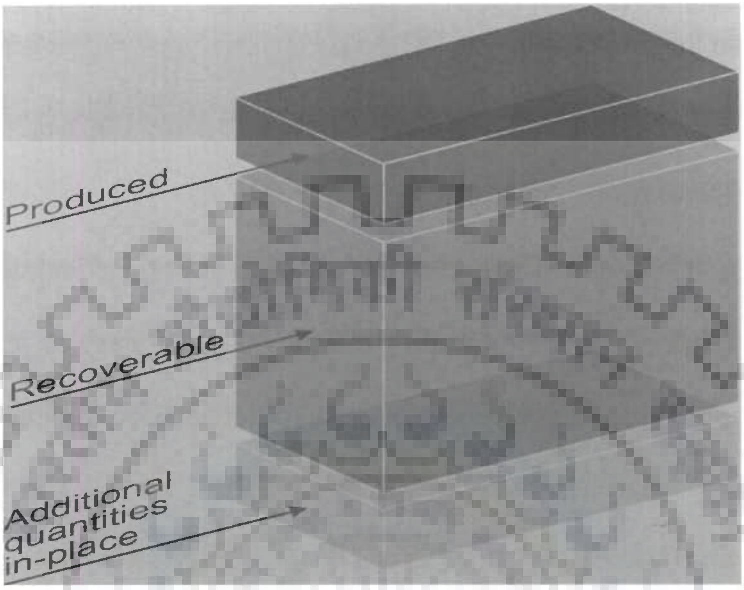


Figure 3.4 Total initial in-place resources (Source : UNFC)

"The total resources initially in-place should be constant for non-renewable resources like crude oil and gas, and in inventories, material balance is to be maintained. Produced quantities are included in the UNFC to facilitate explanation of changes in remaining recoverable quantities resulting from production that has already occurred. Produced quantities are the sum of sales quantities and non-sales quantities as determined at their respective reference points between a specified initial time (often the time of first recorded production) up to a given date and time. Non-sales quantities are considered to have intrinsic economic value."

"Remaining recoverable quantities are the sum of sales quantities and non-sales quantities estimated to be produced at the respective reference points from a given date and time forward."

(UNFC). The “Additional quantities remaining in-place” are quantities estimated to be in-place at the initial time, less the sum of the produced quantities and the estimated remaining recoverable quantities. “Additional quantities remaining in-place” are described in non-economic terms only. Their recoverability and, as a result, their economic viability, has not been assessed. Alternatively quantities may be non-economic in the sense that they may not be recovered in the future, although they may be an integral part of the recovery operations. Both forms of additional quantities remaining in place may hold intrinsic economic value, as do the recoverable non-sales quantities. As per UNFC the ”Total Remaining Resources” may be categorized using the three essential criteria affecting their recoverability (Figure 3.5)-

1. Economic and commercial viability (E),
2. Field project status and feasibility (F), and
3. Geological knowledge G).

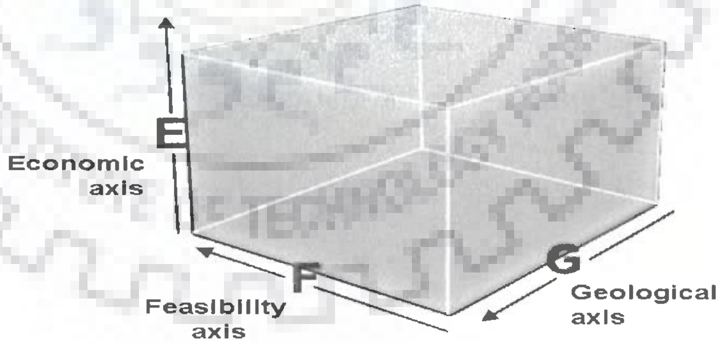


Figure 3.5 Principal elements of the UNFC

According to Kaiser (2006), "Crude oil and natural gas resources are classified according to proved, probable, and possible categories in the U.S. and proven and possible categories in the U.K. Companies operating outside the U.S. and U.K., National Oil Companies, and private firms employ these and other guidelines in reserves estimation. However, the reporting conventions vary by country, and often do not comply with the strict definitions required for company reporting by the U.S. Securities and Exchange Commission (SEC). Proved reserves are estimates of the amount of oil or gas (coal, or other resource) which can be recovered economically using current technologies. Proved reserves is the most certain because it includes only those resources that have already been delineated and developed and shown to be economically recoverable using existing technology under prevailing market conditions. Proved reserves have a high probability of eventual recovery, often interpreted as the 10% fractile of the distribution of recoverable resource; i.e., based on current knowledge there is believed to be a 90% chance (P90) of ultimate recovery exceeding this amount. Probable and possible reserves are further removed from having been tested by the drill bit, and thus, are subject to increasing margins of error. Probable and possible reserves are often referred to as P50 and P10, with probable reserves using a longer-term price assumption and more advanced technology to estimate underground stores."

3.1.4 Global Crude Oil and Natural Gas Resources, Reserves, Consumption and Trade

3.1.4.1 World Proved and Undiscovered Reserves

According to (Kaiser et al, 2006), there are several primary and secondary sources that report oil and gas reserves and resources. Primary sources mostly include company and government data, while secondary sources such as World Oil, Oil and Gas Journal, BP Statistical Review of World

Energy, Agip World Energy Outlook, and Cedigaz compile data from primary sources. Various commercial data sources are also available that collect and analyze reserve estimates on a field-by-field basis. Since all reserves values are estimates, thus there may be wide variation among the different reported sources. The United States Geological Survey (USGS) and Minerals Management Service (MMS) publish periodic undiscovered resource estimates for the world based on geologic information, probabilities of past discoveries, economic conditions, and various other factors. The estimate of the world's ultimate recoverable volume of crude oil has been made by various researchers (Figure 3.6).

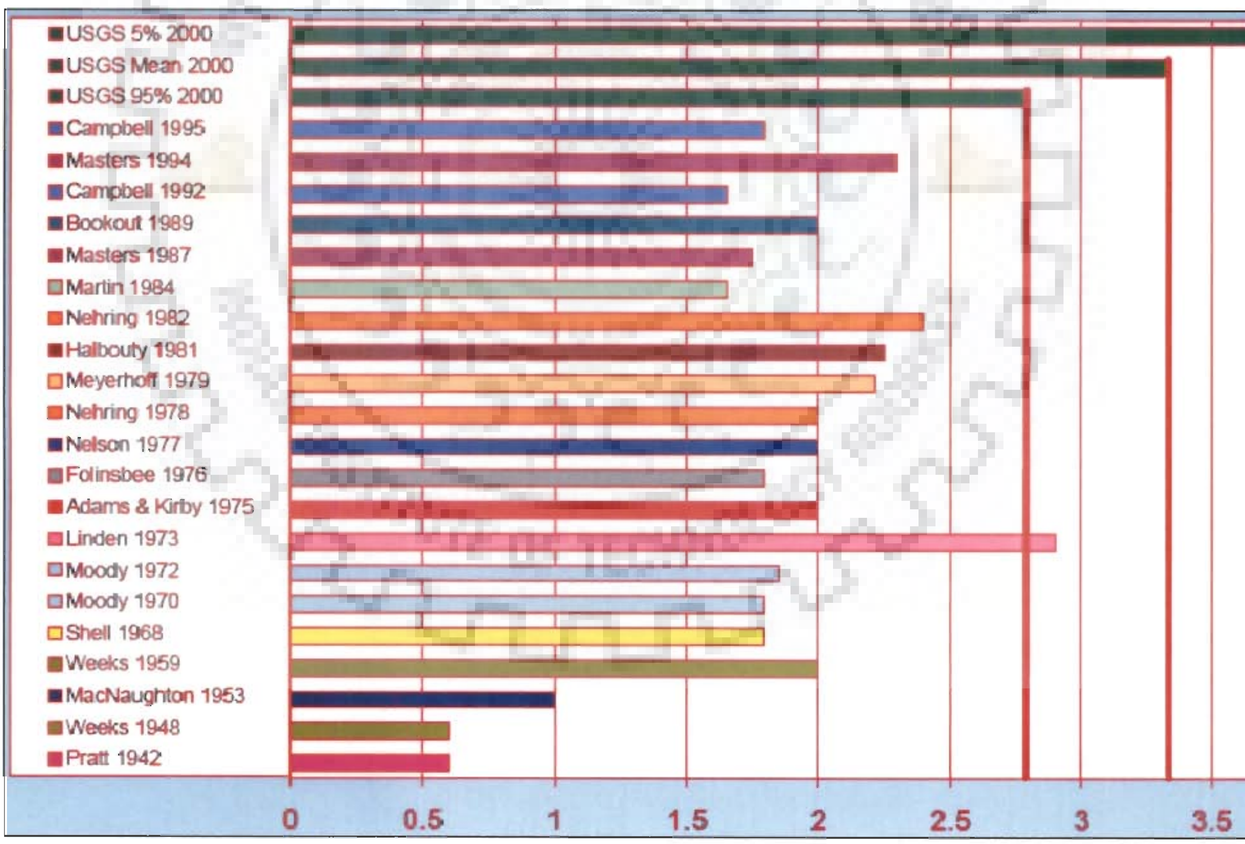


Figure 3.6 Published estimates of the World Ultimate Recovery (Trillions of Barrels)

Most of the hydrocarbon resources are concentrated in a few countries. Figure 3.7 provides the estimates of undiscovered oil potential for few countries.

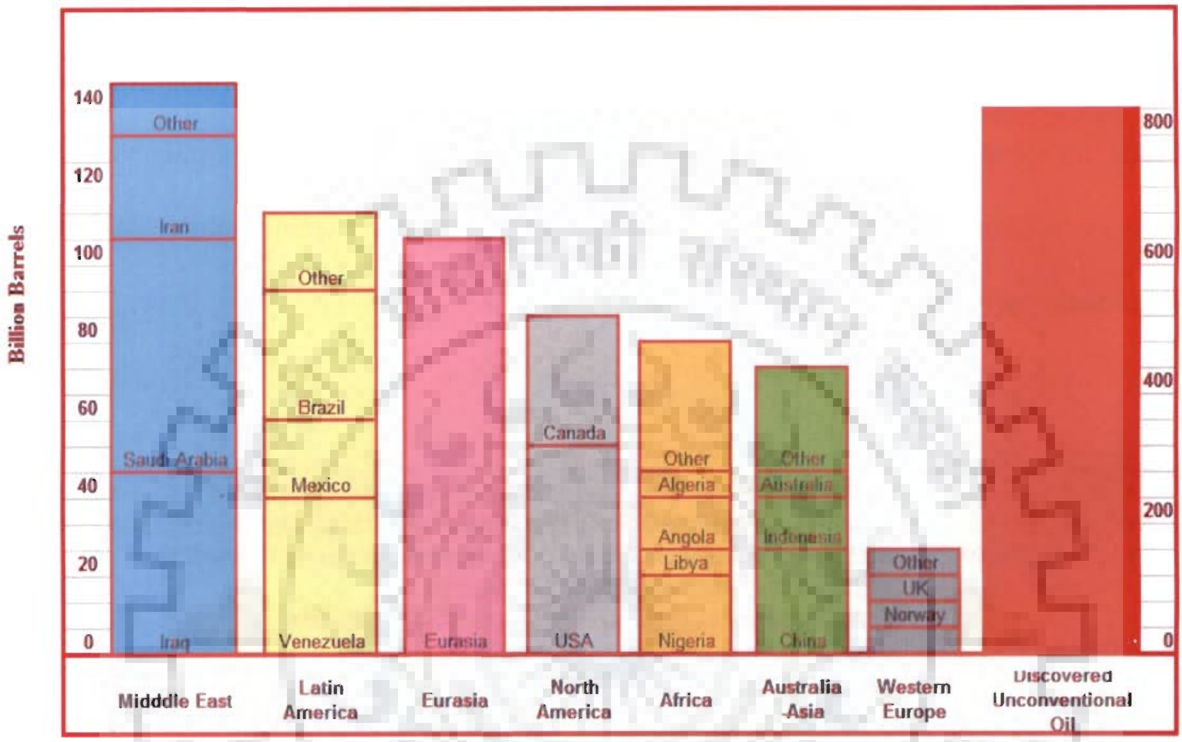


Figure 3.7 Estimates of undiscovered oil-potential

The top ten National Oil Companies (NOCs) control nearly three-quarters of the world's estimated total hydrocarbon resources (Figure 3.8). Any one of the top ten resource holders has more resources than all major oil companies combined together.

3.1.4.2. Reserves and Resource Estimates

The global proved reserves of crude oil and natural gas at the end of 2007 has been estimated at 1237.9 million barrels and 177.36 trillion cubic meters with R/P of about 41, and 60 respectively (Tables 1.1, 1.2 and 1.3, Annexure-i). Table 3.2 provides global crude oil and gas reserves, production and consumption Scenario. The figures 3.9 through 3.20 provide the reserves, distribution of reserves, country wise, consumption, trade movements, and import of LNG.

Year	Global oil Proved reserves (Thousand Million Tonnes)	Global Oil Production (Million tonnes)	Global oil Consumption (Million Tonnes)	Global Natural Gas: Proved reserves (MTOE)	Global Natural gas: Production (MTOE)	Global Natural gas: Consumption (MTOE)
1980	90.7	3088.3	2980.3	74267.42	1311.7	1309.1
1981	93.5	2910.2	2875.7	77727.45	1336.9	1322.7
1982	97.5	2795.7	2781.9	80029.64	1338.9	1328.3
1983	98.9	2759.0	2764.5	82756.08	1344.2	1342.5
1984	103.6	2814.3	2817.7	85981.11	1463.3	1454.2
1985	104.8	2791.8	2808.0	88641.09	1510.4	1501.4
1986	119.4	2935.8	2892.7	94401.68	1552.1	1518.8
1987	123.8	2946.8	2949.3	96171.36	1629.2	1596.0
1988	135.8	3068.9	3041.8	99813.72	1704.4	1672.2
1989	136.8	3102.7	3094.3	112232.77	1759.7	1747.2
1990	136.4	3170.4	3154.9	115211.90	1801.6	1788.0
1991	137.0	3160.5	3149.1	120700.26	1829.3	1824.2
1992	137.8	3190.1	3186.3	123556.91	1840.2	1834.7
1993	138.0	3188.9	3162.9	125302.31	1873.6	1866.3
1994	138.6	3237.4	3218.6	126080.55	1894.4	1874.0
1995	140.0	3281.3	3264.2	126666.13	1928.7	1936.0
1996	142.9	3377.1	3346.6	129656.45	2014.2	2029.8
1997	145.4	3479.9	3433.3	131809.86	2019.1	2026.4
1998	145.3	3547.3	3449.3	134637.62	2067.0	2059.1
1999	148.1	3481.1	3518.1	137620.57	2119.6	2108.4
2000	150.2	3614.1	3558.7	142662.95	2190.9	2199.3
2001	154.1	3600.3	3576.2	154569.17	2243.6	2216.6
2002	160.5	3575.3	3611.3	155387.41	2282.6	2287.5
2003	164.1	3701.1	3681.8	156301.46	2366.4	2341.1
2004	164.7	3866.7	3823.7	156417.66	2440.7	2427.6
2005	166.0	3897.0	3871.0	156866.20	2506.0	2496.8
2006	168.6	3914.3	3910.9	158601.58	2592.8	2558.3
2007	168.4	3905.9	3952.8	159622.27	2654.1	2637.7

Table 3.2 Global crude oil and gas Reserves, Production and Consumption Scenario

Data Source: BP Statistical Review 2008

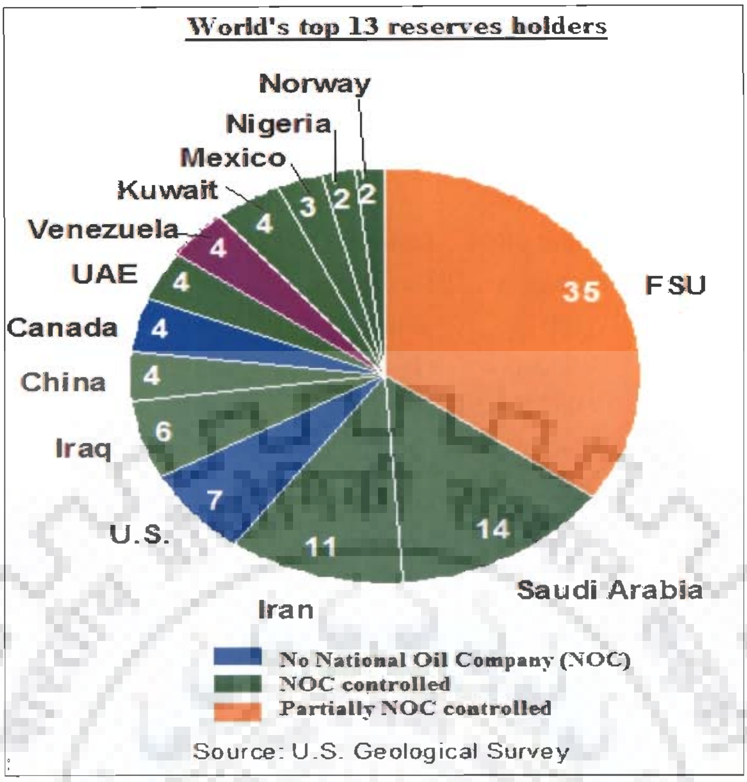


Figure 3.8 Top crude oil and natural gas reserve holder of the world

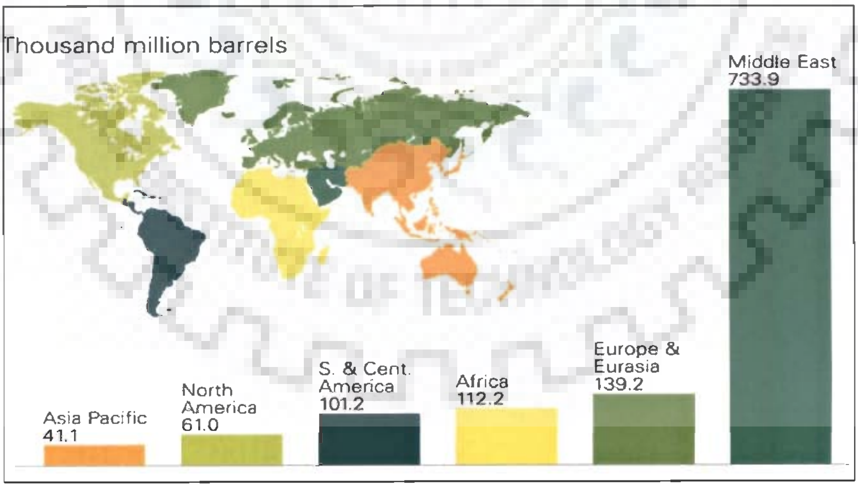


Figure 3.9 Proved Crude oil reserves

(Source: BP Statistical Review)

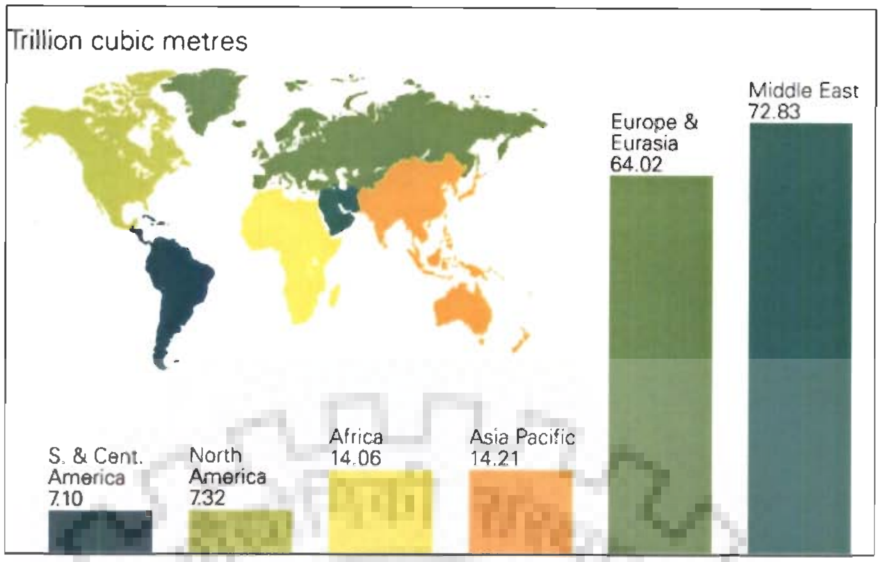


Figure 3.10 Proved Natural Gas reserves

(Source: BP Statistical Review)

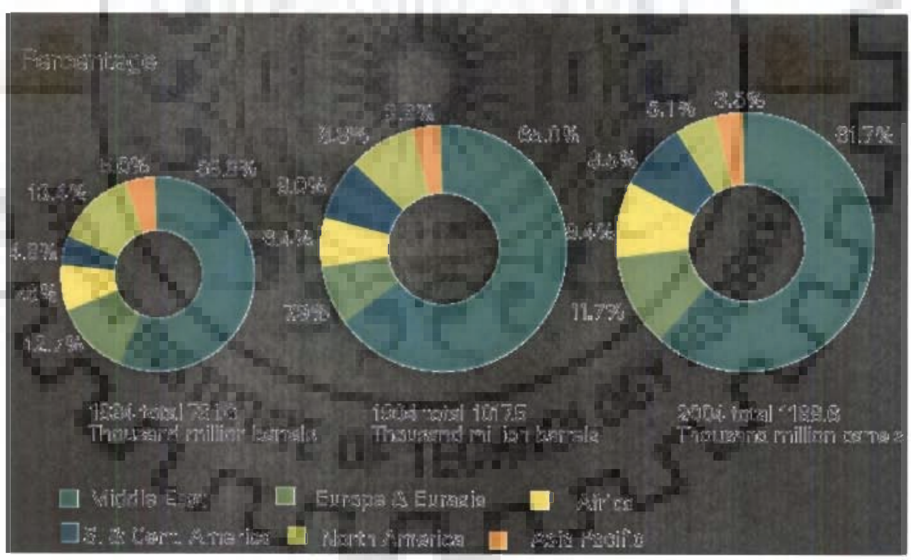


Figure 3.11 Distribution of proved (crude oil) reserves in 1984,1994, 2004

(Source: BP Statistical Review)

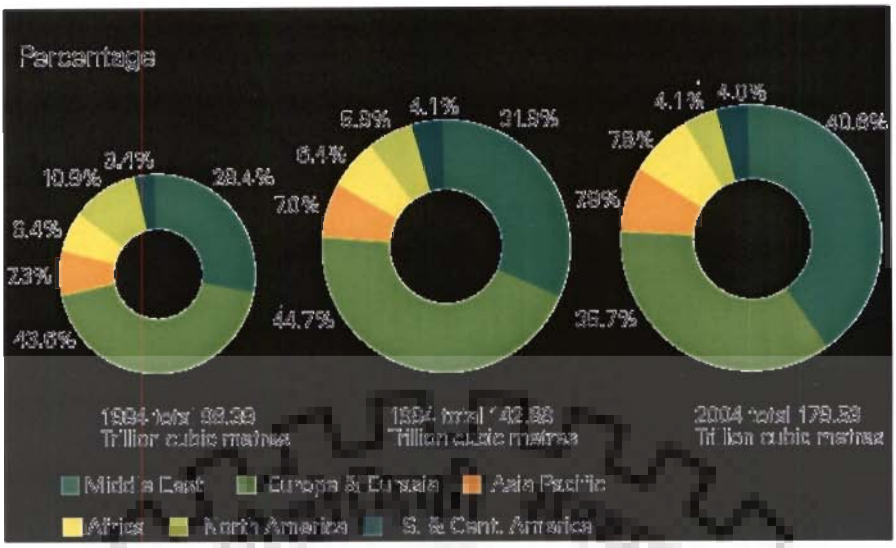


Figure 3.12 Distribution of proved (natural gas) reserves in 1984, 1994, 2004

(Source: BP Statistical Review)

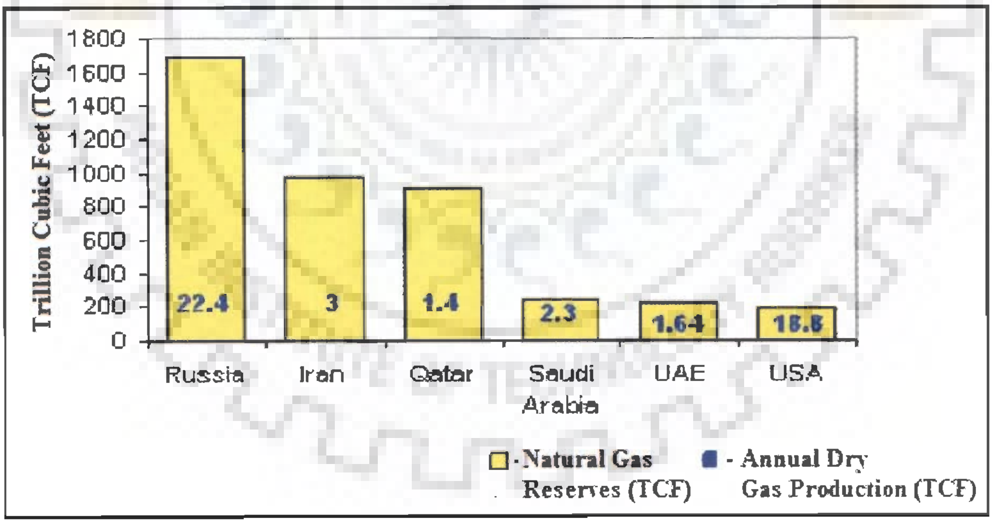


Figure 3.13 World proven Natural Gas Reserves and Annual production (2006)

Source: Oil and Gas Journal (11/2006), EIA International Energy Annual

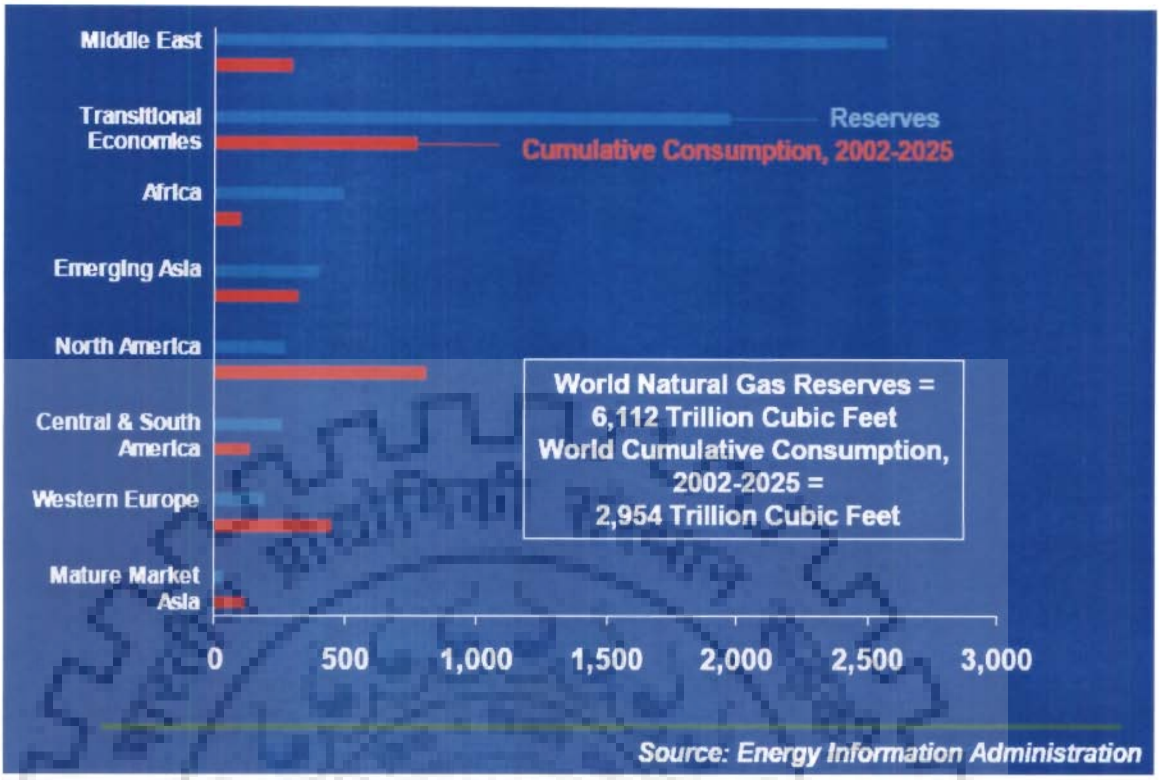


Figure 3.14 World Natural Gas Reserves, and Cumulative Consumption, 2002-2025 as of January 1, 2006

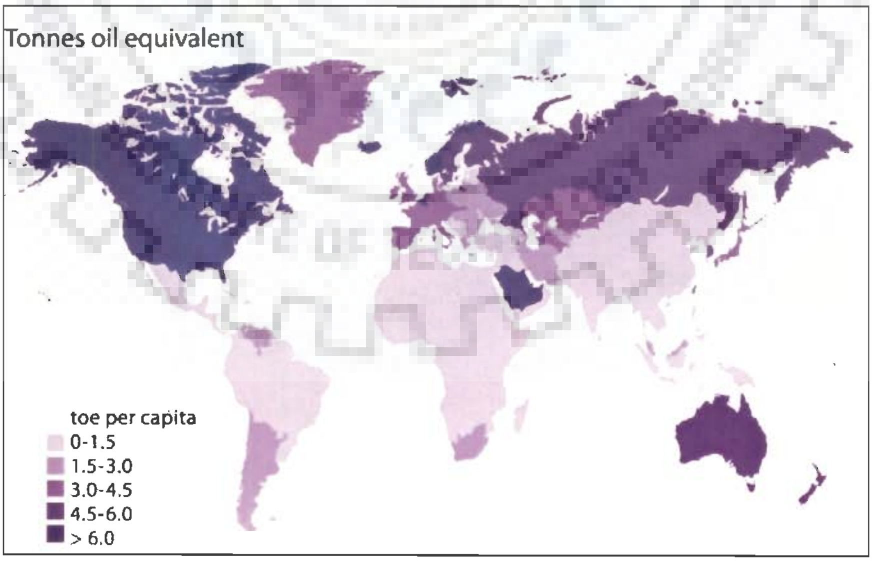


Figure 3.15 Primary energy consumption per capita

(Source: BP Statistical Review)

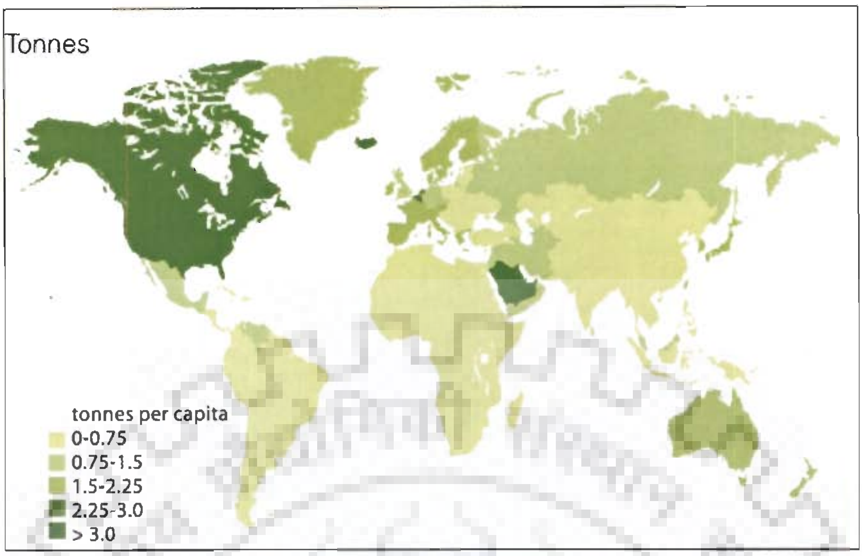


Figure 3.16 Crude oil consumption per capita

(Source: BP Statistical Review)

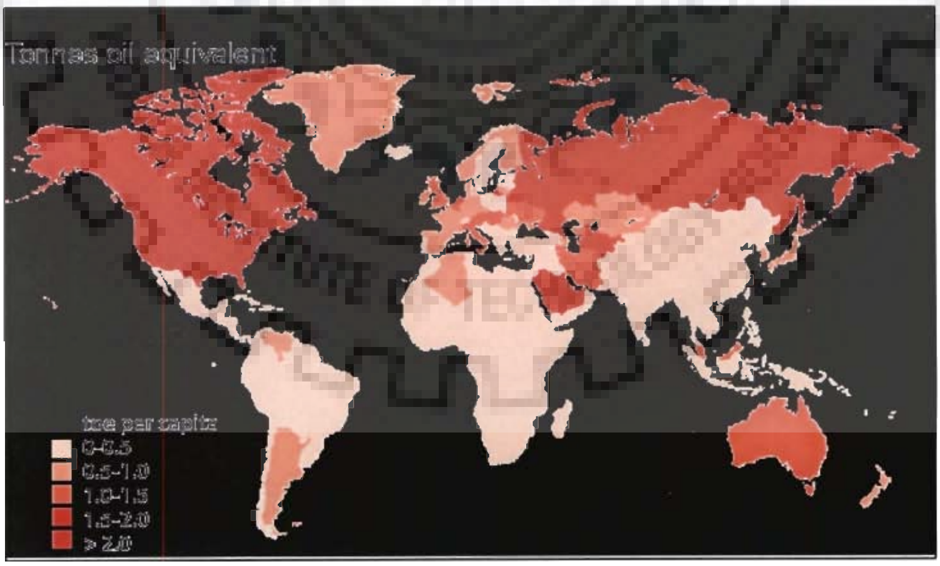


Figure 3.17 Crude Natural Gas consumption per capita

(Source: BP Statistical Review)

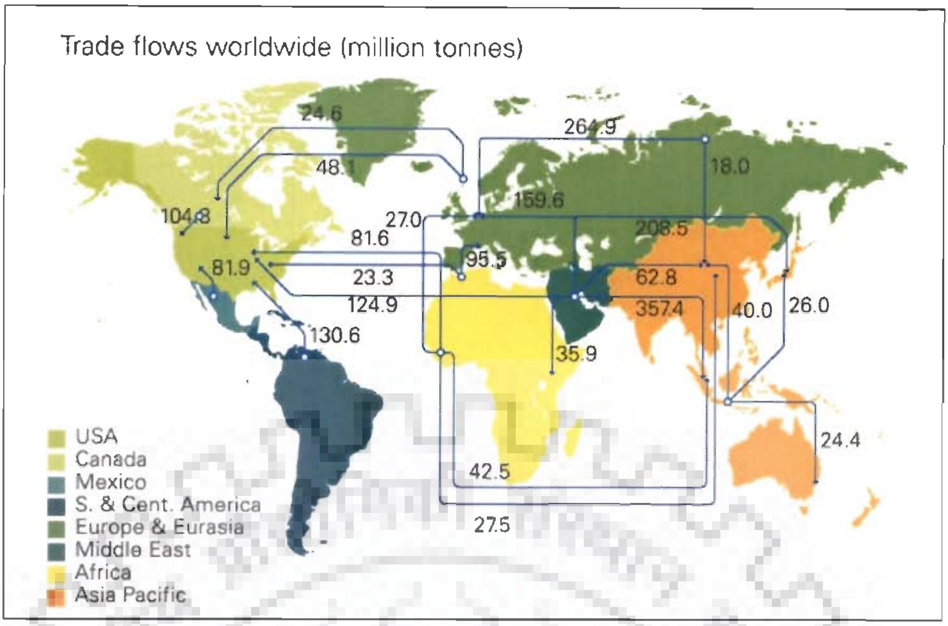


Figure 3.18 Global Crude Oil Trade Movements

(Source: BP Statistical Review)

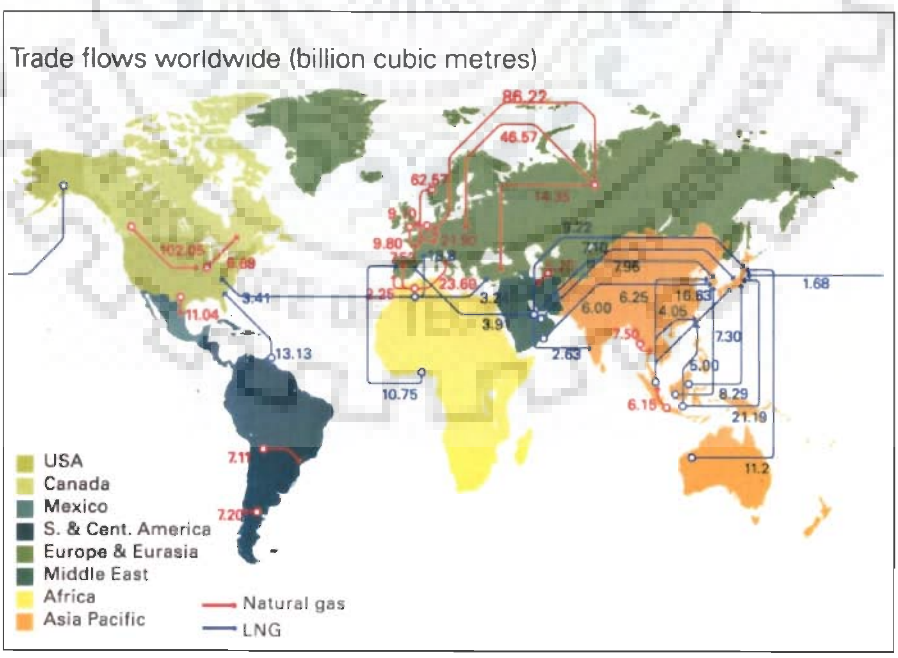


Figure 3.19 Global Natural Gas Trade Movements

(Source : BP Statistical Review)

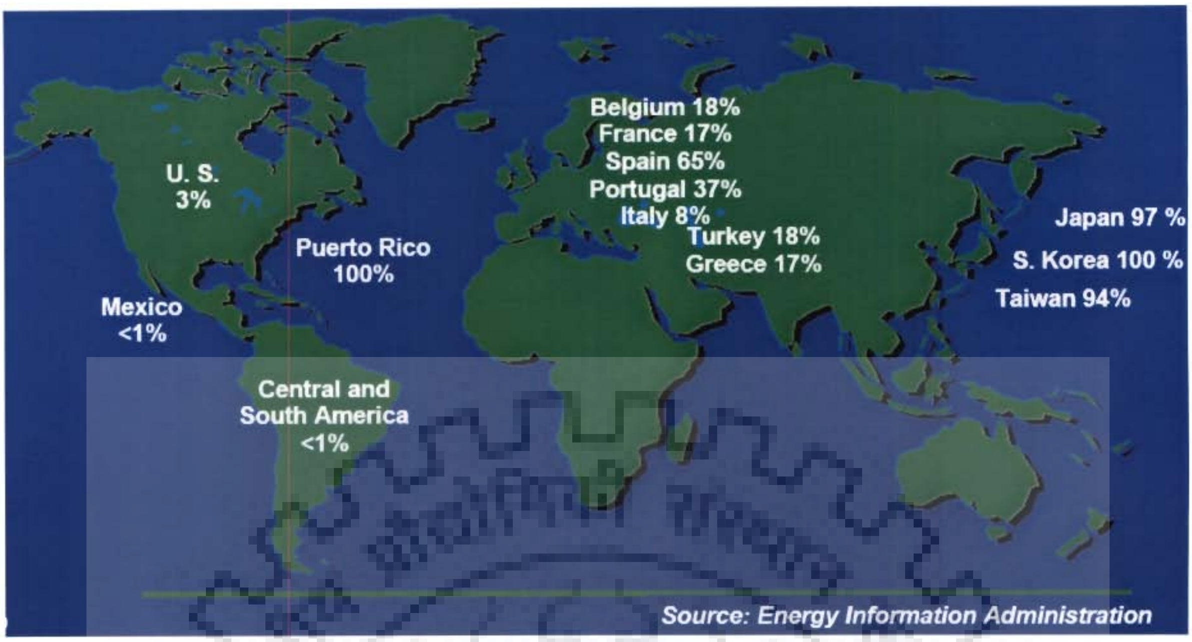


Figure 3.20 World Importers of LNG

(Imports as % of Total Natural Gas Consumption (2004)

3.1.5 OPEC and OECD Countries

In Sept. 1960, in Baghdad, the major oil producers in the world – (Iran, Iraq, Kuwait, Saudi Arabia and Venezuela) decided to collectively come under the banner of Organization of Petroleum Exporting Countries (OPEC) to ensure that the interests of the oil producing countries are protected. Many countries with extensive oil reserves are members of the OPEC. The members of the OPEC cartel hold about two-thirds of the world's oil reserves, allowing them to significantly influence the international price of crude oil. OPEC's mission is to coordinate and unify the petroleum policies of member countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital to those investing in the petroleum industry. More than three-quarters of the world's oil reserves are located in OPEC countries. The proven reserves of OPEC is 900 billion barrels. The bulk of OPEC oil reserves is located in the Middle

East, with Saudi Arabia, Iran and Iraq contributing 56% to the OPEC total (Figure 3.21, 3.22 and 3.23).

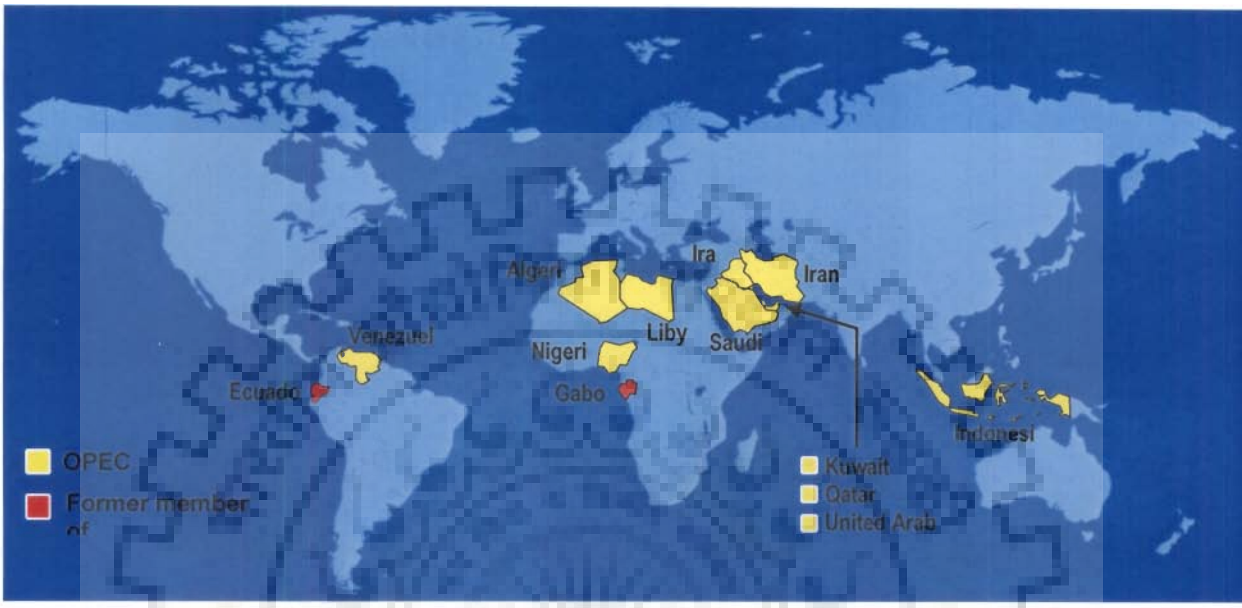


Figure 3.21 OPEC Countries

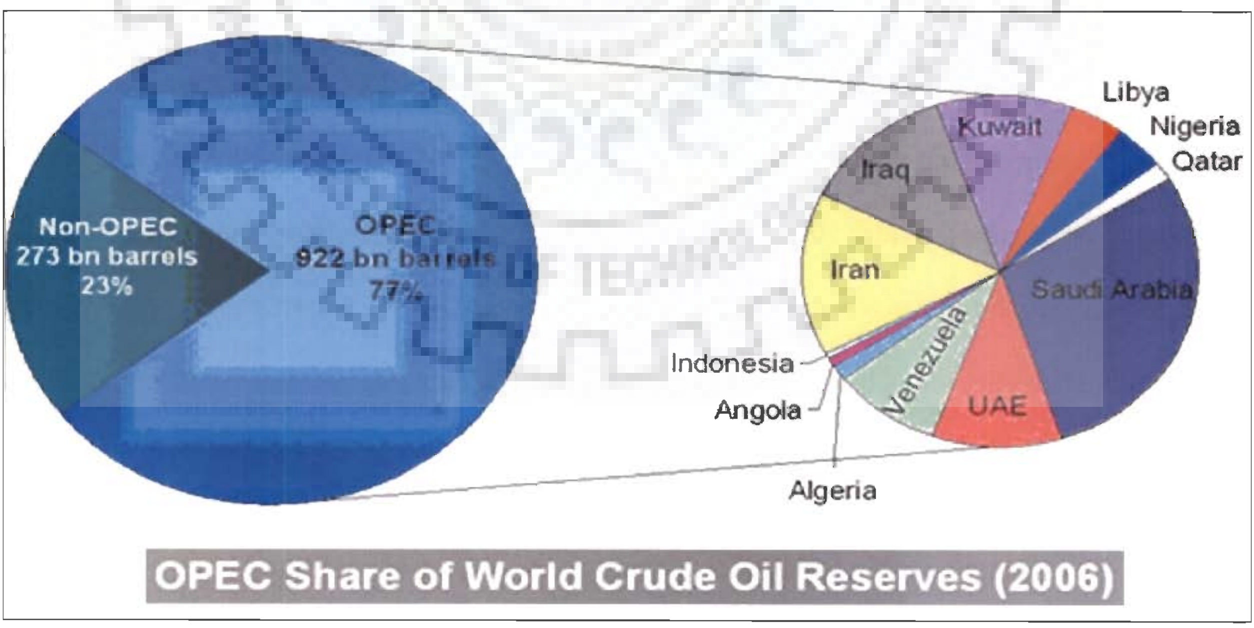


Figure 3.22 OPEC Share of crude oil

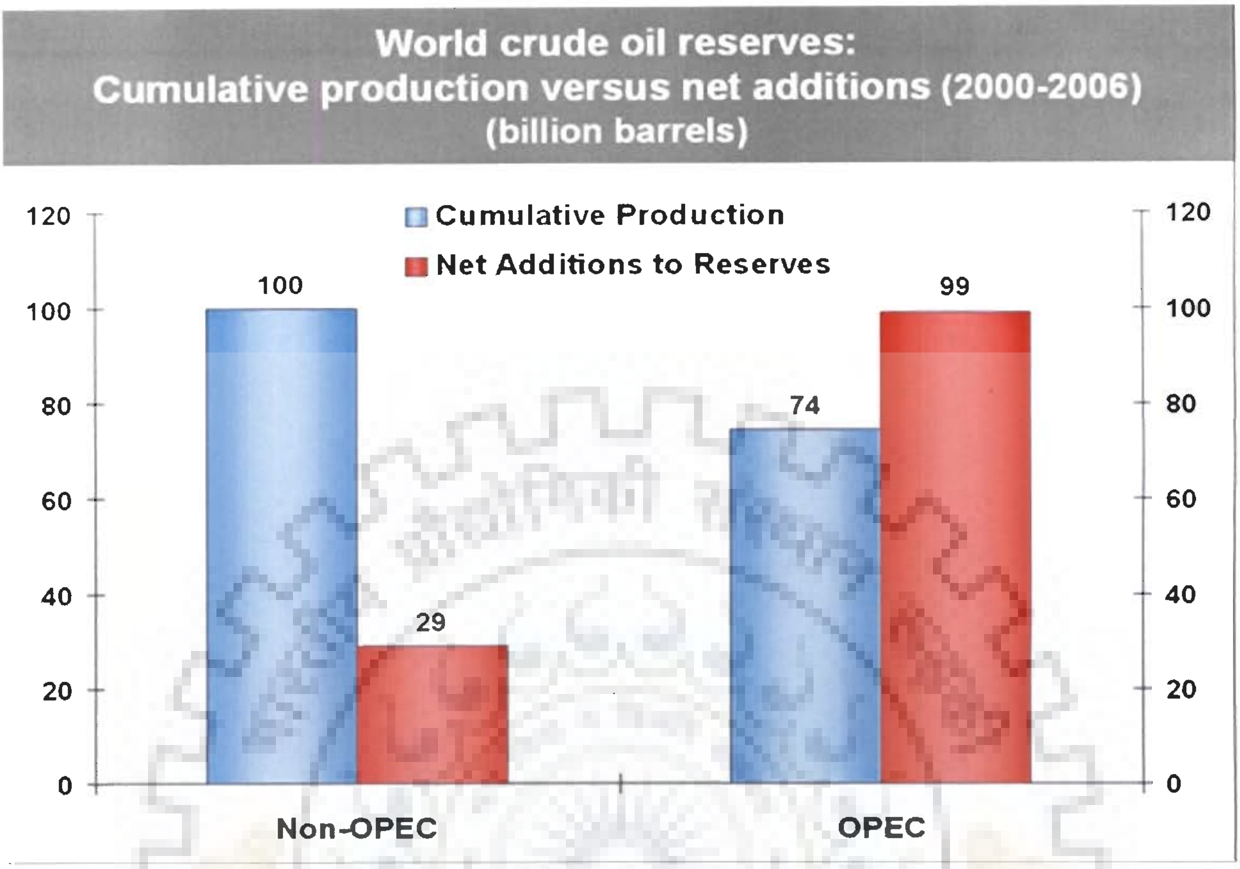


Figure 3.23 OPEC cumulative production and reserve additions of crude oil

Organization for Economic Cooperation and Development (OECD) was established in 1961 at Paris. The groups has 30 member countries (Figure 3.24) committed to democracy and the market economy provides statistics and economic and social data analyses and forecasts economic developments researches social changes and evolving patterns in trade, environment, agriculture, technology, fiscal policy and more. It is helping governments to compare poliy

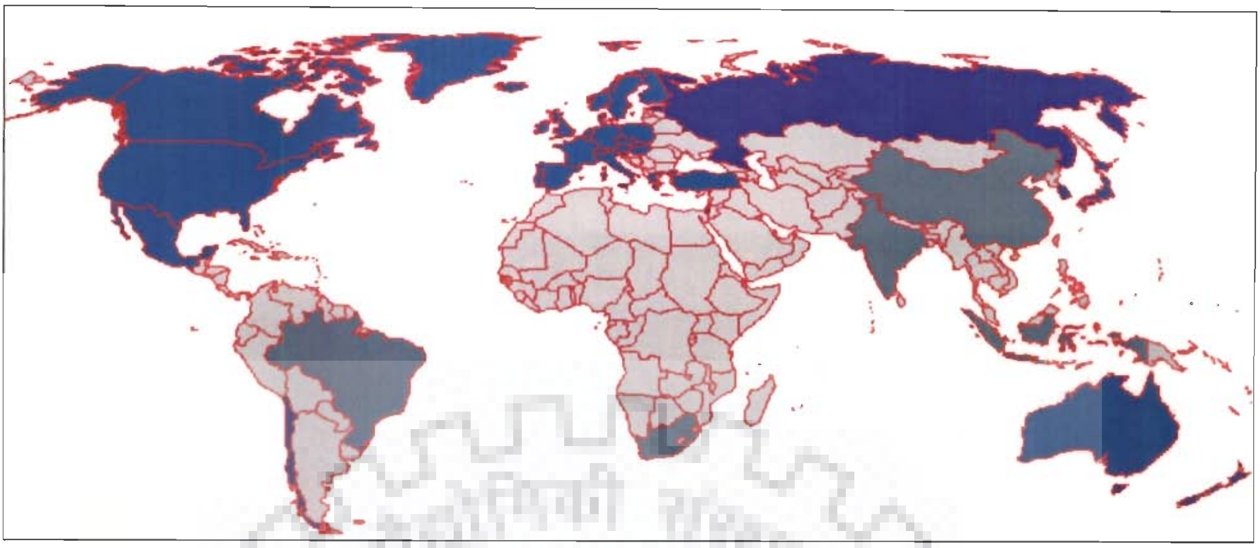


Figure 3.24 OECD Countries

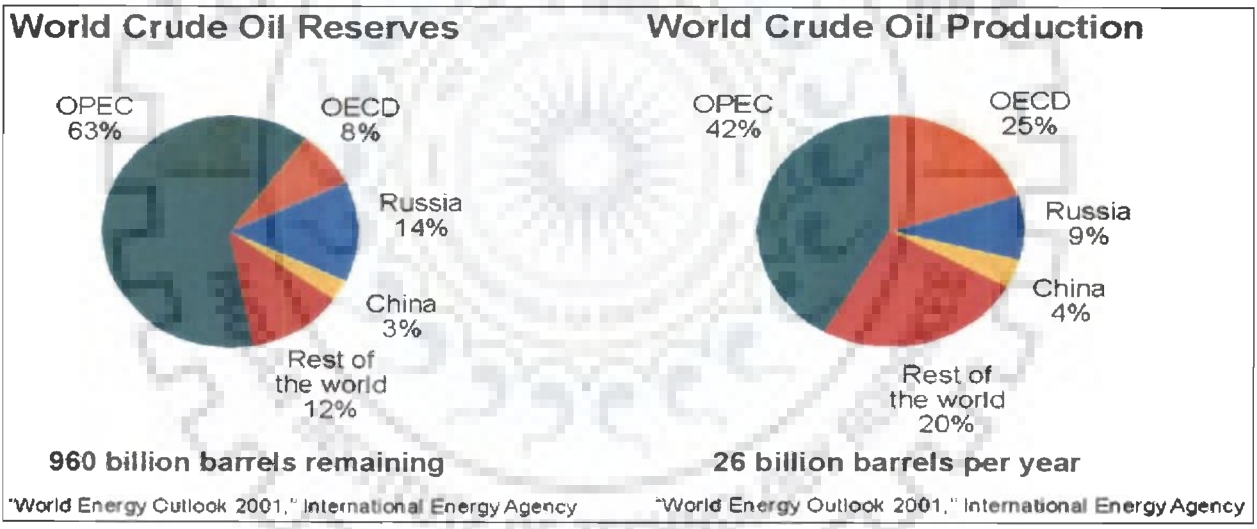


Figure 3.25 World Crude oil reserves and Production

3.2 CRUDE OIL – DOMINANT SOURCE OF ENERGY

Globally energy is characterized by changing pattern of energy mix, dominance of oil and gas, and increasing share of natural gas (Figure 3.26). Oil and gas contribute 62 percent of the energy requirements, and are integrated into the production of many products. Studies suggest that beyond doubt crude oil and natural gas will retain its position as the single largest source of energy.

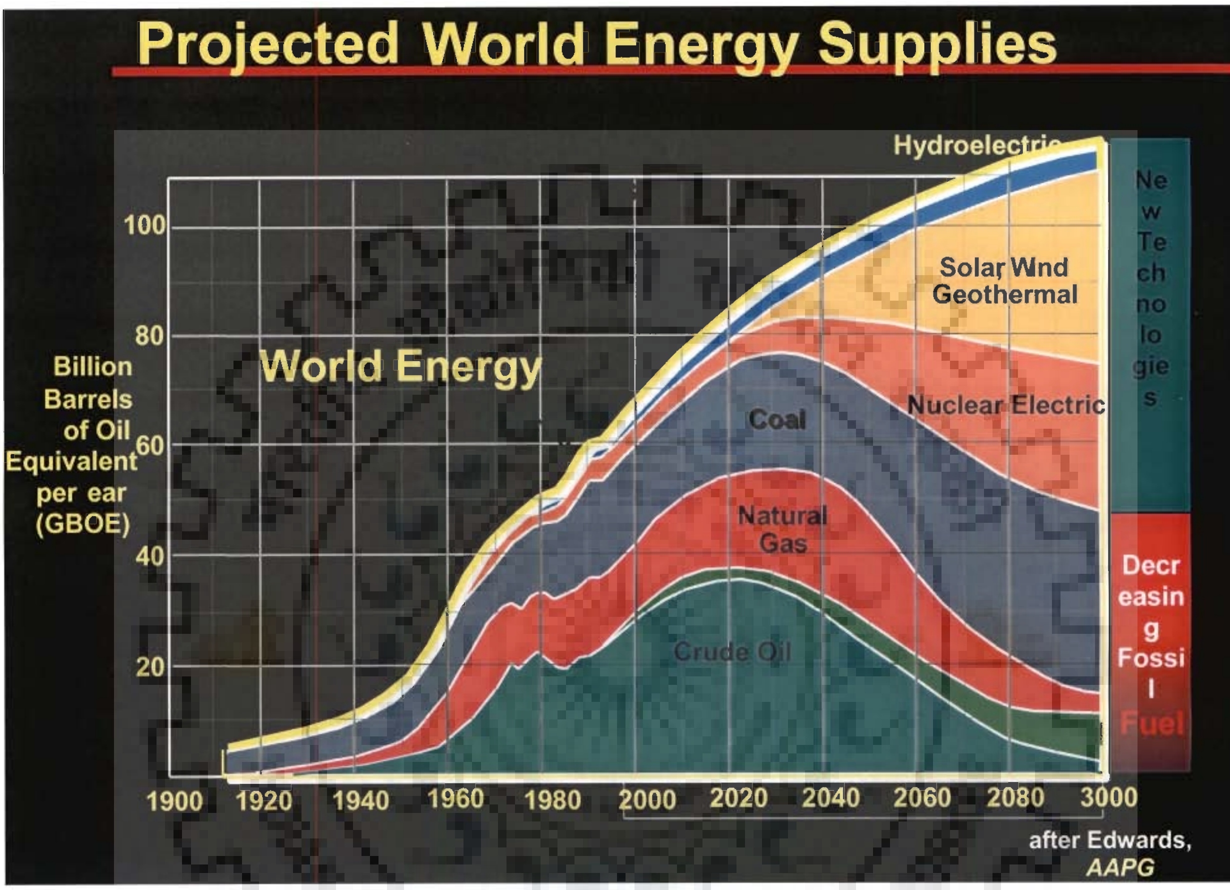


Figure 3.26 Projected World Energy Supplies (Source: Edwards, AAPG)

Many factors impact the demand for and supply of crude oil and natural gas, influence how and where companies invest their capital, determine the manner in which countries compete to attract foreign investment and at the same time screen any country for investment. World oil supply derives from the investment decisions of individual companies, the political decisions of countries in regard to licensing and degree of foreign investment, and a multitude of other variables that influence system dynamics, including price, inventory levels, geopolitics, market psychology and manipulation, OPEC policy, exchange rates, unexpected events, and resource availability.

3.2.1 Economy as driver

Energy is the prime mover for economic development and vice-versa. The energy consumption depends on economy of the region. Energy consumption has been always found to have a positive correlation with the economic trends, even though the relation might be varying with different levels of economy in various countries. Energy demand is economy and population driven. Energy demand hinges on price of crude oil and natural gas. Energy supplies in the developing nations (especially Asian) have reached a crisis point at the present time in view of the spiralling energy prices all over the world. The cost of available of petroleum products with respect to cost and technological intervention provides an insight into future scenario (Figure 3.27)

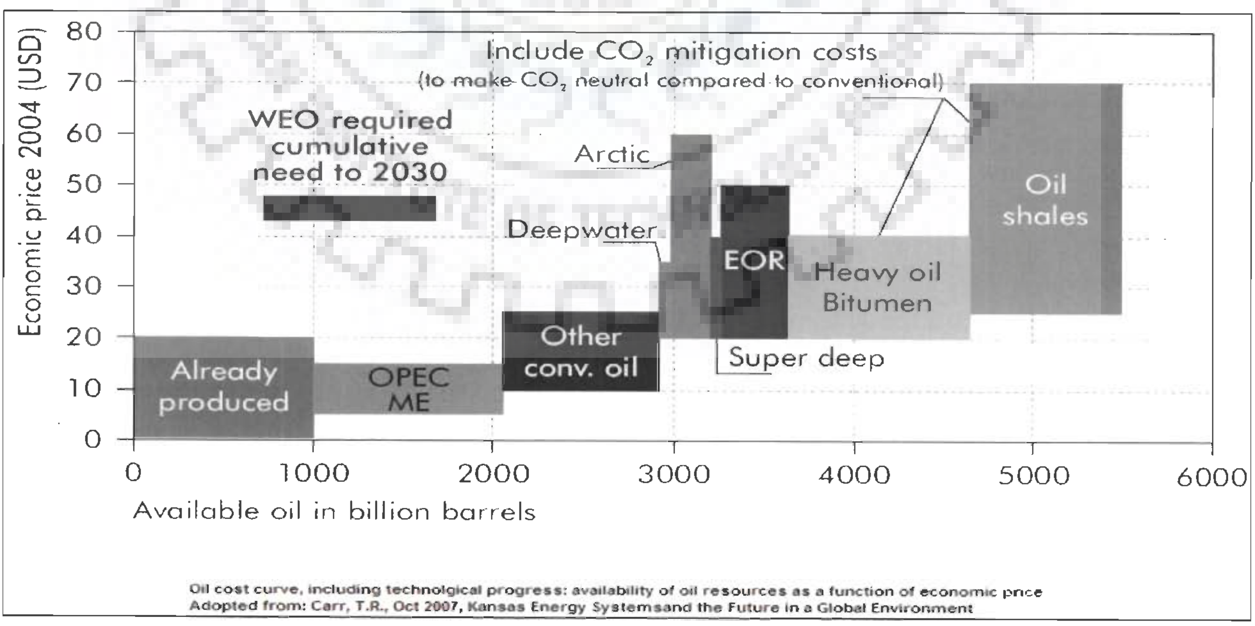
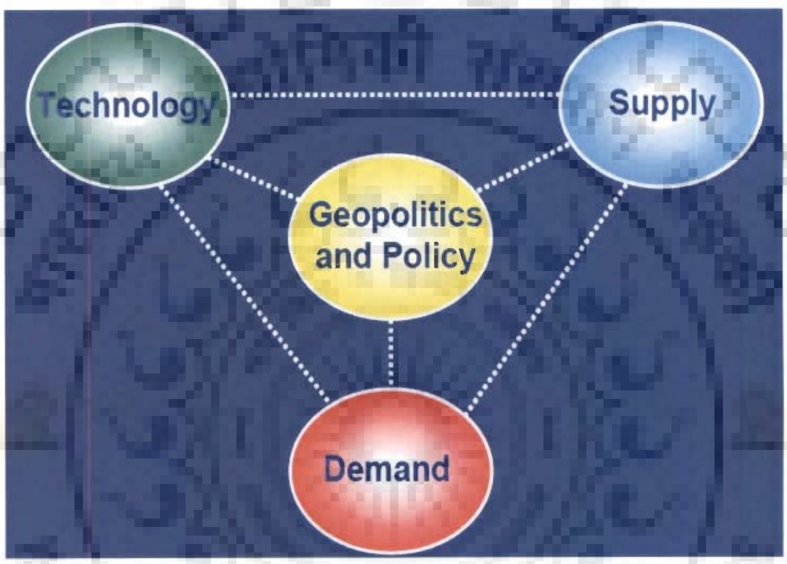


Figure 3.27 Oil Cost Curve, availability of oil resources as a function of economic price

3.2.2 Role of Geopolitics

Geopolitics lies at the center of triad of crude oil exploration technology, demand and supply. The global energy security depends on geopolitical issues impacting diplomatic and trade relationships, regional cooperation, commercial competition, and lengthening energy supply lines.



Geopolitics puts emphasis on political geography, international relations, territorial aspects, and international law. It indicates the links and causal relationships between political power and geographic space. Henry Kissinger (1999) said "By geopolitical, I mean an approach that pays attention to the requirements of equilibrium." A French war-time Oil commissioner said *"He who owns the oil will own the world, for he will rule the sea by means of the heavy oil, the air by means of the ultra-refined oils, the land by means of petrol and illuminating oils, and his fellow men in an economic sense, by reason of the fantastic wealth he will derive form oil-gas the wonderful substance which is more sought after and more precious today than gold itself."* Thus, it is the oil's pre-eminent financial value that enables it to bear so heavily on political behavior.

Thomas Hobbes said "if any two men desire the same thing, which nevertheless they cannot both enjoy, they become enemies; and in the way to their end, endeavor to destroy, or subdue one an other."

Oil industry has been at the center of military strategy throughout the 20th century, beginning with two World Wars. Geopolitics and oil security are intimately related. Oil security means different things to different countries. But, the common point for all nations is a reasonable degree of assurance that a prolonged supply disruption will not occur. Oil security does not stop at national borders, but goes all the way to final consumers. Oil system disruption calls for a multidimensional policy approach to address issues like External (Geopolitical), Internal (operations and investment), Temporal (short- and long-term). The Geopolitical importance of oil can be gauzed by fear about possible supply disruption from geopolitical forces at work in Africa (Nigeria, Sudan), Latin America (Venezuela), Russia (Gas supply) and Middle East (Iraq, Iran and others). Some global examples of geopolitical repercussions are Venezuela which lost more than half a million b/d of capacity in recent years, Nigeria has shut in about 0.6 mbd due to rebel activities, Iraq is some 1.2 mbd below pre-war capacity, and Iran due to tension over nuclear issue (Table 3.3).

Date of Oil Supply Disruption		Supply Duration	Average Gross Supply Shortfall (MBD)	World production prior to disruption (MBD)	Supply Shortfall (%)
Nov. 1956 – Mar. 1957	Suez Crisis	4	2	16.8	11.9
Dec. 1966- Mar. 1967	Syrian Transit Fee Dispute	3	0.7	32.96	2.1
Jun. 1967 – Aug. 1967	Six-Day War	2	2	35.39	5.7
May 1970- Jan 1971	Libyan Price Dispute	8	1.3	45.89	2.8
Oct. 1973 – Mar. 1974	Arab – Israeli War	6	4.3	57.744	7.4
Nov. 1978 – Apr. 1979	Iranian Revolution	6	5.6	62.906	8.9
Oct. 1980- Jan. 1981	Iran – Iraq War	3	4.1	58.338	7.0
Aug. 1990 – Jan. 1991	Iraq invasion of Kuwait	5	4.3	60.487	7.1
Jun. 2001 – Jul. 2001	Iraqi Oil Export Suspension	2	2.1	67.551	3.1
Dec. 2002 – Mar. 2003	Venezuela Labor Strike	4	2.6	68.595	3.8
Mar 2003 – Dec. 2003	War in Iraq	9	2.3	69.041	3.3
Aug. 2005 – May 2006	Hurricanes Katrina and Rita	9	1.4	73.572	1.9

Table 3.3 World Oil Supply Disruptions

Adopted from: Kaiser, M.J and Pulsipher, A.G. Oct. 2006

The world of oil and gas is split between industrialized consumer and producer countries. The Consuming countries want "security of supply" that is reliability and availability of oil-gas at reasonable prices. The Exporting countries want "security of demand" that is sufficient access to markets. The importers focus on supply. Since the oil price shocks of the 1970s, the focus of energy security has been on achieving adequate supplies at reasonable prices, without incurring serious disruptions. The exporters focus on the unimpeded flow i.e. ensuring steady long-term demand for their oil at prices that will maximize their returns without undermining long-term economic growth. The specific security issues that mostly comes to mind are politically motivated- terrorist attack against critical oil infrastructure, and military conflicts. There are variety of concerns. Russia and Middle East -Access to markets, Europe- Dependence for natural gas (from Russia), Japan - Absence of domestic resources (i.e. finding ways to run the economy), China and India - Assuring that energy does not hold back the economic growth needed for development, and USA - finding ways to offset Middle East –style disruption and to achieve "oil-gas independence." Therefore with access of crude oil concentrated in producer nations, oil security and resultant oil diplomacy move along multiple concurrent paths in a multi-polar oil-gas global system of producer and consumer nations, multinational oil companies and other global entities. Dependence on such resources makes it of vital national, regional and international importance where national interests become inextricably bound to global concerns, with diplomatic activity to protect such interests.

The current scenario is that many of the world's leading oil producing countries (most of them belong to OPEC) are either politically unstable and /or at serious odd with other countries. The oil wealth of OPEC countries allows them to be strategic pivot of world politics and economy, and 22% of the world's oil is in the hands of state sponsors of terrorism and under U.S/ U.N sanctions. The pertinent issue is that the growing international trade in oil and gas, has major geopolitical implications and at the heart of these is the regional mismatch between the location of demand and production. The dependence on the Middle East will continue to grow in the net oil-consuming regions – essentially OECD area and some parts of Russia. It raises a whole new set of security considerations, namely potential competition over, security of pipelines once they are built, and need for multilateral and bilateral cooperation among nations. The issue is – while global proven reserves of oil are ample, supply is not guaranteed. The lengthening of oil-supply chain from field to end consumer (Table 3.4), leads to the requirement of tightening of security and surveillance of inter- as well as intra-country pipeline, sea-lanes , and installation for storage, sea ports etc.

Oil: Inter-area movements (Million tonnes) during 2005

From	To: USA	Canada	Mexico	S. & C. America	Europe	Africa	Australasia	China	Japan	Other Asia Pacific	Rest of World	Total
USA	-	7.4	10.1	15.5	11.6	0.7	-	0.4	4.0	3.5	0.9	**54.1**
Canada	107 1	-	0.1	0.2	0.8	-	-	-	0.3	-	-	**108.5**
Mexico	81.8	1.7	-	6.7	10.5	0.1	-	-	-	1.6	0 2	**102.6**
South & Central	140.9	5.3	2.1	-	15.1	1.0	-	5.3	0.1	3.3	-	**173.1**
Europe	53.3	22.0	2.4	2.3	-	12.9	-	0.6	0.3	6.0	4.5	**104.3**
Former Soviet Union	23.0	-	0.1	3.0	287.0	0.5	-	19.6	2.3	3.5	10.0	**349.0**
Middle East	116.5	7.1	0.5	7.8	156.1	37.2	5.6	67.4	211.7	369.2	3.0	**982.1**
North Africa	26.7	8.4	0.3	5.7	97.0	4.1	0.2	3.2	0.1	5.4	0.6	**151.7**
West Africa	96.5	2.0	-	8.4	34.6	4.4	0.2	28.6	3.0	38.1	0.9	**216.7**
East & Southern Africa	-	-	-	-	1.3	-	-	6.7	4.0	1.2	-	**13.2**
Australasia	0.7	-	-	-	-	-	-	1.2	3.2	5.8	-	**10.9**
China	1.6	0.1	-	1.6	0.2	0.1	0.4	-	2.3	14.0	0.4	**20.7**
Japan	-	-	-	-	0.4	-	0 4	3.3	-	1.0	-	**5.1**
Other Asia Pacific	8.3	0.2	0.1	0.3	6.1	0.7	26.8	30.3	24.8	14.6	0.5	**112.7**
Unidentified	10.3	5.5	-	0.3	34.3	-	1.9	0.3	2.1	2.1	-	**56.8**
TOTAL IMPORTS	666.7	59.7	15.7	51.8	655.0	61.7	35.5	####	258.2	469.3	21.0	2461.5

Table 3.4 International oil and gas movements (Data Source: BP Statistical Review)

Thus, the nations try to strike energy partnerships abroad, and exercise diplomatic priorities to meet energy security challenges. International protection of chokepoints and sea routes are imperative (Figure 3.28). These are waterways or overland pipelines that transport large quantities of oil across narrow channels or vulnerable regions. The consequences of natural disaster, accident, or terrorist attacks at any of these points would affect our way of life. Every day, two thirds of the world's oil passes through one or more of seven narrow "chokepoints," to deliver oil.

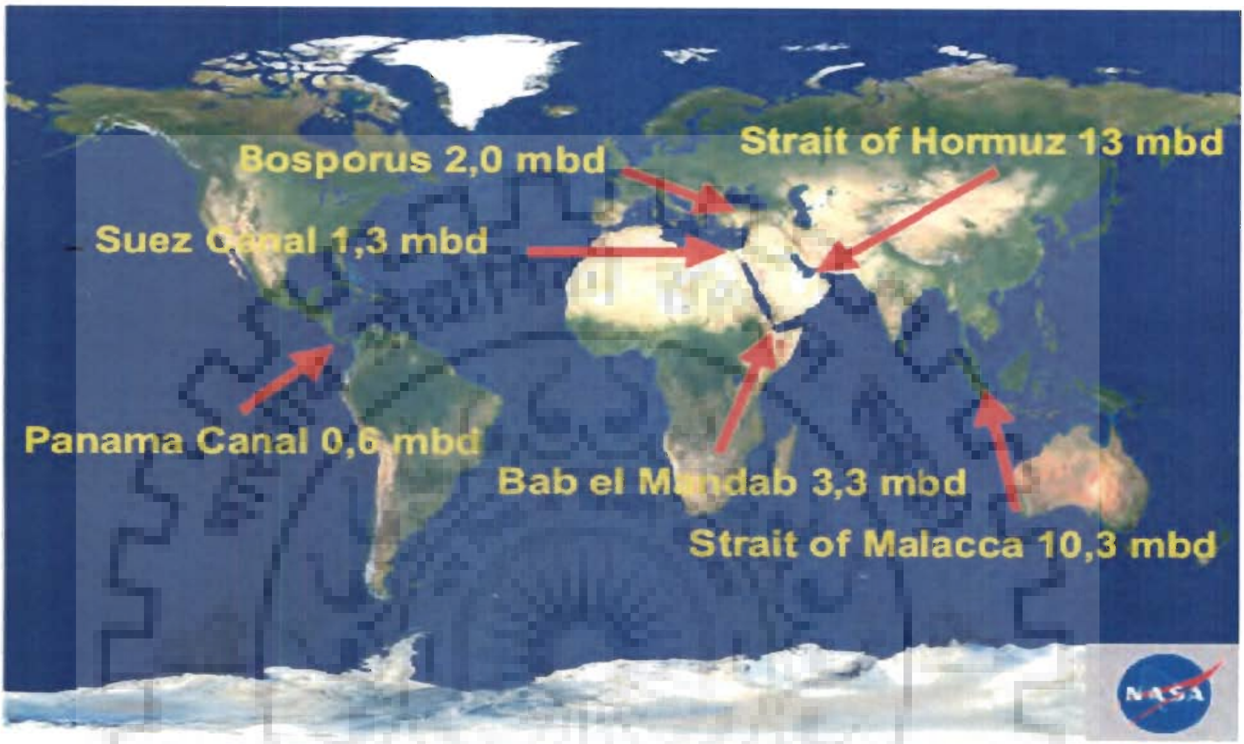


Figure 3.28 World Choke Points

Bosporus Strait

- 17 mile long waterway connecting the Black Sea to the Mediterranean Sea.
- Each day, more than 3 million barrels are transported along this route.
- One of the world's busiest and most difficult to navigate.
- Over 5,000 oil tankers traverse the waterway every year, an average of more than 15 per day.
- Blockage of this route would severely limit oil shipments to Southern and Western Europe.

Baku-Tblisi- Ceyhan Pipeline

- The Baku-Tbilisi-Ceyhan oil pipeline stretches 1093 miles across the countries of Azerbaijan, Georgia, and Turkey.
- Has the capacity to transport 1 million barrels of oil per day.
- Kazakhstan and Azerbaijan has signed an agreement to allow for the eventual export of Kazakh oil through the BTC.
- The pipeline helps to lessen OPECs influence by allowing the West direct access to sources of oil from the Caspian region.
- Its disruption would reduce this valuable diversification.

Strait of Hormuz

- The Strait of Hormuz is located between Iran and Oman and connects the Persian Gulf to the Arabian Sea and Indian Ocean.
- It is by far the world's most important chokepoint; over 17 million barrels of oil per day (roughly one fourth of the world's total oil consumption) travel out of the Persian Gulf through this strait.
- Closure of the Strait of Hormuz would dramatically affect the world oil market, sending oil prices well over $100 per barrel and restricting access to oil products to only the wealthiest buyers.

Strait of Malacca

- The Strait of Malacca runs between islands in Malaysian and Indonesia and connects the Indian Ocean with the Pacific Ocean.
- It is the shortest sea route between the Middle East and Asian markets and allows shipment of nearly 80% of the oil to China, Japan, and South Korea.

- Almost 12 million barrels per day are shipped through this route.
- Thus, Asia would feel the initial and most extreme consequences of a disruption of the Strait of Malacca's shipping lanes, but the effects would eventually damage economies worldwide.

Bab el-Mandeb

- This strait, meaning gate of tears in Arabic, connects the Red Sea with the Arabian Sea, and runs between the Arabian Peninsula and Africa.
- It is an important passage from the Indian Ocean to the Suez Canal complex and the Mediterranean Sea.
- Three million barrels of oil per day flow through the strait.
- Disruption in the waterway would force oil shipments to Europe around the southern tip of Africa, dramatically lengthening the shipping timeframe and raising the price of oil.

Suez Canal and Sumed Pipeline

- The Suez Canal and Sumed Pipeline complex is a 101 mile long canal located in Egypt.
- It traverses the northeast corner of the country and links the Red Sea with the Mediterranean Sea.
- More than 4 million barrels of oil per day are shipped long this route.
- Closure of either the canal or the pipeline would divert oil tankers around Africa and greatly lengthen transit time.

Panama Canal and Pipeline

- The Panama Canal and Pipeline are located on the isthmus dividing North and South America.
- Together, they ship slightly less than 1 million barrels per day.

3.3 PROJECTION OF GLOBAL ENERGY CONSUMPTION SCENARIO

Oil and gas make up 65 to 70 percent of all the energy consumed by the three largest economies in the world - U.S., Japan, and the European Union. Many of the industrializing countries of the Third World, such as South Korea, China, Brazil, and Mexico, have skyrocket oil and gas consumption.

The International Energy Outlook (IEO) 2005 has grouped world economies in to three regions - the mature market economies, transitional economies, and emerging economies (Figure 3.29). The mature market economies include nations whose energy markets are generally well-established. The transitional economies include those nations that are transitioning away from the centrally planned economies of the Soviet Union to free market economies. This region is subdivided into Eastern Europe (EE) and the former Soviet Union (FSU). The emerging economies include those countries whose economies are currently less developed, but whose energy use patterns, in general, are expected to begin resembling those of the mature market economies over the next two decades. The nations in this region, which typically have fairly energy-intensive industrial sectors, include such rapidly growing economies as China and India. Emerging Asia, the Middle East, Africa, and Central and South America are regional subgroups in the emerging economies region.

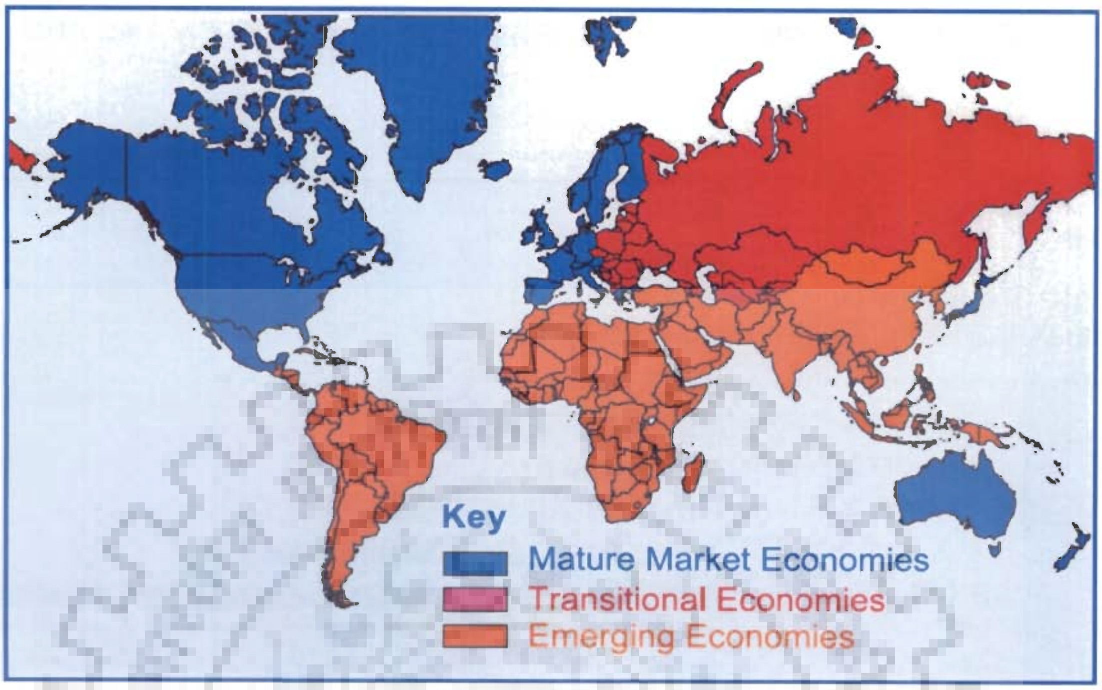
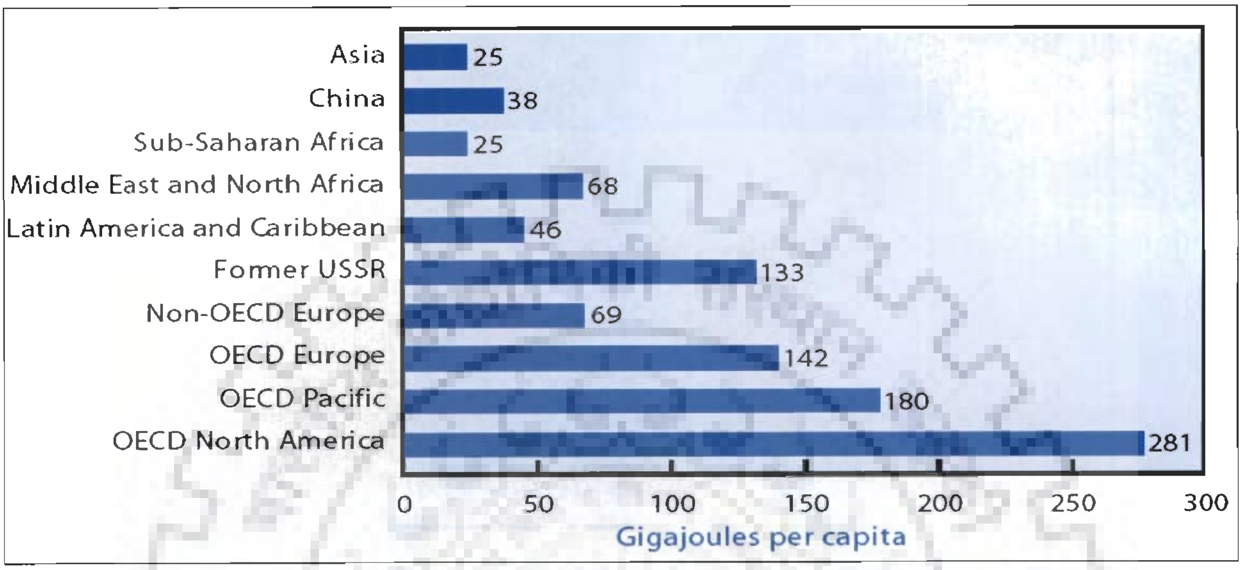


Figure 3.29 International Energy Outlook 2005 (IEO) World Economies

The statistical data on energy consumption may not reflect the true energy usage pattern, because, very often the data takes into consideration only commercial energy sources. In most low-income developing countries, a small number of populations have equivalent commercial energy usage as most people in the industrialized world (Figure 3.30). But, the vast majority of people in low-income developing countries rely on traditional, non-commercial sources of energy using inefficient technologies. Therefore, any business strategic decision or modeling exercise should take in to consideration these facts that data about "per capita" consumption energy resources reflects the commercial energy only, because these data are much easier to collect. Moreover, the non-commercial energy resources are difficult to be quantified. And, it is known quite well that non-commercial energy is used in several under-developed and developing countries more than commercial energy. Thus, the resulting analysis does not accurately reflect the world's energy situation.



Legend

1. Asia excludes Middle East, China, and OECD countries;
2. Middle East and North Africa comprises Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates and Yemen;
3. Latin America and Caribbean excludes Mexico;
4. Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan; Non-OECD Europe consists of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Gibraltar, Macedonia, Malta, Romania, and Slovenia;
5. OECD Pacific comprises Australia, Japan, Korea, and New Zealand;
6. Former USSR comprises Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan,
7. OECD North America includes Mexico

Figure 3.30 Per Capita Energy Use (Commercial and Non-Commercial), By Region, 2000

(Source: World Energy Assessment Overview: 2004 Update)

The global total primary energy (both commercial and noncommercial) use during 2001 has been estimated to be 10.2 Gtoe (Table 3.5, Table 3.6 and Figure 3.32). Fossil fuels (oil, natural gas, and coal) represent nearly 80 percent of the total. The crude oil and natural gas has about 25.6 % share global electricity generation (Figure 3.32, 3.33 and Figure 3.34). The OECD, Commonwealth of Independent States and Eastern Europe, Sub-Saharan Africa, Middle East and North Africa, Asia-Pacific, Latin America and the Caribbean) show large differences in their primary energy mix (Figure 3.35), reflecting both the availability of primary energy sources and consumption patterns. The contributions of petroleum products in electricity production in the upper region varies in the range of 4.6 % to 38.9% (Figure 3.36). The fossil fuels accounts for 83 percent of the energy consumed in industrialized countries, 89 percent in transition-economy countries, and appreciably less in some other regions. There are significant inequities in annual per capita energy use among groups of countries (Table 3.5).

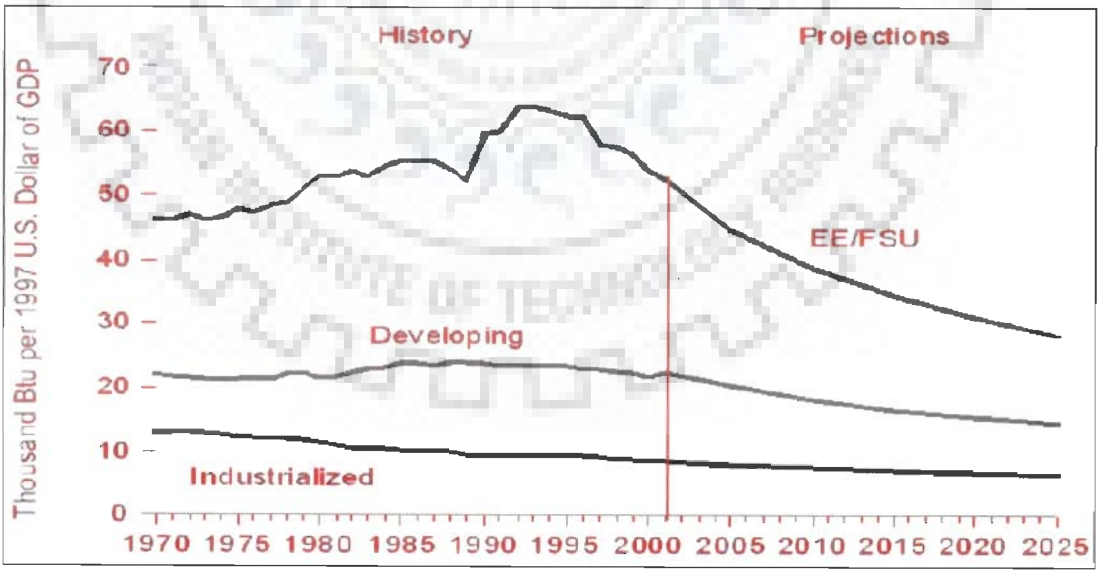


Figure 3.31 Energy Intensity by region, 1970-2024

Source: EIA, International Energy Outlook, 2004

REGION	TPES (Gtoe)	Population (Billions)	toe/capita	Growth rate 1990-2001 %/year
1. OECD (all industrialized countries)	5.33	1.14	4.68	1.52
2. Commonwealth of Independent States and Eastern Europe	1.03	0.35	2.98	-3.26
3. Sub-Saharan Africa	0.40	0.67	0.60	2.23
4. Middle East and North Africa	0.50	0.31	1.62	4.65
5. Asia Pacific (non-OECD) with China	2.31	3.21	0.72	3.18
6. Latin America and the Caribbean (Without Mexico)	0.45	0.42	1.07	2.64
World	10.03	6.10	1.64	1.41
Developing countries (3+4+5+6)	3.66	4.62	0.79	3.19
TPES (total primary energy supply) is the indigenous production of energy, plus imports and positive stock changes minus exports and international marine bunkers.				

Table 3.5 Primary Energy Use, By Region, 2001
(Source: World Energy Assessment Overview: 2004 Update)

The rate of growth in energy use also varies across country groups. Between 1990 and 2001, the average annual growth rate in primary energy use in industrialized countries was 1.5 percent; in developing countries, it was more than twice that amount (3.2 percent, with important variations among different regions of developing countries). Population growth and rising levels of economic activity drive this rapid increase. Thus it is evident that the availability and use of energy around the world is extremely heterogeneous.

Source	Primary energy (exajoules, EJ)	Primary energy (10^9 tonnes of oil equivalent Gtoe *)	Percentage of total (%)	Proved reserves (10^9 tonnes of oil equivalent Gtoe *)	Static reserve – production ratio (years) [a]	Static resource – production ratio (years) [b]	Dynamic resource base – production ratio (years) [c]
Fossil fuels	332	7.93	79.4	778			
Oil	147	3.51	35.1	143	41	~ 200	125
Natural Gas	91	2.16	21.7	138	64	~ 400	210
Coal	94	2.26	22.6	566	251	~ 700	360
Renewable	57	1.37	13.7				
Large hydro	9	0.23	2.3		Renewable		
Traditional biomass	39	0.93	9.3		Renewable		
New renewable [d]	9	0.21	2.2		Renewable		
Nuclear	29	0.69	6.9	55			
Nuclear [e]	29	0.69	6.9	55	82 [f]	~ 300 to > 10,000 [f]	
Total	418	9.99	100.0				

Legend

1 toe = 42GJ

a. Based on constant production and static reserves

b. Includes both conventional and unconventional reserves and resources.

c. Data refer to the energy use of a business-as-usual scenario – that is, production is dynamic and a function of demand. Thus these ratios are subject to change under different scenarios. Dynamic resource base – production was calculated based on a 2 percent growth rate per year from 2000 to peak production (oil 6.1 Gtoe, gas 6.3 Gtoe, and coal 8.9 Gtoe), followed by a 2 percent decline per year until the resource base is exhausted.

d. Includes modern biomass small hydropower, geothermal energy, wind energy, and marine energy. Modern biomass accounts for 6.0 exajoules; 2.9 exajoules comes from all other renewables. 'Modern Biomass" refers to biomass refers to biomass produced in a sustainable way and used for electricity generation, heat production, and transportation (liquid fuels). It includes wood/ forest residues from reforestation and / or sustainable fuel wood in inefficient and pollutant conversion systems.

e. Converted from electricity produced to fuels consumed assuming a 33 percent thermal efficiency of power plants.

f. Based on once-through uranium fuel cycles excluding thorium and low-concentration uranium from sea water. The uranium resource base is theoretically 60 times larger if fast breeder reactors are used.

Table 3.6.World Primary Energy Use and Reserves, 2001

(Source: World Energy Assessment Overview: 2004 Update)

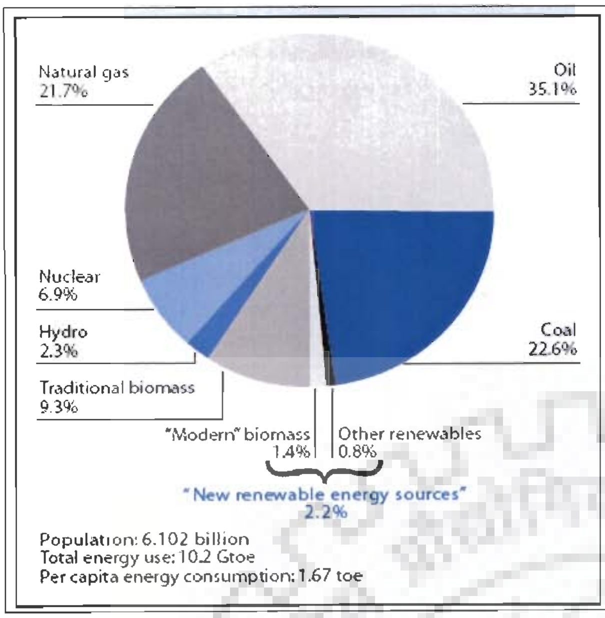


Figure 3.32. World Primary Energy Use, By Energy Source, 2001 (Shares Of 10.2 Gtoe)
(Source: World Energy Assessment Overview: 2004 Update)

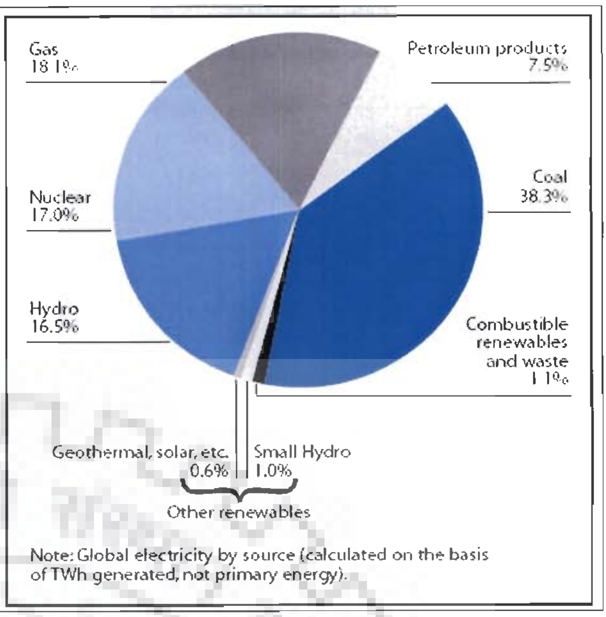


Figure 3.33. World Electricity Production, By Energy Source, 2001 (Shares Of 15,476 Twh)
(Source: World Energy Assessment Overview: 2004 Update)

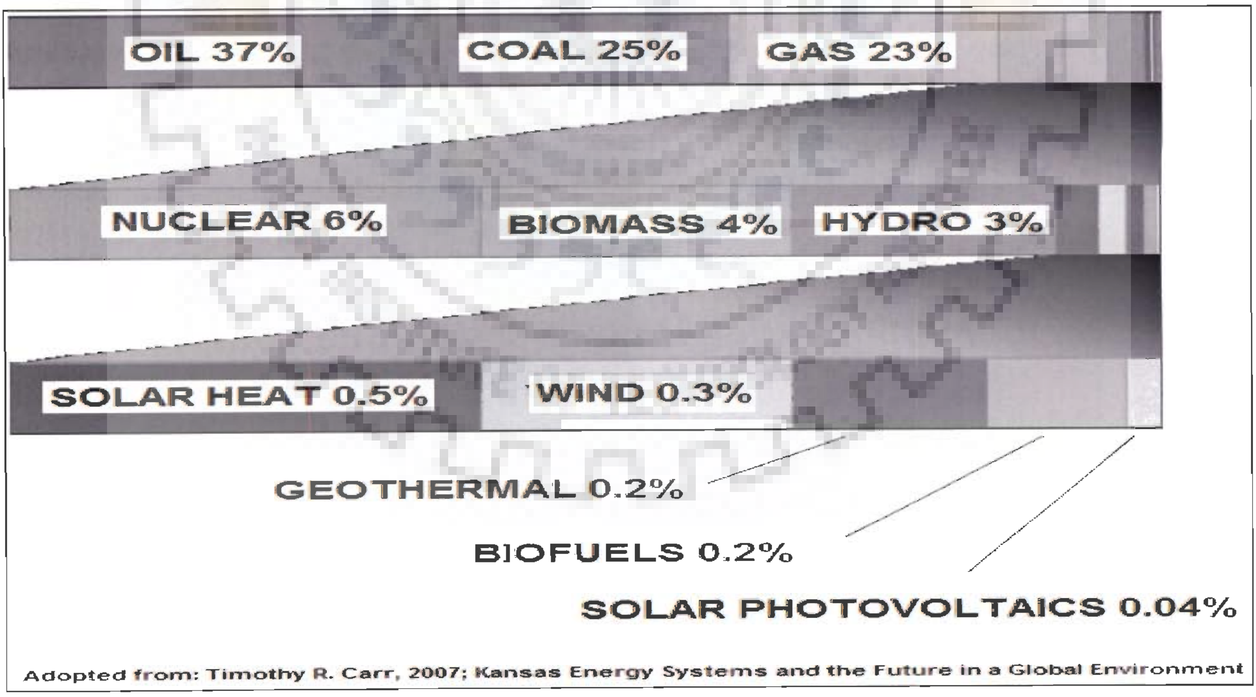


Figure 3.34 World Energy Usage Pattern

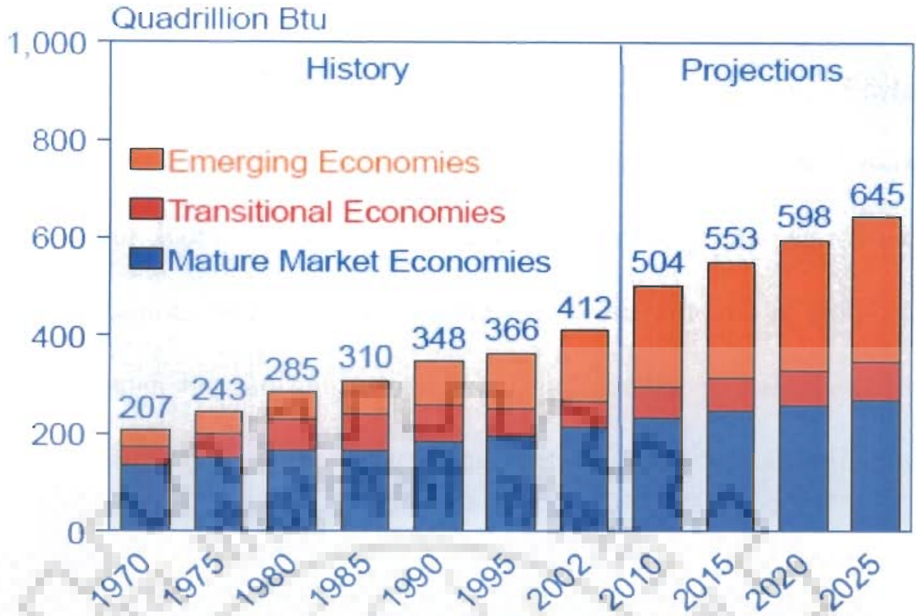
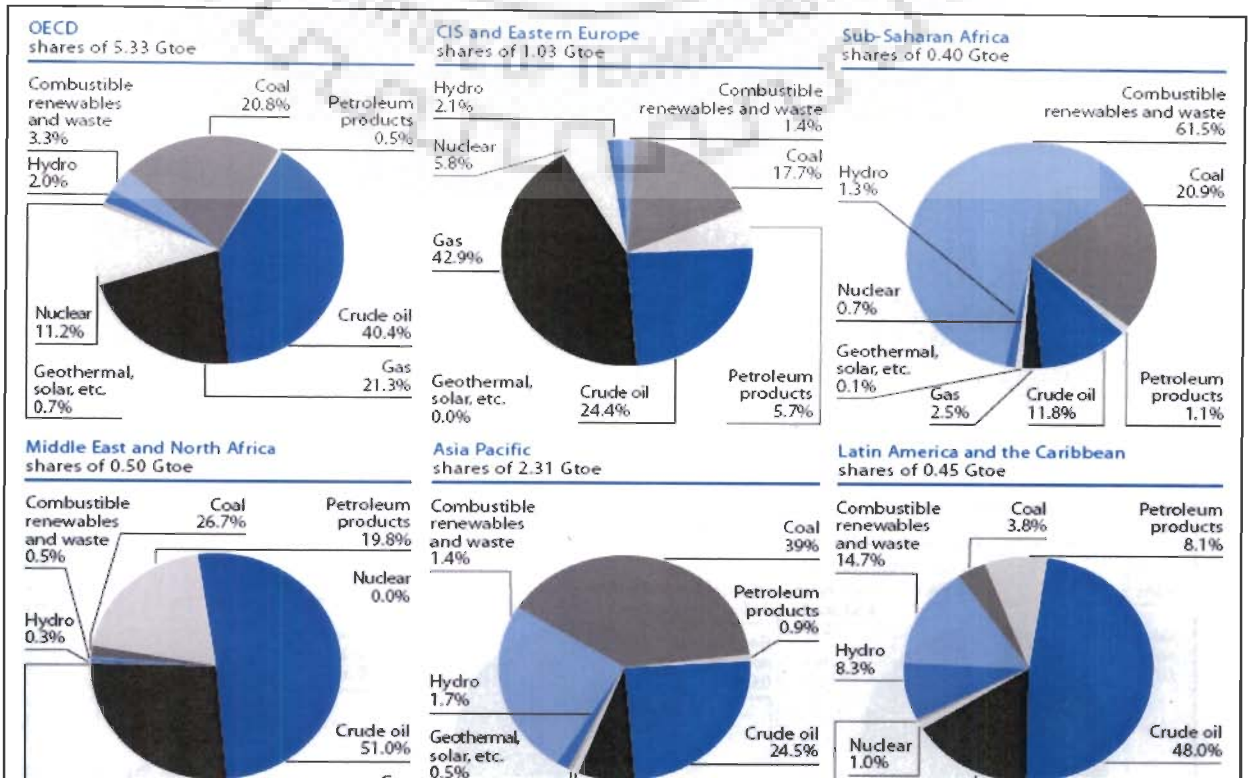


Figure 3.37. World Marketed Energy Consumption by Region, 1970-2025

Sources: Energy Information Administration (EIA),

Projections: EIA, System for the Analysis of Global Energy Markets (2005).



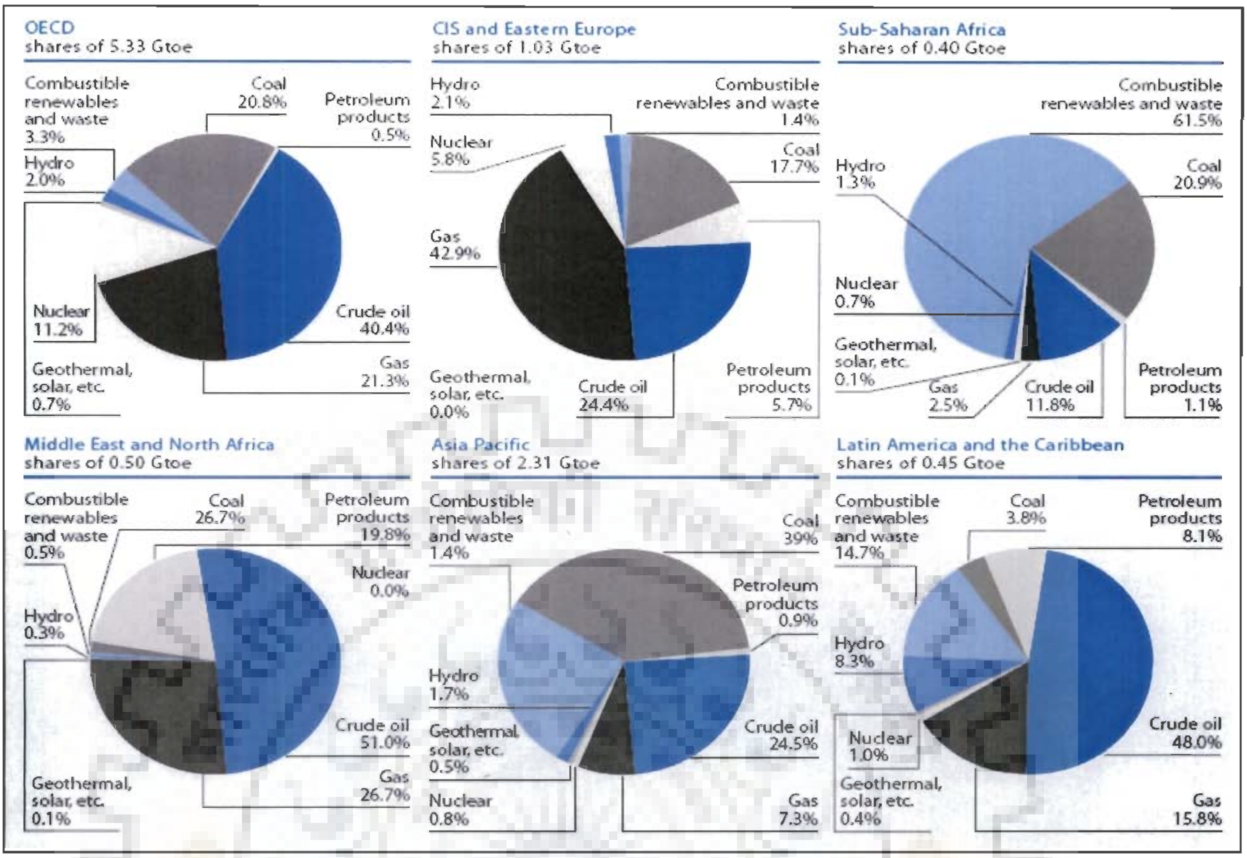


Figure 3.35 Primary Energy Use in Various Regions, By Energy Source, 2001
(Source: World Energy Assessment Overview: 2004 Update)

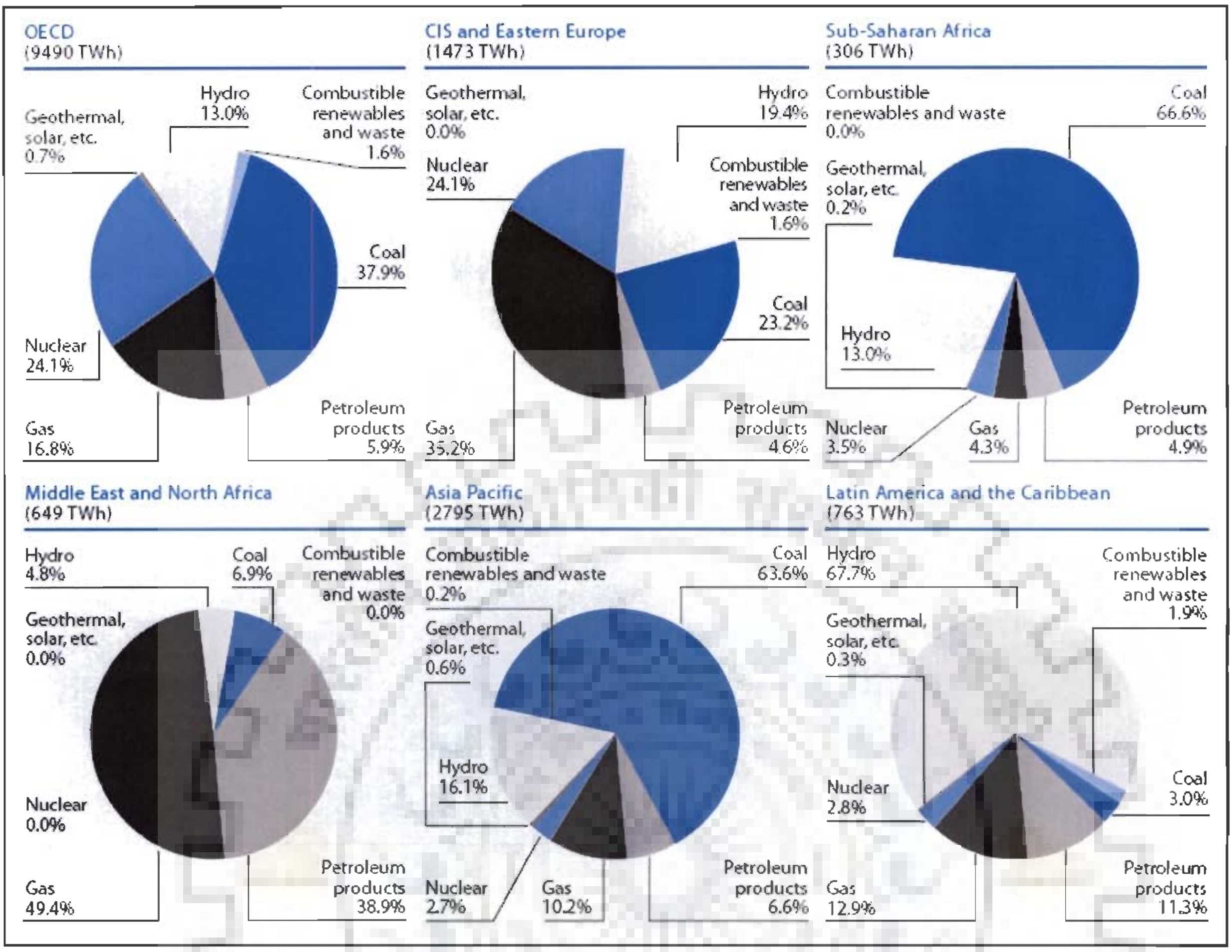


Figure 3.36 Share of different energy sources in Electricity Production in Various Regions

(Source: World Energy Assessment Overview: 2004 Update)

In the International Energy Outlook 2005 (IEO2005) reference case, world marketed energy consumption is projected to increase on average by 2.0 percent per year over the 23-year forecast horizon from 2002 to 2025 (Figure 3.37). In the IEO2005 reference case, the use of all energy sources increases over the forecast period and the use of all sources of energy will increase in the forecast period (Figure 3.38)

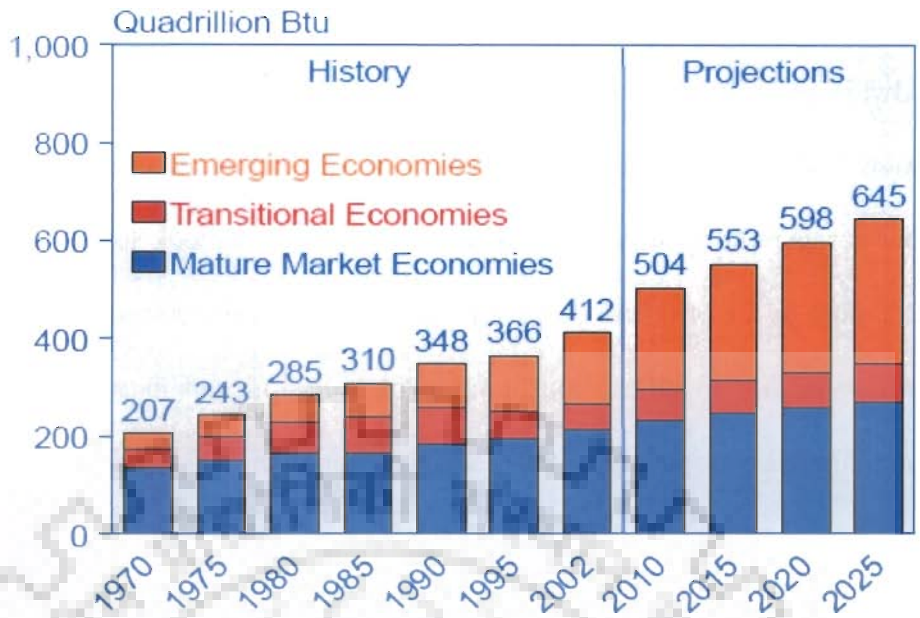


Figure 3.37. World Marketed Energy Consumption by Region, 1970-2025

Sources: Energy Information Administration (EIA),

Projections: EIA, System for the Analysis of Global Energy Markets (2005).

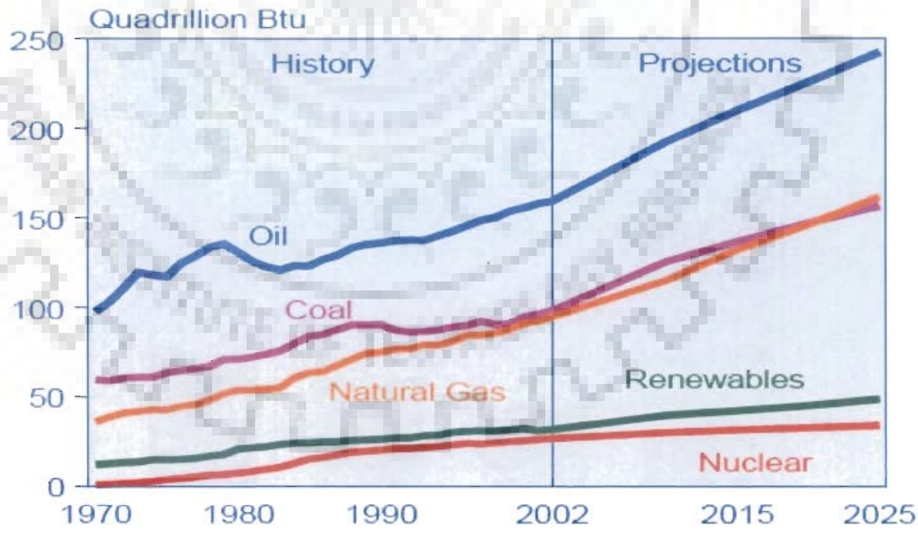


Figure 3.38 World Marketed Energy Use by Energy Type, 1970-2025

Sources: Energy Information Administration (EIA),

Projections: EIA, System for the Analysis of Global Energy Markets (2005).

Thus, fossil fuels (crude oil, natural gas, and coal) will continue to supply much of the energy used worldwide, and oil will remain the dominant energy source, given its importance in the transportation and industrial end-use sectors. Non-fossil fuel use will also grows over the forecast, but not as rapidly as fossil fuel use. Moreover, the outlook for non-fossil fuels will be molded according to the priorities of government policies or programs, environmental laws etc. The projected increase in global consumption of crude oil and natural gas would require a corresponding increase in the production capacity. Moreover, due to worldwide consideration of natural gas an important energy resource for the industrial sector and a desirable alternative for electricity generation, there has been an increase in consumption of natural gas. The electric power sector accounts for 51 percent of the total incremental growth in worldwide natural gas demand over the forecast period (Figure 3.39). OPEC members are expected to be the major contributors to this demand and even non – OPEC members like Caspian Basin, Western Africa, and Central and South America may also provide some contribution.

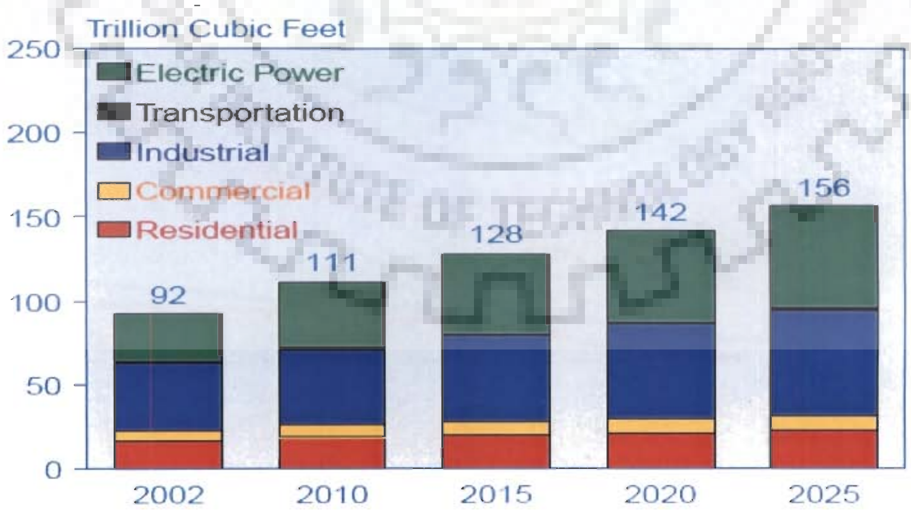


Figure 3. 39 World Natural Gas Consumption by End-Use Sector, 2002-2025
Sources: Energy Information Administration (EIA),
Projections: EIA, System for the Analysis of Global Energy Markets (2005).

3.4 THE BUSINESS CHARACTERISTICS OF PETROLEUM INDUSTRY

The business characteristics of petroleum industry (Kaiser et al 2006) are as follows

- High capital intensity,
- High level of risk,
- Complex tradeoffs between capital and operating expenditures,
- Long time span before a return on investment is received,
- Lack of correlation between the magnitude of expenditures and the value of any resulting reserves,
- High level of regulation,
- Complex tax rules,
- World's largest corporations,
- High level of competition, and
- Complex industry structure.

The exploration and development of crude oil is a high risk, capital intensive business. It is difficult, and costly, business with no guarantees on the success of the outcome. The cost of obtaining leases and conducting exploratory work requires an enormous investment before reserves are quantified and economic viability ensured (Kaiser et al, 2006). According to Kaiser et al (2006), since the crude oil resource exists deep underground in rock formations the quality and quantity is uncertain. Thus, business entities need to address following questions - Does oil exist in the region? If crude oil reserves are found are they of reasonable size to be taken up for venture? In case of a successful venture, the cash flows from the production are subject to various forms of uncertainty and risk. Since the crude oil exploration business requires an upfront investment, which may or may not bring reward later there are questions pertaining to following risk categories (Table 3.7) that need to be considered

	RISK CATEGORY				
	ECONOMIC	**GEOLOGIC**	**POLITICAL**	**LEGAL**	**FORCE MAJEURE**
TYPE	Market	Reserve	Regulatory	Contract	Natural Disaster
	Construction	Production	Transfer-of-profit	Jurisdictional	Civil unrest
	Operation		Expropriation/ nationalization		Strikes
	Macroeconomic				Terrorism

Table 3.7 Risks Exist in oil and gas investment (Adopted from Kaiser et al, 2006).

Besides these there may be certain other risk factors which naturally stem from petroleum exploration business (Kaiser et al, 2006).

- Technical hurdles in completion of projects.
- Probability of a natural disaster affecting the exploration process
- Stability and range of variance of crude oil prices, inflation, of terms of the contract.
- Chances of nationalization, expropriation etc.

According to Kaiser et al (2006), "risks arise from the project (construction, operation, production, reserve), as well as changes in global economic conditions (market, macroeconomic), political circumstances (regulatory, expropriation), legal conditions (contract, jurisdictional), and force majeure (natural disaster, civil unrest, terrorism). The higher the risk associated with an investment, the higher the cost of capital and the higher the return required by investors and lenders." Moreover, once production commences, the pressure which pushes the crude oil to the surface will progressively exhaust and it will require additional investment. It is obvious that more wells, greater production and storage facilities, and greater transportation capacity will be required to produce at a high rate. Thus, the investors need to exercise a trade-off between fast production with large number of wells, high capital expenditures and slow production with fewer wells, low capital expenditures. An investor need to consider the factor that, technologically, a particular field may produce at some optimal rate without any detrimental damage to the reservoir. The prolonged nature, high operating and capital expenditure, associated risk with crude oil exploration and development, these projects result in a long project life cycle to explore the resources and establish the reserve potential. Thus, there is a significant time delay between the magnitude of expenditure and the payout from the project.

3.5 STRUCTURE OF GLOBAL OIL GAS INDUSTRY

The structure of the oil and gas industry is dynamic and highly competitive with several types of companies operating depending upon the segment of activity (Kaiser et al, 2006), as described below.

- Fully integrated: Companies which operate in all segments (i.e. upstream, midstream and downstream) of the industry are,
- Partially integrated or independents: Companies that operate in one or more but not all segments are called.
- Independent oil producer: Involved in only exploration and production;

- Independent refiner: Involved in refining.
- Majors or super majors: The largest integrated oil companies.
- Various other categorizations are also frequently used, such as international integrated, U.S. integrated, large independents, small independents, etc. based on market capitalization, proved reserves, and related criteria.

Majors, independents, and National Oil Companies (NOCs) each have different business models, corporate governance, shareholder expectation, and outlooks of the industry, and all vie for access to resources.

3.5.1. Integrated Oil Companies

Major integrated firms such as BP, Chevron, ExxonMobil, Royal Dutch Shell, and Total tend to seek opportunities on a worldwide basis with large upsides to deploy their management, financial, and technical skills. Majors specialize in managing complex, multifaceted and technically challenging ventures, and seek projects that help balance their portfolio of assets. Capital is allocated to areas on a risk-reward basis within the constraints of maintaining a balanced portfolio of projects. The integrated firms with a geographic specialization are shown in Table 3.8 and include U.S. producers (e.g., Amerada Hess, ConocoPhillips, Murphy Oil), Canadian producers (e.g., Husky, Imperial Oil, Suncor), and international firms which do not have a large presence in North America but are active elsewhere throughout the world (e.g., ENI, Lukoil, Petrobras, Petrochina, Statoil).

International	U.S. Integrated	Canadian Integrated	Non-North American
BP	Amerada Hess	Husky Energy	BASF A.G.
Chevron	ConocoPhillips	Imperial Oil	BG Group
Exxon Mobil	Murphy Oil	Petro Canada	BHP Billiton
Royal Dutch Shell	Marathan Oil	Suncor Energy	ENI
Total			Lukoil
			MOL
			Petrobras
			Petrochina
			Petro Kazakhstan
			Petroleos Mexicanos
			Repsol
			Sinopec
			Statoil

Table 3.8 Examples of Integrated Companies Classified According to Geographic Operation

3.5.2. Independents: Independents seek prospects across a wide range of opportunities: from modest to marginal reserves, high to low risk projects, regional and global locations. Examples of independent companies classified according to size and geographic operation are depicted in Table 3.9. Independents usually have lower overhead than majors, can act quickly on strategic opportunities, and tend to have an entrepreneur flair. Independents may seek to grow in reserves or capital, and may transition across categories depending upon their business objectives, merger and acquisition strategies, and other factors.

International	Large U.S.	Mid-Sized U.S.	Small-U.S.	Non-North American
Anadarko Petroleum	Cabot Oil & Gas	Berry Petroleum	Harken Energy	Cairn Energy
Apache	Chesapeake Energy	Comstock Resources	McMoRan Exploration	Chaparral Resources
Burlington Resources	Forest Oil	Denbury Resources	Meridian Resources	CNOC
Devon Energy	Newfield Exploration	Energy Partners	PetroQuest Energy	Global SantaFe
EnCana	Noble Energy	Houston Exploration	Remington Oil & Gas	Nelson Resources
EOG Resources	Pogo Producing	Magnum Hunter Resources	Tetra Technologies	Transmendian Exploration
Kerr-McGee	Vintage Petroleum	Stone Energy	W&T Offshore	Venture Production
Nexen	XTO Energy	Swift Energy		Woodside Petroleum
Occidental Petroleum				
Talisman Energy				
Unocal				

Table 3.9 Independent companies classified according to size and geographic operation

3.5.3. National Oil Companies: The role of NOCs is the most important factor in the future of the industry. NOCs control the majority of oil and gas reserves known in the world and demand-side NOCs are becoming more active competitors in world markets. State-owned companies are generally formed to maximize revenue from state resources. Governments use NOCs for many different national objectives, however, from resource custodian, securer of supply, revenue collector, or engine of national development.

Country	Company
Abu Dhabi	ADNOC
Algeria	Sonatrach
Angola	Sonangol
Azerbaijan	Socar
Bahrian	Bahrain National Oil (BNOC)
Bolivia	Y.P.F.B.
Brazil	Petroleo Brasileiro SA (Petrobras)
Canada	PetroCanada
China	China National Petroleum Co. (CNPC) China National Offshore Oil Co. (CNOOC) Sinopec
Columbia	Ecopetrol
Dubai	Dubai Petroleum Co. (DPC)
Ecuador	Petroleos del Ecuador
Egypt	Egyptian General Petroleum Corp. (EGPC)
Hungary	Hungarian Oil and Gas Co. (MOL)
Indonesia	Petramina
India	India Oil Corp. (IOC); Oil and Natural Gas Co. (ONGC)
Iran	National Iranian Oil Co. (NIOC)
Iraq	Iraq National Oil Co. (INOC)
Japan	Japan National Oil Co. (JNOC)
Kazakhstan	Kazmunaigaz (KMG)
Korea	Korean National Oil Corp. (KNOC)
Kuwait	Kuwait Petroleum Corp. (KPC)
Libya	National Oil Co. (NOC)
Malaysia	Petronas
Mexico	Petroleos Mexcanos (Pemex)
Nigeria	Nigeria National Petroleum Co. (NNPC)
Norway	Norsk Hydro ASA; Statoil
Oman	Petroleum Development Oman LLC
Peru	Petroperu
Qatar	Qatar Petroleum Corp. (QP)
Romania	Romanian National Oil Co. (Petrom)
Russia	Rosneft; Gazprom
Saudi Arabia	Saudi Arabria Oil Co. (Saudi Aramco)
Trinidad & Tobago	Petroleum Co. of Trinidad & Tobago Ltd. (Petrotrin)
Turkey	Turkish Petroleum Co. (TPAO)
UAE	ENOC
Venezuela	Petroleos de Venezuela SA (PDVSA)

Table 3.10 Selected National Oil Companies

National Oil Companies have broader constraints and obligations than private corporations, basing their decisions on domestic, geopolitical, as well as economic factors. Not all NOCs are created equal.

National Oil Companies can be classified in a number of ways, such as in terms of their degree of privatization (state monopolies, partial privatization, full privatization), resource ownership (resource holders [supply-side companies] vs. resource seekers [demand-side companies]), country/business characteristics (GDP per capital, economic strength, corruption index, reserves), strategic priorities (revenue growth, security of supply, profit/margin, local economic development, international/diplomatic relations, infrastructure development), etc. Demand-side NOCs are changing the nature of competition, offering supply-side NOCs strategic partnerships that extend to economic and infrastructure development. The political alignment between nations and their oil companies can bring a distinct competitive advantage, which will further increase competition for multinational companies in acquiring investment opportunities.

In terms of reserves, over 90% of the proved oil reserves in the world are under direct or partial state ownership, primarily in the Middle Eastern OPEC countries. The top 10 oil and gas company rankings by reserves and production for oil (Table 3.11) and oil and gas (Table 3.12) illustrates the absolute strength of NOCs.

Rank	Company	Reserves (Billion BOE)	Company	Production (MBOE/day)
1	S. Aramco	262.7	S. Aramco	9.830
2	NIOC	132.5	NIOC	4.081
3	INOC	115.0	Pemex	3.754
4	KPC	89.4	PDVSA	2.600
5	PDVSA	77.1	Exxon Mobil	2.571
6	ADNOC	52.6	BP	2.531
7	Libya NOC	28.8	KPC	2.424
8	NNPC	21.2	Royal Dutch Shell	2.333
9	Lukoil	15.9	PetroChina	2.124
10	Pemex	14.8	INOC	2.027

Table 3.10 Top 10 Oil and Gas Company Rankings – Oil (2006)

Rank	Company	Reserves (Billion BOE)	Company	Production (MBOE/day)
1	NIOC	307.2	S. Aramco	10.944
2	S. Aramco	305.6	Gazprom	9.704
3	Gazprom	219.6	NIOC	5.569
4	INOC	135.1	Pemex	4.360
5	QP	128.9	Exxon Mobil	4.347
6	PDV	104.1	BP	4.062
7	KPC	99.4	Royal Dutch Shell	3.918
8	ADNOC	71.6	PDVSA	3.320
9	NNPC	40.2	Sonatrach	3.093
10	Sonatrach	37.9	PetroChina	2.625

Table 3.11 Top 10 Oil and Gas Company Rankings – Oil & Gas (2006)

It is estimated that 65% of the world's proven oil and gas reserves are controlled by governments not open to western companies; 16% proven reserves are held by Russian companies; 12% by governments with limited access for investment; and 7% with full access (Ball, 2006).

3.5.6 Industry dynamics

A wave of upstream market openings has changed the industry dynamics. The International Oil Companies have been granted access to areas in Soviet, South America, and various parts of North Africa and Africa. These areas attract capital and technology and, in some cases, have completely privatized their NOCs. These changes have provided tremendous exploration opportunities for global players. Only two significant areas are still completely closed to foreign participation – Mexico and some countries in the Middle East, particularly Saudi Arabia and Kuwait.

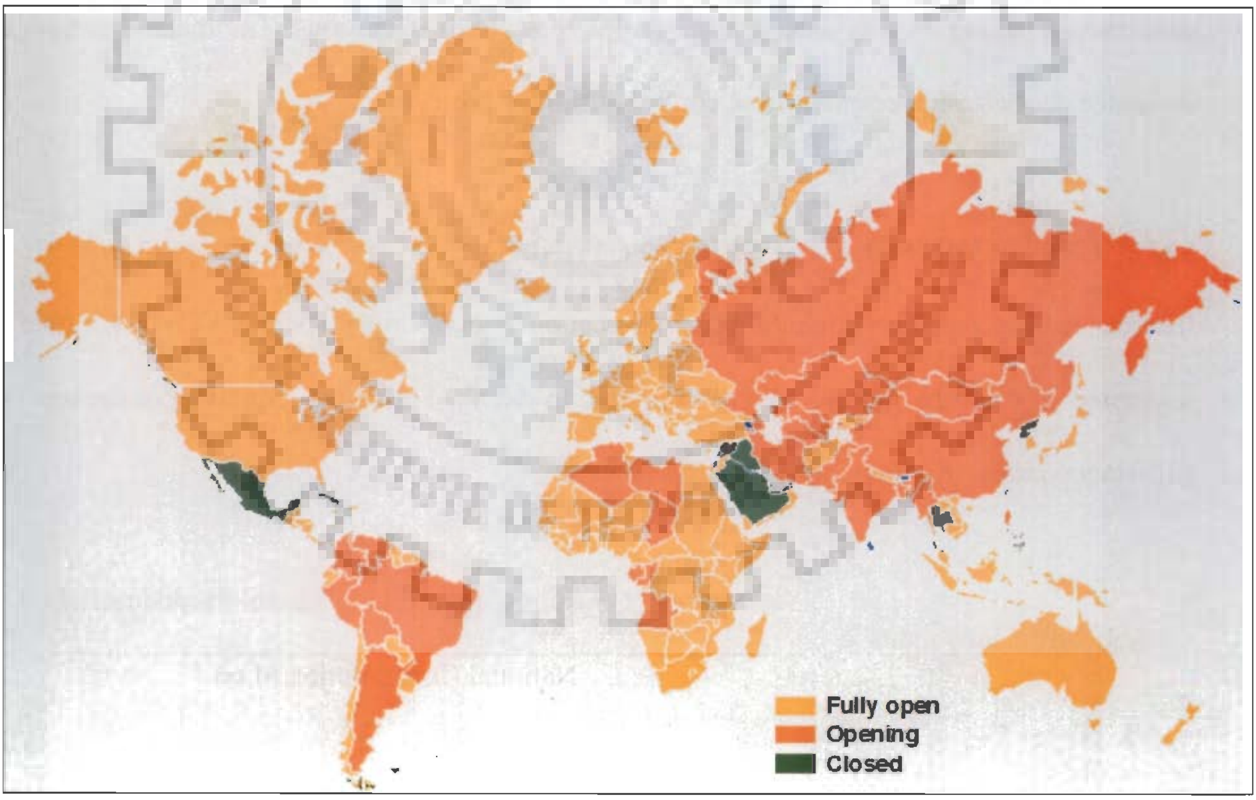


Figure 3.40 Global Industry Dynamics

In the Middle East Iran, Iraq, Kuwait, and Saudi Arabia have some degree of foreign participation. In South America, Brazil, Venezuela and Mexico has opened the E&P business for foreign participation. In Asia, China and India has offered acreages for exploration. The western world has a different story al together. Almost a century ago the Standard Oil Company disintegrated in to seven sisters, and in three years during the period 1998-2001 there has been mega mergers which led the petroleum industry re-consolidating in the form of mergers of BP and Amoco, Exxon and Mobil, and Chevron and Texaco. There are several critical issues which driving such activities of mergers. The mergers provide an ability to assemble an optimal portfolio of mega-projects having higher risk and higher returns. The smaller companies cannot participate in more than a few mega-projects with reasonable working interest. It provides economies of scale by way of cost savings due to scale of operations. The merged majors have increased access to governments that control attractive projects.

3.6 CRUDE OIL SELF – SUFFICIENCY INDEX

In order to find out the vulnerability of an economy to an oil price shock, Bacon (2005) has suggested a variable linking net oil imports to GDP. Following equation describes "self-sufficiency index" for crude oil

$$\text{Self sufficiency index} = \frac{\text{National Consumption of oil} - \text{National Production of oil}}{\text{National Consumption of oil}}$$

These components provides guidelines for the policies to ameliorate the overall vulnerability to higher oil prices. The ratio can be altered by discovery and production of domestic supplies of oil. The self sufficiency index for countries have been attempted (Table 3.12). Negative values x indicate a country to be more than self sufficient, (indicated by red color), zero indicates just self sufficient and a value of one indicates complete import dependency (indicated by green color).

Year	2000	2001	2002	2003	2004	2005	2006	2007
US	0.61	0.61	0.61	0.63	0.65	0.67	0.67	0.67
Canada	-0.44	-0.39	-0.46	-0.49	-0.47	-0.44	-0.54	-0.55
Mexico	-1.00	-1.08	-1.19	-1.26	-1.24	-1.13	-1.11	-0.94
Argentina	-0.99	-1.17	-1.39	-1.29	-1.02	-0.80	-0.70	-0.48
Brazil	0.31	0.29	0.19	0.12	0.13	0.06	0.02	0.06
Chile	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Colombia	-2.38	-1.81	-1.97	-1.79	-1.70	-1.71	-1.60	-1.68
Ecuador	-2.59	-2.56	-2.46	-2.52	-3.31	-2.65	-2.55	-2.25
Peru	0.34	0.32	0.31	0.32	0.38	0.36	0.20	0.24
Venezuela	-6.44	-5.52	-4.52	-4.97	-5.20	-4.85	-4.49	-4.00
Austria	-0.19	-0.17	-0.18	-0.10	-0.14	-0.58	-1.29	-2.16
Azerbaijan	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belarus	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium & Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bulgaria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Czech Republic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Denmark	-0.71	-0.73	-0.89	-0.94	-1.10	-0.99	-0.79	-0.63
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
France	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Germany	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hungary	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Iceland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Republic of Ireland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	0.95	0.96	0.94	0.94	0.94	0.93	0.93	0.93
Kazakhstan	-3.77	-3.50	-4.18	-4.96	-5.73	-5.26	-5.04	-5.48
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Netherlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Norway	-16.08	-15.78	-15.68	-14.41	-14.57	-13.23	-11.88	-10.74
Poland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Portugal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Romania	0.37	0.41	0.43	0.38	0.47	0.48	0.52	0.53
Russian Federation	-1.62	-1.85	-2.07	-2.42	-2.72	-2.86	-2.78	-2.90
Slovakia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spain	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Switzerland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkmenistan	-1.02	-1.18	-1.35	-1.37	-1.28	-1.16	-1.03	-1.08

Ukraine	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United Kingdom	-0.61	-0.49	-0.49	-0.34	-0.17	-0.02	0.07	0.02
Uzbekistan	-0.12	-0.10	-0.14	0.00	-0.01	0.02	0.04	0.14
Iran	-2.03	-1.98	-1.57	-1.87	-1.85	-1.81	-1.76	-1.75
Kuwait	-9.50	-9.03	-7.59	-8.44	-7.92	-7.29	-8.47	-8.24
Qatar	-21.60	-18.45	-13.10	-17.36	-18.65	-16.01	-14.02	-12.00
Saudi Arabia	-5.38	-5.13	-4.85	-5.25	-5.04	-5.04	-4.55	-3.97
United Arab Emirates	-8.63	-7.07	-5.84	-6.48	-6.19	-6.07	-5.79	-5.17
Algeria	-6.86	-6.48	-6.28	-6.80	-6.88	-6.83	-6.48	-6.19
Egypt	-0.43	-0.43	-0.46	-0.42	-0.32	-0.14	-0.17	-0.11
South Africa	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Australia	0.06	0.16	0.17	0.30	0.36	0.38	0.44	0.44
Bangladesh	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
China	0.27	0.28	0.33	0.38	0.45	0.45	0.48	0.49
China Hong Kong SAR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
India	0.66	0.66	0.67	0.67	0.69	0.70	0.69	0.71
Indonesia	-0.41	-0.32	-0.16	-0.07	0.05	0.09	0.07	0.13
Japan	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Malaysia	-0.65	-0.59	-0.53	-0.61	-0.60	-0.54	-0.48	-0.45
New Zealand	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Pakistan	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Philippines	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Singapore	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
South Korea	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Taiwan	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.12 Self Sufficiency Index of Countries, Adapted from: Bacon (2005)

3.7 FACTORS INFLUENCING SUPPLY AND DEMAND OF CRUDE OIL

The supply of crude oil in the world at any point in time is the sum of the production levels achieved by the collection of many private, public, and state-owned companies. Each individual entity plans for and decides on its own supply level independently, with the exception of OPEC members, and possibly, short-term "alliances" that may form during exceptional times; e.g., extreme price levels, military activity etc. For the members of OPEC, the level of supply results from the coordination and collective decisions of the member nations. The goals, strategies, and behavior of private and public companies vary widely, but investment decisions for companies tend to be based on profitability criteria, the companies' cash flow position, and its outlook for the future. International oil companies have shareholders who require a return on their investment. The goals, strategies, and behavior of state-owned companies on the other hand are much more diverse. National oil companies have domestic social and political obligations, the need to create foreign exchange, and the desire to exert geopolitical influence (Kaiser et al, 2006).

The demand for oil and gas begins at the individual and corporate level. Aggregating the individual, commercial, and industrial demands of a nation comprise the demand function for the country.

3.7.1 Economic Activity

The accessibility and consumption of energy plays a key role in the process of economic growth, and conversely, is an essential input into technological advancement in the substitution of machines and other forms of capital for human labor. Energy use is a necessary input to economic growth and is also a function of growth. Energy use is associated with population growth, the expansion of urban centers, industrialization, and the development of infrastructure such as roads and transportation networks. There is a strong correlation between a country's energy consumption and economic activity as measured by GDP. The economic growth is linked to high levels of oil, natural gas, and electricity consumption.

3.7.2. Inventory

The short term supply/demand balance influence prices, but the impact depend on the perception of the importance of the factor.

3.7.3 Crude oil Price

Crude oil price is determined in the world market and depends mainly on the balance between world demand and supply. Markets respond to supply/demand changes with price movements that provide the incentive to increase or decrease supply to correct imbalances. High prices lead to increases in exploration and development budgets, and as new oil and gas is found and brought to the market, supply increases and prices are typically reduced. High prices can also make alternative fuels more competitive, potentially reducing demand, and are likely to encourage conservation, further reducing demand.

3.7.4 Geopolitics

Geopolitical shifts and foreign policies play an important role in global energy security and long-term energy supplies. The fall of communism and the liberalization of economies in Asia and South America have opened vast energy resources previously inaccessible or underdeveloped, while China and India's growing concern about the rising cost of energy and their dependence on import oil has prompted their state-owned companies to aggressively seek acreage and investment opportunity throughout the world, often through aggressive bidding and in regions with high political risk. The demand for steady supplies of oil by China and India is reshaping the global energy market, the environment.

Reforms in a country usually improve production and encourage foreign investment, while nationalism leads to reduced investment. A growing number of countries across South America, for example, are opting for more nationalist, left-leaning governments (e.g., Bolivia, Ecuador, Venezuela) as opposed to the market-oriented policies of previous moderate, socialist governments. Throughout Africa, South America, and the Former Soviet Union, governments and their NOCs are renegotiating contracts to take in more revenue via taxes and royalties (Kaiser et al, 2006). In the 1990s, Russia divested itself of some off its biggest industrial assets in often-controversial privatizations. Since 2002, the Kremlin has sought to regain control of the energy sectors. State-owned energy companies OAO Gazprom and OAO Rosneft, for example, have purchased independent oil producers, OAO Sibneft and OAO Yukos. Iran continues to feud with the West over its nuclear ambitions, and continued conflict in Nigeria maintains a risk premium in the price of oil.

3.7.5 Geology

The geology of a country or province will ultimately determine the energy supply potential of the region. There is a finite amount of oil and gas resources in the world, but whether we ever extract all of the resource or find other alternative sources is a matter of heated debate.

3.7.6 Access to Reserves

According to Kaiser et al (2006), the "resources in the ground are the property of the state, except in a few countries around the world such as the United States and parts of Eastern Canada where private ownership of minerals is legal. Countries maintain sovereign rights over the land and mineral resources within their physical territory, and in the case of access to water (lake, sea, and ocean), offshore continental shelf acreage. Opportunity to explore for and develop oil reserves depend on host country policies on foreign investment, depletion rates, and environmental protection. By the mid-1990s, many countries had at least partially opened their oil sector to foreign investment, but three major oil-producing countries still remain totally closed – Kuwait, Mexico, and Saudi Arabia. Investment in Russia, China, Iraq, and Iran remain constrained by regulatory, political, and administrative barriers and delays (International Energy Agency, 2003)."

3.7.7 Technology

The advances in exploration and exploitation have made a contribution to increasing supply. It has improved productivity and recovery rates and reduced production costs. Due to technological advances offshore and frontier areas are being explored and crude oil and natural gas is being economically recovered. Undoubtedly, technology will continue to make more crude oil reserves available.

3.7.8 Exchange Rates

World over the crude oil is traded in dollars or euro and therefore fluctuation in currency exchange rate of the currency affect the crude oil demand-supply. The effect of a forex impacts the import/export status of the nation. For exporters, the decline in value of the currency leads to their production decisions.

3.7.9 Depletion of Existing Fields

With ageing and sustained production the productive capacity of a field declines. It calls for additional investments to maintain production as per the engineering principles. The investment will protract the decline of the field, depending on the geology of the field, and the nature of the investment. But, eventually, a field will typically decline at a natural rate. Companies spend substantial amount to arrest declining production rates.

3.7.10 Discovery rate

Astronomical rise in the global oil and gas prices stimulate exploration activity, resulting in discovery of new fields and thus many new fields put onstream. It leads to increased production. Very often, despite intensive exploration efforts, the geology and exploration maturity of the region restricts additional reserve addition. Sometimes, factors like infrastructure, distance to market, adverse economics prohibit the field to be commercial. If the region is mature and infrastructure well developed, field discoveries will be small on average but can be brought on-line with relative ease, while if the region is frontier, the chance of a large discovery is greater but the development cost will be more (Kaiser et al, 2006).

3.7.11 Unusual Events

The unpredictable events like war, riots, political instability, natural disaster, and terrorism impact the supply and demand for oil and gas in short-term and long-term. Weather-related disruptions will impact production in the short run, but are not expected to have significant consequences in the long-term.

3.7.12 National Government Policy

The policies of national government have direct impact on supply and demand and investment patterns in the oil and gas sector. These policies include tax structure, price controls, import/export controls, access to prospective territories, fiscal policies governing E&P activity, etc. Very often, nations have geopolitical ambition which affect investment trends, partnerships, strategies alliances, and regional cooperation.

3.7.13 Licensing and Incentives

World over, national governments control the oil and gas sector especially for foreign investment. The open economy may attract investment depending on the perception of the investors about such policy. Very often, the governments provide incentives in the form of tax holiday, royalty relief and other mechanisms, to promote exploration activities in high cost-high risk areas. The openness of countries to foreign direct investment is an important factor in determining how much investment occurs in the country.

3.7.14 Taxation

The taxation strategies of a country depend on government interest, to derive economic benefit from hydrocarbon production. The tax rates vary by country and over time, and often, on a field-by-field, company-by-company basis, negotiated as part of the fiscal system. The taxation systems evolve rapidly in response to market conditions and the margin that the state wishes to allocate to the oil companies. The exporting countries wish to derive the maximum income from supplies, while importers generally attempt to encourage domestic production by stable fiscal regimes and tax incentives. Very often, importing countries have their legal and tax systems to encourage E&P activity on their territory to improve domestic production so that import dependency is reduced.

3.7.15 Fiscal Regime

The fiscal terms offered by host governments are a critical determinant of the attractiveness of an upstream investment. Thus, the governments have to balance their desire to maximize their share of rent versus the need to encourage investment. This is a matter of judgment since the attractiveness of a region depends on perceptions of geological, economic, and political risks relative to projected returns. The stability of a fiscal regime is also important. The increase in rates may require investors to raise their hurdle rates, which may restrict future investment.

3.7.16 Environmental Regulations

The investment in overseas opportunities are affected by environmental stipulations and may lead to escalation in the cost of projects.

3.7.17 Conservation

Conservation policies of a country and tax rates on petroleum products are an important factor affecting the demand for crude oil.

3.7.18 Political Risk

In global oil –gas business the political risk is a matter of concern. The companies are mostly concerned with nationalization. But, the production sharing agreements has minimized the nationalization risk.

3.8 OBSERVATIONS

There has been phenomenal increase in crude oil and natural gas production and consumption (Figure 3.30). Crude oil and natural gas will continue to dominate global energy requirements and will constitute a major item for global business. Oil accounts for 10% of world trade, and is the largest single commodity traded globally. The petroleum industry plays a major role in the great majority of developing countries. In virtually all developing countries, oil is an important source of energy. In a number of developing countries oil production constitutes an important source of income, foreign exchange and budgetary revenue. But, in many other countries, petroleum production is small. During past three decades, developing countries' commercial energy use has increased significantly. It is mainly due to improvement in lifestyle increase in personal incomes, higher population growth rates, and shift from traditional to commercial energy. It leads to import of crude oil and therefore oil import bill is often one of the most important items in the balance of payments.

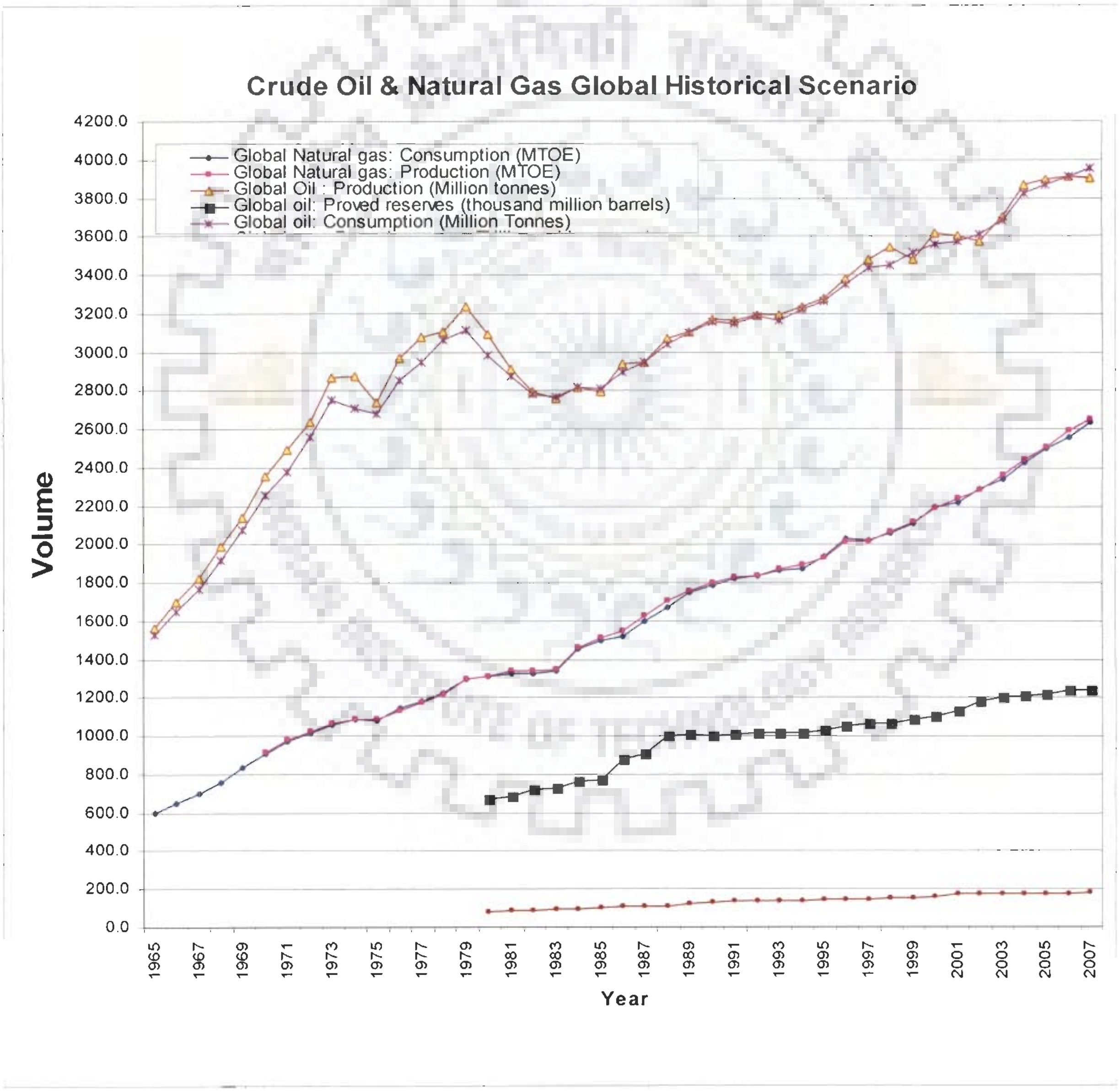


Figure 3.41 Global Oil and Natural Gas Scenario (Data Source: BP Statistical Review 2008)

Therefore the companies these days enter in to global upstream business to get share of crude oil. The factors which matter countries to globalize petroleum sourcing consists of energy requirements for economic growth, the obligation of national government to reduce import dependence. Importing countries resort to diversification to minimize and mitigate supply disruption. Diversification of supply source necessitates development of a scenario where importing and producing countries feel mutually interdependent – the importer by the flow of crude oil and gas and producers by flow of investment requirements. The crude oil and gas sourcing security either by import or by equity from global sources calls for judicious selection of global investment opportunities. Because, the attractiveness of any country for upstream business is influenced by many factors (Table 3.13).

	CATEGORIES				
	Legal	**Geopolitical**	**Geologic**	**Technical**	**Country**
POTENTIAL FACTORS	Rule of law	Political risk OPEC membership Political agenda Political systems	Proved reserves Production Reserves addition Undiscovered resources	Finding and development cost Number of International oil companies Years of production Past peak production Maturity status Frontier acreage Infrastructure availability	GDP GDP per capita Oil revenue volatility Import/ Export status Economic system FDI Macroeconomic stability Negotiation experiences Company type Regional influences Corruption Index

Table 3.13 Factors influencing prospectivity of region, Adapted from: Kaiser, 2006

Therefore, the competitiveness of a country to attract global investors is of prime importance. In the E&P industry, many factors influence decisions and the manner in which a company allocates capital across its portfolio. A firm seeks to maximize profits, but financial forces and shareholders (banks, fund managers, etc.) may require a firm to pursue "growth" (reserves volume) or diversify its operations. At a corporate level, the decision to allocate depends upon its cash flow position, the profitability of the business, preferences for risk taking, competition in the global marketplace for capital, available prospects for drilling, strategic decisions, shareholders obligations, and the firms outlook for the future. At the time a business enterprise sets its budget, it should be able to make a fairly reliable projection of next years production rate and estimated cost. Typically, a planning horizon for oil prices is assumed and projects are evaluated on a common and consistent basis, where judgments on the risks and rewards of the projects under a variety of price scenarios and geologic, technical, production, government, tax, and legal factors are considered (Seba, 2000). It is to be emphasized that the return on overseas investment is dictated by the elements of fiscal system of that country. But, the complex and dynamic nature of oil and gas industry prohibit any simple cause and effect relationships to be developed to explain the nature of a country's fiscal regime. The structure of fiscal regimes depend upon many interdependent non-causal factors such as the reserve base and economic strength of the country, oil supply balance, oil prices, evolution of political systems and historic relationship between the industry and the country, field maturity and development stage, regional demand, the country's desire for foreign capital, geopolitical motivations, and many other variables. Countries with low exploration risk and high prospectivity are generally expected to take a high proportion of economic rent, while countries with high exploration risk and low prospectivity must usually offer a larger share of rent to encourage investment. These factors deserve consideration. Moreover, the investment decisions are made within a firm based on the amount of money a company has to invest, which depends on commodity prices, cash flow, profit margins, and expected profit. High commodity prices tend to lead to higher profit, and vice versa, but since costs and taxes also change with price, the correlation is not perfect. Profit can only be determined on a project-by-project basis taking into account the terms of the fiscal regime, royalties, taxes, production costs, and other relevant factors. Cash flow is the primary source where companies acquire funding for new projects. The price of crude and derivative products are major determinants of cash flow, but like profit, available cash flow is also influenced by several other factors, including dividend reinvestment, share buybacks, and debt reduction. Cash flow tends to follow movements in prices and production. Business enterprise may react to reduced cash flow by cutting investments in upstream sector and shift the available capital to projects in other regions of the world with a better risk-return profile (Kaiser, 2006).

3.9 CONCLUSION

Plentiful, reliable, and affordable energy supplies are essential to economic development. The crude oil and gas will remain predominant among forms of energy supply. World energy demand will keep on increasing due to population growth, industrialization and improved life styles. The developing economies will account for over 60 percent of world energy demand by 2030. Most of the challenges of global energy have global dimension. Several countries depend on import to meet their demand, leading to diversification of supply sources. Diversification of the geographical sources of supply will lead to mitigation of risks associated with energy security for countries. Nations these days resort to enter in to global upstream business to obtain equity crude oil to reduce import dependency. Thus, the crude oil security strategy needs to be targeted to promote adequate and reliable long-term oil and gas supply from overseas.

This chapter has dealt in detail about the global energy scenario, with special focus on crude oil and natural gas. The brief idea about entire gamut of petroleum exploration has been provided. Background information about the concepts of reserves and resources has been given. The chapter provides vivid illustrations of global crude oil reserves, production, consumption, and trade scenario. Brief introduction about the upstream petroleum business has been provided. The global geopolitical issues impacting global petroleum business is discussed. The analysis of historical statistical data for reserves, production, consumption scenario for crude oil and natural gas for more than four decade has led to identification of countries which are self sufficient and where reasonable quantity of reserves and resources of crude oil exists for exploration and exploitation. The study concludes that there are several countries which possess enough crude oil. It is observed that the global crude oil and natural gas business is growing and expanding through international trade, cross-investments, deregulation of domestic markets, and industrial restructuring. This transformation of crude oil-gas industries offers great promise in terms of choice of crude oil source from several countries. A comprehensive understanding of the global scenario constitutes a background for further study to formulate a strategy for India's effort towards overseas exploration. The strategic planning process for globalization initiatives of India requires scanning and understanding the E&P environment and data as discussed in the present chapter for future or collaboration to get equity oil. Subsequent chapter provides a detailed overview of Indian crude oil scenario.

CHAPTER 4

INDIAN ENERGY SCENARIO

Current era symbolize deregulation and liberalization in Indian economy. Augmented economic growth, colossal industrialization, burgeoning population, and environmental issues are matter of concern to India's energy security. This chapter critically evaluates the Indian energy scenario with special reference to crude oil and natural gas and India's concern for crude oil security. Broad understanding of efforts towards crude oil security by India, both within and outside the country has been discussed. The status of petroleum exploration in India, efforts of Indian upstream petroleum industry towards liberalization and deregulation, increased private sector participation to invite additional investment, induction of latest techniques as well as technologies and efforts to attract global players have also been discussed.

4.1 ENERGY PRODUCTION AND CONSUMPTION PATTERN OF INDIA

India, the world's sixth largest energy consumer accounts for about 3.6% of world primary consumption but, with very low energy consumption per capita (Table 4.1)

	India	China	UK	USA	World
Population (millions)	1080.3	1306.3	60.4	295.7	6446.1
Population growth (%)	1.4	0.58	0.28	0.92	1.14
GDP/ Capita (k $)	3.1	5.6	29.6	40.1	8.8
GDP growth rate (%)	6.2	9.1	3.2	4.4	4.9
Energy consumption/ capita (kg oil equivalent)	486	830	3930	7937	
Total energy consumption (million tonnes oil equivalent)	376	1386	227	2332	10224

Table 4.1 Energy, demography and Economic data (Munir, 2005)

It is endowed with non-renewable and renewable energy resources. The energy consumption pattern is attributed to various traditional and modern fuels (Table-4.2, Figure 4.1). Coal and crude oil constitute India's major primary energy sources. Primary energy comprises commercially traded fuels only and does not include fuels such as wood, peat and animal waste, wind, geothermal and solar power generation, as well as biofuels.

Source	Unit	1990-91	2000-01	2002-03	2003-04	2004-05	2005-06	2006-07
1. Pol.Products	MMT	57.75	106.97	111.78	115.99	120.17	122.35	131.67
2. Natural Gas	BCM	12.77	27.86	29.96	30.91	30.78	31.33	30.79
3. Coal	MMT	211.73	309.63	341.29	361.25	382.61	407.04	430.85
4. Lignite	MMT	13.77	22.95	26.02	27.96	30.34	30.06	31.13
5. Electricity (incl.Non-utilities)	Bn.KWH	289.40	554.50	596.50	633.30	665.80	697.40	744.3

MMT: Million Metric Tonnes BCM: Billion Cubic Metres

Table 4.2 Primary Commercial Energy Consumption in India

Source: Website Ministry of Petroleum and Natural Gas, India

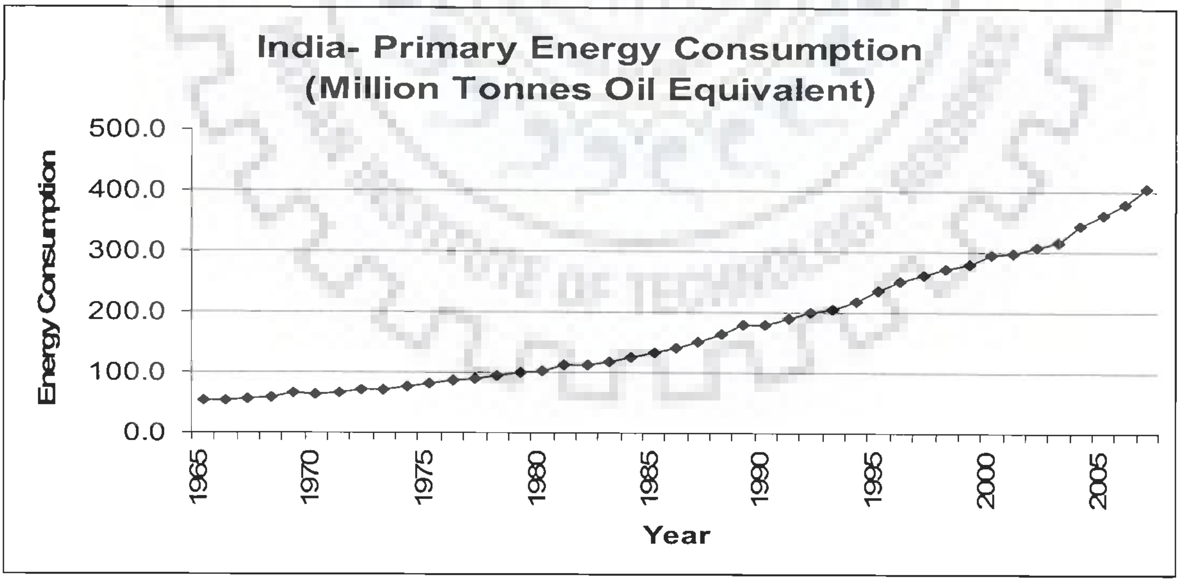


Figure 4.1 India primary energy consumption (Data source- BP statistical review 2008)
(Oil consumption is measured in million tonnes; other fuels in million tonnes of oil equivalent.)

India's energy use is mostly based on fossil fuels (Tenth Five Year plan of India). Although the country has significant coal and hydro resource potential, it is relatively poor in oil and gas resources. As a result it has to depend on imports to meet its energy supplies. The crude oil consumption is estimated at 2.8 % (Tenth Five Year plan of India) – 3% per cent of the world's consumption. The share of hydrocarbons in the primary commercial energy consumption of the country has been increasing over the years and is presently estimated at 44.9 per cent (36.0 per cent for oil and 8.9 per cent for natural gas). The crude oil and natural gas production, consumption pattern (Table 4.2 and Figure 4.2, 4.3) indicates the growing gap.

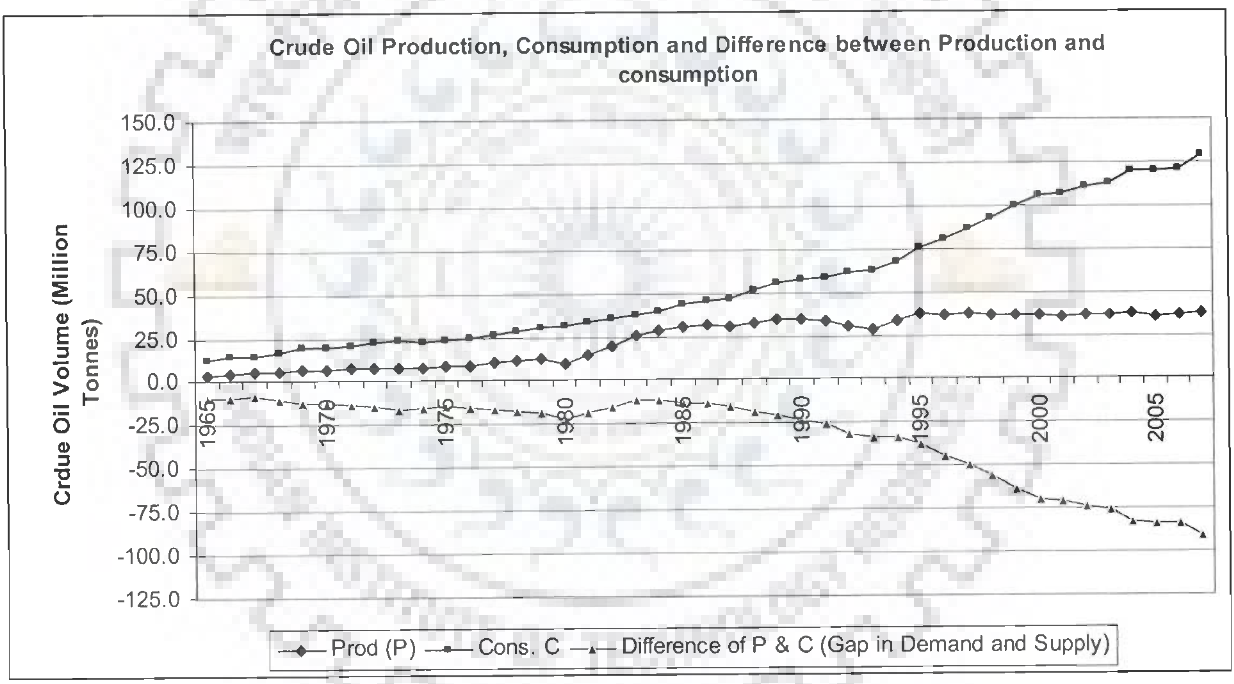


Figure 4.2 India – Crude oil production and consumption

(data source- BP statistical report 2008)

Year	Oil: Production (Million tonnes)	Oil: Consumption (Million tonnes)	GAP (Production - Consumption)	Natural Gas: Production (Million tonnes oil equivalent)	Natural Gas: Consumption (Million tonnes oil equivalent)	GAP (Production - Consumption)
1970	6.8	19.5	-12.7	0.5	0.5	0.0
1971	7.2	20.5	-13.3	0.6	0.5	0.1
1972	7.4	22.1	-14.7	0.6	0.5	0.1
1973	7.2	23.3	-16.1	0.6	0.5	0.1
1974	7.5	22.8	-15.3	0.7	0.7	0.0
1975	8.3	23.3	-15.0	0.9	0.8	0.1
1976	8.7	24.6	-15.9	1.1	1.0	0.1
1977	10.2	26.4	-16.2	1.2	1.0	0.2
1978	11.3	28.7	-17.4	1.3	1.2	0.1
1979	12.8	31.0	-18.2	1.4	1.2	0.2
1980	9.4	31.6	-22.2	1.2	1.1	0.1
1981	15.0	34.0	-19.0	1.7	1.6	0.1
1982	19.9	35.4	-15.5	2.3	2.1	0.2
1983	25.4	37.2	-11.8	2.8	2.4	0.4
1984	28.2	39.9	-11.7	3.4	2.9	0.5
1985	30.2	43.3	-13.1	4.0	3.5	0.5
1986	31.8	45.5	-13.7	5.6	5.5	0.1
1987	30.9	47.0	-16.1	6.7	5.7	1.0
1988	32.7	51.5	-18.8	7.7	6.6	1.1
1989	35.0	55.8	-20.8	9.3	9.6	-0.3
1990	34.8	57.9	-23.1	10.8	11.2	-0.4
1991	33.1	58.9	-25.8	12.2	12.2	0.0
1992	30.2	62.1	-31.9	13.8	13.8	0.0
1993	29.0	62.7	-33.8	14.3	14.3	0.0
1994	33.3	67.4	-34.1	14.9	14.9	0.0
1995	37.8	75.2	-37.5	17.4	17.4	0.0
1996	36.3	81.1	-44.8	18.5	18.5	0.0
1997	37.3	86.5	-49.2	20.7	20.7	0.0
1998	36.5	92.5	-56.0	22.2	22.2	0.0
1999	36.5	100.3	-63.8	23.3	23.3	0.0
2000	36.1	106.1	-70.0	24.2	24.2	0.0
2001	36.0	107.0	-71.0	24.5	24.5	0.0
2002	37.0	111.3	-74.3	25.9	25.9	0.0
2003	36.9	113.1	-76.2	26.9	26.9	0.0
2004	37.9	120.2	-82.3	27.1	29.5	-2.4
2005	36.2	115.7	-79.5	27.4	33.0	-5.6

Table 4.3 Gap in Production and consumption of crude oil and natural gas

(Data Source: BP Statistical estimates, 2005)

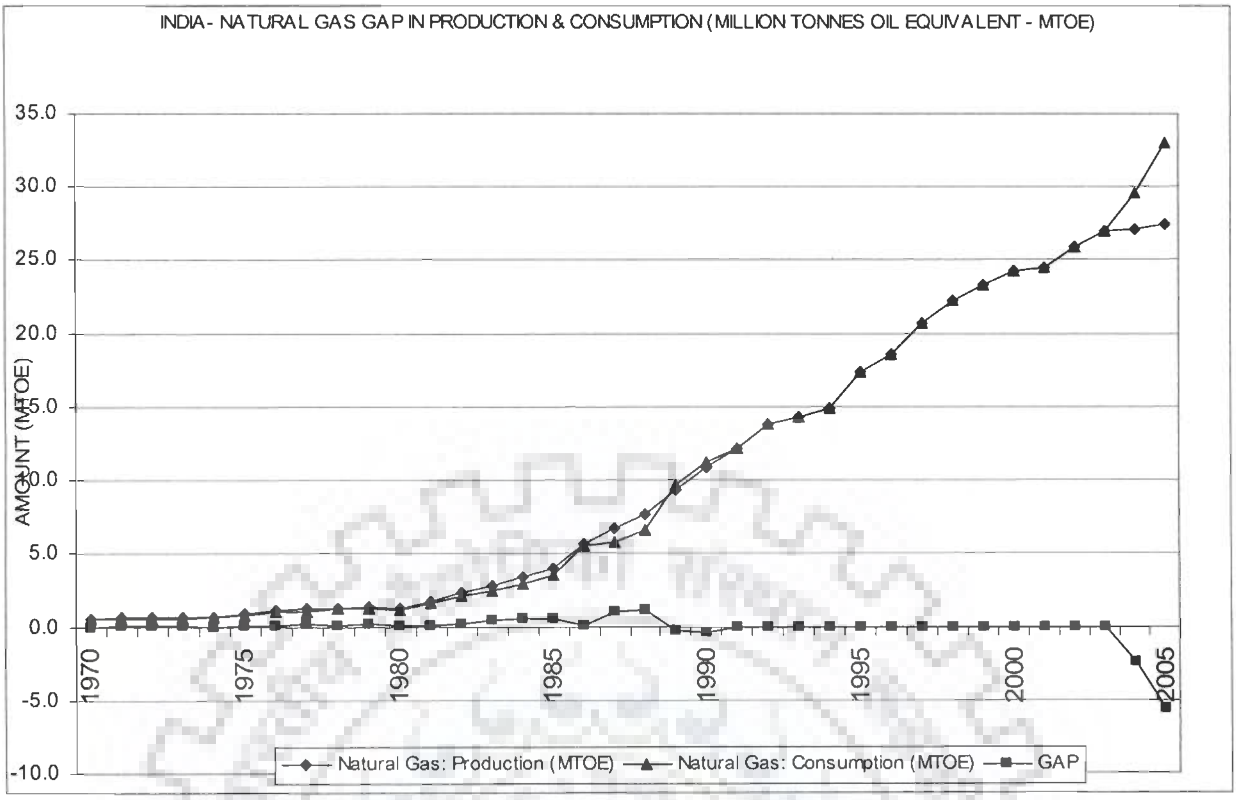


Figure 4.3 India – natural gas production and consumption

(data source- BP statistical report 2008)

4.2 ENERGY DEMAND - SUPPLY SCENARIO OF INDIA

India ranks sixth in the world in terms of energy demand accounting for 3.5 per cent of world commercial energy demand in 2001 (Tenth five year plan). Primary commercial energy demand grew almost three-fold at an annual rate of 6 per cent between 1981 and 2001, to reach 314.7 million tonnes of oil equivalent (MTOE) and with a gross domestic product (GDP) growth of 8 per cent, the energy demand is expected to grow at 5.2 per cent (Tenth five year plan). The projected requirement of commercial energy is estimated at about 412 MTOE and 554 MTOE in the terminal years of the Tenth and Eleventh Plans respectively (Table 4.4) and the commercial energy demand during the Tenth Plan and Eleventh Plan is estimated to grow at an average rate of 6.6 per cent and 6.1 per cent respectively (Tenth five year plan).

Primary fuel	Unit	Demand (in Original Units)		Demand (MTOE)	
		2006-07	**2011-12**	**2006-07**	**2011-12**
Coal	mt	460.50	620.00	190.00	254.93
Lignite	mt	57.79	81.54	15.51	22.05
Oil	mt	134.50	172.47	144.58	185.40
Natural Gas	BCM	47.45	64.00	42.70	57.60
Hydro Power	BKwh	148.08	215.66	12.73	18.54
Nuclear Power	BKwh	23.15	54.74	6.04	14.16
Wind Power	BKwh	4.00	11.62	0.35	1.00
Total Commercial Energy				411.91	553.68
Non-Commercial Energy				151.30	170.25
Total Energy Demand				563.21	723.93

Table 4.4 India - Energy Demand

(Adapted from Tenth Five Year Plan of India 2002-07 India, Chapter 7.3, pp 759-800)

(mt : Million Tonnes: BCM: Billion Cubic Meter; Bkwh: Billion kilo watt hour)

India registered oil demand growth of 100,000 bbl/d during 2006 and produced 648,000 bbl/d of crude oil and consumed an estimated 2.63 million bbl/d of oil (Figure 4.4) (EIA, 2007). The projected production of crude oil and natural gas are also meager in comparison to projected demand.

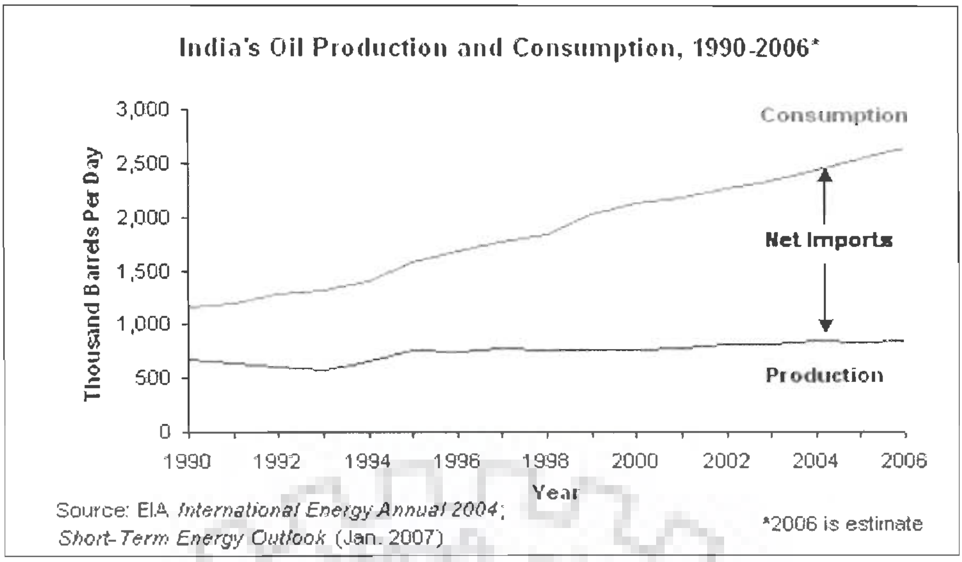


Figure 4.4 India's oil production and consumption scenario

Company	2007-08	2008-09	2009-10	2010-11	2011-12	TOTAL
			Production of Crude Oil (MMT)			
ONGC	27.16	28.00	29.00	28.53	27.37	140.06
OIL	3.50	3.55	3.73	3.91	4.30	18.99
Joint Venture / Private Companies	10.57	10.78	9.76	8.75	7.85	47.71
Total	**41.23**	**42.33**	**42.49**	**41.19**	**39.52**	**206.76**
Actual Production	**34.12**					
			Production of Natural Gas			
	(..........................		MMSCMD		..........................)	(BCM)
ONGC	60.55	61.73	62.38	62.99	60.27	112.39
OIL	8.58	8.79	8.90	8.99	9.75	16.43
Joint Venture / Private Companies	23.42	61.78	80.58	78.82	103.20	126.45
Total	**92.55**	**132.30**	**151.86**	**150.79**	**173.23**	**255.27**
Actual Production	**88.42**					

Source:Draft Eleventh Five Year Plan Document.

Table 4.5 Projected Production of Crude Oil and Natural Gas During 2007-2012 (Source: Website Ministry of Petroleum and Natural Gas, Government of India)

The demand for crude oil is likely to increase further during the next two decades. The transportation sector will be the main driver for the projected increase in oil demand. Consequently import dependence for oil, which is presently about 70 per cent, is likely to increase further during the Tenth and Eleventh Plans.

(Qty :'000' Tonne, Value : Rs.Crore)

ITEM	2004-05		2005-06		2006-07		2007-08*	
	Qty.	Value	Qty.	Value	Qty.	Value	Qty.	Value
A. Crude Oil	95861	117003	99409	171702	111502	219029	121672	272699
B. Petroleum Products								
I.Light Distillates	5391	9973	6074	14514	8005	21369	9462	29010
1. LPG	2334	4413	2719	6579	2278	5766	2829	8563
2. MS	233	501	485	1283	421	1326	326	1132
3. Naphtha	2214	4029	2473	5735	5306	14277	5965	18401
4. Propane/MTBE	610	1030	397	917	0	0	342	914
II.Middle Distillates	1027	2047	1615	3948	2392	6938	5424	17507
1.ATF	3	14	2	11	2	17	3	20
2.SKO	210	429	881	2214	1423	4250	2489	8324
3.HSD	814	1604	732	1723	967	2671	2932	9163
III.Heavy Ends	2410	2868	3988	7113	7263	12853	7830	29926
1.FO / LSHS	741	692	789	1099	2983	5174	1241	2300
2.Lubes / Others[#]	1669	2176	3199	6014	4280	7679	6589	27627
Total(B)	8828	14888	11677	25575	17660	41160	22716	76443
Grand Total(A+B)	104689	131891	111086	197277	129162	260189	144388	349142

Table 4.6 India – Import of Crude oil and petroleum products

(Source: Website Ministry of Petroleum and Natural Gas, Government of India)

4.3 CRUDE OIL RESERVES OF INDIA

India had 5.6 billion barrels (approx) of proved crude oil reserves as of January 2007 (Figure 4.5) which is about 0.4 per cent of the world's proven reserves of crude oil (Table 4.7 and 4.8).

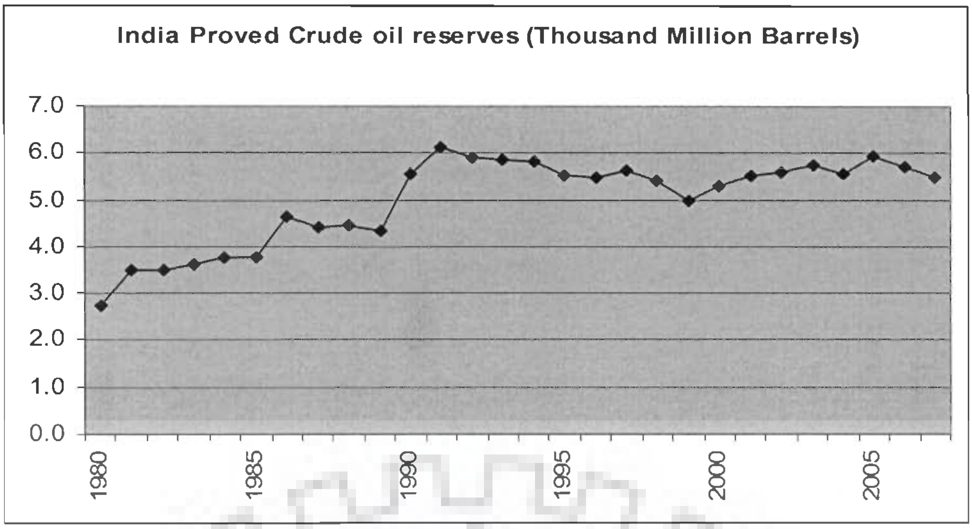


Figure 4.5 India Proved Reserves of crude oil (Source : BP Statistical Review 2008)

	1990	2000	2002	2003	2004	2005	2006	2007
CRUDE OIL (Million Metric Tonnes)								
Onshore	307	317	332	339	357	376	387	357
Offshore	432	386	409	422	382	410	369	368
Total	**739**	**703**	**741**	**761**	**739**	**786**	**756**	**725**
NATURAL GAS (Billion Cubic Metres)								
Onshore	229	299	315	327	339	340	330	270
Offshore	457	461	436	527	584	761	745	785
Total	**686**	**760**	**751**	**854**	**923**	**1101**	**1075**	**1055**

Note: The oil and natural gas reserves (proved and indicated) data relate to 1st January for the year 1990 and thereafter 1st April of each year.

Source: ONGC, OIL and DGH.

Table 4.7 India – Oil and Natural Gas Reserves

(Source: Website Ministry of Petroleum and Natural Gas, Government of India)

Item	Unit	1990	2000	2002	2003	2004	2005	2006	2007*
1. World Reserves :									
Oil & Gas at year end									
(i) Crude Oil	Bn. Tonne	136.5	142.7	156.7	161.8	163.6	165.0	164.5	168.6
of which OPEC	"	105.1	111.1	120.4	121.6	123.2	123.5	123.6	127.6
(ii)Natural Gas	Tr.Cu.ft.	4209	5302	6205	6226	6348	6361	6405	6263
of which OPEC	"	1735	2343	3106	3154	3127	3118	2961	3259
2. World Prodn. of Oil & Gas									
(i) Crude Oil	Mn. Tonne	3180	3618	3576	3701	3863	3897	3914	3906
of which OPEC	"	1199	1560	1438	1523	1644	1692	1702	1681
(ii)Natural Gas Net	Bn.Cu.Mtr.	1991	2427	2526	2619	2704	2776	2872	2940
of which OPEC	"	211	384	415	433	460	501	520	543
3. World Oil Refinery									
(i) Refinery capacity at year end	Mn. Tonne/ Year	3728	4079	4137	4167	4232	4266	4331	4378
(ii)Crude throughput	Mn. Tonne	3099	3430	3446	3539	3636	3693	3718	3762
4. World Oil Consumption									
(i) World Total	Mn. Tonne	3135	3559	3611	3681	3824	3871	3911	3953
(ii)Main consuming areas !	"	1886	2101	2119	2160	2252	2257	2262	2711
(iii)Consumption in main areas as % of world	%	60.2	59.0	58.7	58.7	58.9	58.3	57.8	68.6
5. World Imports/Exports									
(i) Crude Oil	Mn.Tonne	1188	1661	1667	1770	1855	1885	1933	1984
(ii)Pol. Products	"	363	451	486	491	526	576	658	717
Total	"	**1551**	**2112**	**2153**	**2261**	**2381**	**2461**	**2591**	**2701**
6. Export of Crude Oil/ Pol. from OPEC									
(i) Crude Oil	"	797	1020	881	950	1075	1131	1161	N.A
(ii)Pol. Products	"	176	221	199	201	211	220	223	N.A
Total	"	**973**	**1241**	**1080**	**1151**	**1286**	**1351**	**1384**	N.A
7. World Primary Energy Consumption	Mn. Tonne								
(i) Oil	Oil Eqv.	3135	3556	3607	3675	3814	3861	3911	3953
(ii) Natural Gas	"	1771	2193	2286	2342	2435	2512	2558	2638
(iii)Coal	"	2245	2364	2437	2633	2806	2957	3042	3178
(iv) Hydro-Electric	"	189	610	608	608	643	667	697	709
(v) Nuclear Energy	"	517	585	611	599	625	627	635	622
Total	"	**7857**	**9308**	**9549**	**9857**	**10323**	**10624**	**10843**	**11100**

! : Includes USA, Germany, France, Italy, U.K., Japan, China, Russia, India and South Korea.

Table 4.8 International Petroleum Statistics

(Source: Website Ministry of Petroleum and Natural Gas, Government of India)

4.4 NATURAL GAS SCENARIO OF INDIA

Natural gas is a distant third energy resources (the other two being coal and oil) in terms of India's current energy use, accounting for only 8.5% share of the country's energy needs (Zobaa, 2005). Natural gas, however, could have become a potentially important resources in the future (Zobaa, 2005). India possess 0.5% of world proven gas reserves, amounting to approximately 0.92 trillion cubic meters (TCM). Natural gas is fast replacing other fuels in India. About 34% of Indian Natural gas production is used to produce electricity, the rest is absorbed in the production of fertilizer and petrochemical processes (IEA, World Energy Outlook 2000). In the future, gas use will grow fastest and will be multiplied three times by 2020 with most of it being used in power generation (IEA, March 2000). Natural gas domestic production vis-à-vis consumption pattern of India (Table 4.3 and Figure 4.6) suggests that the gap between production and consumption is increasing from 2004, and the demand – supply gap is widening gradually.

India imports LNG from Oman, Qatar, and Australia and during 2005 the import was 0.08, 5.80 and 0.16 billion cubic meters respectively. Forecast of growth in demand suggests that 20-25 million tons per year of LNG could be imported into India by 2010 (Zobaa, 2005). India will continue to import LNG in the short to medium term to close its demand gap, and is already moving to develop the necessary infrastructure (Stein Tonnesson and Asild Kolas, 2006).

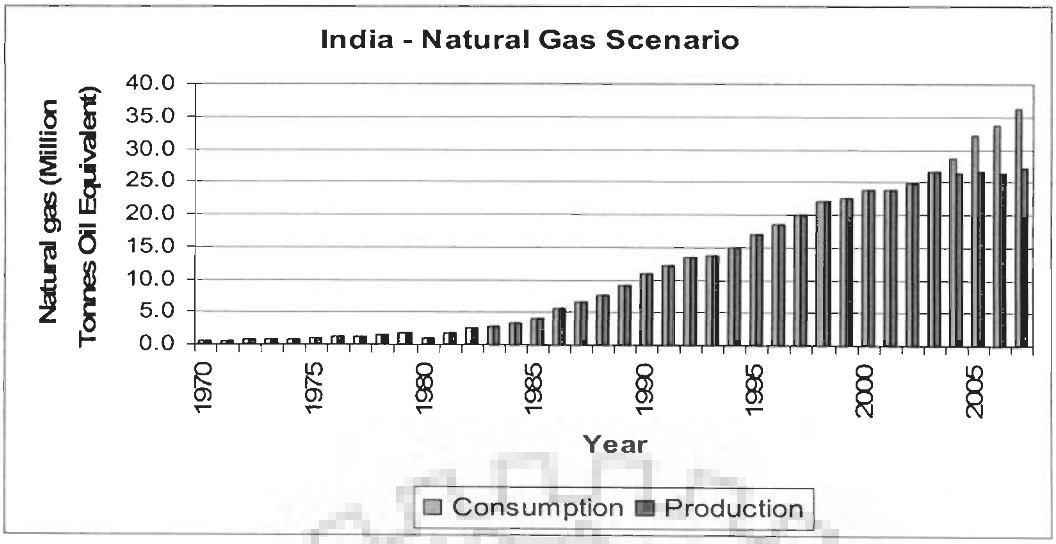


Figure 4.6: Natural gas production – consumption of India

(Data : BP Statistical Review, 2008)

Thus, the natural gas scenario of India projects increased import dependence and like crude oil calls for concerted efforts to sustain the Indian economic growth trajectories.

4.5 INDIA'S CONCERN FOR ENERGY SECURITY

The Indian economy continues to show impressive economic growth (Table 4.10). The country's real gross domestic product (GDP) grew at an impressive rate of 9.1 percent during the first half of fiscal 2006 (April – September 2006). Together with the country's impressive growth, India has also become a significant consumer of energy resources. India's commercial energy demand is expected to grow even more rapidly than in the past as it goes down the reform path (Table 4.9).

	Year		
Energy source	**2000**	**2010**	**2020**
Coal (Million Tons)			
Demand	393.3	569.2	872.3
Production	393.3	569.2	867.6
Imports	-		4.8
Oil (Million Tons)			
Demand	105.0	195.8	297.3
Production	37.2	41.5	45.7
Imports	67.7	154.3	251.5
Gas (Billion Cubic Meter)			
Demand	26.5	86.0	184.9
Production	26.5	17.7	14.1
Imports	-	68.3	170.8

Table 4.9 India-energy demand & supply (Source: TERI)

Indicator	Unit/base	1990-91	2000-01	2003-04	2004-05	2005-06	2006-07	2007-08*
1. Geographical Area	M.Sq.Km.	3.29	3.29	3.29	3.29	3.29	3.29	3.29
2. Population	Million	839	1019	1072	1089	1106	1122	1138
3. Gross National Product								
at factor cost :								
(i) At current prices	Rs.Billion	5034	19022	25199	28553	32496	37603 Q	43037
(ii) At constant prices+	"	6837	18418	22049	23669	25932	28452 Q	31229
4. Net National Product								
at factor cost :								
(i) At current prices	Rs.Billion	4501	17005	22399	25264	28708	33258 Q	37895
(ii) At constant prices+	"	6142	16479	19635	21045	23069	25305 Q	27677
5. Per Capita Net								
National Product :								
(i) At current prices	Rupees	5365	16688	20895	23199	25956	29642 Q	33299
(ii) At constant prices+	"	7321	16172	18317	19325	20858	22553 Q	24321
6. Foreign Exchange Reserves								
(i) Gold++	Rs.Billion	68.28	127.11	182.16	196.86	256.74	29.573	33.151 >
(ii) SDR	Mn. of SDRs.	76	2.0	2.0	3.0	2.0	1.0	2.0 >
(iii) Foreign Exchange	Rs.Billion	43.88	1844.82	4662.15	5931.21	6473.27	8365.97	10501.65 >
Foreign Exchange Rate	Rs./US$	17.94	45.68	45.95	44.93	44.27	42.25	N.A
7. Foreign Trade :								
(i) Import	Rs.Billion	431.98	2308.73	3591.08	5010.65	6604.09	8405.06	9491.34
(ii) Export	"	325.53	2035.71	2933.67	3753.4	4564.18	5717.79	6254.71
(iii) Balance of Trade	"	-106.45	-273.02	-657.41	-1257.25	-2039.91	-2687.27	-3236.63
8. Index of Production :								
(i) Agricultural	@	148.4	165.7	183.0	177.3	191.6	197.1	N.A.
(ii) Industrial	1993-94=100	212.6***	162.6	189.0	204.8	221.5	247.1	N.A.
9. Wholesale Price Index :	1993-94=100	73.7	155.7	180.3	189.5	197.2	210.4	215.7
10. Consumer Price Index:								
(i) Industrial Workers	1982=100	193	444	504	525	551	588	134 $
(ii) Agricultural Labourers	1986-87=100	803**	300	332	340	358	392	413 $
(iii) Urban non-manual workers	1984-85=100	169	377	424	441	463	498	518 $
11. Employment : !								
(i) Public Sector	Million	19.06	19.14	18.20	18.07	N.A.	N.A.	N.A.
(ii) Private Sector	"	7.68	8.65	8.25	8.45	N.A.	N.A.	N.A.
Total	"	26.73	27.79	26.44	26.46	N.A.	N.A.	N.A.
No. of persons on live register								
of employment exchange	Million	34.89	41.23	41.39	42.00	N.A.	N.A.	N.A.
12. Energy Generation (Gross) :								
Coal	Mn.Tonne	211.73	309.63	361.25	382.61	407.40	430.85	266.71 <
Lignite	"	13.77	22.95	27.96	30.34	30.06	31.13	20.27 <
Natural Gas	Bn.Cub.Mtr.	17.998	29.477	31.962	31.763	32.202	31.747	32.274
Crude Oil	Mn.Tonne	33.02	32.43	33.37	33.98	32.19	33.988	34.117
Petroleum Products(Incl RBF)	"	51.27	102.51	121.70	127.12	128.88	146.18	155.67
13. Electricity Generated (Gross)								
(i) Utilities								
Hydel	B.KWH	71.7	74.5	75.2	84.6	99.9	113.4	N.A.
Thermal	"	186.5	408.1	472.1	492.8	506	535.5	N.A.
Nuclear	"	6.1	16.9	17.8	17	17.3	18.6	N.A.
Total	"	264.3	499.5	565.1	594.4	623.2	667.5	N.A.
(ii) Non-utilities	"	25.1	55.0	68.2	71.4	73.6	76.8	N.A.
Grand Total	"	289.4	554.5	633.3	665.8	697.4	744.3	N.A.

$: As on December-2007 <:As on Nov., 2007.

* : Provisional. **: Old base 1960-61=100 Q : Quick Estimates.

@ : Triennium ending 1981-82 + : Figures upto 1998-99 are based on old series at 1993-94 prices and from 2000-01 onwards are based on 1999-2000 prices.

! : As on 31 March

>:Apr-Nov.,2007-08 ++ : Gold is valued at Rs. 84.39 per 10 gms from May 1966 upto Sept. 1990 and closer to international market prices w.e.f. Oct. 17, 1990.

: November-March.

Source : Economic Survey, RBI, Ministry of Statistics/Industry/Finance ***: Based on 1980-81=100

Table 4.10 Indian Economy At A Glance
(Source: Website Ministry of Petroleum and Natural Gas, Government of India)

4.5.1 Vulnerability of India to crude oil price

Vulnerability of India to crude oil price is another issue of concern. India being a net importer of crude oil is vulnerable to crude oil price. The ratio of crude oil imports to GDP provides an index to the likely vulnerability to oil price (Bacon, 2005). The ration can be expressed in terms of three component parts:

$$\textbf{Oil imports} \div \textbf{GDP} = (\textbf{Oil import} \div \textbf{total oil use}) \times (\textbf{total oil use} \div \textbf{total energy use}) \times (\textbf{total energy use} \div \textbf{GDP})$$

Oil imports/ total oil use = 1- self sufficiency in crude oil production

Total oil use/ total energy use = dependence on crude oil as energy source

Total energy use/ GDP = energy intensity

Following equation describes "self-sufficiency index" for crude oil

$$\textbf{Self sufficiency index} = \frac{\textbf{National Consumption of oil} - \textbf{National Production of oil}}{\textbf{National Consumption of oil}}$$

The negative values of self sufficiency index indicate a country to be more than self sufficient, a value of zero indicates just self sufficient and value of one indicates complete import dependency. We have attempted to derive these indices for India (Table 4.11).

		2001	2002	2003	2004	2005	2006	2007
Crude Oil Production (Million Tonnes)		36.02	36.98	36.90	37.77	35.98	37.01	37.33
Crude Oil Consumption Million Tonnes		106.96	111.26	113.07	120.15	119.58	120.41	128.53
Crude Oil Import Million Tonnes		74.10	81.99	90.43	95.86	99.41	111.50	121.67
Total Energy Use (Million Tonnes Oil Equivalent)		296.50	307.83	316.23	343.85	362.19	378.51	404.42
GDP		3.80	4.60	6.90	7.90	9.10	9.75	9.20
Crude oil import / GDP	Vulnerability to crude oil shock	19.50	17.82	13.11	12.13	10.92	11.44	13.23
(1-Self Sufficiency In Crude Oil Production)	(Crude Oil Import / Total Crude Oil Use)	0.69	0.74	0.80	0.80	0.83	0.93	0.95
Self sufficiency in Crude oil production	1-(Crude Oil Import / Total Crude Oil Use)	0.31	0.26	0.20	0.20	0.17	0.07	0.05
Dependence on Crude oil as an Energy Source	Total crude oil Use/ Total Energy Use	0.36	0.36	0.36	0.35	0.33	0.32	0.32
Energy Intensity	Total Energy Use/ GDP	78.03	66.92	45.83	43.53	39.80	38.82	43.96
Self sufficiency Index	(National Consumption of oil – National Production of oil)/ National Consumption of oil	0.663	0.6676	0.674	0.686	0.699	0.693	0.71

Table 4.11 Index of vulnerability to crude oil price and Self Sufficiency Index

(Data source BP Statistical Review)

The Self Sufficiency Index for India is less than one during 2001 to 2007, which is a matter of concern. It can be improved by discovery and production of domestic supplies of crude oil to minimize import, by securing equity oil abroad and by increasing energy efficiency and by other energy sources. These factors provide guidelines for policy and decision making.

4.5.2 Crude Oil Security issues

India is a growing net importer of oil and the dependence on oil imports is expected to increase (Table 4.3). Undoubtedly, the country will faces serious energy shortages leading to increased imports for meeting the demand of crude oil. There is a meager 'domestic crude oil reserve addition" during last two decade. Moreover, there is declining production from existing oil fields. These multi-factor convergences pose a serious threat to sustenance of Indian economy. The dynamics of multifaceted progression path which this nascent, but, rapidly emerging nation has embarked after liberalization and globalization of economy put forward challenge for energy security issues. Sustained energy supply is vital for India's rapidly developing economy. There is a convergence of belief that at the present level of domestic production, India will be import dependent for its energy requirement, and the share of import will increase manifold, unless some significant domestic discoveries of oil/gas is made or there is an initiative to get energy supplement from overseas resources.

This is a matter of concern from the point of view of energy security, more particularly crude oil and natural gas security. It has been argued that some measures are urgently required to be taken up to ensure energy security. With its one billion inhabitants and limited energy resources, India has no other choice than to resort to international oil and gas markets for its energy supply (IEA, March 2000).

Item	Unit	2000-01	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08*
1. Reserves !								
(Balance Recoverable)								
(i) Crude Oil	Mn.Tonne	703	741	733	739	786	756	725
(ii) Natural Gas	Bn.Cub.Mtr.	760	751	854	923	1101	1075	1055
2. Consumption								
(i) Crude Oil (in terms of refinery crude throughput)	Mn.Tonne	103.44	112.56	121.84	127.42	130.11	146.55	156.1
(ii) Petroleum Products (excl. RBF)	"	100.07	104.13	107.75	111.63	113.21	120.75	118.83
3. Production :								
(i) Crude Oil	"	32.43	33.04	33.37	33.98	32.19	33.988	34.117
(ii) Petroleum Products	"	95.61	104.14	113.46	118.58	119.75	135.26	144.93
(iii) LPG from natural gas	"	2.04	2.37	2.32	2.24	2.19	2.09	2.06
4. Imports & Exports								
(i) Gross Imports :								
(a) Qty : Crude Oil	Mn.Tonne	74.10	81.99	90.43	95.86	99.41	111.5	121.67
Pol. Products	"	9.27	7.23	7.90	8.83	11.68	17.66	22.72
Total (a)	"	83.37	89.22	98.33	104.69	111.09	129.16	144.39
(b) Value:Crude Oil	Rs.Billion	659.32	761.95	835.28	1170.03	1717.02	2190.29	2726.99
Pol.Products	"	120.93	88.47	96.77	148.87	255.75	411.6	764.43
Total (b)	"	780.25	850.42	932.05	1318.90	1972.77	2601.89	3491.42
Pol. Imports as per DGCI&S	"	714.97	853.67	945.20	1340.94	1946.4	2582.59	2839.49 **
(ii) Exports :								
(a) Qty :								
Pol. Products	Mn.Tonne	8.37	10.29	14.62	18.21	21.51	33.62	39.33
(b) Value:								
Pol.Products	Rs.Billion	76.72	108.68	167.81	299.28	467.85	810.94	1076.03
(iii) Net Imports :								
(a) Qty : Crude Oil	Mn.Tonne	74.10	81.99	90.43	95.86	99.41	111.50	121.67
Poi. Products	"	0.90	-3.06	-6.72	-9.38	-9.83	-15.96	-16.61
Total (a)	"	75.00	78.93	83.71	86.48	89.58	95.54	105.06
(b) Value:Crude Oil	Rs.Billion	659.32	761.95	835.28	1170.03	1717.02	2190.29	2726.99
Pol.Products	"	44.21	-20.21	-71.04	-150.41	-212.10	-399.34	-311.60
Total (b)	"	703.53	741.74	764.24	1019.62	1504.92	1790.95	2415.39
(iv) Unit Value of Crude oil imports(gross)	Rs./MT	8898	9293	9237	12206	17272	19644	22413
5. India's Total Exports	Rs.Billion	2035.71	2551.27	2836.05	3753.4	4564.18	5717.79	6254.71
6. Pol. imports as percentage of India's total exports								
(i) Gross Imports	%	38.3	33.3	32.9	35.1	43.2	45.5	55.8
(ii) Net Imports	%	34.6	29 1	26.9	27.2	33.0	31.3	38.6
7. Contribution of Oil Sector to Centre/State Resources								
(i) Royalty from crude oil	Rs.Billion	22.72	30.67	31.74	42.71	50.67	58.57	N.A.
(ii) Royalty from gas	"	6.08	7.78	8.54	8.29	8.637	10.75	N.A.
(iii)Oil Development Cess	"	27.28	50.91	51.43	55.37	51.96	71.77	N.A.
(iv) Excise & Custom duties	"	359.12	451.27	507.33	563.95	631.43	718.93	N.A.
(v) Sales Tax	"	233.75	297.41	328.49	390.00	459.34	530.86	N.A.
(vii)Dividend	"	34.82	67.94	63.1	94.36	718.93	115.27	N.A.
8. Natural Gas :								
(i) Gross Production	Bn.Cub.Mtr.	29.477	31.389	31.962	31.763	32.202	31.747	32.274
(ii) Utilisation	"	27.860	29.963	30.906	30.775	31.025	31.368	34.328

* : Provisional. ! : As on 1st April of initial year. **: Apr.07 to Feb.08 N.A.: Not Available.

Table 4.12 Indian Petroleum Industry at A Glance
(Source: Website, Ministry of Petroleum and Natural Gas, Government of India)

4.6 EFFORTS TOWARDS CRUDE OIL SECURITY

The Indian Ministry of Petroleum and Natural Gas (MOPNG) states that the demand and supply projection are indicative of further decline in self-sufficiency of crude oil, which calls for intensification of exploration activity in the country, so that domestic reserves could be added to maintain crude oil and gas production. There is a requirement for acquiring additional reserves of equity crude oil from global destinations as well.

4.6.1 Domestic effort

Intensification of exploration activity can add domestic crude oil reserves and lead to self-sufficiency. The situation justified private sector participation (domestic and foreign) in the exploration and exploitation of petroleum. India resorted to attract foreign investors in petroleum business for more than two decades. Following deals the saga of Indian efforts in this regard, efforts to attract private investment (domestic and foreign) to invest in petroleum exploration in India.

4.6.1.1 Intensive exploration

India is relatively unexplored from hydrocarbon point of view and the only a little hydrocarbon reserves has been established. According to MOPNG, India is one of the least explored regions, with vast expanse of unexplored onshore and offshore. Out of 3.14 million square kilometer of estimated sedimentary area, only 1.09 million square kilometer is held under petroleum exploration licenses. The frontier area like mountainous region of Himalayas of northern and north eastern India is still unexplored (Figure 4.7). The geological global analogs of these provinces like the sub-Andean province of Chile, Peru, Argentina, Ecuador, Columbia, and Venezuela have demonstrated hydrocarbon potential and prospectivity. India is fortunate to have vast coast line. The adjacent coastal, shallow and deep water provinces of India can be explored for oil and gas. The geological analog of these basins in several global provinces have established oil and gas potential.

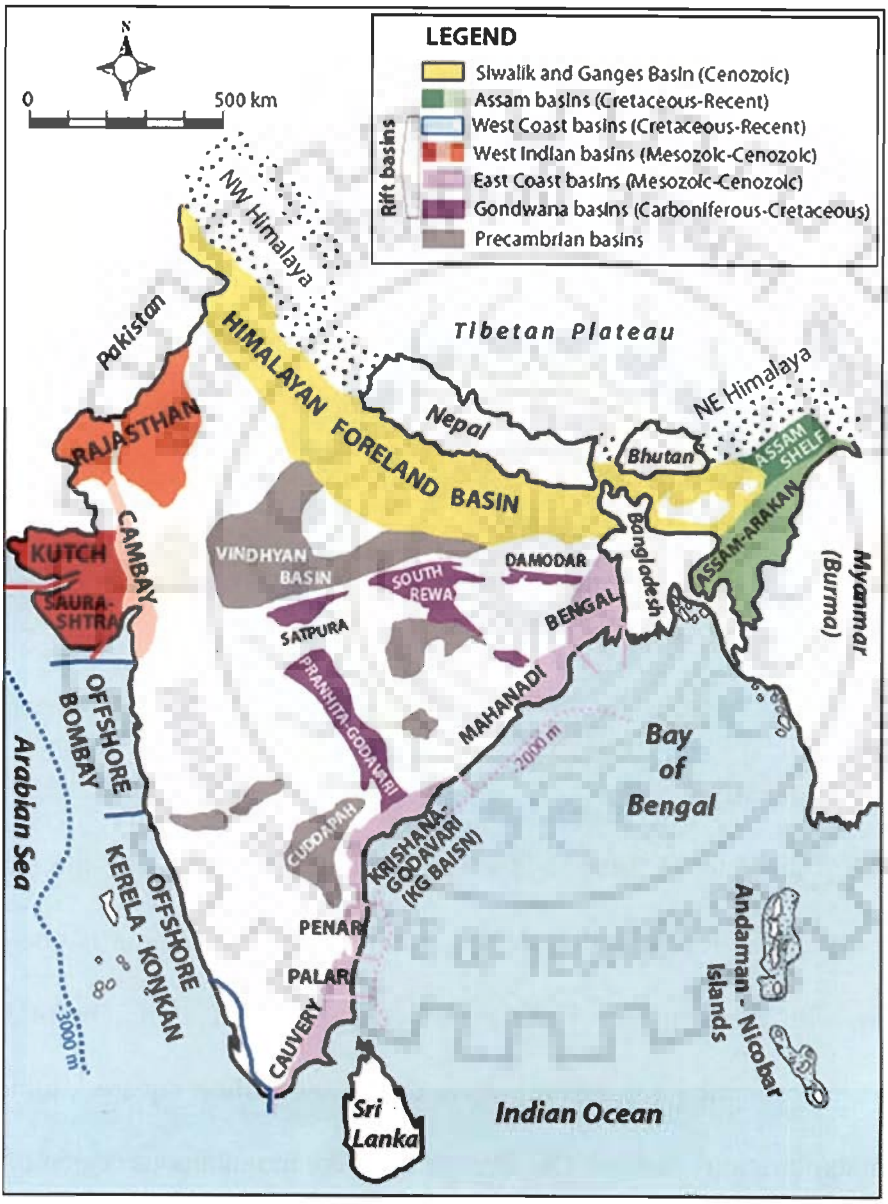


Figure 4.7 India - Sedimentary Basins

4.6.1.2 Requirement of Risk capital

Immense capital investments are necessary for intense exploration of hitherto unexplored, under-explored, frontier and deep water provinces. As per an estimate by the government, by 2010 the investment requirement in exploration and production will be about $7-8 billion. The MOPNG believe that there is need to attract both the domestic National Oil Companies (NOCs), as well as, private sector oil companies (both domestic and foreign) to invest in this critical area to increase domestic oil exploration and production activities.

4.6.1.3 Liberalization, Privatization and Deregulation

A series of policy changes and reforms in the petroleum sector were initiated in the year 1991, e.g. private investment in development of oil and gas fields as well as in refining; deregulation of imports and marketing of certain petroleum products; greater marketing autonomy for gas distribution companies; development of a more transparent pricing structure for oil and gas producers; and creation of the Directorate General of Hydrocarbons (DGH), which has regulatory and supervisory responsibility over public and private sector exploration and production. Another significant development was the reform of the pricing of petroleum products and natural gas.

The policy to promote private participation is guided by the need for attracting additional investment, introduction of better technology and competitiveness. The Restructuring Group for the Oil sector (R-Group) has estimated an investment of about US $ 100 billion in the petroleum and natural gas sector up to the year 2010 for ensuring the security of oil and gas supplies to various sectors of economy. In this background, Ministry of Petroleum and Natural

Gas, in order to attract larger private participation has launched a New Exploration Licensing Policy (NELP) in the upstream sector in 1999. With the launching of NELP, Indian upstream oil sector offers attractive investment opportunity to the companies seeking interests in exploration and production in India. In down stream oil sector, refining and marketing operations have been opened to private sector. As per the Government of India policy initiatives, Foreign Direct Investment (FDI) is allowed in the exploration of crude oil and natural gas, in refining and marketing. In upstream sector, as per the NELP up to 100 percent FDI is permitted. The structural reform is being considered in the form of providing regulatory mechanism so that the functions of regulator and controller can be separated. Some of the major steps taken towards liberalization, privatization and deregulation of petroleum sector is discussed.

i. Disinvestment

The Government has initiated disinvestment of its share of equity in upstream as well as downstream public sector companies as an important step in the process of deregulation and restructuring of oil sector. However, the process has been slow because of one or the other reason like persisting depression in the international market and opposition from some quarters.

ii. Integration of Upstream and down stream business

There is a suggestion for horizontal integration of upstream and downstream public sector companies. It is based on the premise that assured returns from downstream business should be ploughed to provide for exploration risk capital. It will facilitate the national oil companies in upstream business to enter into downstream business of hydrocarbon value chain.

iii. Delicensing in the petroleum sector

The economic reforms, initiated in 1991, further seek to delicense the industry, remove procedural bottlenecks and encourage private sector initiatives for supplementing and speeding up economic growth. The Government has started bidding of exploration blocks for bidding by the domestic and foreign companies.

iv. Reforms in Downstream Sector

The Government has delicensed the refining and marketing sector. Since July 1998, private and joint sector refineries have been allowed to import crude oil for their requirements. The Government has also come up with following policy initiatives in refining and marketing sectors.

- The setting up of new grass root refineries by private sector either on their own or as joint ventures with downstream sector public sector undertakings (PSU).
- Setting up of lube refineries by private sector.
- Parallel marketing of petroleum products by private sector.
- The oil sector public sector undertakings may also form joint ventures among themselves and with Indian and foreign companies.

Marketing rights have been given to a promoter bringing in a minimum investment of Rupees two hundred crores for setting up grass root refineries. This minimum investment may be in terms of equity and debt. Since there is a cap of twenty six (26) per cent foreign equity holding, so debt has also been allowed to be included in the minimum investment.

v. Introduction of The Petroleum Tax Guide, 1998

This guide is a compilation of provisions of law relating to income tax, custom duty, central excise, cess, royalties and license or lease fees as applicable to the process of prospecting for or extraction of production of petroleum which also includes natural gas existing in natural condition under Production Sharing Contracts entered in to on or after 1 January 1999 in terms of New Exploration Licensing Policy (NELP). This guide will help in better understanding of tax structure and aims at attracting private investment in the petroleum sector.

vi. Dismantling of Administered Price Mechanism

The prices of petroleum products in India were fixed for a long time under an Administered Pricing Mechanism (APM) based on the retention price concept under which the oil refineries and oil marketing companies were compensated for operating costs and are assured a return of 12 per cent post tax on net worth. As per notification issued by the Government, the APM has been dismantled by the year 2002 to make the petroleum sector competitive and market driven.

In 1997, the Government decided to dismantle the administered price mechanism for petroleum products in a phased manner by the financial year 2002. The Government also revised the gas pricing by linking the consumer price for natural gas to a percentage of the prevailing prices of a basket of fuel oils, and further review of the pricing formula will be undertaken to bring the price of gas on full parity with fuel oil.

vii The Petroleum Regulatory Board Bill, 2002

The Petroleum Regulatory Board Bill, 2002 has been introduced in the Parliament. The Petroleum Regulatory Board Bill 2002 for regulating transmission, distribution, supply and storage system for natural gas/LNG and to promote development of the sector. The Regulator would ensure access to the gas pipelines on non-discriminatory common carrier principle for all users. It would also approve pipeline tariff for the common carrier pipelines. Till the Regulatory Board is set up, the Government would perform functions of the Regulator.

viii Establishment of Regulatory authority

Establishment of Directorate General of Hydrocarbons (DGH) in 1993 was another landmark event. It was constituted to coordinate the administration of production sharing contracts executed for small and medium size fields and exploration blocks and takes in to account the profit oil and cost oil. The bidding rounds under NELP are being carried on and looked after by the DGH. It maintains national database, and deals with upstream oil activity.

4.6.1.4 Private Participation in Crude oil Business

The private participation in Indian upstream oil sector was introduced in 1980 when the Government offered blocks for exploration in bidding. Since then, bids from private companies are being invited on regular basis. A number of medium, small and marginal fields have been offered for private sector participation. It is providing the much-needed risk capital required for the exploration business, helping to infuse new technology input. It has resulted to further exploratory effort. Furthermore, the economic reforms initiated in 1991 by the Government of India intended to delicense the industry and persuade private sector participation for supplementing and speeding up growth by offering petroleum acreages in bid-rounds. As a result of this initiative, India resorted to systematic efforts to attract private investment in the field of exploration and production in 1991. India may opt prospective de-monopolization, allowing people to invest only in new opportunities, to restructuring in the form of conveying certain existing opportunities for fields, refineries (Figure 4.8) to meet the future demand (Atmananad, 2000). Moore (1996) evaluated different options (Figure 4.9) and suggested that privatization produces more competition, generates more capital and higher government take (Atmanand, 2000). The progression of Indian effort towards exploration of its domestic province for exploitation of crude oil and natural gas can be broadly categorized into five phases (Table 4.13).

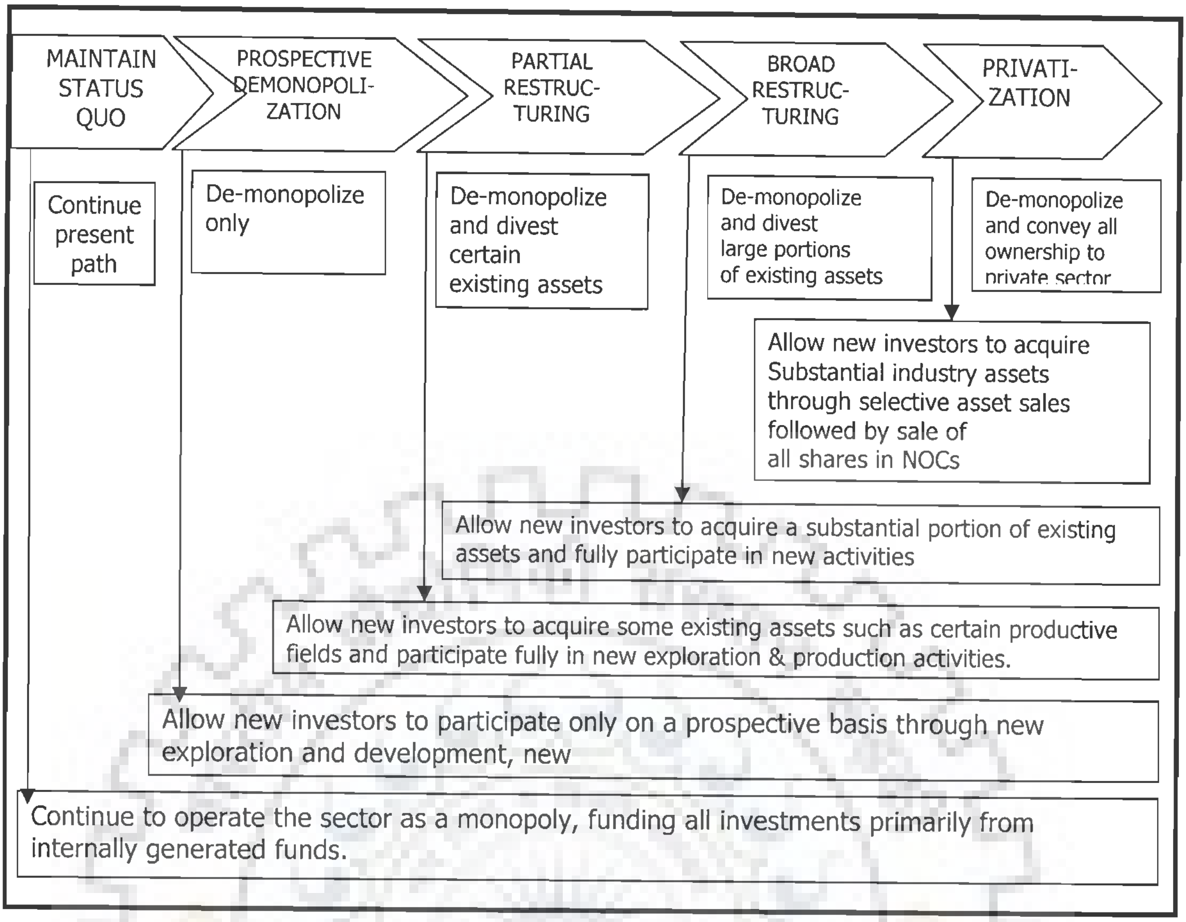


Fig. 4.8 Option for the government (Source: Atmananad, 2000)

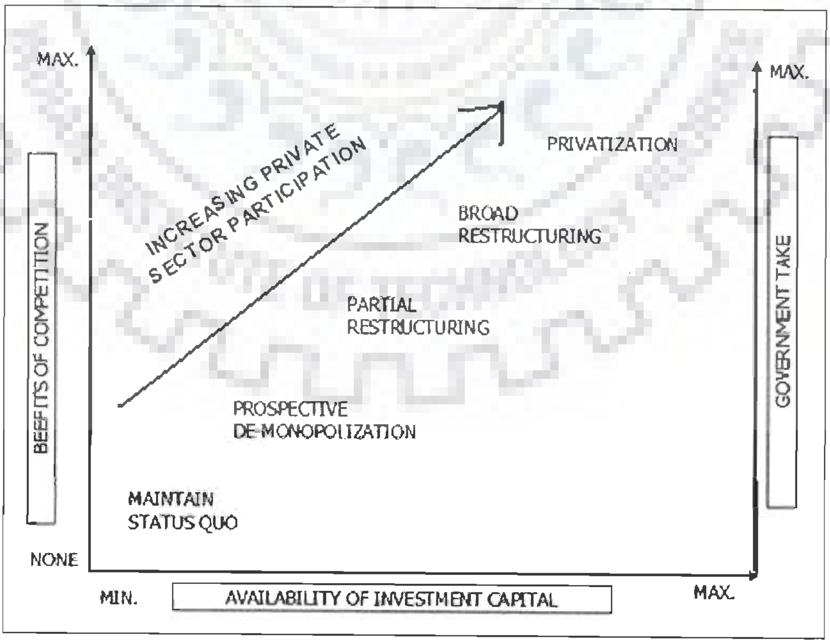


Figure 4.9 Benefits of competition. (After Atmanand, 2000)

Period	1948	1948-1969	1970-1989	1990- 1998	1999 - contd.
Phase	Petroleum industry controlled by Anglo-American company.	Early phase	Development phase	Economic liberalization phase	New Exploration Licensing (NELP) Phase
Event	Development of petroleum industry kept reserved for government sector. Industrial policy resolution (1948) adopted by Government of India (GOI).	Industrial policy resolution (1956) adopted by India. GOI consolidated its control over Indian petroleum industry with Soviet assistance	US companies played dominant role		Create a globally contractual and fiscal environment
Concern	Lack of financial, and technical resource prohibited state to take up activities	To have active role of state, restrict private sector, and shun foreign involvement in petroleum industry.	1973, 1979 - Rise of oil prices.	Speed up petroleum exploration in India.	Earlier attempts to attract private participation not successful
Options	Invite foreign assistance or play dominant role on its own for exploration of hydrocarbon	Reserve future activities in petroleum sector for state/ public sector enterprises.	1. Slow petroleum exploration activity due to lack of resources, 2. Increase indigenous production 3. Intensify exploration efforts to meet growing energy demand. Attract private investment.	Delicense industry and influence private sector participation by offering petroleum acreages in bid-rounds.	Liberalize the terms and provide level playing field at par to domestic players and improve the decision making process.
Action	Industrial policy Resolution (1948) of GOI implemented to make state as a key player in oil-gas exploration.	Industrial policy Resolution (1956) of GOI implemented.	GOI decided to invite foreign participation. In 1980 GOI invited first license round. Blocks were offered in bidding to private players.	Resorted to organized endeavor to attract private investment in 1991. Directorate General of Hydrocarbon (government body acting as regulator) was set up.	New Exploration Licensing Phase (NELP) launched
Result	No significant exploration.	Exploration activities hampered due to scarcity of financial resources and technical capabilities	Industry got risk capital, technology and increased effort.	Several rounds were held and blocks were awarded.	Several discoveries have been reported in these blocks.

Table 4.13 Indian exploration industry through decades (1948-1991)

4.6.1.4.1 Pre- NELP Rounds

After the oil price rise of 1979, the Government of India (GOI) intended to intensify the exploration efforts in India and invited several rounds of biding in 1980, 1982,and 1986 to offer blocks to business entities (both public and private form India and abroad) and offered acreages for exploration of crude oil and natural gas. GOI further liberalized the petroleum policy in 1991 inviting private companies (domestic and overseas) and offered 69 small and medium sized oil and gas fields in onshore and offshore to private sector in 1992 and 1993. Following is the summary of various bid rounds.

Bid Round	Year	Blocks offered	No. of Blocks awarded
First	1980	32 (17 offshore and 15 onshore)	1 in Saurashtra to Chevron
Second	1982	50 (42 offshore and 8 onshore)	Nil
Third	1986	27 (East and West coast)	9 (Chevron-Texaco-4, Shell-2, BHPP, IPC, and AMOCO one each)
Fourth	1993	72 (39 offshore and 33 onshore)	4
Fifth, Sixth, seventh, eighth	1991-1996	More than 125	11
Joint Venture Round			Invited bids for 28 blocks
Development Rounds	1992 and 1993		

Table 4.14 Blocks offered in pre-NELP bid rounds

Figure 4.10 Pre- NELP PEL & ML under operation by NOCs and Private players as on 01.06.1996 (PEL 203, ML 163)

Source: Directorate General of Hydrocarbons, India (DGH)

There has been sizable discoveries in the blocks offered by the Government of India in pre-NELP round (Figure 4.10 and Table 4.15).

Sl. No.	Year	Block/Field	Name of Discovery	Oil/Gas
1	1999-2000	Ravva	Ravva Satellite	Gas
2	2000-2001	CB-OS/2	Lakshmi	Gas/Oil
			Ambe	Oil/Gas
			Gauri	Oil/Gas
			Parvati	Oil
3	2001-2002	RJ-ON-90/1	Saraswati	Oil
4	2002-2003	RJ-ON-90/1	Rageshwari	Oil
5	2003-2004	RJ-ON-90/1	Kameshwari	Oil
			Mangla	Oil
			Greater Rageshwari (GR-F)	Gas
			NA (Aishwarya)	Oil
		CB-OS-2	CBX Structure	Gas
6	2004-2005	RJ-ON-90/1	NC (Shakti)	Oil
			NV (Bhagyam)	Oil
			NR-1	Oil
			NR-2	Oil
7	2005-2006	RJ-ON-90/1	NI#2	Oil
			GS-V-1	Gas
			NC-West-1	Oil
		CB-ON-2	Tarapur-1	Oil
		CB-ON-3	ESU-1	Oil
		Panna-Mukta	SWP-1	Oil/Gas
		CB-ON/2	Tarapur-G	Gas
		SR-OS-94/1	Dhirubhai-27	Gas
		CY-OS/2	FAN A-1	Gas
		CB-ON/7	SPD-1	Oil
		CB-ON/3	ENM-1	Oil

Table 4.15 Oil and Gas discoveries in Blocks offered in pre-NELP Rounds by India

4.6.1.4.2 Post NELP Scenario

The experimentation of Indian Government to offer acreage under various rounds was not a success. The government decided to further liberalize the terms to attract investment in E&P business and a new exploration policy called NELP was implemented. Subsequently, the New Exploration Licensing Policy (NELP) was approved by the Government in 1997 and implemented in January 1999. NELP was launched to accelerate the pace of hydrocarbon exploration in the country by attracting private companies, both domestic and foreign to participate in exploration and development activities. In NELP, besides onland province, India is offering its shallow-, deep- and ultra deep- water blocks for exploration to global players. With the launch of NELP, there has been private sector participation: both domestic and foreign in petroleum exploration and production. The salient features of the NELP as follows.

NELP provides a level playing field to all players in oil business. It provides an opportunity for International Oil Companies (IOC), National Oil Companies (NOC) and private players (both national and international) to realize the oil and gas potential of India. NELP is based on Production Sharing Contract (PSC) and provides fiscal stability provision. There is no requirement of payment of signature, discovery or production bonus, customs duty on imports required for petroleum operations. There is no minimum expenditure commitment during the exploration period, no mandatory state participation /carried interest by national oil companies. There is a freedom to sell crude oil and natural gas in domestic market at market related prices. There is no cess on crude oil production. The royalty for crude oil is 12.5 per cent for onshore areas, 10 percent for offshore areas, and 5 percent for first seven years after commencement of commercial production for deep water areas (beyond 400m bathymetry).

There is an option to amortize exploration and drilling expenditures over a period of ten years from first commercial production. The contribution to site restoration fund is fully deductible in same year for income tax. There is liberal depreciation provision making companies eligible for further tax adjustments. In NELP, the companies bid for committed work program, share of profit petroleum and percentage of annual production to be allocated towards cost recovery. The transparency of the bidding process is achieved by adopting a criteria for evaluation on the basis of assigned weight of six percent for technical capability, four percent for financial strength of the bidder, sixty percent for the committed work program, and thirty percent for the fiscal package.

4.6.1.4.3 Review of NELP Rounds

The description of various bid rounds is given in Table 4.16.

NELP Round	Year	Blocks offered	No. of Blocks awarded	Remarks
First	Jan, 1999	48 (12 deep water 26 shallow water (< 400m) and 10 onshore)	24 (7 deepwater, 16 shallow offshore and 1 onland block)	16 discoveries in 2 KG deepwater blocks and 1 shallow offshore block of Mahanadi –NEC
Second	Dec, 2000	25 (8 deepwater - beyond 400m isobath),8 shallow offshore and 9 onland).	23 (8 deepwater, 8 shallow offshore and 7 onland)	5 discoveries have been made in two blocks in Cambay basin & KG basin
Third	Mar, 2002	27 (9 deepwater - beyond 400m isobath, 7 shallow offshore and 11 onland)	23 (9 deepwater, 6 shallow offshore and 8 onland)	
Fourth	May 2003	24 (12 deepwater - beyond 400m isobath, 1 shallow offshore and 11 onland blocks)	20 (10 deepwater and 10 onland).	
Fifth		20 (2 – shallow water, 6- deep water and 12 – onland)	20	
Sixth		55 (6 – shallow water, 24- deep water and 25 – onland)		Total bids received = 165 for 52 blocks. 3 deepwater blocks did not receive any bid. 17 countries and 36 companies participated in it.
Seventh	April 2008	57 (19 deep water, 9 shallow water and 29 onland blocks)		Only 18 of the 57 blocks are new. Re remaining 39 blocks are those that did not find any takers in the previous auction.

Table 4.16 Summary of NELP Rounds

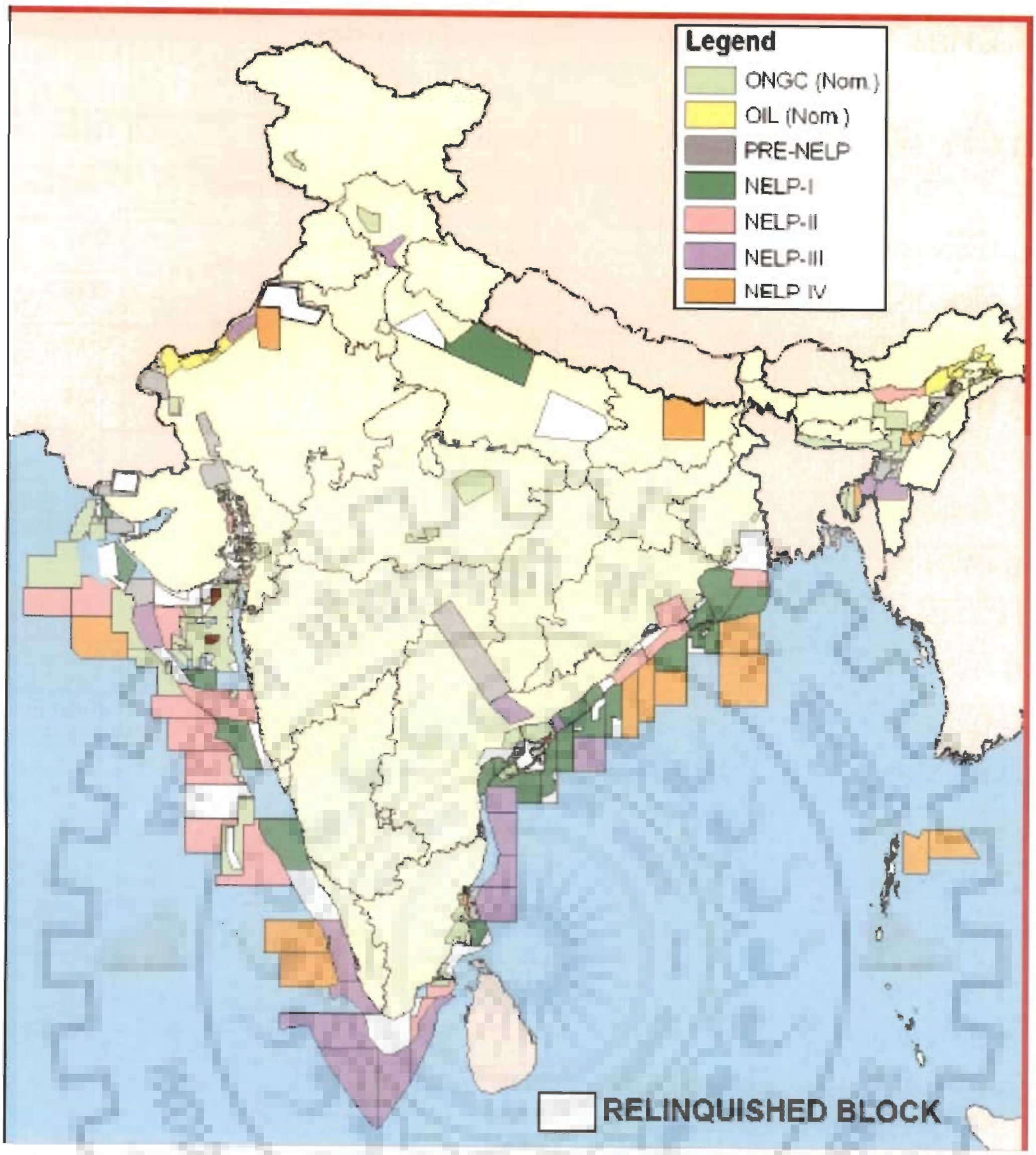


Figure 4.11 Post NELP PEL & ML under operation by NOCs and Private players as on 01.08.2004 (PEL 235, ML 294)

Source: Directorate General of Hydrocarbons, India (DGH)

Several discoveries including few super giant deepwater discoveries in blocks offered in previous rounds have made India a major E&P destination (Table 4.17) and there has been gradual increase in exploration density, reserve accretion, and production of oil and gas (Figure 4.11, 4.12 and 4.13).

Sl. No.	Block/Field	Bidding Round	Name of Discovery	Oil/Gas
1	KG-DWN-98/2	NELP I	Annapurna	Gas
			Kanak Durga and Padmavati	Oil/Gas
2	KG-DWN-98/3	NELP I	Dhirubhai-1,2,3 and 4	Gas
3	CB-ONN-2000/2	NELP II	Bhima-1 and NS	Gas
4	KG-DWN-98/3	NELP I	Dhirubhai-5 and 6	Gas
5	KG-DWN-98/3	NELP I	Dhirubhai-7, 8, and 16	Gas
6	NEC-OSN-97/2		Dhirubhai-9,10, 11 and 15	Gas
7	CB- ONN-2000/1	NELP II	PK#2	Oil
8	KG-DWN-98/3	NELP I	Dhirubhai-18, 19, 22, and 23	Gas
9	NEC-OSN-97/2	NELP I	Dhirubhai-20, and 21	Gas
10	KG-OSN-2001/3	NELP III	KG-8	Gas
11	KG-OSN-2001/2		Dhirubhai-24, and 25	Oil/Gas
12	KG-DWN-98/2	NELP I	DWN-U-1, and DWN-A-1	Gas
13	KG-DWN-98/2	NELP I	DWN-W-1	Gas
14	RJ-ON-90/6	NELP II	SGL#1	Gas
15	KG-OSN-2001/3	NELP II	KG-17	Oil/Gas
16	KG-DWN-98/3	NELP I	Dhirubhai-26	Oil
17	CB-ONN-2000/1	NELP II	Sanand East (1)	Oil &Gas
18	KG-OSN-2001/1	NELP III	Dhirubhai-28	Gas
19	MN-OSN-2000/2	NELP II	MDW-2A	Gas
20	KG-DWN-98/2	NELP I	DWN-UD-1	Gas
21	KG-DWN-98/3	NELP-1	Dhirubhai -31	Gas
22	NEC-OSN-97/2	NELP-1	Dhirubhai -32	Gas
23	MN-DWN-98/3	NELP-I	MDW-4A	GAS
24	GS-OSN-2000/1	NELP-II	Dhirubhai -33	GAS
25	KG-DWN-98/3	NELP-I	Dhirubhai -34	GAS
26	CY-DWN-2001/2	NELP-III	Dhirubhai -35	Oil/Gas
27	KG-DWN-98/2	NELP-I	KT-1	Gas
28	KG-OSN-2001/3	NELP-III	KG-15	Gas
29	CB-ONN-2002/3	NELP-IV	Miroli-1	Oil

Table 4.17 Discoveries in Blocks offered in various NELP Rounds

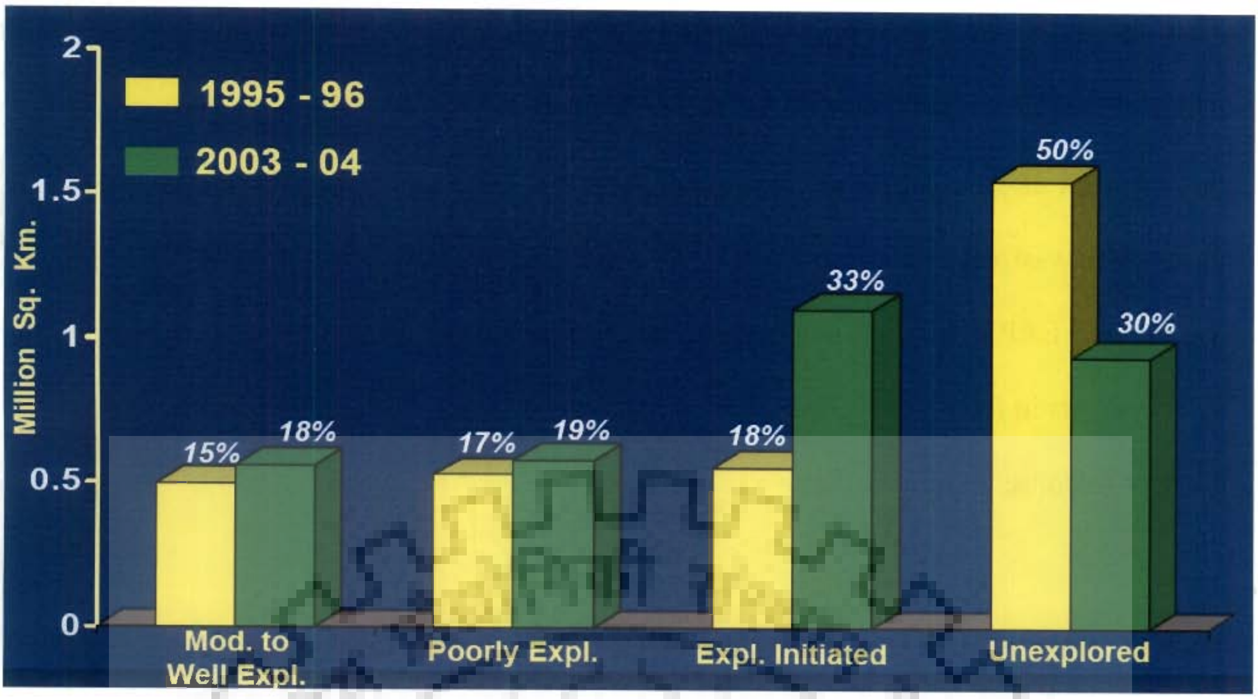


Fig. 4.12 Changing Indian Exploration Scenario

Source: Directorate General of Hydrocarbons, India (DGH)

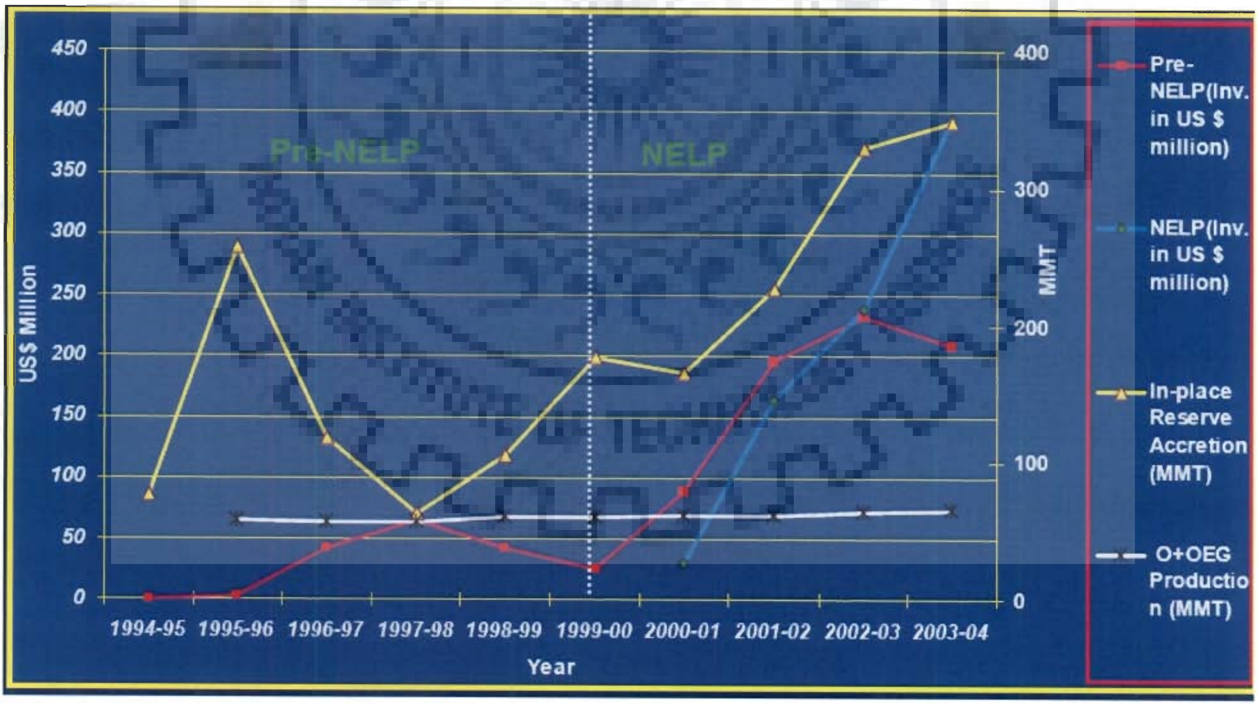


Figure 4.13 Pre-NELP & NELP performance

Source: Directorate General of Hydrocarbons, India (DGH)

4.6.1.5 Response of Global Players in NELP bid rounds

As per EIA (2007), the concern for India has been limited attendance of international oil majors in six already concluded bid rounds, because, India was keen to attract oil majors to utilize their vast deepwater experience and other technical expertise. This poses a serious challenge to E&P sector and requires analysis to find out the reason for non-participation by global players in Indian bid rounds. Following is the discussion about the possible reasons for the poor response to Indian offers.

4.6.1.5.1 Probability of success

According to Alfred Kjemperud (2004), petroleum investments are capital intensive, irreversible and risky. Countries are evaluated with the diverse factors like technical prospectivity (reserves and reserve to production ratio); fiscal terms, tax systems, exploration and development cost; country risk (economic, social and political), markets, and infrastructure. The detailed understanding of risk versus return and what it takes to "play the game" are major issues (O'Connor, 2000). Companies prefer to invest in those parts of the work which have favorable geology and proven resources of oil and gas (Seek, 2000). The total probability of success is a function of factors like probabilities of success in respect of exploration, development, fiscal issues, political and economic (Kjemperud, 2004) and can be propounded probabilistically in empirical form as follows

$$\text{Success Probability} = P_{\text{exploration}} * P_{\text{development}} * P_{\text{fiscal}} * P_{\text{political}} * P_{\text{economic}}$$

Each of these factor conditions need analysis, because investor's decision whether or not to invest in Indian E&P business will depend on their assessment and understanding of attendant risk. We have attempted to estimate the success probability as per the Kjemperud's mathematical expression under different scenarios by applying Monte Carlo Simulation (Table 4.18).

	$P_{Expl.}$	$P_{Development}$	P_{Fiscal}	$P_{Econ.}$	P_{CR}	POS
Country	Reserve	Average of R/P ratio of 2007 & 2008	FISCAL RANK (Min, ML, Max)	Index of Econ freedom	KOF GI	Probability of success
Algeria	12.3	16.80	2,3,4	102.00	45.56	16.54%
Argentina	2.2	8.83	5	108.00	62.24	18.01%
Australia	4.2	20.81	4	4.00	77.35	21.04%
Brazil	11.8	18.69	5	101.00	58.86	15.76%
Canada	17.1	18.90	3,4,5	7.00	81.21	17.78%
Chad	0.9	16.64	5	142.00	38.94	19.26%
China	15.6	11.72	2,4,5	126.00	64.56	15.75%
Colombia	1.5	7.39	3	67.00	52.66	21.48%
Denmark	1.3	9.54	3	11.00	88.42	24.27%
Ecuador	4.9	22.94	3	106.00	54.87	17.19%
Egypt	3.7	15.35	2	85.00	55.15	19.19%
Gabon	2.1	24.53	2,3,4	122.00	50.05	17.93%
India	5.9	18.99	2,3,4	115.00	50.54	17.01%
Indonesia	4.2	11.68	2,3,4	119.00	54.86	17.70%
Iran	137.5	86.43	4,5	151.00	34.23	12.43%
Italy	0.8	17.90	2,3,4	64.00	79.44	20.14%
Kuwait	101.5	23.15	2,3,4	39.00	65.49	14.56%
Malaysia	5.3	17.42	3	51.00	75.6	17.58%
Mexico	13.7	9.60	2,3,4	44.00	56.48	17.58%
Nigeria	36.2	41.21	3,4	105.00	55.95	14.09%
Norway	9.7	8.58	3,4,5	34.00	79.75	17.76%
Oman	5.6	20.88	3,4,5	42.00	53.57	17.65%
Peru	1.1	25.90	3,4,5	55.00	57.65	19.41%
Romania	0.5	12.06	2,3,4	68.00	65.31	21.73%
Russia	77.7	22.06	2	134.00	69.82	14.31%
Thailand	0.5	4.19	2,3	54.00	57.1	25.83%

Table 4.18 Estimation of Probability of success (As per Kjemperud's equation)

The Probability of Success has been computed by taking following parameters. The figure for reserves, reserves to production ratio, Van Meurs fiscal rank, Index of Economic Freedom and Globalization Index of Derher (2006) has been used to represent probability of exploration, development, fiscal, economic and political respectively. These values have been simulated using Monte Carlo Simulation technique and the median values have been taken to represent the probability of success. India compares well with other similar economies. Furthermore, the probability of exploration and development for India can be verified by the resources, reserves and reserves to production ration.

4.6.1.5.2 India's Resources worthiness

India has 26 sedimentary basins and only 15 basins have established petroleum reserves (Businessworld, 2008). The technical prospectivity can be judged by the prognosticated resources of India estimated at 205 billion barrels from 15 basins and 66 billion barrels reserves in place as on 1 April 2007 (DGH and Businessworld, 2008). The gap of 139 billion barrels is an opportunity for global players in Indian sedimentary basins (Businessworld, 2008). As per Economic Survey report (2008), the investment made by Indian and foreign companies in NELP blocks, as on April, 2007 was 3887 billion dollars, out of which 30 percent was by Indian national oil companies (Businessworld, 2008).

4.6.1.5.3 Hydrocarbon worthiness

There has been four fold increase in the area under exploration, which was only 11% of Indian sedimentary basin prior to launch of NELP, the exploration has resulted in 49 oil gas discoveries in 15 blocks (5 in NELP-I, 4 in NELP-II and III, and 2 in NELP-IV) and their has been reserve accretion of more than 600 million tons of oil equivalent. The discoveries strengthen the hydrocarbon worthiness of the Indian sedimentary basins (Mr. Murli Deora, 2007). Indian unexplored or under explored areas by geological analogy with global experiences seem to be favorable locale for hydrocarbons and with sustained exploration efforts further petroleum discoveries can reasonably be expected.

4.6.1.5.4 Availability of open acreage

Many international oil companies generally have the view that the most prospective acreage is still being reserved for the two national oil companies (Blakeley, 2003). But, it most likely refers to Petroleum Exploration Licenses (PEL) of several acreage being held by Indian National Oil companies (NOCs) i.e. Oil and Natural Gas Corporation Ltd. (ONGC) and Oil India Limited (OIL), which were awarded to them on nomination basis prior to implementation of NELP as per provisions of Indian law for carrying out exploration. The PEL granted under nomination regime was considered to be valid for four years with a provision of two renewals of one year each. After six years the PEL was either to be relinquished or NOCs were supposed to reapply for PEL for fresh grant of license. If there is discovery, the particular PEL acreage is upgraded to lease for mining. In order to accomplish the execution of ongoing exploration in existing PEL acreage Government of India (GOI) put forth relinquishment criteria. The criteria calls for one time re-grant of PEL of four years with a provision of extension of maximum two years. As on date the PELs available with NOCs (ONGC – 112 and OIL- 18) are in re-grant phase. Thus the PELs awarded to the NOCs on nomination basis will expire by 2010. All these PELs unless converted to mining lease will be relinquished by NOCs and GOI will offer these blocks in subsequent NELP bid-rounds.

4.6.1.5.5 Fiscal Stability

The stability and transparency of fiscal system is another major factor. According to IMF (2007), all key parameters of PSC, tax exemptions, non-tax payments (license, rentals, and lease fees), bonus (including signature bonus), should be made available to public. Many project agreements include fiscal stability clauses to provide assurance to investors against any unfavorable changes in the fiscal regime. Recent announcement by GOI to do away with seven years tax holiday in upstream and downstream investments including seventh NELP bid rounds may affect the bidder's particularly foreign players (Times of India, March 11, 2008). According to the reports in press, the proposal would impact investors sentiments as seven years tax holiday has been the salient feature of all bid rounds, including the latest i.e. NELP seventh bid round, and would be a dampener to the government's efforts to attract at least $4 billion in oil and gas exploration (Times of India, March 11, 2008). In this round companies are expected to bid for 57 blocks (29 onshore, 19 deep sea, and 9 shallow water). This is adverse to the premise of fiscal stability provision expected in exploration agreements. Doing away with tax holiday is a matter of concern for investors, because it will take longer period for investment recovery.

4.6.1.5.6 Country Risk

One of the major considerations in international operations is the element of country risk (Johnston, 1994). Several agencies like ICRG, Standard & Poor, etc forecast probability of Country risk – (Economic, Social and Political). India does not rank low in the surveys which rank countries in order of their political and business risk. Corruption also constitutes a factor which investors consider while investing in overseas business. Transparency International has ranked countries on the basis of corruption – called Corruption Perception Index, and India ranks 74 which is not considered extremely unfavorable to do business based on this rank.

According to Johnston (1994), nationalization or expropriation of assets (which is not illegal in the eyes of international law) once loomed foremost as the greatest risk that the industry faced overseas and the Governments that hint of nationalization, expropriation or confiscation can send ugly signals and it takes years to reassure investors. Indian accomplishment during past with the Burma oil Company, Assam Oil Company, ESSO, Luke India undertaking etc. may corroborate the fear. According to Johnston (1994), changing rules and policy shifts including changes in government, fluctuating tax laws, and contract flexibility constitute major risks. Operational risk, which takes in to cognizance some of the risks associated with doing business in a country adds another dimension to distract foreign companies in doing business in a particular country (Johnston, 1994). As per a report on ease of doing business (World Bank and IFC, 2007) the situation is not so favorable in India which ranks 134 out of 175 economies.

Various indicators generally taken in to cognizance for globalization destination by an entrepreneur are summarized in (Table 4.19). India does not rank low in the surveys which rank countries in order of their political and business risk. The political risk assessment, besides other factors takes in to account the level of corruption and local disturbances. Transparency International has ranked countries on the basis of corruption – called Corruption Perception Index, and India is not considered extremely unfavorable to do business based on this rank.

	Oil - Gas Reserves Oil & Gas Journal (Billion Barrels)	Ease of Doing Business Rank Source: World Bank	GCI 2006 Rank World Economic Forum	Rank of Fiscal system Source: Van Muers	Corruption Perception Index Source: Transparency International	KOF Index of Globalization Dreher, Axel (2006);
Angola	5.412	156	125	302	142	na
Australia	1.437	8	19	76	9	80.91
Bangladesh	0.028	88	99	124	156	36.01
Brazil	11.2433	121	66	20	70	59.6
Myanmar	0.05	na	na	261	162	27.29
Cameroon	0.4	152	108	211	138	41.32
Canada	178.7924	4	16	52	14	87.49
Chad	1.5	172	123	55	157	39.56
Gabon	2.499	132		291	90	49.2
India	5.84784	134	43	187	74	49.7
Indonesia	4.301	135	50	285	134	51.31
Kazakhstan	9	63	56	19	23	na
Nigeria	35.876	108	101	98	150	52.97
Pakistan	0.289202	74	91	13	13	52.35
Romania	0.95562	49	68	233	na	63.34
South Africa	0.01568	29	45	142	na	62.45
Sudan	0.563	154	na	252	na	na
Taiwan, China	0.00238	47	13	na	na	na
United States	21.757	3	6	47	na	80.83
Uzbekistan	0.594	147	na	219	na	
Venezuela, RB	79.729	164	88	313	na	53.75
Vietnam	0.6	104	77	94	na	na
Yemen	4	98	na	231	na	na

Table 4.19 Elements of globalization strategy of select countries.

4.6.1.6 India and 12 commandants of FDI

We have evaluated the Indian petroleum exploration sector with respect to the twelve commandments of FDI as per US Chamber of Commerce (Table 4.20).

No.	Commandments	Modifier	Issues for investors	Indian scenario for petroleum investors.
1.	Macroeconomic policy	Stable and predictable	Rule of game will not change in the middle of context.	Favorable
2.	Government	Effective and honest	Transparent working	India does not rank very low in Corruption Perception Index.
3.	Market size	Large and growing	High purchasing power and scope of doing a profitable business	Unfavorable purchasing power and scope of doing business
4.	Free market	Degree of competition and government interference	Lesser degree of government interference to foreign investors	Very favorable for international investors.
5.	Government regulation	Minimal	Minimal intervention in the affairs of private companies.	Minimum and transparent intervention
6.	Property rights	Protection	Protection of investor's tangible and intangible assets.	Reasonably good
7.	Infrastructures	Reliable	Established transportation and power network, as well as insurance and financial systems.	Inferior as per global benchmarks, but improving
8.	Factors of production	Superior	Quality of man and material	Material as well as trained and skilled manpower available
9.	Local currency	Strong	Local currency devaluation leads to loss of investment.	Local currency is improving.
10.	Remit proceeds from investments	Allowed	Investors are allowed to remit profits, dividends and interest out of country.	Favorable
11.	Tax structure	Favorable	It should attract investors	Favorable
12.	Inter- and/or intra-market operation	Permissible and flexible	Mostly liked by investors	Restrictive

Table 4.20 Twelve commandments of FDI and Indian petroleum exploration sector

4.6.1.7 Summary of Domestic effort

Indian petroleum sector have been opened for private participation in upstream and downstream activities. NELP has been launched to renew investor's interest in India. India, a free market has an established legal system and better infrastructure. The government's commitment towards transparent and speedy award of contracts illustrates Indian conviction to continue this momentum to attract FDI in petroleum sector. But, investors need a secure and stable fiscal environment to make long-term investment decisions. "Investors want to know up front the "rule of the game" which should be clear and unambiguous (Seek, 2007)". A clear commitment to a transparent legal and regulatory framework is especially important for any investor and they prefer those countries which have a proven track record of attracting and supporting investments including honoring of past agreements (Seek, 2007). Thus, drafting, implementing, and continuing the proper fiscal regime can bring faith in Indian system.

Technical worthiness of offered area is another pivotal issue. The global oil majors are still keeping a distance from embarking an exploration in India (Blakeley, 2003). One reason may be scarce geological data available for frontier, unexplored or under-explored provinces. The country is still perceived to be low in hydrocarbon potential, but, certain oil companies may well be re-assessing their perception of the prospectivity of Indian basins in light of recent discoveries (Blakeley, 2003). The petroleum worthiness of eastern and western offshore province of India has been established beyond doubt. But, the world community must realize that even the petroleum potential of mirror image basins in deep offshore of Atlantic in offshore South America, and Lower Congo and that of Kutei Basin in Mahakam Delta province of Indonesia was not recognized till recent past. Same may be true with the frontier basins of Himalaya which has several geological analogs hosting significant petroleum reserves in Andean province. With the application of new technology crude oil prospect in deep offshore of Makassar Strait (Indonesia) has been identified. In Brazil, commercial oil production dates back to the early 1940s, exploration in offshore Brazil started in 1967, and the first super giant field could be discovered in 1985. India has vast area unexplored from petroleum perspective. The success probability for exploration in Indian province is also found to be favorable. It is corroborated by the discovery of crude oil and natural gas in various blocks awarded under pre-NELP and NELP (Table 4.21)

	Award of blocks under	Number of blocks awarded		Discovery in pre-NELP and NELP blocks								Total Discovery	
				2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Pre-NELP blocks	NELP Blocks
Pre 1999	**Pre-NELP**	28		4	1	1	5	4	5	3	2	25	
1999	**NELP-1**		24		3	4	2	7	8	5	3		**33**
2000	**NELP-2**		23			2		1		4	1		**8**
2001									3	1	2		**6**
2002	**NELP-3**		23								1		**1**
2003	**NELP-4**		20										
2004													
2005	**NELP-5**		20										
2006	**NELP-6**		52										
2007													
2008	**NELP-7**												
Total		28	165	4	4	7	7	12	16	13	9	25	48

Table 4.21 Discovery in various blocks awarded under pre-NELP and NELP

Furthermore, the technical analogs with global provinces confirm hydrocarbon prospectivity of these provinces. Plethora of instance corroborate that with sustained efforts, provinces with identical technical mix yielded giant fields, and with sustained committed capital investment, infusion of latest and superior technology, as well as investor's confidence India may augment with domestic crude oil production.

The reforms in petroleum sector have concentrated on opening up of this sector to private participation in upstream and downstream activities and restructuring of public sector oil companies through disinvestment of Government holdings. The modern Indian environment, peaceful atmosphere and modern infrastructure are just a few of the strong points and the Government of India has already shown its commitment to finalize the awards and signing of contracts in a time bound and expeditious manner and is committed to continue this momentum to expedite the decision making process.

4.6.1.8 Attractiveness of India to Foreign Investors

We have attempted to find out the Country Attractiveness Index (CAI) of Indian exploration industry to foreign business entity by multiplying the number of bids received in a bid round by the factor obtained by dividing the total number of block bid to the number of blocks offered (Equation 1). Another index "Investor Confidence Index" (ICI) has been obtained by the ratio of number of blocks awarded to the number of blocks awarded (Equation 2). The "Exploration Favorability Index" (EFI) has been worked out by multiplying number of discoveries to Investor

Confidence Index (Equation 3). The data for working out these indexes are given in Tables 4.22, 4.23 and 4.24.

$$\text{COUNTRY ATTRACTIVENESS INDEX (CAI)} = \frac{\text{No. OF BLOCKS BID FOR}}{\text{No. OF BLOCKS OFFERED}} \times \text{No. OF BIDS RECEIVED} \quad \text{.............................. } 1$$

$$\text{INVESTOR'S CONFIDENCE INDEX (ICI)} = \frac{\text{Blocks awarded}}{\text{Blocks offered}} \quad \text{..................................} 2$$

$$\text{EXPLORATION FAVORABILITY INDEX} = \text{NO. OF DISCOVERIES} \times \text{ICI} \quad \text{..... } 3$$

	NUMBER OF BLOCKS OFFERED				No. OF BIDS RECEIVED	No. OF BLOCKS BID FOR	NUMBER OF BLOCKS AWARDED			
	Total	Deep Water	Shallow offshore	Onland			Total	Deep Water	Shallow offshore	Onland
NELP- I	48	12	26	10	45	28	24	7	16	1
NELP- II	25	8	8	9	44	23	23	8	8	7
NELP- III	27	9	7	11	52	24	23	9	6	8
NELP- IV	24	12	1	11	44	21	20	10	0	10
NELP- V	20	6	2	12	69	20	20	6	2	12
NELP- VI	55	24	6	25	165	52	52	21	6	25

Table 4.22 Details of NELP Rounds

	NUMBER OF DISCOVERIES MADE			
	Total	Deep Water	Shallow offshore	Onland
NELP- I	41	31	10	0
NELP- II	7	0	3	4
NELP- III	10	1	9	0
NELP- IV	8	0	0	8
NELP- V	2	2	0	0
NELP- VI	0	0	0	0

Table 4.23 Number of discoveries in NELP Rounds

	COUNTRY ATTRACTIVENESS INDEX	INVESTOR'S CONFIDENCE INDEX (Blocks awarded/ Blocks offered)				EXPLORATION FAVORABILITY INDEX (NO. OF DISCOVERIES * INVESTOR CONFIDENCE INDEX)			
		Total	Deep Water	Shallow offshore	Onland	Total	Deep Water	Shallow offshore	Onland
NELP-I	26	0.50	0.58	0.62	0.10	20.50	18.08	6.15	0.00
NELP-II	40	0.92	1.00	1.00	0.78	6.44	0.00	3.00	3.11
NELP-III	46	0.85	1.00	0.86	0.73	8.52	1.00	7.71	0.00
NELP-IV	39	0.83	0.83	0.00	0.91	6.67	0.00	0.00	7.27
NELP-V	69	1.00	1.00	1.00	1.00	2.00	2.00	0.00	0.00
NELP-VI	156	0.95	0.88	1.00	1.00	0.00	0.00	0.00	0.00

Table 4.24 Index for various NELP rounds

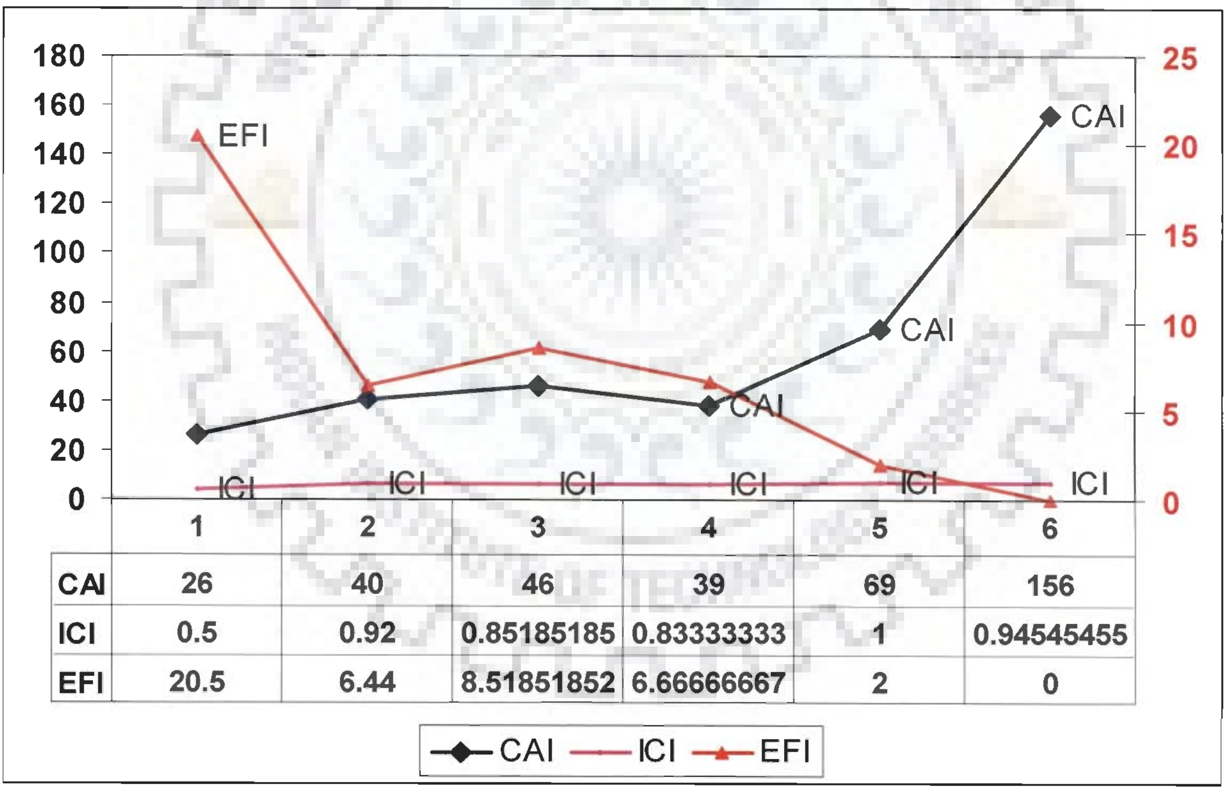
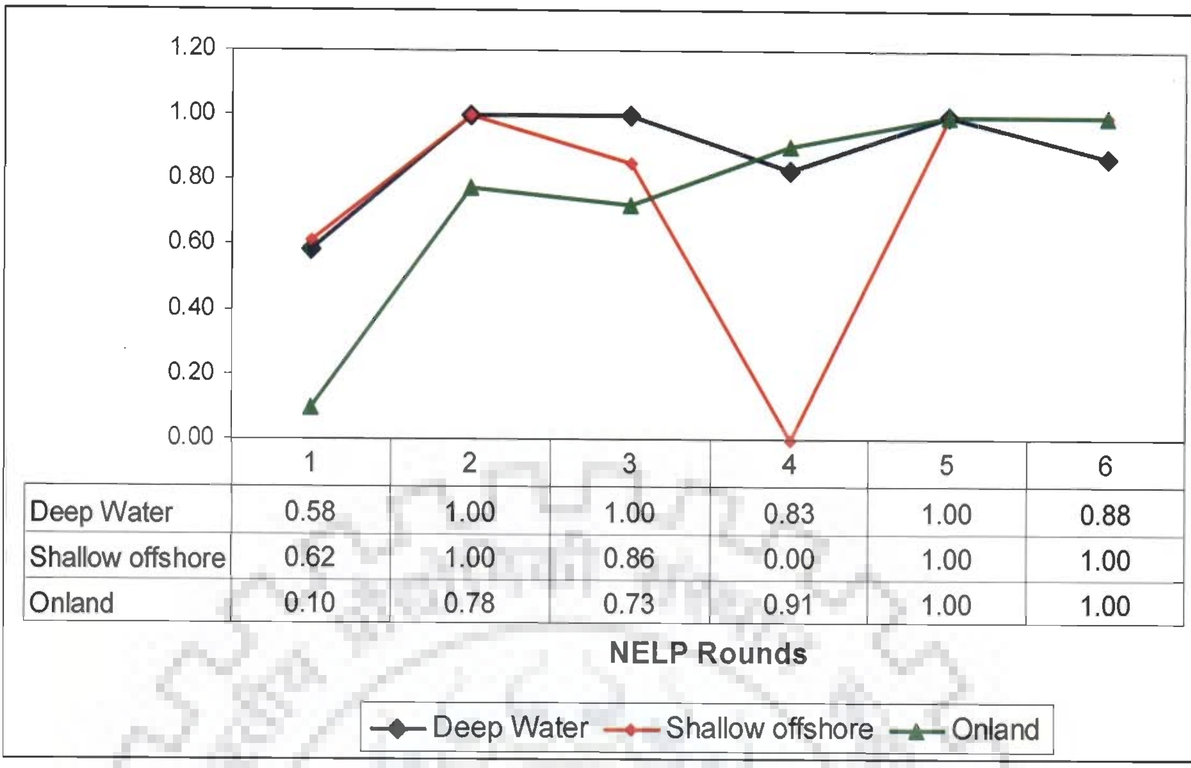


Figure 4.14 CAI, ICI and EFI for India



	1	2	3	4	5	6
Deep Water	0.58	1.00	1.00	0.83	1.00	0.88
Shallow offshore	0.62	1.00	0.86	0.00	1.00	1.00
Onland	0.10	0.78	0.73	0.91	1.00	1.00

Figure 4.15 Investor's Confidence Index for NELP Rounds

The Country Attractiveness Index has shown a growing trend and the Investor's Confidence Index has a uniform trend (Figure 4.14). These factors speak favorably about the confidence of investors in Indian NELP bid rounds. The trend of exploration favorability may not tell the real picture, because majority of blocks are still in early exploration phase and it will take some time to verify the success or failure from these blocks. The Investor's Confidence Index for onland and deep water blocks is very promising (Figure 4.15). It reflects the confidence of investors in these exploration provinces. These areas have well established petroleum potential since decades of Indian exploration history.

4.6.2. Overseas ventures

Indian companies (both state owned and private) have taken scores of initiatives and the overseas business efforts are targeted to secure a stable supply of crude oil (Bagge, 2005). The strategy adopted by Indian companies to secure overseas business in crude oil exploration and production is discussed.

4.6.2.1 Overseas investment of India

ONGC Videsh Limited (OVL) -the overseas arm and wholly owned subsidiary of Indian flagship exploration company ONGC has acquired properties in 15 foreign countries - Vietnam, Russia, Sudan, Iraq, Iran, Libya, Syria, Myanmar, Australia, and Ivory Coast (Figure 4.16). The production of oil and gas from overseas ventures is currently 6.33 MMTOE (Figure 4.17).

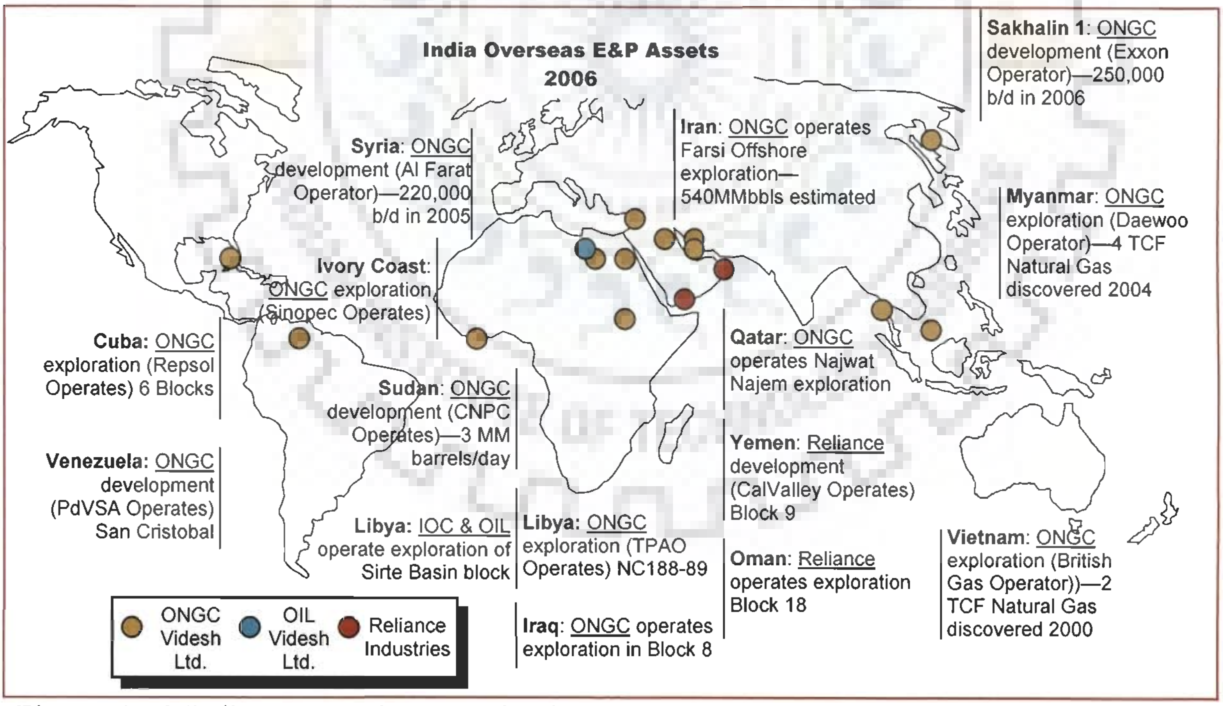


Figure 4.16 Indian companies operation in overseas in the exploration and development of oil and natural gas. Source: MacDonald, J.A, 2006

The producing, development and exploration assets of India are given in Table 4.24, 4.25 and 4.26. India is constantly looking out to acquire more overseas equity.

No.	Country	Acreage	India's Share	Production status
1	Columbia			Producing oil @ 20000 BPD
2	Russia	Sakhalin-1	20%	Producing oil @ 40000 BPD
3	Syria	Al Furat		Producing oil @ 153000 BPD
4	Sudan	GNOP	25%	Producing oil @ 255000 BPD
5	Sudan	Block 5A	24.125%	Producing oil (Rate not available)
6	Vietnam	Block 6.1	45%	Producing gas @ 12.5 MMSCMD

Table 4.25 Indian overseas producing assets

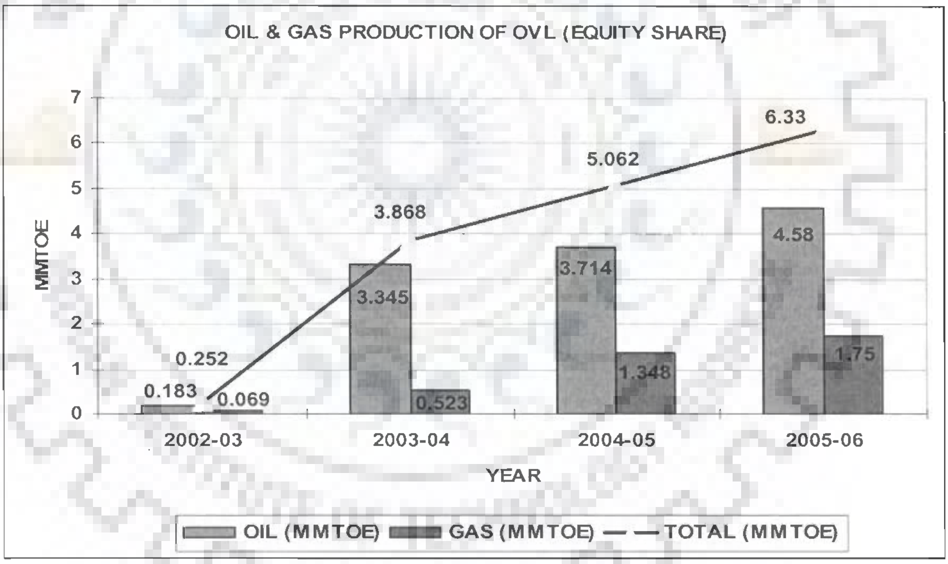


Figure. 4.17 Oil and gas production of ONGC Videsh Ltd.

No.	Country	Acreage	India's Share	Status
1	Brazil	BC 10	15%	In Development phase
2	Egypt	Block 6	70%	Exploration & Appraisal
3	Myanmar	Block A1 & A3	OVL-20% & GAIL-10%	Discovered gas in Jan 2004. Under Appraisal
4	Qatar	Block NN	OVL -100%	Exploration & Appraisal

Table 4.26 India- overseas assets with discoveries (under development)

No.	Country	Acreage	India's Status
1	Cuba	8 Blocks	2 Blocks as operator and 6 Blocks as Partner (OVL)
2	Iran	Farsi offshore	(OVL-40%; IOC – 40%; OIL – 20%)
3	Iraq	Block-8	OVL-100%
4	Libya	NC 188, 189 & BI 81-1	OVL -49% in NC 188 & 189 OVL -100% in BI 81-1
5	Nigeria	JDZ	OVL -13.5%
6	Nigeria	3 Blocks	OMEL 100%
7	Syria	Block 24	OVL-60%
8	Sudan	Block 5B	OVL- 23.5%
9	Vietnam	Block 127, 128	OVL-100%

Table 4.27 India- overseas exploration assets

In Cuba ONGC Videsh Ltd (OVL) has 30% participating interest in the deep water exploration Blocks 25, 26, 27, 28, 29 and 36 in partnership with Respol-YPF OF Spain (40%) and Norsk Hydro of Norway (30%). The blocks are spread in an area of about 12000 sq. km in Exclusive Economic Zone of Cuba. The hydrocarbon resource potential in the blocks is estimated to be in excess of four billion barrels. In Qatar OVL has Appraisal, Development and Production Sharing Agreement (ADPSA) with the Government of Qatar for the Najwat Najem oil structure with OVL as the operator. The Najwat Najem oil structure is in the Persian Gulf, at a water depth of approximately 135feet. In Sakhalin OVL has 20% holding in Production Sharing Agreement (PSA) for the Sakhalin-1 (Russia) since 1996. Exxon Neftegas Limited is the operator for the multinational Sakhalin-1 Consortium (ExxonMobil interest 30 percent). Partners include the Japanese consortium SODECO (30 percent); affiliates of Rosneft, the Russian state-owned oil company, RN-Astra (8.5 percent) and Sakhalinmorneftegas-Shelf (11.5 percent); and the Indian state-owned oil company ONGC Videsh Ltd. (20 percent). The Sakhalin-1 Consortium declared the project commercial in October 2001 and the 20 year Development Period under the PSA commenced. Sakhalin-1 is one of the largest single foreign direct investments in Russia. In Sudan OVL has acquired 25 per cent of equity in the Greater Nile Oil Project in Sudan in March 2003, which is a producing oil property and India receives significant volume of crude oil from this project. The other consortium members are China National Petroleum Corporation, CNPC (40%), Petronas Carigali Overseas Sdn BHD, PETRONAS (30%) and Sudan National Oil Company, SUDAPET (5%). The project has oil reserves of more than one billion barrels with a plateau oil production of about 3,00,000 barrels per day. Indian oil gas companies has taken contracts in the refinery upgradation and pipeline in Sudan. In Iran OVL holds 40 per cent interest in Farsi offshore block of Iran (Persian Gulf,) which was awarded to it in 2002. OVL has drilled oil wells in the block. Indian Oil Corporation (India's major downstream company) has 40 per cent and the remaining 20 per cent is with Oil India Ltd. (a national oil company of India having dominance in North East and Rajasthan). In Vietnam OVL has involvement in the exploration project along with British Petroleum and PetroVietnam (Vietnam). OVL has signed Production Sharing Contract (PSC) in Vietnam for gas field having reserves of 2.04 TCF, with 45 per cent stake in partnership with BP and PetroVietnam. Gas production has commenced from January 2003. The gas production has commenced from November 2002. In Myanmar Indian companies have made foray in petroleum business in Myanmar. OVL along with other Indian partners has secured equity participation in offshore Myanmar. OVL and GAIL (India) Ltd. signed a production sharing agreement in August 2002 to explore oil and gas in the Rakhine offshore Block A-1 area with foreign companies Daewoo International Cooperation of the Republic of Korea and Korea Gas Corp. In Nigeria ONGC- Mittal (OMEL) has acquired two blocks in the Gulf of Guinea. OMEL is registered in Cyprus. Mittal Investments Sarl is the investment arm of global giant Mittal Steel. The business is basically based on the premise of public-private partnerships. Earlier, ONGC has lost against its rival, China's CNOOC and Korean National Oil Corp. After loosing twice in Nigerian bids, ONGC adopted this strategy to win in the bid. In the latest Nigerian round, another Indian company, Global Steel, made its debut. According to reports from Lagos, the company has been awarded Block 281 in return for commitments to build a $1.8-billion CNG plant. Reliance Industries a private Indian player in oil-gas succeeded in getting offshore blocks in a bid in frontier exploration offshore Area in East Timor. In Brazil OVL has acquired 15% stake in one Block BC-10 in partnership with Petrobras of Brazil (35%) and Shell Brazil EP (50%). Shell is the operator for the block. Reliance Industries (RIL), has a acreage in Oman and has 25 per cent interest in the acreage in the onshore block in Yemen.

4.6.2.2 Connecting up or competing for equity oil

China and India are racing to ensure future supplies by either buying new foreign oil and gas fields or signing supply contracts when new reserves come on stream. OVL had competed with the Chinese firms for oil properties in Central Asia, West Africa and Latin America. They were pitched head-on for buying Canadian firm PetroKazakhstan, which has most of its operations in Kazakhstan, and EnCana's Ecuador assets. In Nigeria, India has to face tough competition from China. The China National Petroleum Corporation won four of the 17 blocks on offer. Undoubtedly, China is more firm than India in oil deal. China adopts amalgamated approach – government level bilateral agreements and offering of infrastructure loans to secure the equity oil. India also has of late adopted similar strategy. India's collaborating with Mittal for overseas oil ventures is based on similar grounds. The deal articulates that Mittal will extend the development fund. OMEL, will finance to an extent of $6 billion to build a refinery, a power generation plant and develop railway infrastructure in Nigeria. Compared to the Mittal's offer, China has offered $4 billion for a refinery in Nigeria and repair of railways. ONGC has tied with a Chinese firm to acquire a Syrian oilfield. ONGC has paid $573 million to a Canadian firm (PetroCanada) for taking over their equity stake in al-Furat field. This was the first time that Indian and Chinese companies had made a joint bid for acquiring oil properties overseas. The two government-run firms, often competing against each other in the race for acquiring overseas assets, are sharing equity in 50:50 ratio. This essentially would give the two firms access to about 58,000 barrels of oil equivalent per day from Syria. According to Business Standard India and China, which were once rivals in the race for global oil and gas, have agreed to form a joint venture company for acquisition of hydrocarbon assets in Africa and Latin America. As per the report both countries have in-principle agreed to work out a mechanism to bid jointly for oil and gas properties in Africa and Latin America. Indian and Chinese flagship companies will pool resources together to form a special purpose vehicle or a joint venture company to scout for assets in third countries.

4.6.2.3 Review of Indian overseas ventures

The scrutiny of overseas petroleum exploration opportunities requires finding volume of crude oil likely to be obtained, operating environment, and risks associated with various projects, so that expected return compensates the risks.

Vietnam. The estimated petroleum reserve of Vietnam is 3-4 billion cubic metres (BCM). Vietnam employs Production-Sharing Contracts (PSCs) which has continuously progressed to encourage foreign investors, to ensure equity between the revenue of the State and the profit of the company, while strengthening the role of State management in the operation of oil and gas activities. The Law of Foreign Investment in Vietnam (1987), the Petroleum Law (1993) etc. are attracting foreign investment. Government of Vietnam has adopted Joint Operating Agreement (JOA) which is an extended type of conventional PSC, which has been applied for most prospective projects since 1998 on the basis that foreign parties shall bear all the costs and take risks during the exploration phase. The cooperation is represented by the Joint Operating Company (JOC), a Vietnamese legal entity which merely acts as an agent on behalf of the contracting parties. The major differences are that PetroVietnam has higher participating interest than in a PSC, normally of 30-50% and the right to assign its own staff to the JOC from the beginning. The amendments to the Petroleum Law in June 2000 introduced incentives for foreign investment.

Oman. According to Oil & Gas Journal, proven oil reserves in Oman stood at 5.5 billion barrels as of January 2007. Oman is not a member of the Organization of the Petroleum Exporting Countries (OPEC), though it is a significant exporter of oil. Most of Oman's crude oil exports go to Asian countries, with China, India, Japan, South Korea, and Thailand the largest importers (Source: EIA).

Colombia. Colombia has recoverable reserves of oil 2.5 MMBO and gas 6,600 BCF. The terms and conditions for participation in upstream ventures are comparable with many other countries. They are neither very attractive, nor least attractive. The royalty is 20% for both oil and gas. Corporate income tax rate is 30%. There is a foreign remittance tax.

4.7 CONCLUSION

India produces meager amount of the natural gas it consumes. It imports crude oil and natural gas to meet requirement. Huge resources of crude oil and natural gas may be locked in several petroliferous provinces of India. The exploration and exploitation of this credible crude oil and natural gas resources are severely limited by impediments to development of necessary infrastructure and government policies. India is making intensive exploration and exploitation of its domestic province for crude oil. Keeping in view India's energy security, the long-term exploration and production policies to enhance hydrocarbon reserves and increase domestic production has been conceptualized, implemented and under execution for explorations in frontier areas like deep water and other geologically and logistically difficult areas. New Exploration Licensing Policy (NELP) has been introduced for enhancement of crude oil reserve through accelerated exploration of Indian province leading to increased domestic oil supply. NELP is one of the landmarks in liberalization in the petroleum sector, allowing the encouragement of participation of foreign and Indian companies in the exploration and development activities to supplement the efforts of national oil companies. Seven rounds of bidding and award of blocks for petroleum exploration under NELP has been completed. The business environment in India and government rules, regulations has been conducive for petroleum exploration allowing increased private participation. It is leading towards better exploration coverage of the Indian province. India is making efforts for the development of oil fields, implementation of Improved Oil Recovery (IOR) or Enhanced Oil Recovery (EOR) schemes, technology acquisition and absorption along with development of indigenous R&D, and measures for the maintenance of reservoir.

Thus, deregulation of hydrocarbon sector created an enabling environment and provided level playing field for public and private players, both domestic and global. The sops for investment has considerably accelerated the exploration investments in India during last couple of years. Despite these the domestic production is around 30 MMT and India continues to import about 75 per cent of its crude oil demand. Oil- starved India has resorted to intensive hunt for overseas equity oil for national energy security. There are several business opportunities for crude oil exploration in the world. Acquisition of established oil-gas acreage overseas will provide crude oil asset to India. It seems logical that Indian oil companies aggressively pursue the globalization spree to snatch and seize overseas equity oil. The globalization initiative should be targeted towards doing business and fetch energy security for the nation.

Globalization strategy for crude oil security of India is intended to bridge the gap between the requirement and domestic supply competence. The strategic intent of Indian business entities is guided by the philosophy - the target country in question has a government that has acceptance for Indian enterprises, possess sizable petroleum volumes, has reasonable success rate of petroleum exploration and provides terms that are favorable for the nature of high-risk exploration. These factors combined with predictable regulation, reasonable tax rates and a well-defined legal system make the country attractive.

In this chapter we have provided a detailed account of Indian energy scenario, with focus on crude oil. The efforts made by India during last sixty years and the results in terms of addition of domestic reserves have been described. Reference is also provided to the liberalization initiatives by Indian government in petroleum sector and the opening of this sector for private enterprise (domestic and foreign). The rational behind creating a level playing field and the launch of process to offer acreage in bid rounds to all players has been discussed. The post-liberalization scenario in upstream domain has been provided. The efforts made by Indian players in overseas have been discussed. Finally, a conclusion has been drawn based on analysis of Indian efforts in domestic as well as overseas. Alternative strategies have been proposed to address the concern of energy supply security. It is envisaged that the future strategies should focus on increasing exploration activities to enhance the level of recoverable reserves of the country. There is need to provide for crude oil security through diversification of oil imports and investing in equity oil abroad. The acceleration of exploration efforts, especially in deep offshore and frontier areas, and equity oil and gas abroad should be the thrust area. In view of the stagnating domestic production of crude and the widening gap between demand and supply of oil and gas, there is a need to diversify oil supply sources, and acquire equity oil and gas abroad. This would be an important component of the strategy to achieve oil security.

India has taken initiatives for the exploration of geologically complex and logistically difficult Indian frontier areas by joint venture partners to sharing the risks and rewards. As part of its strategy for future, India should focus on acquisitions of prospective exploration blocks as well as producing properties overseas either independently or with a joint venture partner. Indian companies have entered into pursuing upstream business opportunities overseas. They are having exploration service contract, acquired equity participation in project, participating interest in blocks and are in the process of acquiring stake in block in several countries.

The findings of this chapter in consistency and agreement with the earlier chapter on global energy scenario will provide background knowledge for identification of focus countries and designing a strategy for global business for Indian players to enter overseas upstream business for crude oil security. The effort will facilitate in formulating a strategic plan, which will be a key instrument in designing a business structure to make an effort for acquisition of prospective exploration blocks and producing properties in overseas. It will help India to maintain its strong presence in the presently acquired global regions, and to gear up to spread its business overseas.

CHAPTER 5

GLOBAL BUSINESS ENVIRONMENT & PETROLEUM BUSINESS

5.1 INTRODUCTION

The global business environment has been growing constantly and dramatically since World War II, and the number of enterprise considered international is now very large. Investment outside the home country by way of Foreign Direct Investment (referred to as FDI) constitutes a major force in today's world. Crude oil and natural gas with 24.6% share constitute the largest contributor in global business (Mendenhall, 1999). The decision to enter any country for exploration and production of crude oil calls for two basic questions, how to globalize and where to globalize. The selection of country in general depends upon the criteria of attractiveness, accessibility, and petroleum potential which it holds for an enterprise to perform the business at profit. The decision about mode of entry is taken only when the decision to enter is taken up. There are three options to enter overseas business – exporting, licensing, and FDI. The decision is taken after scanning the global business environment constituting the factors like GDP growth rate, fiscal and monetary policies, exchange rate, inflation, interest rate and bilateral, regional, and multilateral agreements of host and target countries. The global political environment, the rules and regulations like export- import controls, tariff and non-tariff barriers, exchange control, marketing regulations, antitrust issues etc. also play significant role. The cultural environment encompassing values, beliefs, attitudes, and practices influence investment decisions. This chapter provides an understanding about the global business environment. The modes of foreign investment, various fiscal systems which affect the strategic decision of investor to opt for any overseas upstream business decisions, contract negotiation as well as drafting of an agreement, acquisition and mergers and strategic alliances has been discussed.

5.2 GLOBAL INVESTMENT SCENARIO

The global economic liberalizations have significantly changed the environment for international private financial flows. The surge in international capital flows has substantially impacted the business environment. The massive flow of international investment has resulted in an increase in global production, employment generation and trade. The global experience of advanced economies shows that establishing a broad and robust domestic industrial base holds the key to successful development because of its potential for strong productivity and income growth. The process is associated with a strong investment drive in industry, rapidly rising productivity and a growing share of the sector in total output and employment. The trend in capital formation, growth and industrialization offers an idea about where the economies stand in relation to each other out of following categories:

- **Mature industrialized economies:** It includes the economies like the Republic of Korea and Taiwan Province of China, which have already achieved industrial maturity through a rapid accumulation of capital, growth in industrial employment, productivity and output, as well as manufactured exports.

- **Rapid industrialized economies:** These are countries with a rising share of manufactures in total output, employment and exports, based on strong investment and upgrading from resource-based and labor-intensive activities to middle-range technology products. This group includes China and India.

- **Enclave industrialized economies:** It includes countries which have also moved away from dependence on commodity exports by linking to international production chains with a heavy reliance on imported inputs and machinery. However, their overall performance in terms of investment, value added and productivity growth is poor.

- **Deindustrialized economies:** This group includes most countries in Latin America, which have achieved a certain degree of industrialization but have been unable to sustain a dynamic process of structural change through rapid accumulation and growth.

5.3 FOREIGN DIRECT INVESTMENT

Direct investment refers to a category of international investment made by a resident entity in one economy (direct investor) with the objective of establishing a lasting interest in an enterprise resident in an economy other than that of the investor (direct investment enterprise). "Lasting interest" implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence by the direct investor on the management of the direct investment enterprise. Direct investment involves both the initial transaction between the two entities and all subsequent capital transactions between them and among affiliated enterprises, both incorporated and unincorporated.

Accordingly, the term direct investment enterprise refers to an incorporated enterprise in which a foreign investor owns 10 percent or more of the ordinary shares or voting power for an incorporated enterprise or an unincorporated enterprise in which a foreign investor has equivalent ownership. Ownership of 10 percent of the ordinary shares or voting stock is the guideline for determining the existence of a direct investment relationship. An "effective voice in the management", as evidenced by an ownership of at least 10 percent, implies that the direct investor is able to influence, or participate in, the management of an enterprise; absolute control by the foreign investor is not required.

Foreign Direct Investment (FDI) is defined as an investment involving a long-term relationship and reflecting a lasting interest and control by a resident entity in one economy (foreign direct investor or parent enterprise) in a enterprise resident in an economy other than that of the foreign direct investor (FDI enterprise or affiliate enterprise of foreign affiliate). FDI refers to investment in a foreign country where the investor retains control over the investment. It typically takes the form of starting a subsidiary, acquiring a stake in an existing firm or starting a joint venture in the foreign country (Figure 5.1). Direct investment and management of the firms concerned normally go together.

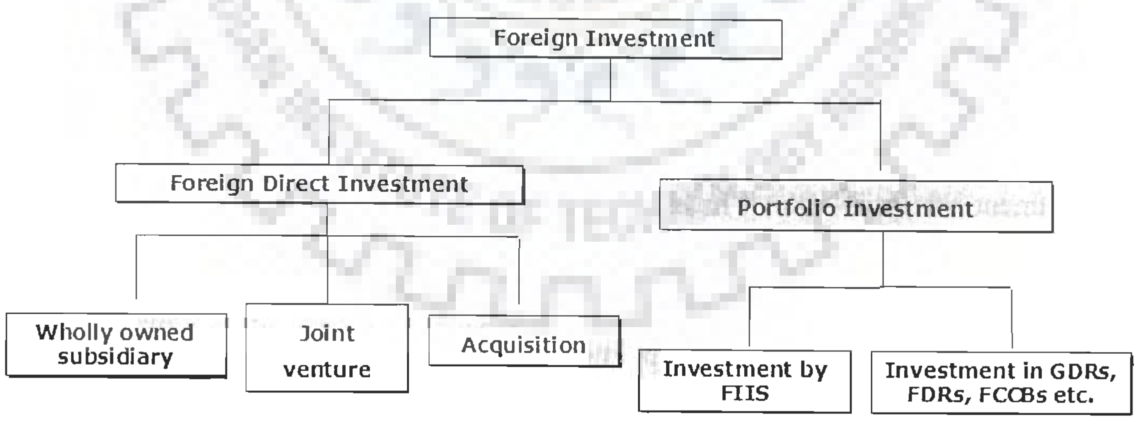


Figure 5.1 FDI Mechanism

FDI may take the form of Green - field investment, i.e., establishing an entirely new enterprise in the foreign market. It may be by Mergers and Acquisitions (M & A) i.e., merging or acquiring an existing firm in the foreign country. In recent years, cross-border M & A has been the major driver of FDI. The liberalization and deregulation of several vital industries in many countries across the world have given an impetus to cross-border M&As in both developed and developing countries.

FDI has three components: equity capital, reinvested earnings and intra-company loans. The equity capital is the foreign direct investor's purchase of shares of an enterprise in a country other than its own. The reinvested earnings comprise the direct investor's share (in proportion to direct equity participation) of earnings not distributed as dividends by affiliates, or earnings not remitted to the direct investor. Such retained profits by affiliates are reinvested. The intra-company loans or intra-company debt transactions refer to short- or long-tem borrowing and lending of funds between direct investors (parent enterprises) and affiliate enterprises.

5.3.1 Factors affecting international investment

There are several factors affecting international investment. The host country economic determinants are quest for resources, market and efficiency. Following are the various determinants of FDI for host country.

Market-Seeking FDI	▪ Market size and per capita income ▪ Market Growth ▪ Access to regional and global markets ▪ Country-specific consumer preferences ▪ Structure of markets

Resources/ Asset Seeking FDI	▪ Raw materials ▪ Low-cost unskilled labor ▪ Skilled labor ▪ Technological, innovatory and other created assets (e.g., brand names), including as embodied in individuals, firms and clusters ▪ Physical infrastructures (ports, roads, power telecommunication)
Efficiency-Seeking FDI	▪ Cost of resources and assets listed under resource/asset- FDI, adjusted for productivity seeking of labor resources ▪ Other inputs costs, e.g., transport and communication costs to / from and within host economy and costs of others intermediate products ▪ Membership of regional integration agreement conductive to the establishment of regional corporate networks

Table 5.1 Host Country Determinants of FDI

The changes in the composition of the capital flows and the substantial increase in the magnitude of some of the flows, like FDI, have remarkably changed the balance of payments and foreign exchange reserves position of several countries. The contribution of FDI to sustainable economic development of the host countries depend to a large extent on the production linkages between foreign affiliates and domestic firms. The linkages can take the form of backward, forward or horizontal. Backward linkages exist when foreign affiliates acquire goods or services from domestic firms, and forward linkages when foreign affiliates sell goods or services to domestic firms. Horizontal linkages involve interactions with domestic firms engaged in competing activities. Linkages, broadly defined, can also involve non-business entities like universities, training centers, research and technology institutes, export promotion agencies and other official or private institutions.

5.3.2 Significance of Foreign Investment

FDI shifts the burden of risk of an investment from domestic to foreign investors. The repayments in case of FDI are linked to profitability of the underlying investment, whereas under direct financing the borrowed funds must be serviced regardless of the project costs.

5.3.3 Factors attracting Foreign Direct Investment

The growth and dispersion of FDI depends on technological change, shrinking economic distance and new management methods which favor international production. The growing overseas markets lead global business entities to invest, while depressed markets inhibit them. There are several aspects which attracts Foreign Direct Investment

- Stable, predictable macro economic policy
- An effective and honest government
- A large and growing market
- Freedom of activity in the market
- Minimal government regulation
- Property rights and protection
- Reliable "infrastructure"
- Availability of high-quality factors of production
- A strong local currency
- The ability to remit profits, dividends and interest
- A favorable tax climate
- Freedom to operate between markets

5.3.4 FDI Performance Index

The Performance Index relates FDI inflows to market size, to standardize absolute inflow figures by the economic size of countries (GDP). Performance can vary considerably from year to year. There are two kinds of Performance Index- Inward Performance Index, and Outward Performance Index

a. The Inward FDI Performance Index

It is the ratio of a country's share in global FDI inflows to its share in global GDP. The Inward FDI Performance Index ranks countries by the FDI they receive relative to their economic size.

$$INDi = \underline{(FDIi / FDIw)} / (GDPi / GDPw)$$

Where,

INDi = The Inward FDI Performance Index of the i^{th} country

FDIi = The FDI inflows in the i^{th} country

FDIw = World FDI inflows

GDPi = GDP in the i^{th} country

GDPw = World GDP

A value greater than one indicates that the country receives more FDI than its relative economic size. A value below one that it receives less (a negative value means that foreign investors disinvest in that period).

The rank shows large variations over time because the numerator (FDI shares) and the denominator (GDP shares) can shift significantly from year to year. It is to be observed that the variations can be particularly large for economies with very small share in global GDP and in these circumstances even a few large investments can effect a significant shift in the ranking. Thus, in such cases it is to be taken in to consideration that the strong inward FDI performance may be temporary phenomena.

The index captures the influence on FDI of factors other than market size, assuming that, other things being equal, size is the "base line" for attracting investment. These other factors can be diverse, ranging from the business climate, economic and political stability, the presence of natural resources, infrastructure, skills and technologies, to opportunities for participating in privatization or the effectiveness of FDI promotion.

b. Outward FDI Performance Index

It is calculated as the share of a country's outward FDI in world FDI as a ratio of its share in world GDP.

$$OND_i = (FDI_i / FDI_w)/(GDP_i / GDP_w)$$

where,

OND_i - The Outward FDI Performance Index of the i^{th} country

FDI_i - The FDI outflows in the i^{th} country

FDI_w - World FDI outflows

GDP_w - World GDP

The Index reflects two sets of factors that determine outward FDI by Trans National corporations (TNCs) headquartered in a given country. Or, to put it in other terms, differences in the index values among countries reflect differences in these two sets of factors determining outward FDI by TNCs headquartered in different countries:

- "***Ownership advantages***", or firm-specific competitive strengths of TNCs (such as innovation, brand names, managerial and organizational skills, access to information, financial or natural resources, and size and network advantages) that they are exploiting abroad or wish to augment through foreign expansion.

- "***Location factors***", which reflect primarily economic factors conducive to the production of different goods and services in home and host economies, such as relative market size, production or transport costs, skills, supply chains, infrastructure and technology support.

Driven by the competitive pressures of a globalizing world economy, both factors work together to lead firms - large and small ones, from developed and developing countries alike - to invest abroad by establishing foreign affiliates. These affiliates then become a source of the competitive strength of their respective corporate networks.

5.3.5 Four-fold matrix of inward FDI performance and Potential

In order to provide data on some variables, which can be quantified for a large number of countries, UNCTAD benchmarks two parameters - inward FDI performance and potential, ranking countries by how they do in attracting inward direct investment.

The Inward FDI Performance Index is the ratio of a country's share in global FDI inflows to its share in global GDP. It provides ranking of countries by the FDI they receive relative to their economic size.

The Inward FDI Potential Index captures several factors, which may affect an economy's attractiveness to foreign investors. It is an average of the values following of 12 variables:

1. GDP per capita, with the expectation that higher income economies attract relatively more FDI geared to innovative and differentiated products and services.
2. The rate of GDP growth over the previous 10 years, a proxy for expected economic growth.
3. The share of exports in GDP (to capture openness and competitiveness).
4. The average number of telephone lines per 1,000 inhabitants and mobile telephones per 1,000 inhabitants (As an indicator of modern information and communication infrastructure)
5. Commercial energy use per capita (for the availability of traditional infrastructure).
6. The share of R&D spending in GDP (to capture local technological capabilities).
7. The share of tertiary students in the population indicating the availability of high-level skills.
8. Country risk (a composite indicator capturing some macroeconomic and other factors that affect the risk perception of investors).
9. The world market share in exports of natural resources (to proxy for the availability of resources for extractive FDI).

10. The world market share of imports of parts and components (for automobiles and electronic products, to capture participation in the leading TNC integrated production systems).
11. The world market share of exports of services (to seize the importance of FDI in the services sector that accounts for some two thirds of world FDI).
12. The share of world FDI inward stock, a broad indicator of the attractiveness and absorptive capacity for FDI, and the investment climate.

The comparison of the two indices viz. FDI Performance and FDI Potential leads us to a four-fold matrix of inward FDI performance and potential, which is as follows:

	HIGH FDI PERFORMANCE	**LOW FDI PERFORMANCE**
HIGH FDI POTENTIAL	Front - runners	Below potential
LOW FDI POTENTIAL	Above potential	Under-performers

Among the "**Front-runners**" are the countries with high FDI potential and performance. It includes many industrial, newly industrializing and advanced transition economies. It includes many developed countries such as France, Germany, Sweden, and Switzerland and Asian newly industrialized economies. The countries belonging to this category if they want to maintain or improve their position, they need to ensure continuing success.

The "**Above potential**" refers to the countries with low FDI potential but strong FDI performance. The "Above potential" includes many developed, newly industrializing and advanced transition economies, as well as a few developing countries. The group includes several countries (such as Bolivia, Colombia and Nicaragua) in Latin America and Albania, Kazakhstan and Sudan. The countries belonging to this category if they want to maintain or improve their position, they need to be concerned about raising their potential if they are to sustain past FDI performance.

"**Below potential**" represents the countries with high FDI potential but low FDI performance. In 2000-2002, countries performing below potential include the United States, Australia, Egypt, Italy, Japan, the Republic of Korea, South Africa, Taiwan Province of China and Thailand. The countries belonging to this category if they want to maintain or improve their position, they need to address the shortcomings that prevent their structural FDI potential being realized.

Under-performers are the countries with both low FDI potential and performance. It includes all the South Asian economies and many poor and least developed countries. These are mainly poor (or unstable) economies but also include countries affected by economic shocks such as Argentina and Indonesia. The under-performers include some large economies such as India and Nigeria, and resource-rich countries like Venezuela, which, for various reasons, are performing below their economic potential. The countries belonging to this category if they want to maintain or improve their position, they need to boost their performance in both attracting FDI and enhancing their potential.

5.3.6 FDI and Production Linkages

FDI in the natural resource sectors and other sectors in developing countries increase trade. Investment increases trade and foreign production by FDI substitutes foreign trade in many cases. It has been observed that, due to the protectionism and some other factors, large amounts of FDI have been taking place in the developed countries leading to substitution of foreign production for foreign trade.

5.4 INVESTMENT SCENARIO

Global upstream oil and gas industry is at a crossroads due to economic, political and market factors. Global oil markets are currently marked by uncertainty and turmoil, evidenced by record high prices, constrained spare capacity, and steadily increasing demand. With geopolitical risk and unrest in the several oil domains, it is even more important to develop newer sources of crude oil. Several global destinations hold tremendous upstream oil-gas growth potential. Rich in hydrocarbon resources, these provinces constitute an increasingly important investment position for global companies. The petroleum production under normal condition will lead to the transformation of a non-renewable asset into reproducible capital (Rafael, 1990). The asset may be a source of profitable business for a global business entity provided it generates an income commensurate to its investment. Therefore, the global investor need to weigh the investment against the return on investment, keeping in mind the various risks generally associated with such ventures and than select the strategic options.

5.4.1 Strategic Options

Business entities pursue Importing and Exporting, Licensing, Franchising, Strategic alliances, and Direct investment, to enter international market. The import and export requires small cash outlay, has little risk, and requires little or no adaptation by business entity. But, the tariffs and taxes and government restrictions are some disadvantages. The licensing leads to increased and extended profitability. The disadvantage of licensing is inflexibility of agreed terms. Strategic alliance provides quick entry to market and access to materials and technology. But there is shared ownership of resources leading to controls and profits. The strategic alliance mutually strengthens the partners, leading to exploit economies of scale. The success of strategic alliance depends on selection of partners, bridging the cultural differences, honoring the commitment, some required degree of flexibility, and structured decision-making. The direct investment is another mode of entry in to global business. It provides enhanced control to partners as well as sharing of existing infrastructures. But, there are some disadvantages as well like complexity of managing the business leading to greater uncertainty.

There are four generic strategies – Global, Transnational, International and Multi-domestic. The business of exploration and exploitation of crude oil focus International Strategy. Austin et al (1995) has put forward that the business relationship in oil business may take many forms e.g. volume discounts, turnkeys, service bundling, integrated services, joint ventures, partnership, alliances- each has a place in the continuum of business practice, each with different levels of cooperation, and trust. Each has some advantages and disadvantages. In the volume discounts and turnkeys the service company bids for the jobs and do it as per the requirement. In service bundling, several services are gathered under one contract to have one contract between operator and contractors. Joint ventures tend to denote shared equity and sometimes result in acquisition of one party by another. Partnership is a project specific short tem relationship between partners. The alliance is similar to partners but, it persists beyond the scope of individual project.

The philosophy behind entering a country for exploration and production of crude oil is to secure proceeds of business. The objectives of host country offering acreage and the contracting country intending to enter that country converge at one point i.e. exploration of crude oil. There are several other areas where the objectives of the parties diverge. The primary aim of government is to ensure economic benefit to the country and in order to meet this objective it intends to control over terms and conditions, price, and levels of production so as to capture the maximum economic rent at an acceptable level of risk. The contracting company or foreign investor is therefore concerned about the fiscal regime of the host country, especially with regard to the ex post facto changes. Seba (2003) has provided following difference in priorities between two parties.

Host Government	Foreign Investors
1. Earn foreign exchange	1. Maximize economic returns
2. Maximize economic return	2. Receive reasonable return for degree of risk undertaken
3. Maintain control over natural resources	3. Minimize pay back period
4. Promote local ownership	4. Ensure repatriation of funds and export of entitled crude oil
	5. Retain ownership and claim profits
	6. Retain operating control and assure production economics

The following section attempts to make an analysis of petroleum fiscal system and to understand investment opportunities and constraints in the global provinces.

5.5 PETROLEUM FISCAL SYSTEM

The arrangements which the host country and the company make to allow the latter to carry out oil and gas exploration, appraisal, development and production activities in the former are incorporated in the oil and gas agreement and it defines the petroleum regimes of that country. The fiscal arrangement is the Government's most important tool for managing petroleum resources (Kjemperud, 2004).

The counties have their own fiscal systems and way to carry bidding, screening of the bids, and finally award of contracts. A business entity interested in global business of exploration and exploitation of crude oil screen opportunities which match their interests and risk-taking strategy. The fiscal terms offered by the country to any foreign entity is well drafted with little scope for negotiations. Thus, prior to entering any overseas venture for exploration and exploitation of crude oil the sound knowledge and proper understanding of target countries fiscal system is imperative, because the economics of crude oil production are greatly affected by specific contract terms. Therefore, a comprehensive understanding of the partners to the nuances of the contract, the structure and provisions of the various contracts in vogue, and the respective probabilities of the geological, political and fiscal risks involved is necessary. Keeping these divergent motives and objectives in view the foreign investors is expected to have sound knowledge of various petroleum fiscal systems.

There are various types of upstream petroleum regimes found in the world having different tax and sharing arrangements. The tax imposed affects the production strategy, which affect firm's profitability and government rent. "The excessive tax burden can lead to premature abandonment of fields, generating inadequate production strategies and forcing producers to direct investments to countries or regions that are more attractive. On the other hand, a non-neutral tax regime can provoke unnecessary reduction in government revenues, with little or no increase in overall production (Rafael, 1999)." Not only that the Governments attempt to capture as much as economic rent as possible through various fiscal regimes. According to Rafael, "royalties are attractive to regulators because they are certain and reasonably predictable, ensure a stable flow of revenues over the life of a producing field, and are easy to estimate and monitor. At the same time, royalties are criticized for being regressive and failing standards of economic efficiency." Therefore, the system which offers equilibrium in the way revenue and profit are shared between the regulatory regime and the oil company will be most attractive. Following is the brief discussion of fiscal system prevalent globally.

5.5.1 Historical Developments of Fiscal Systems

Initially, oil and gas exploration outside of North America and Europe was carried out by a small number of multinational companies (the "Seven Sisters" and their predecessors), strongly supported by their respective governments in the United States and Europe. The crude oil discoveries have been recorded several thousands of years back. Colonel Edwin Drake is credited with the discovery of oil and is known as the father of the modern oil industry. In 1865, John D Rockefeller founded Standard Oil. In the early days, kerosene was the main fuel produced from crude oil. A number of companies started to distil crude oil to produce kerosene. However, the quality of the kerosene was not maintained leading to several accidents due to explosion. It was Rockefeller who decided to produce 'standard' kerosene and the name Standard Oil for kerosene. After about 40 years Standard Oil was dissolved due to anti-trust regulations in the US in the year 1911 and out of the dissolution of the giant Standard Oil emerged companies named Standard Oil, New Jersey (later known as Exxon), Standard Oil, New York (later known as Mobil), Standard Oil, California (later known as Chevron), Standard Oil, Ohio (Sohio), later become the US arm of BP, Continental Oil (later known as Conoco), Atlantic (later known as Arco), etc. Until the 1960s, the global oil industry was dominated by multinational western companies popularly known as the 'Seven Sisters'. These 'Seven Sisters' were none other than the large oil companies, namely Exxon, Mobil, Chevron, Texaco, Royal Dutch Shell, British Petroleum, and Gulf Oil. These were vertically integrated oil companies. They owned oil acreage, refining and petro-product marketing networks and thereby having virtual control over the entire oil supply chain. Consequently, there was very little spot oil trading in the market. These companies managed the supply and demand situation by regulating or increasing oil supplies in line with demand. This was the era when oil prices were stable with very little volatility. This situation gave the multinational oil companies an overwhelming advantage with respect to the countries in which they explored. During this phase of development of the international oil industry, almost all exploration was carried out under concession type agreements (described in detail later in this chapter).

Following World War II, the nature of the international oil industry began to change dramatically. As more and more countries gained independence from then- colonial rulers, they began to exercise more control over their oil and gas resources. In addition, the independent oil companies began to explore internationally and, in doing so, showed a much greater willingness than the multinationals to accommodate the desires and aspirations of the newly-emerging nations. As a consequence, the host countries and the foreign oil companies began to use different types of contracts. This trend has continued to the present day with the result that a plethora of oil and gas contracts now exists in the world with variety of fiscal systems.

5.5.2 Description of fiscal systems

The basic petroleum regimes for exploration and exploitation of petroleum around the world can be categorized in to two – Concessions and Contracts and the exploration for petroleum occurs on the basis of concessions, leases, or contracts granted by governments.

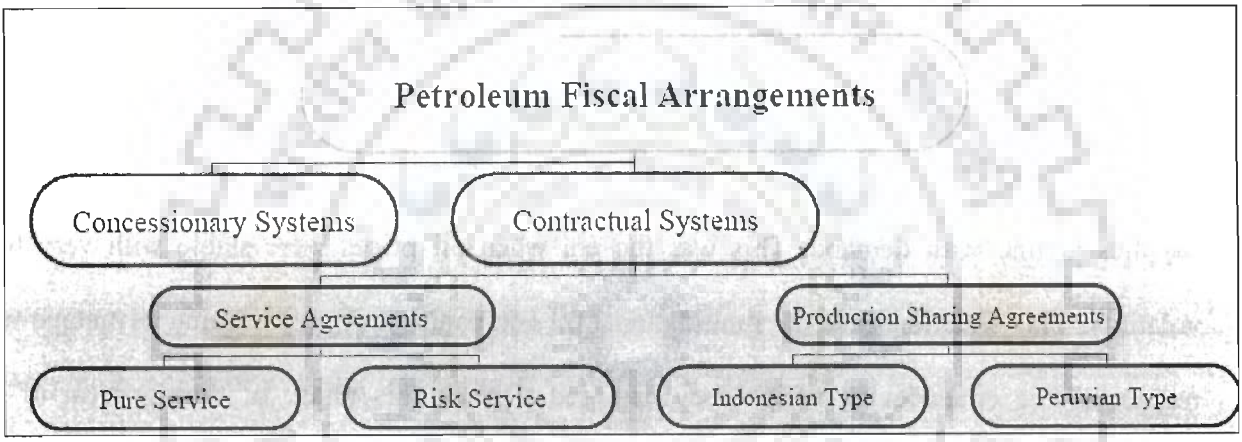


Figure 5.2 Petroleum Fiscal Regimes
(Adapted from Kjemperud, 2004)

The terms and conditions of such arrangements are established by law or negotiated case by case (Khelil, 1995). However, almost all agreements are variations of three basic types, namely: Concession (Tax-Royalty) Agreement, Production Sharing Agreement, Service Agreement (Figure 5.2), and Pure Service Contract and Risk Service Contract. The framework representing the international oil and gas agreements has been described in the following schematic (Figure 5.3 and 5.4).

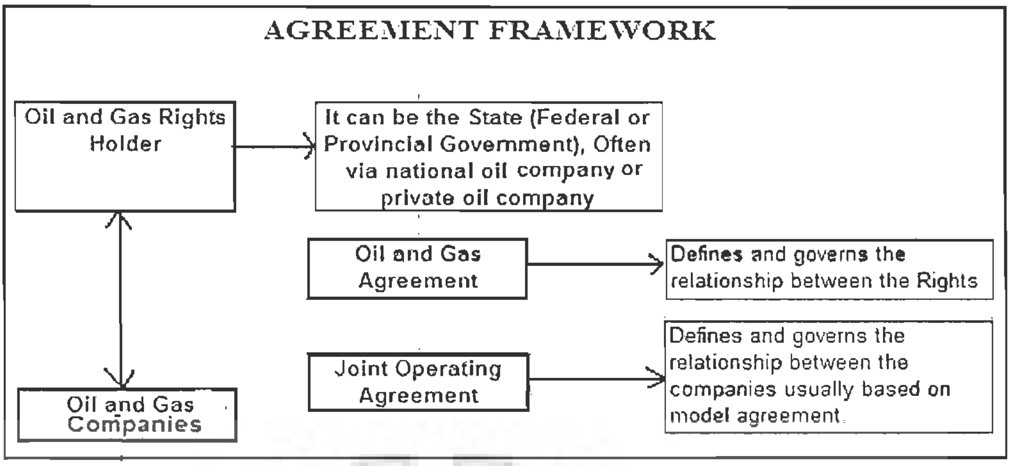


Figure 5.3 Framework of international oil and gas agreements

(Adapted from Johnston, 1994).

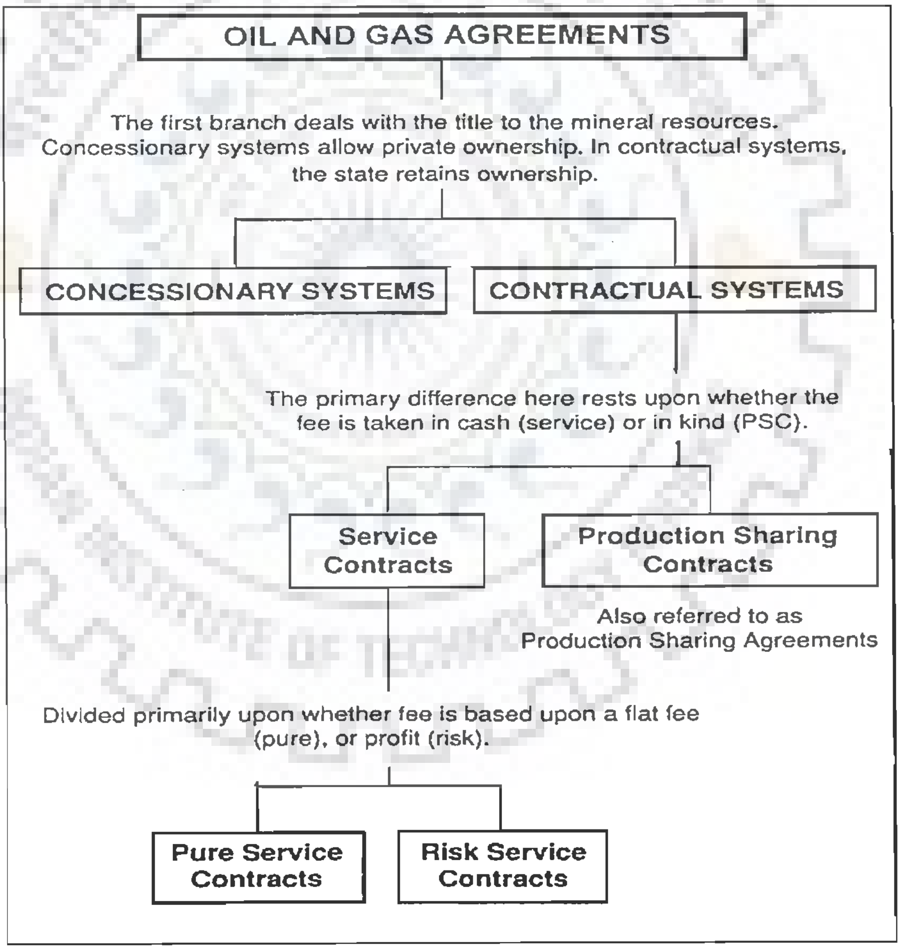


Figure 5.4 Classification of Oil and Gas Agreements

(After Johnston, 1994)

Petroleum fiscal regimes covers the legislative, tax, and contractual issues. According to Khelil (1995) "together all the payments to government required under petroleum arrangement can be called a 'fiscal system'. In some countries, a single fiscal system applies to the entire country; in others, a variety of fiscal systems exist." There are more fiscal systems in the world than there are countries due to negotiation of terms (Kjemperud, 2004) (Table 5.2, 5.3 and 5.4). The large number of acreage available on global scale coupled with variety of fiscal systems and several companies in fray has led to the creation of "international market" for exploration acreage (Khelil, 1995).

World Petroleum Fiscal System Statistics			
	PSCs	World Average	Royalty/Tax Systems
Number of Systems	72	136	64
Government Take	70%	65%	59%
Gvt. Participation			
Systems with Gvt. Participation (%)	36 (50%)	65 (48%)	29 (46%)
% Participation in those Systems with Gvt. Participation	25%	27%	30%
Royalty	5%	7%	8%
Effective Royalty Rate	23%	17%	8%
Ringfenced Systems	75%	55%	30%
Lifting Entitlement	63%	77%	92%
Savings Index	39¢	47¢	56¢
Cost Recovery Limit (PSCs only)	65%	N/A	N/A
Systems with ROR features or "R" factors	17%	21%	25%

Table 5.2 World Petroleum Fiscal System Statistics
Adapted from (Johnston, 1994)

REGION	CONCESSION (Royalty/ Income Tax)		PRODUCTION SHARING		RISK SERVICE
North America	Canada, USA				
Latin America	Argentina Bahamas, Barbados Belize Costa Rica, Paraguay Peru Surinam Trinidad	Brazil	Bolivia Guatemala Guyana Honduras Panama Uriguay Venezuela Brazil		Chile Venezuela
Europe	Austria Bulgaria Denmark France Germany Greece Greenland Ireland Italy	Malta Netherlands Norway Poland Portugal Spain Sweden Turkey United Kingdom	Albania CIS Romania Yugoslavia		
Africa	Chad Congo Gambia Guinea Bissau Mali Morocco	Namibia Niger Nigeria Senegal Seychelles Sierra Leone Somalia South Africa Tunisia Zaire	Algeria Angola Benin Burundi Cameroon Cote d Ivoire Egypt Equatorial Guinea Ethiopia Gabon	Guinea Mauritania Kenya Liberia Libya Mozambique Sudan Tanzania Togo Zambia	Madagascar
Near East	Israel UAE		Bahrain Jordan Oman Qatar Syria Yemen		
Far East/ Australasia	Australia Brunei Cambodia Fiji New Zealand	Pakistan Papua New Guinea South Korea Thailand	Bangladesh China India Indonesia Laos Malaysia	Mongolia Myanmar Nepal Sri Lanka Vietnam	Philippines

Table 5.3 World Fiscal system (Adapted from Seba, R.D. 2003)

Country	Duration (in years)		Relinquishment	Royalty	Bonuses	Depreciation	Taxation	Domestic market obligation	Cost Recovery
	Expl.	Pro.							
Algeria	4+2 extn.,	12	-	Zone N 20%,AreaA 16.25%, AreaB12.25%	Nil	Dry holes 100%. Producing wells 25%/year. Building & facilities 20%/year Pipelines 10%/year	Income Tax ZoneN 85% AreaA 75% AreaB 65%	Yes	NO
Angola	3+2 extn.,	20	-	Nil	Yes, signature	5-years	Income Tax 50%	Nil	-
Argentina	4-6 onshore & 6-9 offshore, 25+10extn.for production		-	12 % 5%marginal field 15% to pre commercial prod.	-	-	30% income tax 1%sales tax, 1% assets tax	Yes	-
Azerbaijan	5 , 25+5 extn.				Signature, Production		Income tax liability from the state's share		Yes
Brazil	30 overall including 9yr max exploration		100% after predetermined period	10% royalty which may reduced to 5% marginal field	Yes, signature		15% income tax		
Chad	**Up to 10 yrs :** With the initial period		50% alter three yrs.,25% of the remaining area on	-	Yes, Signature, comercial	-	-	-	-

	of five yrs with two renewals 3+2yrs	first renewal & 25% of the remaining area on Second renewal		discovery bonus				
	Up to 35 yrs 25 +10 developement & production	-	12.5% for oil and 5% for gas but may be relaxed	Yes, production	6 year straight line	Income tax 45%	Yes	-
China	7 , 15+extn. (with approvals)	-	Yes	Yes, Signature	6 years	Income tax 30% 3% local income tax 10 surtax	Nil	50-62.5%
Columbia	28 including exploration up to 10 for exploration	50% at the end of 6years 25% more at the end of 8 years	8-25%	-	-	35% Income tax,10 % Surcharge , Remittance tax 7%	Yes	100%
Ecuador	6 ,25max		Nil	Nil		Corporate income tax 25% etc.		
Egypt	8 , 20	After the each phase 25% of original area	0-10% negotiated	Yes, Signature, production	8 years	Paid by the govt.	-	40%
Equatorial guinea	5 , 30 oil 50 gas	40%at end of 3rd year, additional 20% before end of 5th year	10%	Yes, Signature , Discovery, First oil	25%/year	25% Income Tax	Yes	-

				sales, Production				
Gabon	3+2extn ,20	3years25% 5years 50%	Yes, 5-20%	Yes, signature, production	5-years	56% income tax paid by the govt. out of the contractors share of profit oil	Up to 20% of profit oil sold at 75% market price	55%
India	8, 20+5 production	-	12.5%onshore and 10% offshore(reduced to 5% for 7 yrs for 400 m.)	Nil	4 year	38.5% income tax for local companies and 42% for foreign companies	-	100%
Indonesia	3 , 20	25% or 100% no discovery	Nil	Yes, signature, production	Oil – 25% Gas-10%	48% Income tax	Contractor receive10% of market price for 25% of oil	80%
Kazakhstan	10 ,25 or 40 for large field		Yes sliding scale royalty	Yes, signature		Fixed 30% income tax		Yes
Malaysia	29 max, 7+ yrs exploration	Nil	10%	Nil	10yrs	38% income tax 10%duty on profit oil	Nil	50% for oil 60% for gas

						exported		
Mexico	20max	Yes	-	-		32% income tax,1.8%assets tax		
Nigeria	- -	-	Based on increasing depth 16.667-0 %	Yes	-	50%	-	40% ,under old contacts
Norway	30max	-	Nil	Nil	6yrs	28%income tax,30% special tax	Nil	100%
Peru	30 max for oil & 40 max for gas		5-20%basedon daily production rates			30% corporate income tax		Yes
Rep.of Congo	10 , 30	-	14.5-19 Oil,9 gas	Yes	5yrs	55	Yes,30%of contractor's oil	-
Russia federation	5+, so long as prod is justified		6-16% and an additional 10% for existing field	Negotiable signature & production		Income tax 30%.excise Tax on production, Export duty etc.		negotiable cost ceiling recovery
Sudan	30 for both	-	-	Yes, Signature & production	-	Income tax met from state's share	-	Cost recovery ceiling
Syria	7+ , 25+10	-	11%	Yes, Signature & production	5 yrs	Taxes paid by the govt.	-	35%of gross prod. less royalties
Thailand	Up to 9 yrs	-	Based on BOPD	Yes,	5yrs	50% income	-	-

	exploration & 20+10 prod.		5-15%	signature	tengible,10 for intangibles	tax		
Trinidad & Tobago	25-30 over all 6-9 for deep offshore ,	-	10-12.5%,onshore royalty reduced to 0% for well prod.up to5b/d	Signature Production	-	50% petroleum profit tax	-	Yes
Tunisia	- -	-	Yes ,2-15%	-	30%/yr	Yes	Pro rate up to max 20%	Yes
Turkmenistan	25+10extn.	-	Yes,0-15%	-	-	25% income tax	-	Yes
United kingdom	18 , field specific	-	Nil	Nil	25% declining balance	33%income tax,75% petroleum revenue tax	Nil	100%
Uzbekistan	7 , 23	25% after 4yrs ,25% each year thereafter	10%max	Yes, signature	5yrs	Income ,export, VAT	-	60%
Venezuela	Total 35+15 extn.	-	Min 30% which can be reduced up to 20%	Yes signature	-	50%income tax	Yes,10% reserved for local market.	-
Vietnam	5yrs+6months etn. , 25+5yrs extn.	25%at the end of 4th yrs	8-25% or 6-20% for deep water for oil, 0-10%or 0-6% for gas	Yes, Signature, production	Not clear	Taxes paid by petrovietna-m	Yes	Higher cost recovery up to 70%
Yemen	20	-	Nil	-	-	-	-	30%

Table: Salient features of Petroleum Fiscal system of few countries compiled from various data sources e.g. Johnston, 1994, IHS Energy

The entire gamut of petroleum exploration comprises of distinct phases from pre license to abandonment (Figure 5.5). Each phase entails a cost and income component. The fiscal system of a country defines the allocation of revenue from production (Figures 5.6 and 5.7) and suggests whether the fiscal system is progressive or regressive (Figures 5.8 and 5.9).

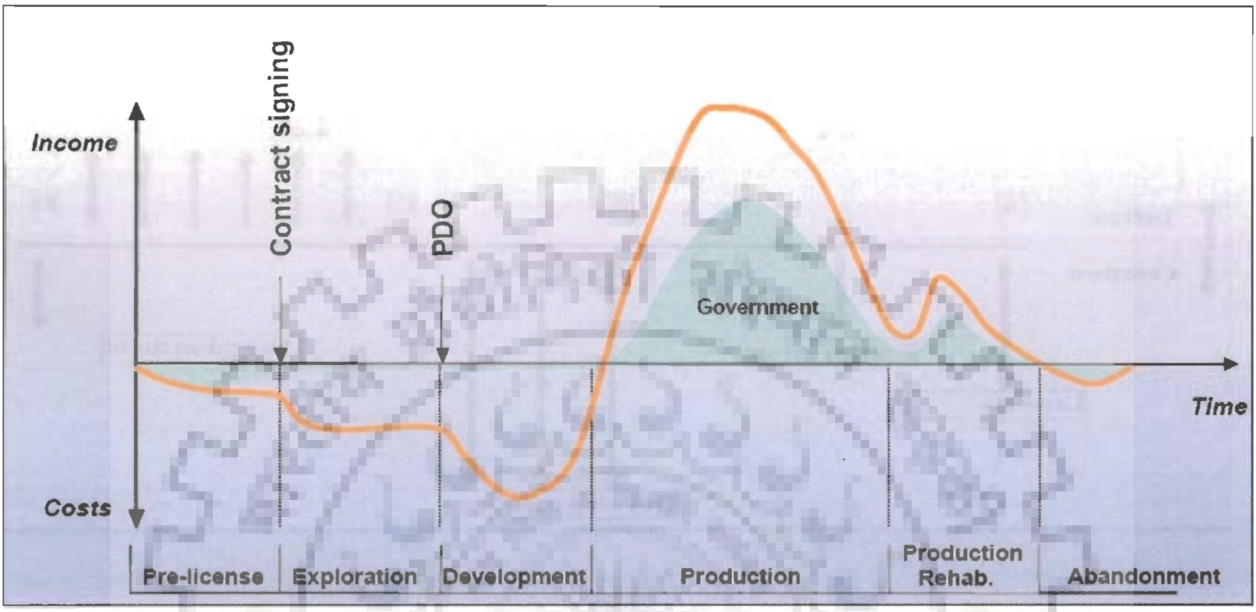


Figure 5.5 Exploration activities and cash flow (Adapted from Kjemperud, 2004).

In exploration and production of crude oil business large investments are required long before cash inflows begin. Thus, cash flows are highly risky as a result of the uncertainties during the life of the project. The investments can increase tremendously during development if performance is poor. The cash inflows may decline as production declines. Necessarily, considerable cash outflows are necessary well before cash inflows begin (Figure 5.6). The cash flows included in economic analysis must consider the life of a project (Figure 5.7) prior to making any decision. In an economics analysis full-cycle economics, and sunk-cost should be included as well as the tax benefits. These analyses are to be carried out to determine whether to enter an exploration project, or to determine if a discovery should be developed, and to value a producing field.

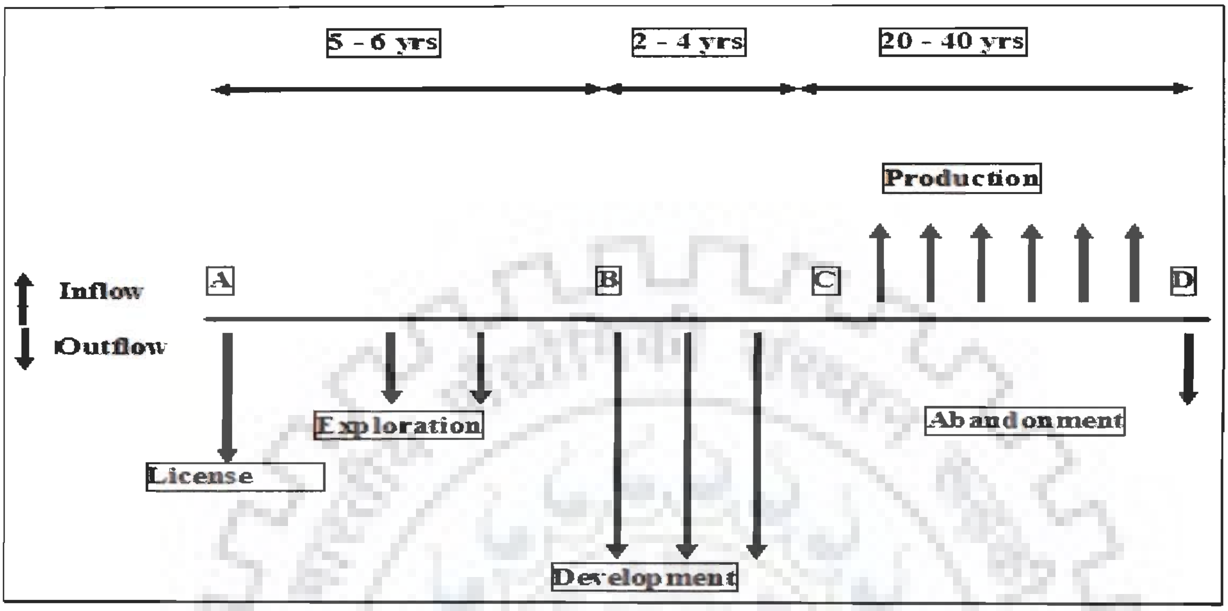


Figure 5.6 cash Inflow and outflow in E&P business

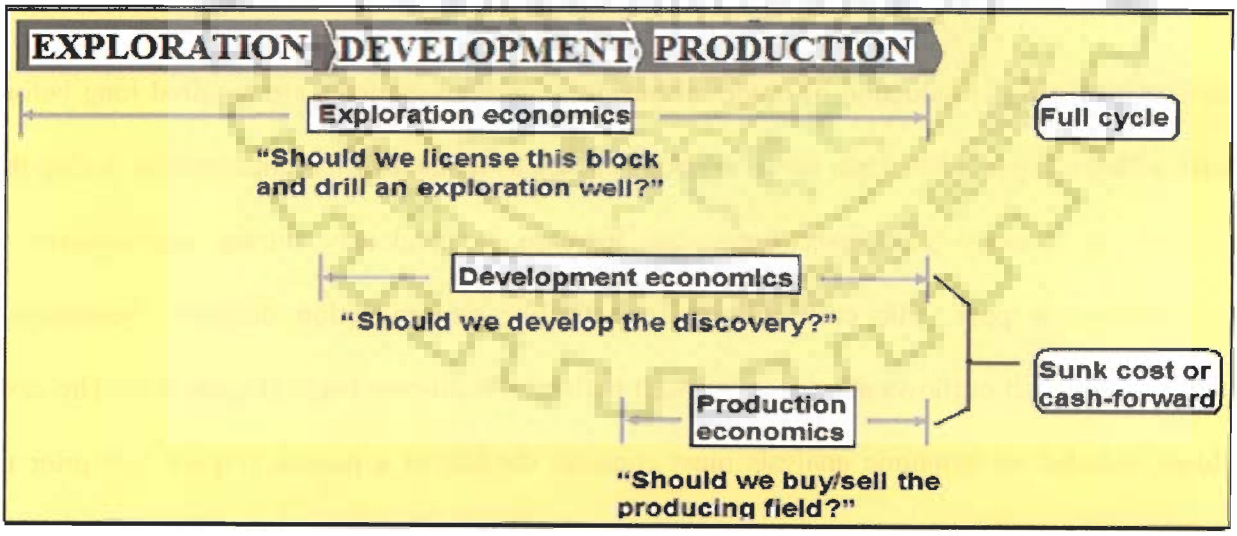


Figure 5.7. Economics of an E&P Project

The economic profit (or cash flow) represents cumulative gross revenues less cumulative gross costs over life of the project (full cycle). The Government take percent (Figure 5.8) depicts the government receipts from royalties, taxes, bonus, production or profit sharing, and government participation, divided by total economic profit. The contractor take percent is one minus the government take. In other words it is the contractor net cash flow divided by economic profit.

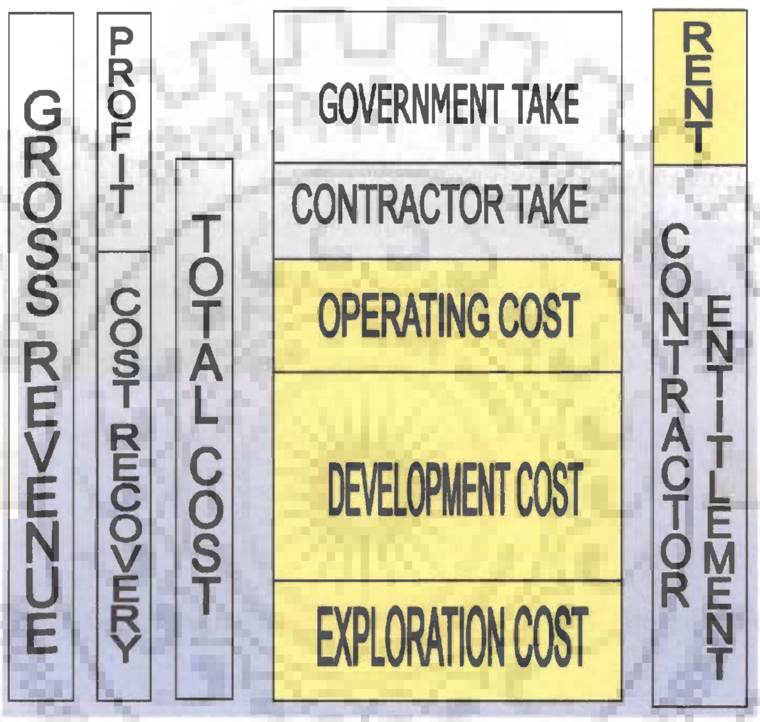


Figure 5.8 Allocation of revenue from production (After Johnston, 1995)

Adapted from Kjemperud, 2004

The government take is the total effect of fiscal system on the cash flow of an oil field expressed in percentage and it also refers to the 'price' for the acreage. For example, a government take of x% means that the total government revenues from fiscal system represent x% of the cash flow of the oil field. The world average government take is 64% with Ireland having a low rate of

25% and Yemen with highest of 95% (Khelil, 1995). Khelil (1995) has provided the fiscal system ratings of the world which is outcome of study initiated and supported by the World Bank, in which 226 fiscal systems in 144 countries were rated. Khelil (1995) has provided following grouping for world fiscal system for few countries.

Very favorable: Ireland, Spain, United Kingdom, Argentina, New Zealand, Pakistan (zone 1), and Denmark (fourth round).

Favorable: Northwest Territories (Canada), Illinois, Peru, Australia (offshore), and U.S. outer contintental shelf (Gulf of Mexico, deep).

Average: The Philippines, U.S. outer continental shelf (Gulf of Mexico, shallow), Thailand (gulf, 1995 terms), China (offshore), Malaysia (deep water), Nigeria (offshore to 200 meters), Viet Nam, and Trinidad and Tobago (onshore).

Tough: Kazakhstan, Alaska (onshore), Ecuador (regular terms), Texas (offshore), Alberta (third-tier oil), Netherlands (1995 terms), Norway, and India.

Very tough: Louisiana, Russia (production sharing contract), Venezuela (new model contract), Indonesia (1994 terms), Malaysia (conventional), Angola, Nigeria (Niger Delta), Syria, and Yemen.

During the past two decades the exploration end of the business has not been profitable due to the reason is that relative to the prospectivity in most countries, fiscal terms are too tough as represented in Figures 5.9 and 5.10 (Johnston, 1994).

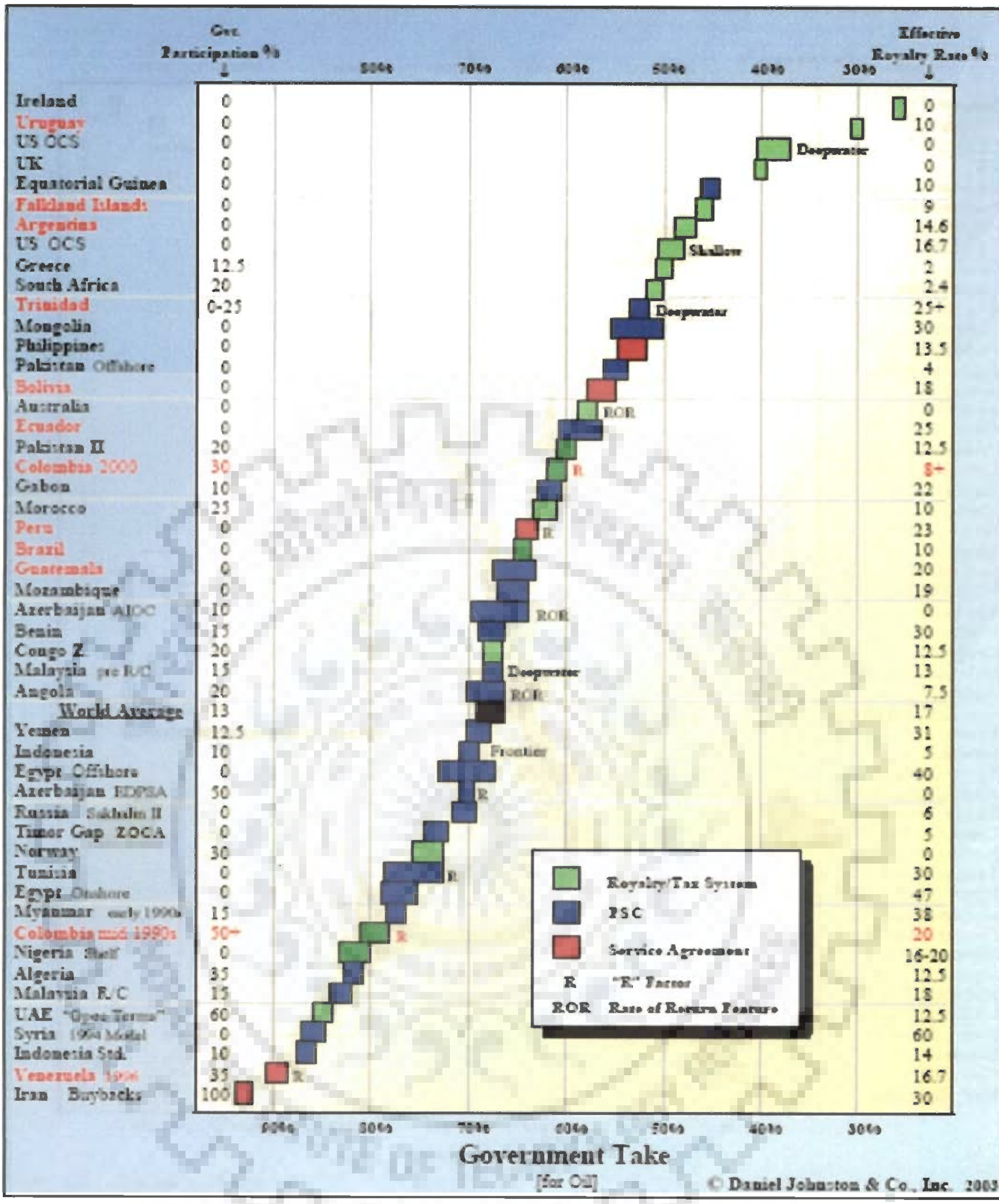


Figure 5.9 World Fiscal system

(adapted from Johnston, 1994)

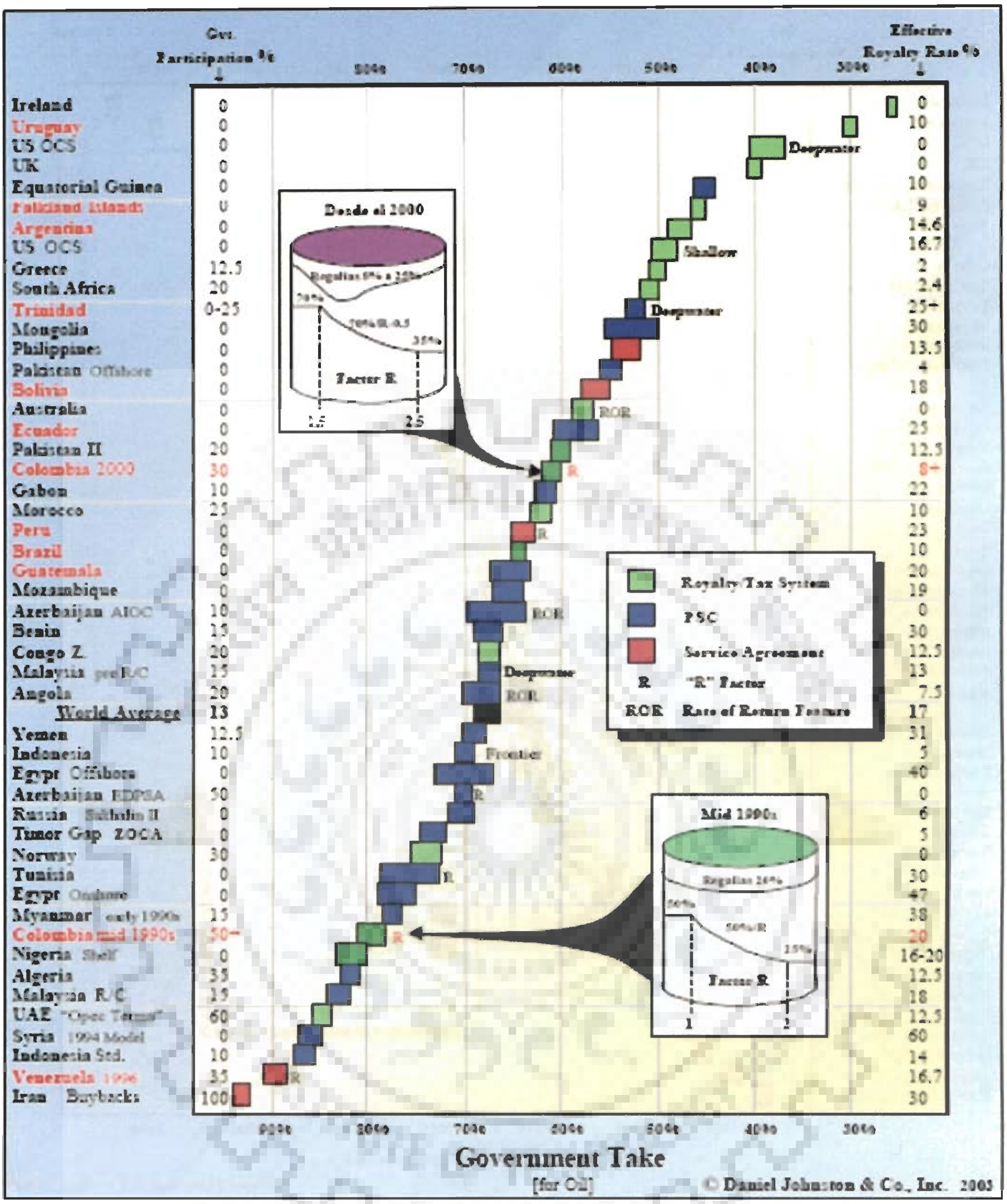


Figure 5.10 World Fiscal system

(adapted from Johnston, 1994)

The countries with unfavorable conditions for exploration offer very favorable terms, and countries with favorable conditions demand tough or very tough terms (Khelil, 1995). According to this study, the world average fiscal system is regressive, i.e. the government take is a higher percentage of the cash flow for small and marginal fields than for large and profitable fields (Figure 5.11, 5.12 and 5.13). Another finding is that the world average fiscal system is front end loaded. According to Van Meurs (1998), the world wide competition for exploration and production rights has led to improvement in the fiscal terms offered by governments to international oil and gas companies in 1997. Van Meurs (1998) have ranked the world fiscal systems (Table 5.5). The five stars are very favorable to investors. Four-star systems are favorable to investors; whereas the three-star systems are average; two-star systems are tough to investors; and one-star systems are very tough. Kaiser et al (2006) provided the contract terms and government take for various countries (Table 5.6).

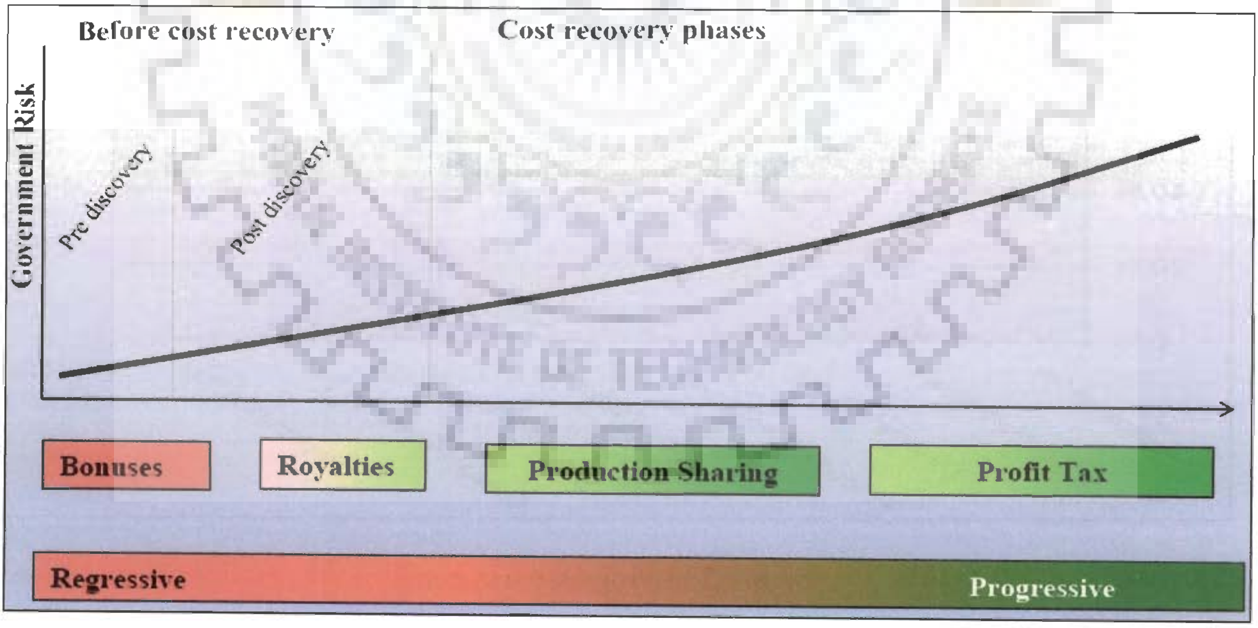


Figure 5.11 Regressive and progressive fiscal regime

(Adapted from Kjemperud, 2004)

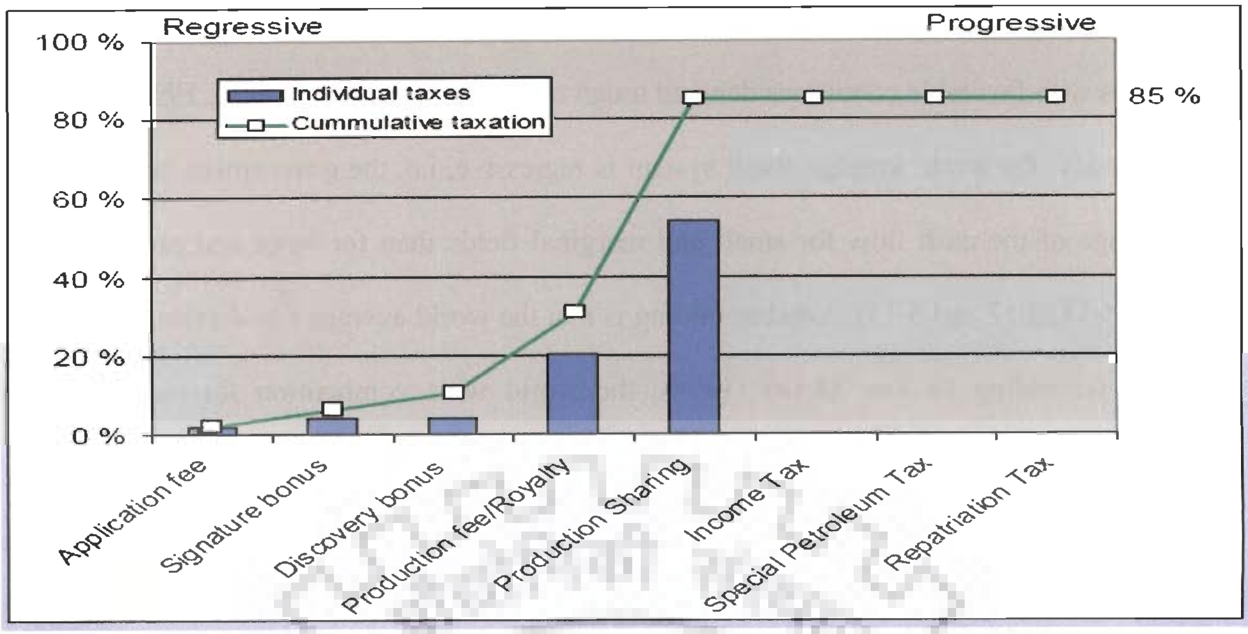


Figure 5.12 Regressive fiscal system

(Adapted from Kjemperud, 2004)

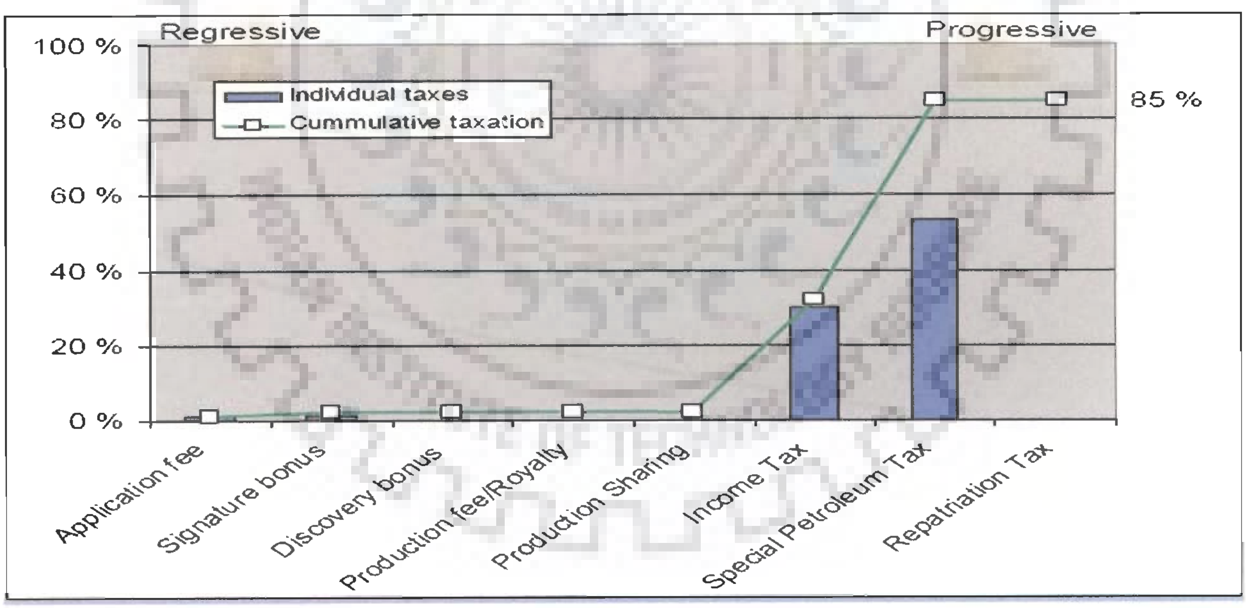


Figure 5.13 Progressive system

(Adapted from Kjemperud, 2004)

Van Meurs ranking of world fiscal systems

Rank	Country	Fiscal system
Five star systems		
1	Svalbard	Svalbard
2	Argentina	Tierra del Fuego
3	Palau	Palau
4	Spain	Spain
5	Lebanon	Onshore
6	Ireland	Frontier
7	Ireland	Deep water
8	Ireland	Shallow water
9	Bahamas	Bahamas
10	Paraguay	Paraguay
11	Moldova	Moldova
12	United Kingdom	General
13	Pakistan	Offshore PSC—Deep water
14	Israel	Offshore
15	Israel	Onshore
16	Portugal	Deep water
17	Nicaragua	Nicaragua
18	Cyprus	Cyprus
19	Kazakhstan	Oman Oil Co.—PSC
20	Brazil	Proposed new law—Small fields
21	Sweden	Sweden
22	Uruguay	Uruguay
23	United Kingdom	Northern Ireland
24	Mongolia	Mongolia
25	Puerto Rico	Puerto Rico
26	Belgium	Belgium
27	Falkland Islands	Falkland Islands
28	Pakistan	Offshore PSC—Shallow water
29	Austria	Austria
30	Portugal	Offshore—Shallow
31	Germany	Offshore
32	Portugal	Onshore
33	Italy	Offshore
34	Antigua	Antigua
35	Jamaica	Jamaica
36	Argentina	General
37	Poland	Poland
38	Costa Rica	Costa Rica
39	Hungary	Hungary
40	Fiji	Fiji
41	Dominican Republic	Dominican Republic
42	Belize	Belize
43	Greenland	Greenland
44	Switzerland	Switzerland
45	Mauritius	Mauritius
46	Pakistan	Zone 1 (Onshore)
47	United States	Federal Onshore
48	Greece	Greece
49	Peru	Offshore—Block Z-29
50	Niger	Niger
51	Kazakhstan	Oryx PSC
52	Canada	Alberta—3rd tier—With tax credit
53	Haiti	Haiti
54	Ukraine	Krymgeologia/Hytexplor
55	Chad	Chad
56	Eritrea	Minimum terms
57	Germany	Schleswig Holstein
58	New Zealand	New Zealand
59	Barbados	Barbados
60	Czech Republic	Czech Republic
61	China	Taiwan
62	Canada	Ontario
63	France	France
64	Maldives	Maldives
65	St. Pierre & Miquelon	St. Pierre & Miquelon
66	Turkey	Turkey
67	Germany	Lower Saxony
68	Guyana	Guyana
69	Pakistan	Zone 2
Four star systems		
70	United States	OCS—Chukchi Sea
71	Philippines	Deep water
72	United States	OCS—GOM—Waters >800 m
73	Japan	Japan
74	Lithuania	Lithuania
75	United States	OCS-GOM—>400-800 m
76	Australia	New South Wales
77	United States	Illinois
78	Ecuador	Minimum terms
79	Canada	Alberta—Oil sands
80	Pakistan	Zone 3
81	Croatia	Croatia
82	Canada	Newfoundland onshore
83	Slovakia	Slovakia
84	Peru	Model contract
85	Australia	South Australia
86	Australia	Northern Territories
87	Australia	Queensland
88	Australia	Victoria
89	United States	Alaska—Offshore state waters
90	Philippines	General terms
91	Netherlands Antilles	Netherlands Antilles
92	Mali	Mali
93	United States	Alaska—Onshore
94	Vietnam	Petroleum Law—Deep water
95	United States	OCS—GOM—200-400 m
96	Central African Republic	Central African Republic
97	United States	Utah
98	Nigeria	Offshore—over 1,000 m
99	Australia	Offshore
100	Timor Gap	ZOCB
101	Cote d'Ivoire	Offshore—Deep
102	United States	West Virginia
103	United States	OCS-General terms
104	Australia	Tasmania
105	Italy	Onshore
106	United States	Colorado
107	Sierra Leone	Sierra Leone
108	Australia	Western Australia
109	Canada	Northwest Territories
110	Vietnam	Petroleum Law—Shallow water
111	Togo	Togo
112	Canada	Newfoundland—Offshore
113	Canada	Nova Scotia—Offshore
114	Guatamala	1997 Bidding round—15° API
115	Surinam	Suriname
116	Sao Tome & Principe	Sao Tome & Principe
117	United States	Michigan
118	United States	California—Onshore
Three star systems		
119	Panama	Panama
120	Nigeria	Offshore—800-1,000 m
121	United States	OCS—Beaufort
122	Zambia	Zambia
123	United States	Arkansas
124	Bangladesh	Bangladesh
125	Peru	Camisea
126	Tonga	Tonga
127	United States	OCS—GOM—less than 200 m
128	Kenya	Kenya
129	Nigeria	Offshore—500-800 m
130	Bolivia	Non-traditional area
131	Bolivia	Traditional
132	United States	Wyoming
133	Canada	Indian owned lands
134	Ecuador	Triton contract
135	United States	Ohio
136	Joint Dev. Area	JDA (Thailand—Malaysia)
137	United States	North Dakota

Table 5.5 World Ranking of Fiscal System (Adapted from Van Meurs, 1998)

Van Meurs ranking of world fiscal systems (continued)

Rank	Country	Fiscal system
138	Nigeria	Offshore—200-500 m
139	Albania	Onshore
140	United States	Montana
141	Canada	Inuvialuit owned lands
142	South Africa	South Africa
143	Kazakhstan	Elf—Temir PSC
144	Thailand	Deep water
145	Guinea	Guinea
146	Senegal	Senegal
147	Denmark	4th round terms
148	Malaysia	Deep water
149	Korea (North)	Korea (North)
150	Zaire	Zaire
151	Cambodia	PSC-2—General terms
152	Jordan	Jordan
153	Denmark	Outside Central Graben
154	Albania	Offshore—new terms
155	Egypt	Mediterranean—Contract 3
156	United States	New Mexico
157	Italy	Sicily
158	Tanzania	Model contract
159	Madagascar	Madagascar
160	Ethiopia	Ethiopia
161	Nigeria	Offshore—up to 200 meter
162	Nepal	Model contract
163	Bolivia	Old hydrocarbons
164	Bulgaria	Bulgaria
165	Namibia	Namibia
166	United States	Mississippi—Offshore
167	Ras Al-Khaimah	Ras Al-Khaimah
168	Benin	Benin
169	Peru	Murphy contract
170	Trinidad & Tobago	Onshore
171	Korea (South)	Korea (South)
172	Ukraine	96 Bid terms
173	Guatemala	97 Bid terms—30° API
174	Nepal	Shell contract
175	Tanzania	Rukwa Graben
176	United States	Oklahoma
177	Ajman	New PSC
178	Kyrgystan	Model PSC
179	Gambia	Gambia
180	United States	Florida
181	Thailand	Shallow water
182	Lebanon	Offshore
183	Cambodia	PSC1—Premier contract
184	Tanzania	Ruvuma basin
185	Laos	Laos
186	United States	Texas—Onshore
187	India	PSC—No carried interest
188	Congo	Kitina PSC
189	Algeria	Minimum terms
190	Tunisia	Frontier terms
191	Turkmenistan	Turkmenistan
192	Canada	Newfoundland—Hibernia
193	China	Offshore
194	Trinidad & Tobago	Offshore PSC
195	Thailand	Khorat Plateau
196	Mozambique	Mozambique
197	Tunisia	General terms
198	Chile	Chile
199	Denmark	Central Graben
200	Canada	Manitoba
201	United States	Alabama—onshore
202	Morocco	Deep water
203	Morocco	Shallow water
204	Equatorial Guinea	Current terms
205	Thailand	Central onshore
206	Congo	Petroleum Law terms
207	India	PSC—With carried interest
208	Seychelles	Seychelles
209	Canada	Alberta—3rd tier to tax credit
210	China	Onshore—Frontier terms
211	Cameroon	Basins other than Rio del Rey
Two Star systems		
212	Burundi	Burundi
213	Ghana	Ghana
214	Dubai	Dubai
215	United States	Texas—Offshore
216	United States	Mississippi—Onshore
217	Timor Gap	ZOCA
218	Egypt	Mediterranean—Contract 1
219	Uzbekistan	Uzbekistan
220	China	Onshore—Regular terms
221	Russia	Komi Republic PSC
222	Qatar	Restated contract
223	El Salvador	El Salvador
224	Thailand	Gulf of Thailand
225	Equatorial Guinea	PSC-1
226	Vietnam	Oxy PSC
227	Congo	PNGF
228	Brunei	Offshore more than 20 miles
229	Cote d'Ivoire	Shallow water
230	Trinidad & Tobago	Offshore
231	Yemen	Contract 2—Revised terms
232	Colombia	Traditional
233	Romania	Romania
234	Cameroon	Rio del Rey basin
235	Papua/New Guinea	PNG
236	Brunei	Offshore less than 10 miles
237	Congo	N'Kossa
238	Canada	British Columbia
239	United States	Louisiana—Offshore
240	Norway	Barents Sea
241	British Virgin Islands	BVI
242	Fujairah	Fujairah
243	Russia	Elf-Interneft
244	Indonesia	EOR-Frontier areas
245	Egypt	Onshore 1
246	Cayman Islands	Cayman Islands
247	Brunei	Onshore
248	Yemen	Contract 4
249	Egypt	Gulf of Suez Contract 1
250	Honduras	Honduras
251	Libya	Libya
252	Sudan	Existing
253	Oman	Oman
254	Netherlands	1995 terms
255	Indonesia	Pre-Tertiary—Frontier
256	Egypt	Gulf of Suez Contract 2
257	Norway	North Sea
258	Canada	Alberta—New—Non-heavy
One star systems		
259	United States	Louisiana—Onshore
260	Egypt	Mediterranean Contract 2
261	Myanmar	Amoco contract
262	Canada	Alberta—New—Heavy
263	Egypt	Onshore Contract 4
264	Nigeria	Inland
265	Somalia	Somalia
266	Canada	Saskatchewan
267	Egypt	Contract 3
268	Vietnam	Lasmo PSC
269	Peru	Block 52 (Chevron)
270	Sudan	New Fields
271	Umm Al-Qaiwan	Umm Al-Qaiwan
272	Azerbaijan	R-factor Contract
273	Netherlands	Pre-1995 terms
274	Albania	Offshore—Old terms
275	Egypt	Onshore Contract 2

Table 5.5 World Ranking of Fiscal System contd. (Adapted from Van Meurs, 1998)

Van Meurs ranking of world fiscal systems (continued)

Rank	Country	Fiscal system	Rank	Country	Fiscal system
276	Indonesia	Deep offshore	301	Indonesia	Marginal fields
277	Uganda	Uganda	302	Angola	Angola
278	Liberia	Liberia	303	Azerbaijan	AIOC
279	Russia	Typical PSC	304	Yemen	Contract 3
280	Indonesia	Marginal fields frontier areas	305	India	Enron
281	Guinea Bissau	Guinea Bissao	306	Syria	Model PSC
282	Egypt	Onshore Contract 5	307	Aruba	Aruba
283	Mauritania	Mauritania	308	Sharjah	Sharjah
284	Georgia	Georgia	309	Neutral Zone	Onshore
285	Indonesia	Pre-Tertiary	310	Qatar	Model agreement
286	Russia	Typical JV	311	Indonesia	Conventional terms
287	Azerbaijan	Ad Petrol contract	312	Yemen	Contract 1
288	Indonesia	1994 Incentive terms	313	Venezuela	Contract 6
289	Myanmar	Yukong contract	314	Venezuela	Contract 5
290	Yemen	Revised terms	315	Neutral zone	Offshore
291	Gabon	Gabon	316	Russia	Sakhalin 2
292	Abu Dhabi	Abu Dhabi	317	Venezuela	Contract 4
293	Nigeria	Niger Delta	318	Syria	UNOCAL
294	Algeria	PSC	319	Vietnam	BHP PSC
295	Colombia	1995 model contract	320	Venezuela	Contract 3
296	Bahrain	Bahrain	321	Kazakhstan	Tengiz JV
297	Myanmar	1994 model contract	322	Venezuela	Contract 2
298	Yugoslavia	Serbia	323	Yemen	Contract 5
299	Yemen	Contract 6	324	Venezuela	Contract 1
300	Malaysia	Conventional terms			

Table 5.5 World Ranking of Fiscal System contd. (Adapted from Van Meurs, 1998)

Country	Contract Type[a]	Government Take[b]	Star System[c]
USA	R/T	Deepwater: (38, 42) Shelf : (48,51)	Deepwater: 4 Shelf: 3
Mexico	SC	(30, 32)	
North America			
Argentina	R/T	(47, 49)	5
Colombia	R/T	(79, 82)	1
Ecuador	PSA	(58, 60)	3
Peru	PSA, R/T	(58, 62)	5
Trinidad & Tobago	PSA	Offshore: (48, 50) Onshore: (62,66)	Offshore: 4 Onshore: 3
Venezuela	SC	(88, 93)	1
South & Central America			
Italy			5
Norway			2
United Kingdom			5
Europe			
Kazakhstan	PSA, ROR	(83, 88)	
Russian Federation			1
Former Soviet Union			
Syria	PSA	(83, 87)	1
Yemen	PSA	(72, 79)	2
Middle East			
Angola	PSA	(81, 88)	
Republic of Congo	R/T	(67, 69)	
Egypt	PSA	(79, 82) (85, 90)	Offshore: 3 Onshore: 1
Gabon	PSA	(69, 76)	1
Nigeria			1
Tunisia	PSA, R/T	(79, 85)	
Africa			
Australia	R/T	Off: (53, 56) On: (63, 66)	Offshore: 4 Onshore: 3
Brunei	R/T	(82, 84)	2
China	PSA	(72, 77)	3
India	PSA	(61, 69)	
Indonesia	PSA	East: (69, 71) West: (87, 89)	1 1
Malaysia	PSA	Frontier: (69, 74) Onshore: (88, 91)	Frontier: 3 Onshore: 2
Papua New Guinea	R/T, ROR	(67, 76)	2
Thailand	R/T	(69, 74)	2
Vietnam	PSA	(79, 82)	
Asia Pacific			

(a) PSA = Production Sharing Agreement,
R/T = Royalty Tax, ROR = Rate of Return Features, SC = Service Contract.
(b) Source: (Johnston, 1994).
(c) Source: (Van Meurs and Seck, 1995 and 1997).

Table 5.6 Representative Contract Terms and Government Take

Source: Kaiser et al, 2006

Since a majority of the exploration possibilities are failure the profit margin for the oil companies must be large enough to accommodate these events. Thus, the fiscal terms must account for the large risk in the oil business. Kjemperud (2004), has suggested that oil companies are high risk takers and they can reduce risk by diversification; whereas the governments are low risk takers and they can reduce risk by introducing a regressive tax system (bonuses and royalties). The business entity attempts a trade off between the geological or technical promise of a petroleum prospect and the government take, and necessarily will select a country having optimized fiscal system (Figure 5.14).

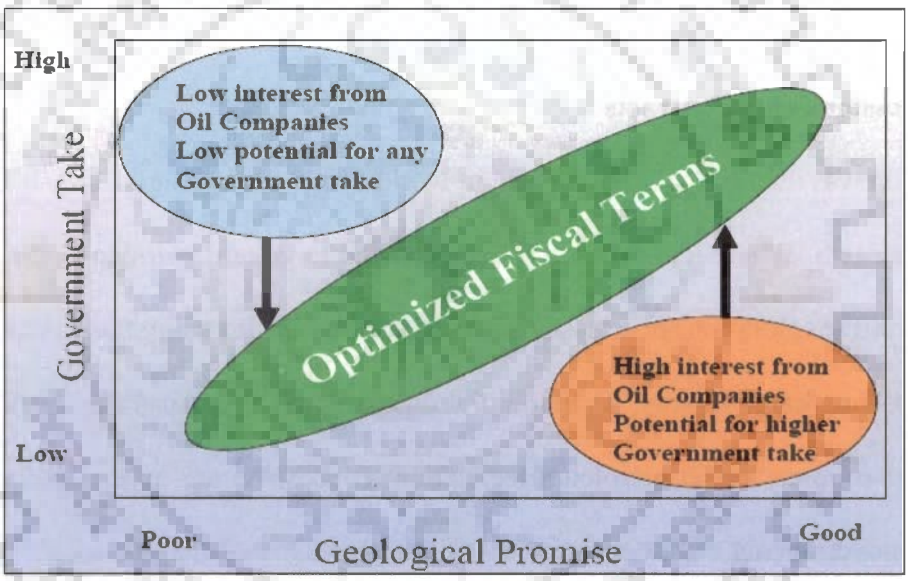


Figure 5.14 Trade off of Government take vs expected crude oil (Adapted from Kjemperud, 2004)

A 25 million bbl field in Ireland gives the same profit after tax for the oil company as a 144 million bbl field in Indonesia (Figure 5.15). It reflects the importance of fiscal regimes and the degree of attractiveness of one country against another (other elements considered similar).

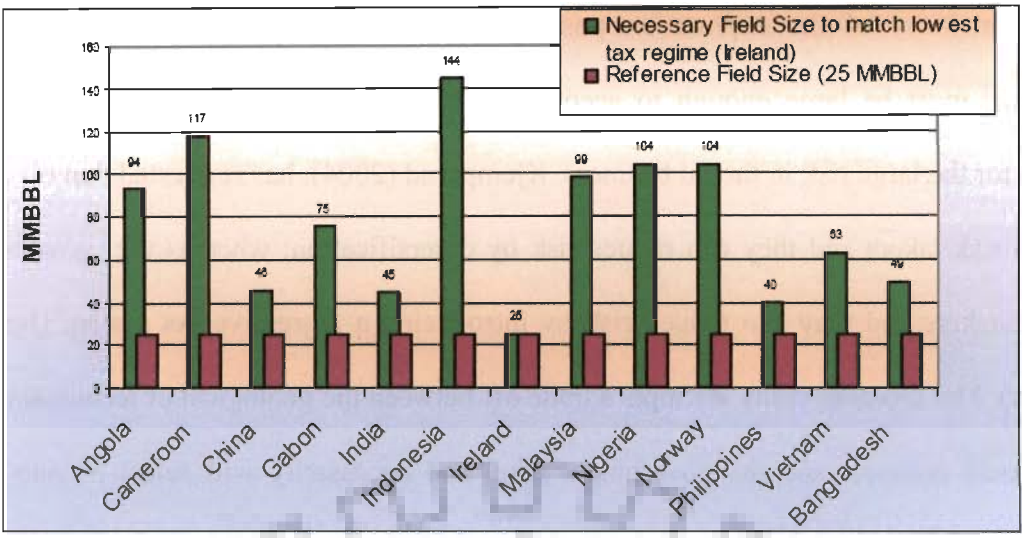


Figure 5.15 Value of discovery after Tax - Illustrated as Field Size
(Adapted from Kjemperud, 2004)

5.5.3 Concessions and Contracts

The concession was the original system used in world petroleum arrangements. It is still the most widely used system. Where legislation has been enacted to govern petroleum, it may be called a license or permit (exploration) or a lease (exploitation) .Countries using this system are as varied as the United Kingdom, Norway, Thailand, the united States and Australia. In the Middle East where there is minimal or no petroleum legislation, concession are given through negotiations directly with governments. .

5.5.3.1 Concessions

The concessionary system allows private ownership of mineral resources (Johnston, 1994 and Kjemperud, 2004). The concession is an arrangement whereby the oil company receives the right- in exchange for its payment of all costs and specified taxes- to explore for petroleum and, if production is begun, to produce and market the oil and gas (Figure 5.16). The right to transport hydrocarbons that are discovered is usually included in the agreement. In exchange, the company pays a royalty and income tax in addition to costs. Bonuses and minor taxes may be levied as well. The company is usually given the right to export crude oil or gas produced, subject to various obligations. Such obligations are extensive. They include satisfying national consumption needs before export, employing nationals and using local products.

In the concession contract, the oil company usually pays a cash bonus to acquire the concession and/ or may commit to a work program (seismic/drilling) within a certain time frame. The oil company - has the exclusive right to explore for and produce the oil and gas reserves within the concession, undertakes the exploration and production at its own risk and expense, owns the production from the concession and is free to dispose of its asset it sees fit, owns the equipment and installations used in its operations, receives all the revenue from commercial production, and pays surface rentals to the host country.

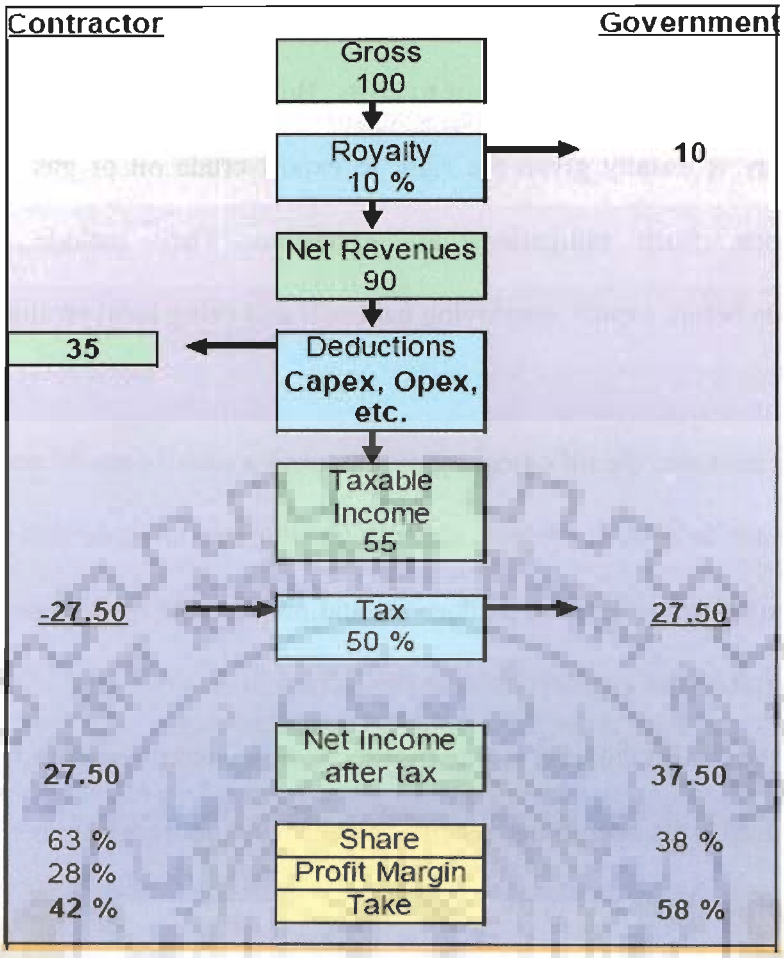


Figure 5.16 Royalty/Tax System (Concession Flow Chart)
(Adapted from Kjemperud, 2004)

In the event of success, the oil company pays a royalty to the host country (either in cash or oil) and pays taxes to the host country on the profits it receives from production. The exploration and development capital costs as well as operating costs are written off against taxable income; usually, capital costs are depreciated according to a depreciation schedule whereas operating costs are deducted in the year they are incurred.

The basic difference between concessions and all types of contracts lies in the division of oil and gas production. To even out the profitability of these arrangements requires a higher tax and royalty. The concession basically gives all production to the concessionaire while imposing commensurately higher tax and royalty rates. In most countries the government owns all mineral resources, but under concessionaire systems, it transfers little of the minerals to the concessionaire. The concessionaire is then subject to payment of royalties and taxes. The Government may participate in the concession directly or through its own National oil company. This is the system used extensively in the Middle East where participation was gradually raised from an original 25% in the early 1970s to 60% and, in most of the larger producing areas, subsequently to 100%. The most illustrative example of this is Saudi Arabia, which in 1981 completed payment for and received 100% of the Aramco concession holding.

The principle disadvantages of the concession system are long duration of concession, absence of relinquishment provisions or where such provisions existed, failure to comply with its requirement, suspension of the right to tax, discretion given to concessionaire to determine pace of exploration and to decide what areas should be developed and for long areas should be idle. In concession the managerial decision is exclusively in the hands of foreigners. There may be arbitrary pricing policies and adoption of accounting methods and procedures which has the effect of reducing 'government take'.

5.5.3.2 Contract

Under contractual systems the government retains ownership of minerals (Johnston, 1994 and Kjemperud, 2004). The oil companies have the right to receive a share of production or revenues from the sale of oil and gas, in accordance with a production sharing contract or a service contract.

The fundamental difference between the concession and contract stems from different attitudes towards ownership of oil and gas resources. Under the Concession system, private ownership of oil and gas resources is allowed. This concept of ownership derives from Anglo-Saxon legal tradition. Under a Concession system, the government will transfer title to the oil and gas to the company when production commences; this is sometimes expressed as transfer of title at the well head.

Under Production Sharing/Service Contracts, the government retains ownership of the oil and gas. This concept arises from the Napoleonic legal tradition that mineral wealth should not be owned by individuals, but by the state for the benefit of all citizens. The companies have a right to receive a share of production or revenues from production under both Production Sharing and Service Contracts. Under a Production Sharing Contract, transfer of title to the oil effectively takes place at the point of export. Under those Service Contracts where the company receives part of its per barrel fee in oil or where it has the right to purchase part of the production, the company takes title at the point of delivery.

5.5.3.2.1. Production Sharing Contract (PSC)

"Production Sharing Contract (PSC) is commercial contract between the investors and the state to allow the investor to undertake large-scale, long-term and high-risk investments. The purpose of PSCs is to define the terms and conditions for the development of a natural resource (Seek, 2000)." Production sharing contract was pioneered in Indonesia and was first used in agriculture which was later adopted for petroleum sector. The first production sharing contract was signed by IIAPCO in August, 1966, with Pertamina the national oil company of Indonesia. The contract was later adopted by a number of countries like Peru, Malaysia, Guatemala, Libya, Egypt, Syria, Jordan, Bangladesh & Philippines etc.

Principle Elements of Production Sharing Contract

In PSC, the exploration and production is conducted by the state, usually represented by the national oil company. The national oil company then appoints the foreign oil company as contractor for acreage. This gives a greater degree of control over operations of the private contractors to the government. The foreign oil company operates at its sole risk and expense. However, the contractor shares the risk with the Government. The production belongs to the host country and a royalty may be paid to the government. PSC divides the production between government and the contractor after allowing, royalty and cost recovery (Figure 5.17).. Government retains the ownership of minerals. The contractor gets a share of production usually in kind. The contractor is allowed to recover both its capital and operating costs out of the production from the contract area; this portion of production is usually referred to as "cost oil". The limit of cost recovery varies generally between 20% and 40%. After deduction of cost recovery, production is divided between the oil company and the Government. This is known as the production split and it varies widely from 15% Government /85% company in Chile to 85% Government /15% company in Egypt.

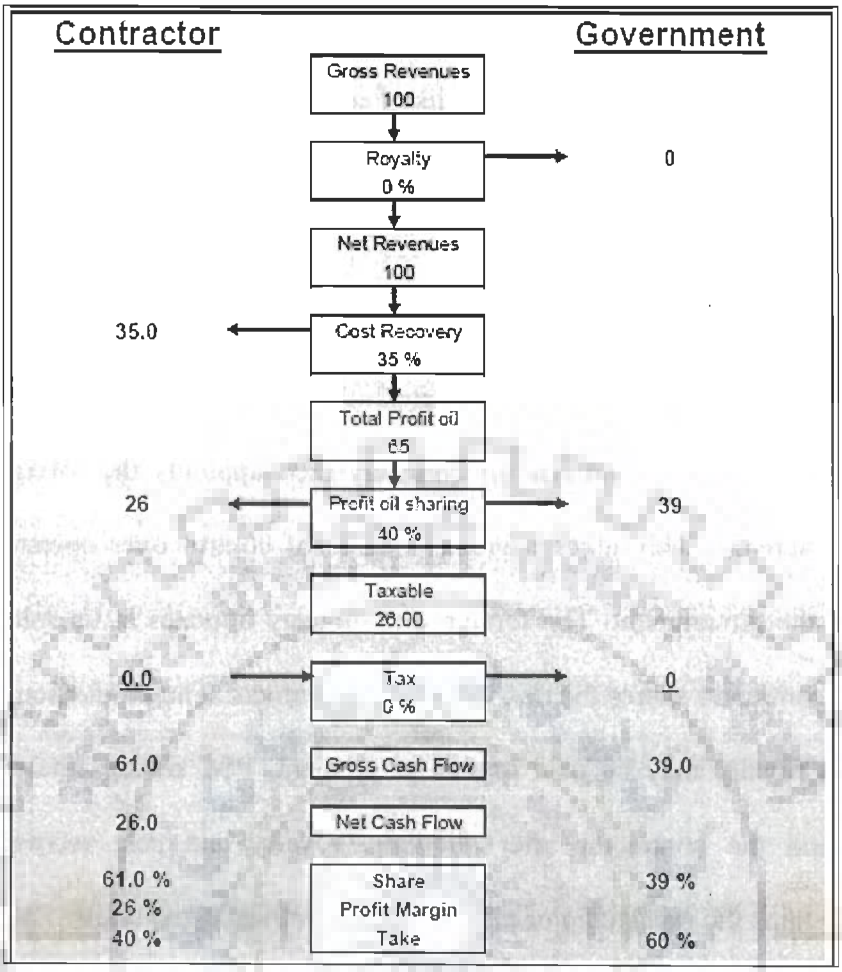


Figure 5.17 Production Sharing Contract Flow Chart
(Adapted from Kjemperud, 2004)

The exploration and development capital costs are reimbursed according to a reimbursement schedule which may place a " cap" on the amount of revenue which can be allocated to cost recovery; operating costs are usually recovered in the year they are incurred. After cost recovery, the remaining production is shared in pre-negotiated proportions between the national oil company and the foreign oil company; this portion of production is usually referred to as "profit oil". Following example illustrates the PSC system (Figure 5.18)

Partners	Major oil company and a NOC
Fences	Three adjacent oil fields which, after a 6-month negotiation, have been defined as three separate fences
Cost oil	Exploration investment: 100% major Development investment: 50% major, 50% NOC Operating expenses: Major 50%, NOC 50% Transportation cost: (1.35 \$/Bbl) Royalties: (12.5%) 100% NOC
Profit oil and sliding scale	Major profit oil share: 35.0% up to 15,000 BOED 30.0% from 15,000 to 25,000 BOED 20.0% from 25,000 to 50,000 BOED 15.0% from 50,000 to 75,000 BOED 12.5% over 75,000 BOED
Cost and profit oil recovery limit	Major's cost and profit oil must not exceed 49% of total production revenue
Duration	Initial duration 12 years, renewable for another 10 years

Figure 5.18 Elements of PSC

In PSC, generally, oil companies are subject to national corporate income tax on their share of production. The income of the foreign oil company from the "profit oil" portion is usually subject to taxation. The rate of return of the oil company can be controlled by varying the tax rates. These tax rates differ from country to country. The equipment and installations become the property of the national oil company, either at the beginning of production or progressively in accordance with agreed-upon amortization schedules.

The Government may participate in the PSC through a joint venture. This practice has been adopted in Indonesia where Pertamina, the Indonesian national oil company, held 50%

participation in production sharing contracts with Mobile, Exxon, Caltex and others during 1980. This made Pertamina an equal partner in these joint ventures. Similarly, many countries, in contracts, signed with private companies, reserve the option to participate, after commercial discovery.

5.5.3.2.2 Service Contract

In the Service Contract the host country contracts with foreign oil company or foreign service company to undertake certain tasks. There are two types of service contract - Pure Service Contract and Risk Service Contract

Pure Service Contract

The services provided by contracted company include the management of oil and gas production operations for the host government, the provision of technical advice and trained personnel to the host government, the training of the citizens of the host country in the operation and management of oil and gas production. In return for providing these services, foreign company receives fee in U.S. dollars for each barrel of oil and/or oil-equivalent gas produced. Sometimes foreign company may have right to purchase some of the oil it produces, or it may have the right to receive part of its fee in oil.

Risk Service Contract

In Risk Service Contract, the foreign oil company assumes all technical and financial risks of carrying out exploration, development and production. If exploration is unsuccessful and commercial production is not established, contract is terminated without reimbursement to foreign company. If exploration is successful, foreign company develops the field and places it on production. The capital invested by the foreign company is reimbursed with interest, together with a per barrel fee. From this point, management of daily production operations may be carried out by the foreign company, or may be taken over by the national oil company of the host country. If foreign company manages the operation of the field, its operating costs are also reimbursed by a per barrel fee. As with the Pure Service Contract, the foreign company may sometimes have the right to purchase some of the crude which it produces

5.6 PROS AND CONS OF AGREEMENTS

5.6.1 Concession (Tax- Royalty) Contract

Under the concession agreement, the host country benefits from the receipt of bonus payments, surface rentals, and in the event of success, royalties and income tax. However, the host country generally has little or no involvement in the development of its national resources. Furthermore, its citizens usually do not have the opportunity to acquire the knowledge and technical skills necessary to manage oil and gas operations. In summary, under the concession agreement, the host nation remains dependent on the oil and gas company to develop and manage its petroleum industry.

5.6.2 Production Sharing Contract

Under the Production Sharing Contract, there are several important advantages for the host country. Firstly, for a host country with limited financial resources, it allows for the development of its natural resources at no cost to itself. Secondly, the host country takes possession of the oil installations and equipment used in the development of its resources. Finally, the citizens of the host country work directly with the staff of the foreign oil company, thereby gaining specialized knowledge and experience. For these reasons, the Production Sharing Agreement form of contract has been eagerly adopted by many countries, and especially by developing countries with limited financial resources.

5.6.3 Service Contracts

Both types of service contract are attractive to countries which do not have the technical capability to undertake sophisticated exploration, development and production programs themselves, especially if there is a constitutional restriction or political sensitivity against foreign companies "owning" natural resources. However, service contracts are usually only attractive to foreign companies where large volumes of oil and gas are produced, in which case the per barrel fee can provide significant revenue.

5.7 BOOKING OF RESERVES

The "Booking of Reserves" for different types of concessions and contracts are not the same. Following is the brief description of booking of reserves for different types of contract.

5.7.1 Concession (Royalty Tax) Contract

The company takes title to oil at wellhead and usually books Net-Revenue-Interest-Reserves (working-interest-reserves minus royalty)

5.7.2 Production Sharing Contract

In PSC, the Cost Oil and Company Profit Oil is usually paid in kind. The company takes title to oil at point of export. The company usually books Entitlement Reserves (working-interest-reserves minus royalty minus Government profit oil) and the entitlement of reserves vary with oil price

5.7.3 Service Contracts

In the service contracts the company paid a fee and it does not take title to oil. However, if contract provides the company may take part of its fee in kind. The company takes title to oil at point of export and usually does not book any reserves.

5.8 OTHER TYPES OF OIL AND GAS ARRANGEMENTS

There are three other types of oil and gas agreements which do not confirm to those mentioned above. These are discussed in following paragraphs.

5.8.1 Government Participation Contract - Principal Elements

This contract can be a feature of both Concessions and Production Sharing Contracts. It is also termed as Government-Company Joint Venture (Figure 5.19). The arrangements vary from pure joint ventures in which the government and the company share equally in all costs and risks (rare) to joint ventures in which the government is carried by the company through the exploration and development phases up to the establishment of production.

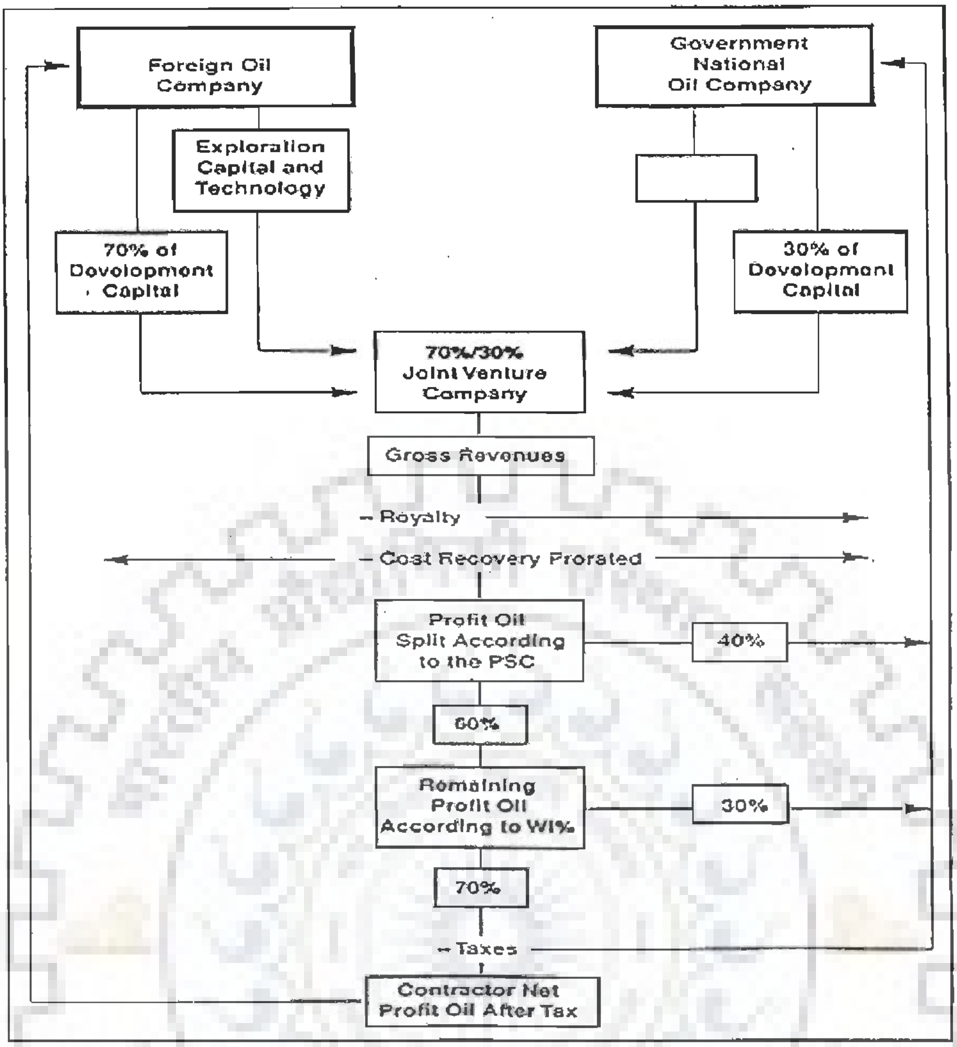


Figure 5.19 Government Participation in Contract

Adapted from Johnston 1994

The company recovers the costs of exploration and development through either direct reimbursement from the government or cost recovery deductions. Typically the government is carried through the exploration and appraisal phase and the company is allowed to recover its costs out of production. All forms of government participation reduce the potential rewards of exploration to the company while still exposing the company to the full risks associated with exploration. Such arrangements are especially popular with governments which have organizations and personnel in place that need to be integrated into future operations (e.g. Former Soviet Union, and Eastern Europe).

5.8.2 Technical Assistance Contract

The Technical Assistance Contract can have a feature of both Concessions and Production Sharing Contracts. It normally involves proved reserves beyond the primary recovery stage. Such contracts are used for enhanced recovery projects or rehabilitation/ redevelopment schemes (Figure 5.20).

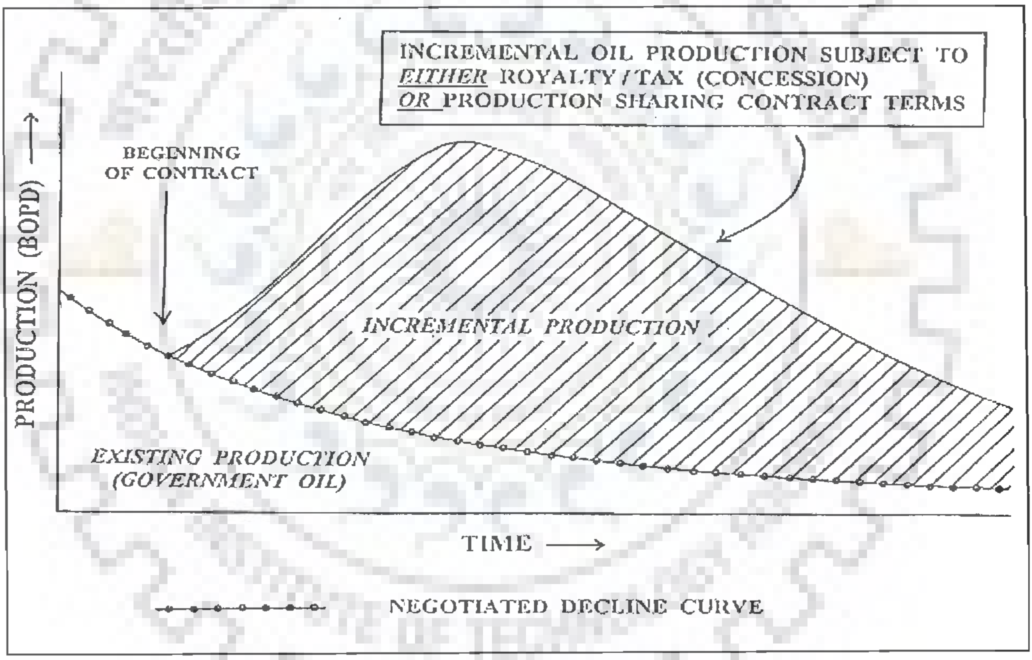


Figure 5.20 Technical Assistance/ EOR contract (Adapted from Johnston, 1994)

There is no exploration risk involved and the company takes over the existing operations, including equipment and personnel. The government and the company may sometimes jointly manage the project. "Assistance" usually includes a capital commitment related to the application of some advanced or special technology. If there is existing production, a production profile is negotiated by the government and the company; the company does not share the production associated with this decline curve. Incremental production above the negotiated production profile is either subject to royalty and tax (Concession) or shared between the government and the company (Production Sharing Contract).

5.8.3 Profitability Contract

The Profitability Contracts are flexible and progressive and can be a feature of both Concessions and Production Sharing Contracts. The Government take is a function of profitability as measured by Rate of Return or Return on Investment (not pseudo profitability as measured by production rate). Moreover, the "Government take" increases as project profitability increases. The Profitability Contracts take into account all the factors which influence project profitability, such as costs, timing, production rates, and product prices. There is initially modest royalty and tax in these contracts. The government receives no other remuneration until the company has recovered its initial investment a predetermined threshold Rate of Return or Return on Investment. Above the threshold Rate of Return or Return on Investment, additional royalties and/or taxes are levied by the government although the company still receives a share of the "excess" profits.

5.8.4 Joint venture

The expression "joint venture" connotes a legal entity in the nature of a partnership engaged in the joint undertaking of a particular transaction for mutual profit or an association of persons or companies jointly undertaking some commercial enterprise wherein all contribute assets and share risks. The concept of joint venture encompasses a wide range of transactions and relationships. In a joint venture relationship two or more parties either establish a common enterprise or decide to carryon a business related activity in which they jointly and directly participate. A party can also enter into a joint venture relationship in an already existing joint venture through framing in the participating interest in a contract or by taking over a joint venture company or through transfer of its share.

Joint venture is not a type of petroleum arrangement but is only an association of two or more persons or companies to explore, drill, develop and operate jointly owned properties. Each owner has an undivided interest in the property. They do this under their agreed partnership rules, the operating agreement.

Joint ventures in upstream petroleum contracts take place in both types of arrangements, whether it is concession or contractual arrangement. Under joint venture arrangements, the State and/or National Oil Company, on the one hand, and contractor, on the other hand, share equity in a joint operation to explore, develop and/or produce petroleum. The contractor consists of more than one company as joint venture has to have more than one party out of which one is normally a foreign company, which acts as an operator. The partners share risks, costs, production, or profits according to the terms stipulated in the joint venture agreement, which is generally in proportion to the participating interest.

In downstream there can be joint venture between transporter and refinery owner; between refinery owner and marketing company. For example, in the case of Liquefied Natural Gas

(LNG) the chain starts from the production site which is linked to consumer through coast, terminals, processing facility (if needed before transportation) and storage facilities, leading to shipment, re-processing, storage, and distribution. All these stages carry their own risks and rewards. So, if seller, buyer and ultimate consumer, i.e. all the players in this chain share the risks and rewards through a mechanism of joint ventures, it acts as a catalyst in successful execution of bargain and reduces the chances of disputes cropping up.

The main reasons which lead towards the establishment of joint venture include sharing and spreading risk, taking up capital intensive projects, access to proprietary technology, availing market base and after-sale service facilities, competitiveness, as a control mechanism, vehicle for transfer of technology and security and control of operations

A Joint Venture Agreement is entered into among the members entering into joint venture containing the provisions whether joint venture will be incorporated or un-incorporated. In case of incorporated joint venture, shareholder's agreement may contain Memorandum and Articles of Association of the proposed Joint Venture Company. In case of contractual joint venture it may contain provisions dealing with consortium leader, cash call, formation and decision making process in committees, accounting principles, etc.

The issues and problems which are commonly faced while negotiating and thereafter in the working of joint ventures includes delay in decision making, fear of exploitation by minority stake holders, fear with respect to loosing hold on technology, difference in corporate and commercial objectives, and dispute resolution.

5.9 CONTRACT NEGOTIATION

Once the company has decided to enter in to agreement with any overseas company/ country it needs to enter in to a legal agreement with that company. Prior to entering in to the legal agreement the parties negotiate the terms and conditions of business and draft the documents. Negotiation generally involves making of statement of facts, taking of positions, stands, etc. Therefore due care needs to be taken to verify facts before statements are made. It is also because of the legal position that consent of a party must be free and not tainted by misrepresentation, fraud, coercion, threat, etc. The negotiation team, headed by a leader should consist of experts from law, finance, technical background as well as a consultants who may either be used to get advise on specific issues. The team must consist of group of experts with specialized knowledge to cover all angles of negotiations.

5.10. RISK MANAGEMENT IN CONTRACTS

Various provisions are incorporated in contracts to guard against the risk of uncertainty. These provisions create a dynamics of mutual obligations which operate automatically and insulate the negatively impacted party by diluting strict liability and prove a safety valve. These are the factors which act as shock absorbers or relief valves like change in law, escalation, force-majeure, imposition of liquidated damages for default, provision of security, insurance, etc. These are incorporated during the drafting stage of contract. Following are the some of the provisions which are incorporated to manage risk in contracts.

5.10.1 Grandfather Clause/ Change in Law and Stability

The problem posed by change in law assumes critical dimensions when one of the contracting parties is a State as in Production Sharing Contracts and may legislate to vary the terms of the contract to the detriment of other parties. To safeguard the interest of private parties, stabilization clauses which are also termed as grandfather clause, have been evolved wherein change in law is provided as a ground for taking stock of the situation and corrective measures to be taken.

5.10.2 Provisions Relating to Guarantees

Contracts contain provision for obtaining guarantees in certain contingencies. As for example even before a formal contract is signed, bid guarantee for the purpose of keeping the offer open, is required and furnished by bidders. In production sharing contracts provision is kept for taking bank guarantee to ensure completion of work program by the contractor during exploration phase. In case subsidiary is executing the contract, then a guarantee from principal company is taken in to consideration.

5.10.3 Exchange Rate Variation

In contract where foreign exchange is involved, it is to be decided beforehand that what will be the exchange rate for the purpose of comparison of bids.

5.10.4 Price and other Adjustments

This clauses take care of both way swings- price increase, i.e. escalation or slump or crashing down of market - and are in fact price-adjustment clauses. A formula is provided for calculation of negative or positive effect on price.

5.10.5 Hardship

In some cases circumstances may be such that neither can be covered exactly within the ambit of impossibility or force-majeure nor do they lead to frustration but make the performance of the contract tenuous, difficult or costly. These circumstances fall in the twilight zone and give rise to potential dispute situation. As per provisions a party can not be absolved from liability to perform a contract merely because of performance becoming more onerous as disappointed expectations do not lead to frustration. Therefore, a clause is incorporated in the contract so that a mechanism remains available to the parties to sort out the matter.

5.10.6 Force-majeure

The term 'force-majeure' includes circumstances beyond the control of the parties like act of God, war, civil strife, rebellion, strike, riot, acts of Government. Two types of force-majeure clauses now-a-days are found in the contracts: open ended and close ended.

5.10.6.1 Open ended and Closed ended

In an open ended clause, a general ground, i.e. circumstances beyond the control of parties, is mentioned, thereby keeping its door open for each and every contingency which is beyond the control of the parties. The Close ended clause contains exhaustive list of the circumstances or events that trigger operation of force-majeure.

The type of clause to be incorporated in a contract depends on the nature of business and whom one is representing, and attendant facts and circumstances. A contractor may insist for inclusion of open ended clause whereas it is in the interest of employer to bargain for a close ended clause.

These clauses generally contain a notice requirement. Care is to be taken that the right to serve the notice where situation so demands must be available to both the parties. The party alleging the existence of force-majeure circumstances and serving the notice must be required to prove that force-majeure circumstances in fact exist and provision is to be included to deal with this aspect. It would be better if a provision is also included requiring contractor to take all steps which can reasonably be taken to prevent any foreseeable risk or damage by providing and taking insurance or otherwise so that risk of loss or actual loss, as the case may be, could be minimized.

5.11 DRAFTING OF DOCUMENTS

There are some important points that are to be kept in view while drafting a document. These are discussed as follows:

5.11.1 Clarity

Every effort has to be made to keep language of the document simple and clear to the extent possible. The basic provisions of the contract like payment terms, execution details, designs, specifications, time period, assignment, proper law, dispute settlement mechanism, jurisdiction of courts, etc. must be closely scrutinized so that there is no ambiguity or vagueness. The provisions of the contract should be understandable to the executors and should be capable of only one interpretation.

5.11.2 Consistency

There must be complete internal consistency of terminology, expression, and arrangement between different terms and parts of document.

5.11.3 Comprehensiveness

All the terms and conditions should be incorporated in a single document to avoid any confusion as to terms to which parties have consented and finally agreed.

5.11.4 Status of Parties

It must be ensured that legal status and constitution of each of the parties has been clearly specified, i.e. whether they are individuals, firms, corporation, etc., under which laws have been registered and what is the address of their registered office. The document should clearly state full names and addresses of the individuals signing on behalf of the parties so that later on there may not be any confusion about their identity. In case of companies there must be a Resolution of Board of Directors authorizing the person signing on behalf of company or some other delegation of power to act on behalf of the Company and to bind it. In case of partnership firm, the contract is to be signed by a partner in the name of the firm.

5.12 ACQUISITION AND MERGERS

Mergers and acquisitions (alternatively referred to as M&As, takeovers and business combinations) are among the most important corporate events in the life of a firm (Pandit, 2008). Cross-border mergers, occurs when the assets and operation of firms from different countries are combined to establish a new legal identity, and cross-border acquisitions, occur when the control of assets and operations is transferred from a local to a foreign company (with the former becoming an affiliate of the latter). M& A is a transfer of existing capital assets of one company to another.

Mergers and acquisitions in the oil and gas industry occur for various reasons, generally related to the need for increased efficiency and cost savings. It may also be driven by the desire or need to diversify assets, enhance stock values, and respond to price volatility. The vast majority of the mergers (approximately 85% of the total) occurred in the upstream segment, involving one company purchasing an asset from another company, such as a refinery, pipeline, or producing properties. The downstream segment accounted for about 13% of the mergers; the midstream segment about 2%. (Kaiser et al. 2006). Globally, companies optimize their portfolios by buying and selling property to meet business objectives. The decision to acquire a producing oil field requires an evaluation methodology, strategy, and negotiation, because a huge sum of money is involved in acquisition and divestiture. The buyers must possess the ability to merge, analyze, and do risked evaluation of geological, geophysical, engineering, land, legal, marketing and financial data and then decide the bid strategy. The buyers need to be vigilant about the price of bid so that they have to repent later that the price paid for the acquisition of the property has been so high that the transaction is not profitable (Haag, 2005). The process of acquisition and divestiture of exploration and producing either stand alone or in package differ in treatment of evaluation, which is probabilistic for exploration asset and deterministic for the producing asset. In the 'market' of crude oil and natural gas assets there are two players – buyers and sellers, each having different goals and objectives. Following is the brief discussion on acquisition of producing assets.

5.12.1 Buyer's perspective

The ability to create value above the purchase price is expected from the buyer (Haag, 2005). It can be achieved by the following either singly or jointly – the purchase price is low, the product price (i.e crude oil price) goes high, the buyer gets technology, and is able to execute a successful exploration and exploitation program leading to sizable reserves addition, with lower operating cost. But, these possibilities have an element of serendipity because, the purchase price can only be low if seller commits a mistake, and luck has favored in striking bigger than expected reserves. But, a buyer can not attempt acquisition or mergers based on these issues. The buyers need to pre-acquisition analysis to get a picture of potential cash flow. According to Haag (Haag, 2005), there are occasions when the seller did not have any intention to get rid off an asset, but potential seller was doing homework to acquire it, and it was so aggressively dealt by the buyer that a deal was made. It emanates for the fact, that mostly the high value property are rarely considered for sale, but, an imaginative buyer is clear in the proposed transaction structure and identifies the high risk upside potential of the asset. Per chance the seller did not have an interest to fund the exploration and development of this asset and the proposal of the buyer to share some of the upside with the seller "as a carrot" works in successful persuasion from buyer and seller agrees to divest the asset.

The "price protection" clause which is incorporated in the contract provides a shield or protection to either parties in case of extreme fluctuation of crude oil price leading to substantial gain or loss to them (Figure 5.21).

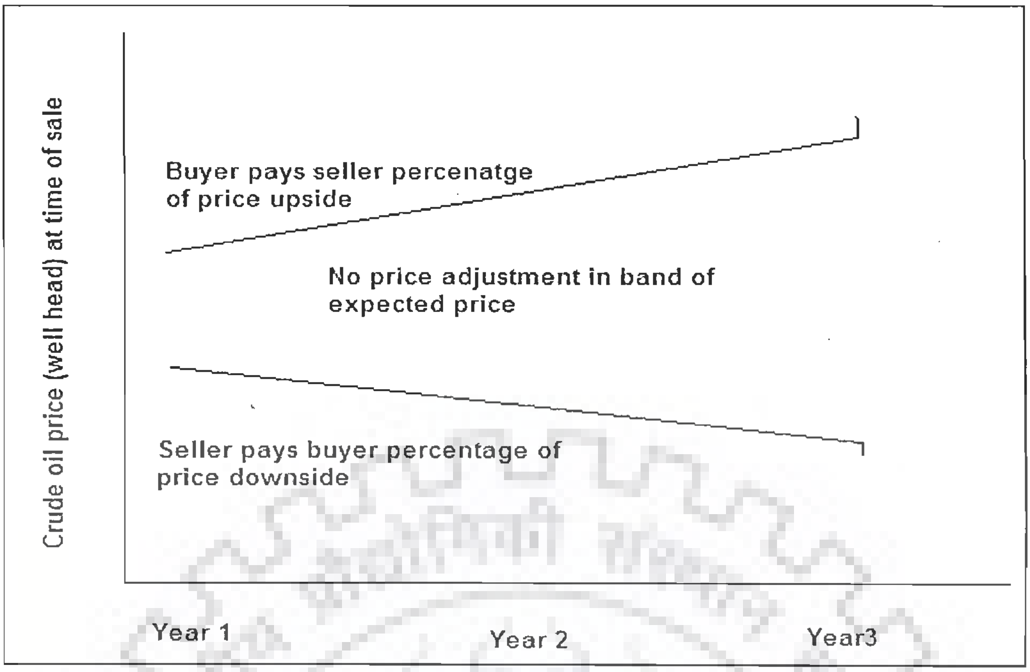


Figure 5.21 Price protection in sales contract (Adapted from Haag, 2005)

This emanates from the philosophy that seller may want a share of the additional revenue for a few years after closing if prices rise significantly above an agreed upon forecast to guard against a significant increase in cash flow to the buyer. At the same time a buyer may want the same protection after the closing to guard against a drop in product price. In the later scenario if the product price drops below a mutually accepted forecast, the seller would return a portion of the purchase price to the buyer (Haag, 2005).

Hedging the near term price of crude oil the buyer may fence in a relatively predictable stream of cash flow. The buyer can lock in the profitability of the deal by hedging (or paying a fee to guarantee a floor price for the production) (Figure 5.22). It is aimed to guard against a price drop that would lead to loss.

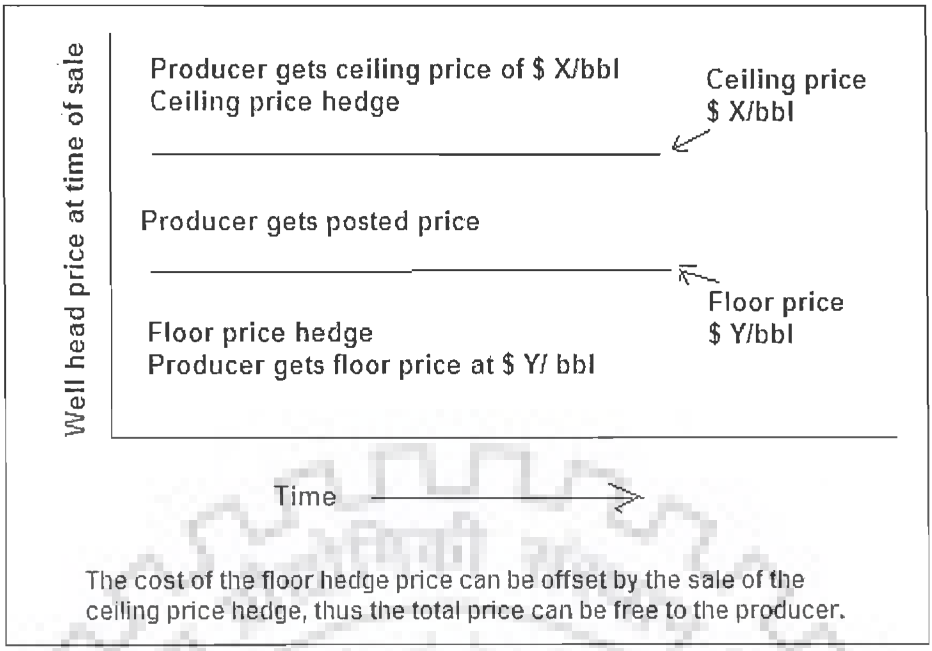


Figure 5.22 Price protection by hedging (Adapted from Haag, 2005)

As per Haag (Haag, 2005), the divested properties which were considered as non-core by major, have lead to significant value addition in the portfolio of independents. It is due to the fact that these small companies have lower hurdle rates and are willing to exploit smaller targets having challenging economies.

There are many reasons – compelling or strategic that motivate a buyer to purchase an asset. The buyer may decide to acquire a property due to several reasons. It may be that the asset is in desired geographic area and may provide an established production immediately, which may suffice to maintain its production level. Moreover, the buyer may have confidence that it can increase production and create value beyond seller's vision. Very often that company wants to distribute its overhead across an increased asset volume and attain improved financial performance. Occasionally, a long unsuccessful exploration venture motivates a company to purchase a producing asset. Sometimes the company may be pursuing the strategy of volume growth. Besides these commonly known motivating factors there are some other factors which may drive the company towards acquisition and mergers. It may be that the company wants to go public. Through acquisition it may reach the desired market capitalization to proceed for public issue (Haag, 2005).

5.12.2 Sellers Perspective

"The most successful sellers are also accomplished buyers. They are experts in property evaluations and know the nuances and pitfalls of the transaction process, (Haag, 2005)." Historically, the majority of sellers through the early 1990s were the major oil companies, and majority of buyers were the smaller independents. From 1998 onwards, there have been mergers of majors as well as smaller independents-leading to three tier hierarchy of companies according to size – huge majors, large independents and smaller independents. The companies feel to get rid of the portfolios that do not fit to their business strategy, and leads to selling of assets. But, the approach to sale varies and is dependent upon field characteristics, value, geography, and associated abandonment or environmental liabilities.

Several reasons may motivate a company to sell an asset. It may be due to unattractive geographic location, poor financial metrics (leading to low profit margin), unfit in the company's portfolio, change in business environment, diminished upside potential, risk in production and shipment, and declining production. Occasionally, even an unsolicited offer by buyer of an amount that exceeds its retention value leads to selling the asset. Besides the strategic reasons, there are fiscal factors which may govern the selling of any asset. Sometimes, the company need money for investments or debt service requirements and it may be necessary to monetize producing assets. In this situation the company may think to get rid off the least desirable fields which can generate the necessary funds. Occasionally, the degree of value of an asset is more to a buyer than seller, because the seller is not in a position to operate entire asset. Even due to the cost involved in abandonment of operation or meet environmental stipulations the owner of an asset feels to sell the asset. The seller may find interest in such asset which is near to abandonment only if the reserve value offsets the future costs and provide reasonable profit (Haag, 2005).

5.12.2.1 Retention value

Once the asset is identified for sale its retention value is calculated. The retention value is defined as the value of the property, managed as if it remains in the portfolio. The cost towards management of asset varies widely for companies and is contingent upon their internal metrics. The retention value computed taking in to consideration the reserves and associated risk, CAPEX, tax and earnings etc. (Haag, 2005).

5.12.2.2 Selling options

There are several options which may be applied for selling of an asset. The primary building blocks for all options is to provide the data pertaining to property so that buyer can have a fair idea about the property and work out its worth. Auction of an asset is generally done if the value of asset is low. But, the fear which runs high with the seller is that it may attract a low bid and even below the asking price. The seller has an option to fix a minimum bid value so that the property is not sold below that amount. But an inherent risk to this is that the asset may not be sold. Very often the services of brokers are taken to sell an asset. It may help seller to access a wide market of potential buyers via the brokers network of clients. The broker also facilitate in amicable negotiation and finalization of deal. The brokers facilitate the seller to obtain a third party fairness option for the seller. But, the seller need to define the requirements and process to be followed for sale as well as the services required from broker, together with the boundaries and areas of activities well in advance to avoid any interruption or litigation during the long process.

5.12.2.3 Process for selling

The decision to sell an asset leads to firming up a time frame for sale. It calls for reviewing the characteristics of an asset, its book value, techno-commercial evaluation, quantify upside potential, minimum sale price and financial impacts, way to sell the asset, fixing bidder's qualification, data coverage and permission form co-owners of data (if any) for public display of data. Once these are done a data room is established and hard and soft data is displayed there. The potential buyers are contacted. The offers which are received are analyzed to screen the best offer. Occasionally, a field trip will be required and duel diligence. The price and contract terms will be negotiated. The co-owners need to be contacted parallel so as to offer them preferential right to purchase. The consent of landowners is required. Upon completion of these activities the transactions with buyer is over and the unsuccessful bidders are informed. The regulator is informed about the change of ownership.

5.12.3 The Acquisition process

The steps and processes followed for the acquisition of oil/ gas property differs from company to company and is influenced by the type of asset to be acquired. Following steps are being followed (Haag, 2005):

Step 1 Perform a quick screen

It is to find out the growth opportunities and synergies with neighboring operations. The willingness of the seller, co-owner's activity, preferential rights and potential competition need to be evaluated.

Step 2 Decide to move forward

This phase takes in to consideration the review of land and lease, the depletion scenario, well status, reserves, production profile till abandonment, forecast of CAPEX and OPEX, and review of financials.

Step 3 Capture the exploration potential

It is aimed to understand the growth scenario.

Step 4 Analyze sensitivities

In this step the un-risked and risked reserves, investment scenario, abandonment and environmental issues are assessed.

Step 5 Company Impacts

The competitiveness with other companies on existing operations are reviewed.

Step 6 Bid Analysis

The economic parameters of bid are evaluated. The tax structure, discount rate, etc are examined.

Step 7 Review other impacts

The revenues and costs, off-lease production processing, marketing infrastructures, mechanical and production risk, past performance and projection of economic limit is studied.

5.12.4 Risk in acquisition and mergers

The M&A very often lead to destruction of shareholders' value (Pandit, 2008). In the case of exploration and exploitation of crude oil, it is true that the producing property has a life cycle, which is unique in its length, risk, cost, recover, and value (Haag, 2005).There is always an element of uncertainty during exploration. During delineation and development stage the uncertainty is of the field size and production profile, as well as the projected plateau and peak period of production. Each phase need to be thoroughly studied and understood for minimization or risk.

5.12.5 Valuation of asset

The asset is described in terms of fair market value which is defined as the average value calculated by a mix of competent engineers and geoscientists who have no interest in the company, its sale or its purchase. In other words the fair value is the price a willing buyer will pay a willing seller, both having full knowledge of the facts, neither being under pressure to make a deal, with the property being available to a representative portion of the market for a reasonable period. The premium paid by the successful buyer represents the "investment value" that it assigns to the property. Because the investment value is greater than the fair market value, it is not obvious that what was the fair market value. Even the amount of premium paid is not clear. It is widely agreed that the fair market value is difficult to be determined. Moreover, in a dynamic market the motivation of buyers are not clear. Therefore, prior to signing of contract the buyer must be convinced about the fair market value (Haag, 2005). The Society of Petroleum Engineers has devised a monograph for calculation of fair market value.

5.12.6 Acquisition by preferential rights

The preferential rights clause says the when one owner divests the title to the property the other owners have the right to take the transaction if the terms of the deal are matched. If the property have preferential clause provision than despite a buyer making all attempts, the other owner(s) may make the attempt futile at last leg by exercising their right. The acquisitions of property having preferential rights need to be evaluated in right perspective.

5.12.7 Competency of buyer

The seller needs to ascertain that the buyer is competent to carry out the exploration and production till end-of-life and will take care of all costs till abandonment. The technical and financial strength of the company needs thorough scrutiny prior to selling the property. The costs of abandonment and meeting environmental requirements may be significant. Thus a seller is required to verify that the buyer will return the property to its pre-exploration condition upon cessation of production. Because, in case of failure to do so, it becomes the sellers responsibility to undertake these jobs at their cost as per directives of the regulatory agency. Therefore some protection and guarantee is required by the seller so that the funds for these costs will be available in the future. Usually this is done by performance bond protection. The buyer pays the premium for this bond (Haag, 2005).

5.12.8 Negotiation, government approval, and due diligence in acquisition

The purchase and selling agreement of an asset is negotiated after the seller and buyer has agreed on other issues. The agreement is the benchmark enumerating the expectation of both the parties. The seller decides the effective date for the transfer of rights. Due diligence requiring investigation of field conditions as well as office and records etc are carried out by the buyer. The finalization of deal is deemed fit after the requisite approvals from respective responsible government agencies have been obtained.

5.13 STRATGIC ALLIANCE

"Nike, the largest produce of athletic foot-wear in the world, does nit manufacture a single shoe. Gallo, the largest wine company on earth, does not grow a single grape. Boeing, the preeminent aircraft manufacturer, makes little more than cockpits and wing bits (Quinn, 1995) (Elmuti, et al, 2001). The way these companies are able to do it is expressed is expressed by the term 'strategic alliance' in business parlance, which has been described as "an agreement between firms to do business together in ways that go beyond normal company-to-company dealings, but fall short of a merger or a full partnership" (Wheelen et al, 2000). Strategic alliance is turning out to be the most preferred initiatives in upstream as well as downstream. It is driven by the rapid pace of technology innovation, development, and adoption, and meltdown of barriers of global expansion. From 1980s the leading companies in virtually every industry have dominated the alliance process. An alliance is an association based on common objectives, shared resources, shared risk, and mutual benefits. Most alliances, to some degree result in virtual integration of the partners through contract defining roles, rights, and responsibilities, or through joint ownership of a third party. Some alliance result in actual integration. Strategic alliance have been categorized in to some forms depending upon the degree of integration. The simplest form with the least degree of integration is licensing, followed by resource sharing arrangements, partial acquisitions, and joint ventures (Figure 5.21) (Margulis, 1995).

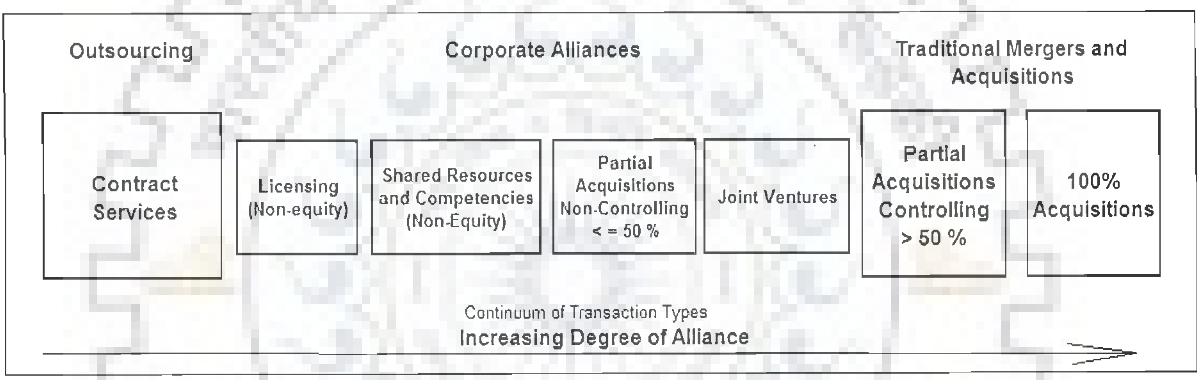


Figure 5.23 Forms of Alliances (Adapted from Margulis, 1995)

Margulis (1995) taking examples from the following cases considers the partial acquisitions and joint ventures as equity alliance.

- Joint Ventures (new entities): Chevron and Texaco, Fuji and Xerox, Microsoft and NBC, 3M and Siemens. Proctor and Gamble and Coca-Cola.

- Cross equity (Having a stake in each other): British Airways and American Airlines, GM and Fiat, long – term credit bank and Swiss Bank Corp., Mitsubishi and Volvo.

- Minority positions (one holds a stake in the other): Mazda and Ford, American International Group and Blackstone, Amazon.com and HomeGrocer.com, Microsoft and DreamsWorks.

- Group Acquisitions (partners acquire together): Johnson & Johnson and Merck, Diageo PLC and Pernod Ricard, Ameritech and Random House.

According to Margulis (1995), few decades back companies needed to excel in only one or a few differential capabilities and serve one major market region to succeed. With slow innovation in technology there were well defined boundaries and globalization was not that much prevalent. The firms opted to either develop or procure the technology which it did not possess. But, after the Industrial Revolution of 1980s there were diversification across industries and products but little expansion by companies in global markets. But, suddenly companies such as GE, 3M, Ford, and Philips began to experience flattening of sales growth. There was a surge of new school of thought focusing attention on competitive strength and core competencies from a new set of gurus like Michael Porter, gay Hamel, and Deming. It led to divestures of non-core businesses by some companies and companies rapidly retrenched into their core business leading to strengthening of their competitive positions, increased market share and profit margins. But, while these companies were refocusing on their core businesses, they were confronted by two phenomenon – technology innovation and diminishing barriers to global expansion, which paved the way for alliance (Figure 5.24).

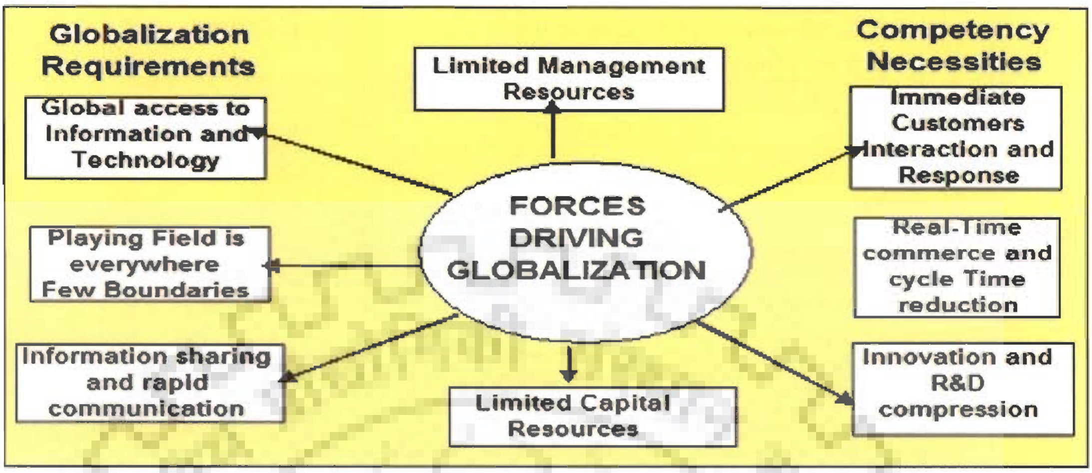


Figure 5.24 Globalization and competency Forces Driving Alliances

(Adapted from Margulis, 1995)

Many companies addressed this issue by teaming with other companies. Thus, the companies which were earlier doing business in isolation moved towards collaborative model i.e. alliance building. It led to more and more alliance formation resulting in increased revenue and market capitalization. According to Margulis (1995), Ernst & Young's Center for Business Innovation with the Wharton Business School found that alliance were critical to increasing market capitalization across all industries and this study has identified alliances as the number one factor in driving market value in e-commerce (Figure 5.25).

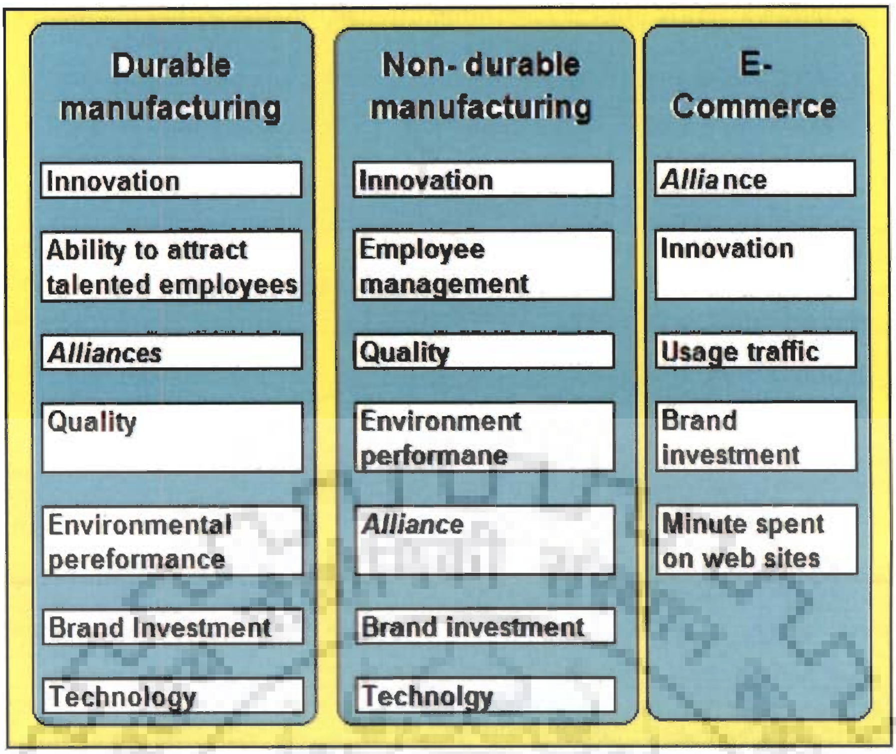


Figure 5.25 Alliance in driving market value

(Adapted from Margulis, 1995)

According to Margulis (1995), globally companies recognized the importance and benefits of alliance in value-creation strategy, but, the ability to form alliance is itself a competency, and the success depends on the skill to negotiate and structure the alliance. Lack of this competency may lead to failure to meet desired expectations. The key to success lies in understanding the partners' perspective, because the need of partners may differ. One may be interested in making alliance for risk sharing, the other for access of technology (Figure 5.26). The parties should realize the others core competence as well as anticipate and solicit the objective, requirements and expectations of each during negotiations so as to eliminate performance ambiguities and misunderstandings. Leverage analysis may help in successful negotiations.

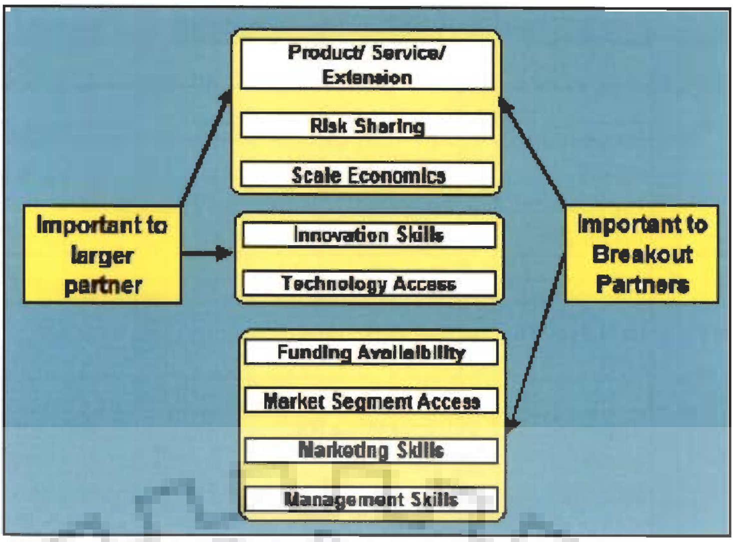


Figure 5.26 Understanding partner's perspective in alliance

(Adapted from Margulis, 1995)

According to Austin et al (1995) an alliance themselves may take many shapes. It may be an agreement between an operator and a service company for a single service, or it may several companies or several product lines within a company which will lead to an integrated alliance. Austin et al (1995) suggests that strategic alliance often describes alliance that area part of the partner companies' strategies, which implies that the companies share their strategies openly. Few oil field alliances have reached such a level of cooperation and openness (Figure 5.27)

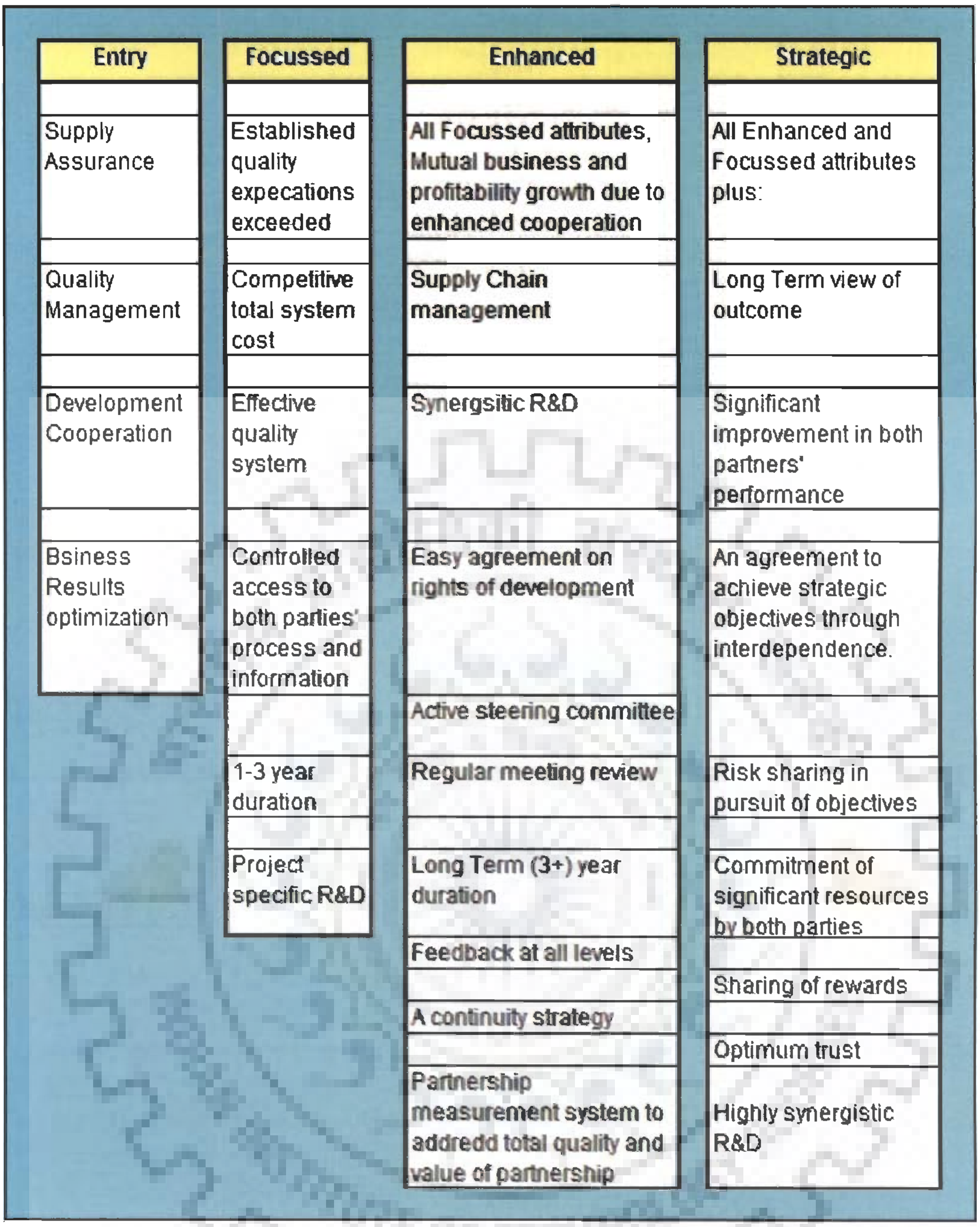


Figure 5.27 Stages in evolution of Alliance (Adapted from Austin, 1995)

5.13.1 Structuring the Alliance

There are well recognized building blocks to strategic alliance (Figure 5.28) and a weak foundation may lead to collapse of alliance.

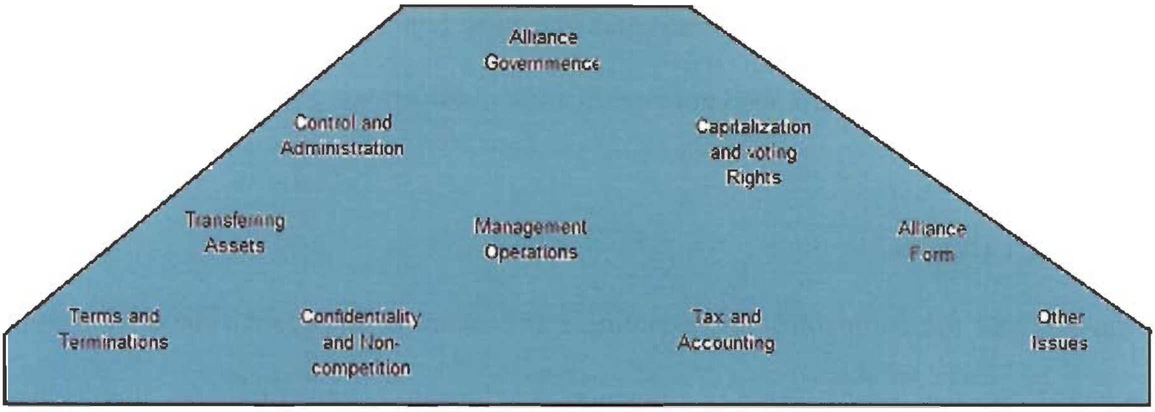


Figure 5.28 Building Blocks of Alliance Pyramid

(Adapted from Margulis, 1995)

Margulis (1995), has suggested that following issues need to be addressed for successful alliance

- Legal form of alliance
- Delegation of operational and organizational control
- Whether interests in the alliance may be transferred to other parties and if so under What procedures and circumstances.
- Mode of allocation of profits and losses
- Responsibility of each party fro future capital requirements
- Terms for termination of alliance

The alliance governance is the greatest challenge because of many rights, privileges, procedures and obligations that must be addressed to form a functional and sustainable structure. Meditation, arbitration and dissolution may lead to dispute resolution. The strategy to implementation is facilitated by good governance. Moreover, alliance does not require equal equity participation to allow 50:50 representation on governance and operating boars. And unequal representation on governance and operating board need not significantly disadvantage a minority partner.

5.14 CONCLUSION

Governments and the companies are becoming more aware of the global market for crude oil exploration (Johnston, 1994). There is a business relationship between the host country and the foreign investor and the eventual profit is shared on the basis of mutually agreed formula.

World over the companies generally look in to same aspect while appraising and comparing worldwide crude oil exploration and production investment opportunities – viz. geology, operating environment, and risks associated with various projects. The objective is to answer the question- are the expected earnings commensurate with the risks? The investor while evaluating a project first considers the underlying geology, followed by the profitability of the project under the terms offered. This process that takes into consideration the probabilities of discoveries of varying sizes as well as the uncertainty about future oil prices.

The PSC is becoming the most chosen form of fiscal system (Jonston, D., 1994). The age of easy exploration and discovery are gone and the provinces available for exploration are mostly frontier, offshore of in difficult terrain. But, these may hold promising hydrocarbon return. An explorer need long time to explore and exploit the area. The technical prospectivity of the area available for lease in terms of volume of available hydrocarbon (also known as exploration potential), the political risk and ultimate economic potential (after taking in to account all taxes) of the acreage holds key role in deciding the ultimate potential for the business entity desirous to lease that area for getting crude oil. Johnston (1994) describes this phenomenon as a trade off between the geological conditions against the fiscal and political conditions. According to Johnston (1994), if the balance is in favor of oil companies' interest, then perhaps there may be of interest for exploration and developing activity. In most of the cases the fiscal adjustments lead to successful exploration and development efforts and negotiations provide appropriate balance for win-win condition.

In case of acquisitions of producing assets the business entity must understand the nuances of the processes, adopt screening methodology that best fit in to the company strategy. The value basis of property to be acquired i.e. the reserves and upside potential, the production forecast, abandonment and environmental obligation are to be addressed in respect of the financial and cost aspects to determine the profitability of acquisition in the acquired property's life cycle. The services of broker may be taken, but, with defined area of responsibilities. The fair market value, due diligence, preferential clause (if applicable) and the necessary clearances from government agencies as per the statutory provisions must be taken in to consideration prior to making bidding and negotiations. The strategy should be to avoid the low-value, non-operated property. Occasionally, if a proactive deal for acquisition is made, the objectives and demand of either party must be clear. The buyer should make sustained and continued communication and effort to reach common ground. Even it pays to maintain relationship with competitors in the market.

This chapter has dealt with the thorough understanding of concessionary or contractual fiscal system, process of acquisition and mergers, and philosophy of strategic alliance. These deserve critical consideration for strategy formulation prior to entering the overseas exploration and production business of crude oil. The understanding of these concepts together with the aspects of risk and uncertainty in petroleum exploration and production projects leads to formulation of model for globalization strategy for screening and evaluating various opportunities. This exercise constitutes the foundation for critical selection of acreage.

CHAPTER 6

RISK AND UNCERTAINTIES IN OVERSEAS PETROLEUM EXPLORATION BUSINESS

6.1 INTRODUCTION

The crude oil exploration and production business is challenging and unique among the world's commercial activities, involve a number of distinctive features as an enterprise (Ikoku, 1985) and is riddled with risk and uncertainty (Seba, 2003 and Bailey et al 2000). Until 1960's only a few large companies were into global petroleum exploration business (Khelil, 1995), but, these days companies of all sizes participate in international ventures (Bagge, et al 2005). It obviously leads to a healthy business circumstances for governments interested in giving their acreage to bidders, but, it may not be healthy for most companies (Johnston, 1994). The global oil markets are marked by uncertainty and turmoil, evidenced by record high prices, constrained spare capacity, and steadily increasing demand. With geopolitical risk and unrest in few provinces, it is ever more important to get secure supply sources of oil. Chinese and Indian oil companies are searching the world in an effort to secure crude oil reserves to secure reserves to supply rapidly growing economies. The challenges are getting magnified day-by-day with declining potential, maturing basins, and tough fiscal terms. There are several global destinations which are rich in hydrocarbon resources, and could become an increasingly important engine of production growth for oil companies. While the amount of exploration acreage available worldwide has multiplied manifold so has been the multiplication in the number of companies seeking opportunities vying to snatch and seize opportunities. The upstream oil and gas industry in many of these destinations is at a crisis and political and market factors could lead to disappointment. Thus the decision for entering global destinations for E&P business require forward-looking analysis of risk and uncertainty to help companies make strategic decisions concerning investment.

This chapter discusses various issues pertaining to risk factors which may impact global crude oil and gas business. The study will provide a framework for understanding of potential versus reality of future opportunities and constraints in the business environment. These aspects and associated assessments will lead towards firming up strategies for entering in to long-term viable foreign participation, taking in to cognizance the impact of long-term geopolitical events on investment projects, current status of established reserves, and production.

6.2 RISK AND UNCERTAINTIES

The global business is very often confronted with one or the other kind of risk elements. Risk is a combination of uncertainty and undesirable consequence and it may lead to the downside potential at a certain probability level (Kjemperud, 2003). The terms risk, probability and uncertainty are common terms inherent in our daily life. Uncertainty refers to the fact that the actual outcome of a future activity is unknown, because there is a range of possible outcomes. Probability refers to the chance of attaining a defined value. Risk and uncertainty are for practical purposes synonymous. Statisticians often differentiate between risk and uncertainty by saying that "uncertainty" is used when there is no data upon which to base the probability of the outcome, while "risk" is used for the cases in which probabilities can be defined from the data available. This distinction suggests that risk is a special case of uncertainty. Risk is often associated with a value (money) and carries with it the negative connotations of potential loss. According to this definition one would not perceive any risk in an outcome unless they were going to be affected by the outcome. However, if one had placed a stake on the outcome then some would state that the risk involved is of that much value (the maximum possible loss) (Cook, 1999).

6.2.1 Risk in oil and gas upstream business

The oil and gas business is often quoted as being risky (Seba, 2003 and Cook, 1999). It reflects the fact that something is at stake, and things can go wrong. But, the issue is what that something may be and how much it could be? It may refer to money, environment, human well being, equipment, or brand image. For this reason, investors in the business need to have a priori understanding of the risks involved, in order to balance these against the potential rewards and to develop methods to mitigate risks. Within the E&P business, many technical and commercial parameters are taken in to consideration for this. The parameters which are used for analyzing the attractiveness of an investment contain uncertainty like the inaccuracy of measurement limited number of measurement points (Cook, 1999). Seba (2003) has put forward following risk categories which affect impact petroleum exploration project (Table 6.1).

Technical	Economic	Political
Dry Holes	Inflation	Government Policy
Geological	Oil and Gas price	Government regulations
Engineering	Gambler's ruin	Laws
Storm Drainage	Interest rates	Nationalization
Earthquake	Environmental	Environmental
Timing	Timing	Timing
	Exchange rate	Exchange rate
	Financing/capital	Financing/ capital
	Supply Demand	Taxation
	Operating cost	Export/ import
		Personnel

Table 6.1 Types of Risk (Adapted from Seba, 2003)

The country risk constitutes one of the major elements in the international operations (Johnston, 1994). It can be political, economic or social risk. The understanding of country risk (which encompasses economic, political and social risk) is very important for global investors due to the increasingly global nature of investment portfolios (Harvey, et al 1996). The flow diagram in (Figure 6.1) exhibits the role played by political factor in risk framework.

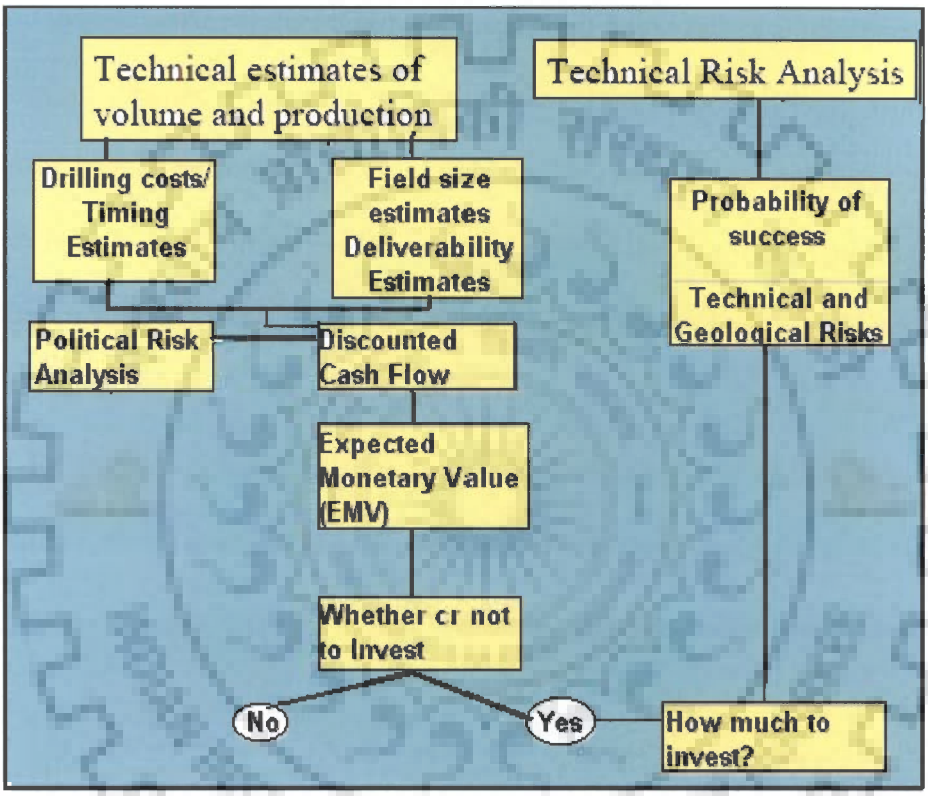


Figure 6.1 Risk Analysis flow diagram

(Adopted and modified from Johnston, 1994 and Kjemperud, 2003)

Exploration and production for crude oil attracts varying range and probabilities of success of geological, fiscal (changes in fiscal terms), economic (exploration and development costs and hydrocarbon prices) and political risks (Johnston, 1994 and Kjemperud, 2003) (Figure 6.1).

According to Seba (2003), three types of uncertainties hold significance in evaluation of projects involving exploration and development for crude oil – uncertainty of occurrence, uncertainty of magnitude, and uncertainty of rate of production. Seba (2003) puts forward that during the exploratory phase, uncertainty of occurrence is of major concern, and once a discovery is made the uncertainty of magnitude (value and volume of crude oil) and rate becomes the dominant certainty. Following paragraphs briefly describes various types of risk.

6.2.2 Technical Risk

6.2.2.1 Petroleum Prospectivity

The crude oil potential and likelihood of striking a discovery form available acreage holds prime importance. The resources and reserves, likely field size distribution, and probability of success are some of the factors which deserve thorough scrutiny. Given a volume of resources and reserves the explorer may not be certain about the positive up side potential of the acreage. There are chances of making no finds at all or striking a small, medium or large discovery needs consideration. The past statistics may be misleading. The degree of maturity of the province in terms of technical input for exploration may provide a reasonable degree of confidence about the past exploration statistics and their role in judgment about the future. If as per the expected filed size distribution all the structures which could have provided economic return to investment have already been discovered than perhaps the acreage hold little value to business entity. But, a tradeoff can be thought off if the small acreage leads to economic return owing to it being in a well-developed area where technical facilities and infrastructures etc which are most commonly required for exploration and production are available. Such condition may lead to economic returns.

6.2.2.2 Geological Risk

During the exploration phase of business the existence of hydrocarbons, the magnitude of discovery, and type of hydrocarbon likely to be encountered (oil and/or gas) holds importance. During the development phase the technical risk is primarily about the development and pool delineation, optimization of production profile. Kjemperud (2003) has suggested following range of probability of success for geological risk (Table 6.2).

Exploration / Development Phase	**Probability of success**
A step out or delineation well, or of an adjoining structure	0.50
Exploration in an area with many similar plays and structures and for and exploration well which is in such a structure not too far from existing discoveries	0.20 - 0.30
Exploration in a well explored area with a variety of different plays and on a new location	0.10 - 0.20
Exploration in a poorly explored area or a new geological basin in which previously no wells have been drilled or only dry holes have been drilled	0.02 - 0.05

Table 6.2 Probability of success for geological risk (Adapted from Kjemperud, 2003)

As per Johnston (1994), "estimating the probability of success (some refer to this as "chance factor") is an absolutely critical element in exploration risk analysis. Most companies have been making these estimates directly (expected value analysis) or indirectly (gut feel) for decades. Either way though, we have been overestimating the probability of success for our prospects and it is killing us."

6.2.2.3 Risk due to Over Optimism

Johnston (1994) has put forward that the exploration portfolios of the 1980s and 1990s shows consistently overoptimistic estimates of two key variables: prospect size and success ratio. For any exploration portfolio there is an average prospect size and estimates of success probability for each prospect. However, consistently the average size of actual discoveries is smaller than the anticipated (estimated) prospect size and actual success rates are lower than what was estimated. According to Johnston (1994), the estimation of reserve potential of an un-drilled prospect is an extremely important part of international exploration and the industry have been consistently overestimating prospect sizes by 30 to 160%. Such practice emanates from the belief that explorationists project inflated figures of prospect size to sell their projects.

The probability of success increases with the level of technical knowledge of the acreage (Figure 6. 2).

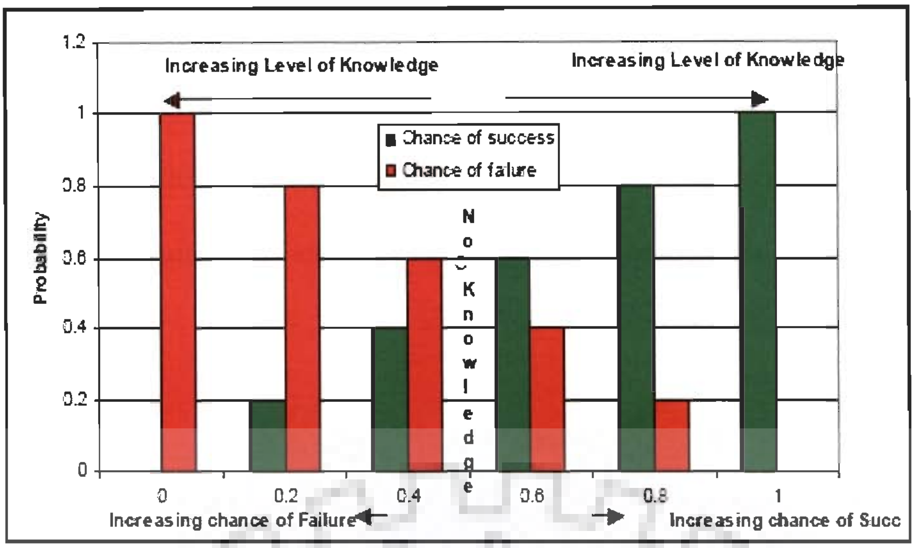


Figure 6.2 Knowledge vs. chance of success

(Adapted from Kjemperud, 2003).

The knowledge building exercise may help improve the situation and may lead to close to realistic estimate of likelihood volume of crude oil in the acreage as well as chance of success.

6.2.3 Economic Risk and Fiscal Risk

6.2.3.1 Economic Risk

The economic environment of a country is a unique mix of its economic system i.e market, growth potential, natural resources, infrastructure and foreign exposure. The alternative investment opportunities need to be evaluated. The evaluation involves economic analysis, financial analysis and intangible analysis (Ikoku, 1985). According to Ikoku (1985), "many times an investment alternative that looks attractive may be rejected for financial reasons because funds are not available and can not be obtained at reasonable interest rates to finance the investment proposal. In addition, intangible considerations such as potential loss of public goodwill, pollution problems, or possible future litigation may cause economically sound investments to be rejected." But, for the present our focus is on economic analysis only.

It is reasonably well understood that business entity operates not merely to produce oil and gas, but, also to make a profit. According to Ikoku (1985), the need for economic analysis arises due to decreasing chance of major discoveries, increasing finding costs, impact of inflation, uncertainties in crude oil price, and government control and regulations. Ikoku (1985), puts forward that besides the factors mostly considered for capital investment, there are some characteristics of petroleum explorations that may affect the economic analysis. These factors are the long lead time from exploration to production, political and social environment, taxation structure, finite and non renewable nature of deposits, and vulnerability to nationalization, takeovers, etc.

According to Ikoku (1985), the environment in which the decisions are taken for petroleum exploration has elements of risk and uncertainty, because of the probabilistic nature of activity. The entire environment of exploration and production has inherent chance factor attached to it which renders this business to be called "the greatest gamble on the earth." Moreover, there are no decision methods that is capable to eliminate or minimize the risk and uncertainty. The application of economic evaluation techniques may lead to evaluate, quantify, and understand risk and uncertainty making it convenient for adopt a decision which may minimize the firm's exposure to risk and uncertainty.

6.2.3.2 Risk of Oil Price

The ROR for international oil companies follows the oil price (Figure 6.3).

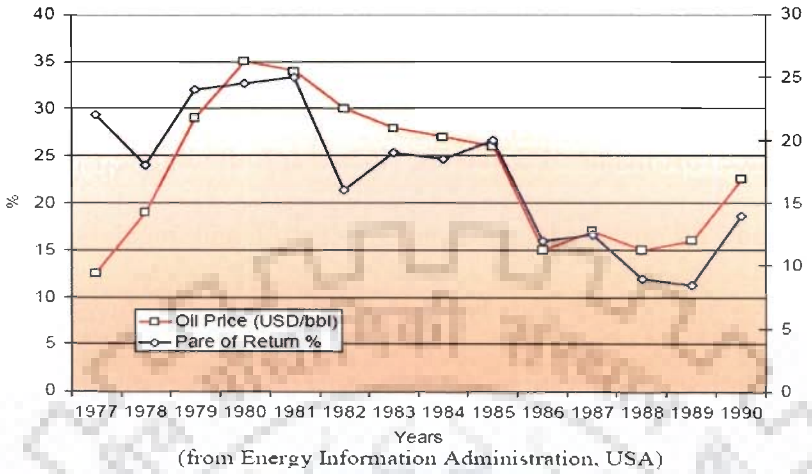


Figure 6.3 Rate of return of company vs. oil price

(Adopted from Kjemperud, 2003)

6.2.3.3 Fiscal Risk

The fiscal aspects primarily include continuity in the levels of local and national taxation, exchange controls and limitations on import and export, changes in levels of custom duty, and imposition of locally denominated prices for the products (Seba, 2003). The fiscal system has significant on the country's prospectivity (Johnston, 1994). Nine out of ten exploration possibilities are unsuccessful. Thus, the profit margin for the oil companies must be large enough to accommodate failures. The fiscal terms must account for the large risk in the oil business. The oil companies are high risk takers and can reduce risk by diversification. The governments are low risk takers and they can reduce risk by introducing a regressive tax system (bonuses and royalties) (Kjemperud, 2003).

6.2.4 Political Risk

The political risk relate to exercise of power or authority (Kobrin, 1988) and involve the uncertainty arising from possible changes in the policies of regulatory authorities and the degree to which such changes may affect the project revenues (Seba, 2003). The exercise of authority may include the control of economic system, formulation of laws and regulations, struggle for authority, expression of opposition, diplomacy, multilateral agreements etc (Kobrin, 1988). The political scenario may lead to domestic instability, foreign conflict, political climate and economic climate. If the foreign investor faces the impact of these events on either its asset base, strategy, or operation either singly or collectively it is said to be at potential political risk (Kobrin, 1988). The political scenario has significant impact on the country's exploration game and thus on the prospectivity (Johnston, 1994). The political mechanisms encompasses factors like protectionism involving tariff, quota, subsidy and cartel. It also includes issues like bribery, extortion etc. The political instability or frequent changes in the rules and regulations leads to one of the most difficult situation to conduct business overseas (Johnston. 1994). The policy shifts may lead to fluctuating tax laws. The flexibility in contract terms may lead to some stability in the event of political upheavals.

There are another category of non-fiscal political risks, which may arise due to possible interruption by regulatory authorities over environmental matters, disagreement over hiring of local personnel, nationalization, transfer of ownership to the National Oil Company (Seba, 2003).

The political risk analysis is generally carried out to fulfill corporate requirement of taking investment decision in a country, or the planning process may require scanning and analysis of business environment, or if any global political event has occurred and the investor may be interested to foresee the probable impact of such event on its business in a foreign country. According to Kobrin (1988), the political risk plays a role in strategic planning process and not in the determination of strategies. The strategy and political risk must be determined simultaneously, because political environment may place limits on strategic options.

6.2.4.1 Operational Risk

Operational Risk constitutes the real and tangible risks associated with doing business in a foreign country (Johnston, 1994). It is a fact that the partnership between a government and an outside oil company is not confined to the written contract terms and conditions. Therefore, a healthy working partnership will lead to attaining positive business objectives.

6.2.4.2 Risk of Nationalization and Expropriation

Nationalization and expropriation of assets by host government can also be a major risk element. Expropriation is not considered illegal if it is done in national interest and the companies whose assets have been expropriated are reasonably compensated. Even if the compensation is justified, the very act of expropriation leads to a negative signals in the global market and it is very difficult to regain investors confidence for future investment in similar or different kinds of projects. Moreover, the expansion of global economy and interdependency of various countries in trade and business has diminished this less likely event, because of likelihood of imposition of severe penalties on a government which expropriates the asset of an expatriate company by international business and financial communities (Johnston, 1994).

The creeping nationalization can also be a major risk factor in overseas investment. It overshadows the confiscation of assets. The host government may resort to expanding taxes, progressive labor laws, or price controls in the guise of nationalization (Johnston, 1994).

6.2.4.3 Risk with landlocked countries

In a scenario when the country is landlocked the situation turns out to be worst, because of the inherent problem of contractor to negotiate with multiple countries for carrying out part of full business activity. It may involve transportation, logistics, cross-country pipelines etc.

6.2.4.4 Socio-cultural Risk

The cultural environment of any country is a combination of languages, symbols, values and beliefs.

6.3 Time Related and Non-time related risk

According to Van Meurs (1981), a company faces generally two kinds of risk:

1. Time related and
2. Non-time related risk.

6.3.1 Time related Risk

The time related risk relates to risk which generally increase with time. The political, economic and technical risks are time related risks, whereas geological risk is non-time related risk. The political risk relates to the chance that major change in government legislation will make a project unattractive. The economic risk relates to the chance that important change in supply, demand, costs, markets, etc will occur which can not be foreseen at this point of time. Technical risks may arise due to the chance that accidents or natural disasters will cause severe loss. In all these cases, it is difficult to predict where and / or when such changes will occur.

The political risk can be analyzed on the basis of political, economic, and social development of a country. In the case of economic risk, it is important to establish the variables which are likely to affect a project like crude oil price, inflation, capital expenditure, and operating expenditure. It may be worth to attempt sensitivity analysis on each of the min variables and explore how different assumptions about these factors influence the profitability of the project. The best way to judge whether a project will be able to stand time related risks is to analyze the pay out and internal rate of return (Van Meurs, 1989).

6.3.2 Non-time related risk

Geological risk during exploration of crude oil is a non-time-related risk. The chance of drilling a dry well is non-time related risk. The possibility of success in any province is dependent upon the geological condition. The possibility of success therefore varies from area to area. In one area it may be that one out of ten is successful, while in other four out of ten may be successful. These are the examples of geological risk. Even the possibility of success in any province depends upon the exploration maturity of the province. Following example (Table 6.4) after Van Meurs (1989) provides an insight into the concept of probability of success.

1. The probability of making a commercial discovery is determined as 0.1. The probability of drilling a dry hole is therefore 0.9.
2. In case a commercial discovery would be made, the probability for an oil discovery is

assessed as 0.6 and a gas discovery at 0.4. 3. In the case an oil or gas discovery is made, the chance on a large field is 0.2 and a medium sized filed is 0.8. 4. Geological and sea bed conditions may be such that there is a chance of 0.6 for low cost developments and 0.4 for high cost developments. Now, following outcome with probabilities emerge

Case	Outcome	Chances	Probability
1	Dry hole		0.9
2	Large low cost oil discovery	0.1*0.6*0.2*0.6	= 0.0072
3	Medium sized low cost oil discovery	0.1*0.6*0.2*0.4	= 0.0048
4	Medium sized high cost oil discovery	0.1*0.6*0.8*0.6	= 0.0288
5	Large low cost gas discovery	0.1*0.6*0.8*0.4	= 0.0192
6	Large high cost gas discovery	0.1*0.4*0.2*0.6	= 0.0048
7	Large high cost oil discovery	0.1*0.4*0.2*0.4	= 0.0032
8	Medium sized low cost gas discovery	0.1*0.4*0.8*0.6	= 0.0192
9	Medium sized high cost gas discovery	0.1*0.4*0.8*0.4	= 0.0128
Total			1.0000

Table 6.4 Probability of success

(Adapted from Van Meurs, 1989)

6.4 Role of Bargaining Power in Risk Aversion

Johnston (1994) has discussed the relative bargaining power of the company desirous of taking overseas project and the local government. The business entity entering overseas business may try to achieve upfront agreement on certain trivial issues which may be perceived by it to turn out to be a risk at a later date. According to him there are natural milestones along the evolutionary path of bargaining power, but, the trend clearly shifts power over to the state as the cycle progresses. The relative bargaining power of the company desirous of taking overseas project is the greatest in the early stages prior to signing of the contract and after that before the strike is made. The bargaining power of the contractor also begins to diminish after discovery (Figure 6.4). Johnston (1994) suggests that the relative strength of bargaining positions shifts during the cycle of petroleum exploration and development.

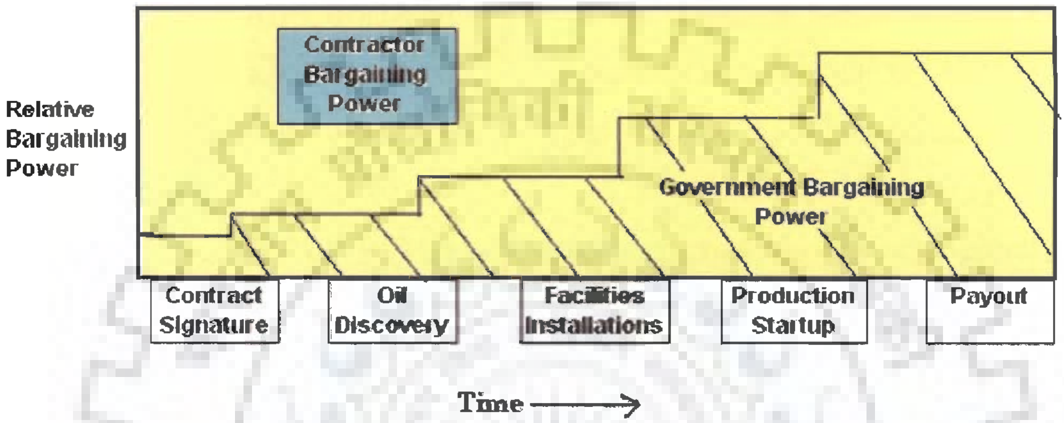


Figure 6.4 Relative Bargaining power with time

(After Johnston, D. 1994)

The bargaining power begins to shift with the commercialization of the project. The contractor gains strength with the commencement of investments for development and production of acreage. It derives from the fact that prior to this phase (i.e. commencement of production) the capital investment is sunk cost and the facilities installed in a foreign country can represent a significant source of vulnerability to the contractor.

6.5 Risk Analysis

Oil and gas exploration deals with many unknown with high risk and uncertainty. Megill (2005) provides following formula to roughly express the economics of petroleum exploration

Petroleum potential + Economics + Risk = Decision

In any petroleum exploration projects the volume of crude oil and gas which is likely to be discovered and is recoverable with present technological input constitute the petroleum potential. The total volume in sub-surface is referred to as resource and that which can be recovered or produced is called reserves. But, besides taking in to consideration these volumes another aspects which deserves consideration are the economic consequences and significance of risk. Frequently the quantification of risk possibly leads to quantifying ignorance, or bias or both. Very often the decisions are made on mental quantification, which is based on experience. But such experience leads to divergent quantification and same risk may be quantified as 'long shot' by one, 'fair chance' by other and 'risky' by third. Thus, some standard method is required to have comparable definition of risk, which will allow consistency in risk quantification and expression. The concept of probability has been introduced to estimate the most likely happening (Megill, 2005). Such most likely event in petroleum exploration business can be the presence or absence of crude oil and gas, possibility of production, the economics of the project. The numerical treatment to probabilistic element in the answer to these question lead to estimation of risk and in turn facilitate firm and logical decision making. Such analysis help in analyzing the projects.

6.5.1 Evaluating an exploration opportunity

The oil industry has witnessed a gradual evolution of investment policies, opportunities, and evaluations. There have been a gradual evolution in the yardsticks with time to fit the state of knowledge, skill, technology and even political conditions (Megill, 2005). The investment evaluation in exploration industry implies the following

- The expectation of future profits, usually involving both uncertainty and risk.
- Income generated over a period of time.
- A freedom of choice among investments.

The measuring methodologies basically refer to the criteria which help in measuring, comparing and describing investment opportunities. These methodologies can be broadly categorized in following four groups

- Measurement based on cash flow analysis,
- Measurement involving time,
- Measurements based on accounting principles, and
- Measurements related to risk.

Abdel-Aal et al (1992) has provided the following classification of mathematical methods for evaluating profitability, where time value of cash flow received from a project is the criterion. For the annual rate of return (ROI) and payout period (PP) methods, time value is neglected, but it is considered for the discounted cash flow of return (DCFR) and net present value methods.

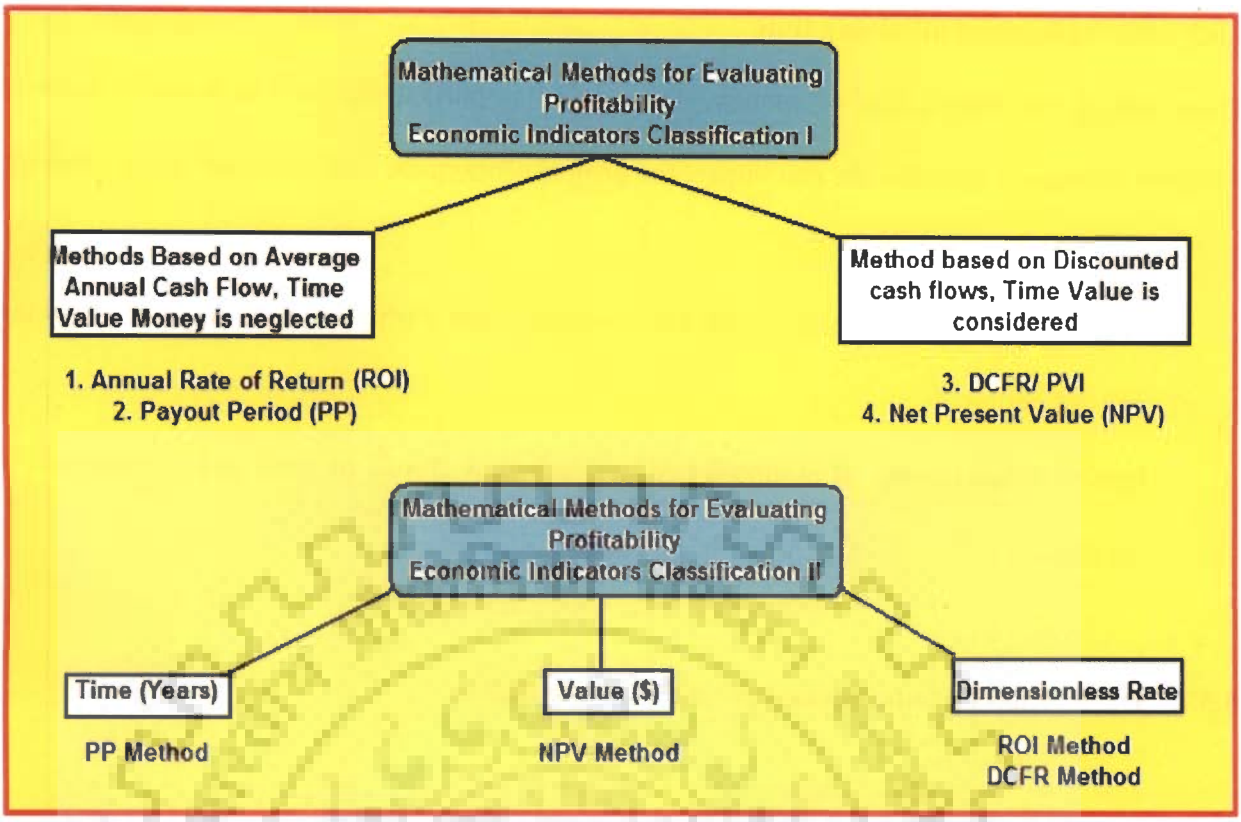


Figure 6.5 Classification of economic methods for evaluating profitability of oil projects

Following is the brief description of these methodologies most commonly used for this purpose.

6.5.2 Cash flow analysis

It includes

- calculation of before and after tax.
- Maximum negative cash flow.
- Net profit or loss.
- Ultimate net income ratio, which is total profit divided by the cumulative maximum negative cash flow.
- Profit to investment ratio which is total profit divided by investment.

6.5.3 Methodologies involving time

These reflect the time value of money. Time is an important element in analysis because inflation. Change in tax rates etc can impact the project economics. Following are some criterion

Payout period: The point at which the cumulative net cash flow becomes positive is the pay out period.

Present value money: It is discounted net cash flow (profit or loss) and is expressed in percent.

6.5.4 Description of some commonly used methodologies

6.5.4.1 Discounted Cash Flow criteria

The DCF analysis has been widely used investment tool in the petroleum industry.

6.5.4.1.1 Net present value (NPV)

NPV is the present value of future cash flows discounted at the opportunity cost of capital minus (net of) the initial investment. The NPV of an investment is the difference between its value and its cost. The NPV rule is to take a project if its NPV is positive. In order to calculate NPV the business entity has to forecast the project cash flows, estimate the opportunity cost of capital (the discount rate), use the opportunity cost of capital to discount the future cash flows, and finally subtract the initial investment (cash outflow) from the present value of the forecasted cash flows. NPV can be represented by the following formula

$$NPV = I_0 + \frac{I_1}{1+r} + \frac{I_2}{(1+r)^2} + \ldots + \frac{I_n}{(1+r)^n}$$

Where, the I' s are income amounts for each year. The subscripts (which are also the exponents in the denominators) are the year numbers, starting with 0, which is this year. The discount rate -- assumed to be constant in the future -- is *r*. The number of years the investment lasts is *n*.

6.5.4.1.2 Internal rate of return (IRR)

The IRR is the discount rate that makes the estimated NPV of an investment equal to zero. The IRR rule is to take a project when its IRR exceeds the required return. When project cash flows are not conventional, there may be no IRR or there may be more than one.

6.5.4.2 Payback criteria

6.5.4.2.1 Payback period

The payback period is the length of time until the sum of an investment's cash flows equals its cost. The payback period rule is to take a project if its payback period is less than some pre-specified cutoff.

6.5.4.2.2 Discounted payback period. The discounted payback period is the length of time until the sum of an investment's discounted cash flows equals its cost. The discounted payback period rule is to take an investment if the discounted payback is less than some pre-specified cutoff.

6.5.4.3 Accounting criterion

6.5.4.3.1 Average Accounting Return (AAR)

The AAR is a measure of accounting profit relative to book value. The AAR rule is to take an investment if its AAR exceeds a benchmark.

6.5.4.3.2 Profitability index (PI)

The PI, also called the benefit-cost ratio, is the ratio of present value to cost. The profitability index rule is to take an investment if the index exceeds 1.0. The PI measures the present value per dollar invested.

6.5.4.4 Scenario analysis

It is a process of analyzing possible future events by considering alternative possible outcomes (scenarios). The analysis is designed to allow improved decision-making by allowing consideration of outcomes and their implications

6.6 Managing Uncertainties

Cook (1999) has suggested following schematic (Figure 6.6) to manage uncertainties. The variables or the factor conditions need to be examined for their dependencies. As per Cook (1999), some variables often have dependencies, which can be examined by seeing the linear dependency of two variables (say x and y) by calculating the covariance between the two variables (say x and y) and the correlation coefficient (r). The value of r varies between plus and minus one, the positive values indicates a positive correlation (as x increases, so does y), and the negative values indicates a negative correlation (as x increases, y decreases). The closer the absolute value of r is to zero, the stronger the correlation. A value of $r = 0$ indicates that the variables are unrelated. With true dependency between variables being established an equation can be generated equations which link the two using methods such as the least squares fit technique. A correlation factors above 0.9 would suggest good

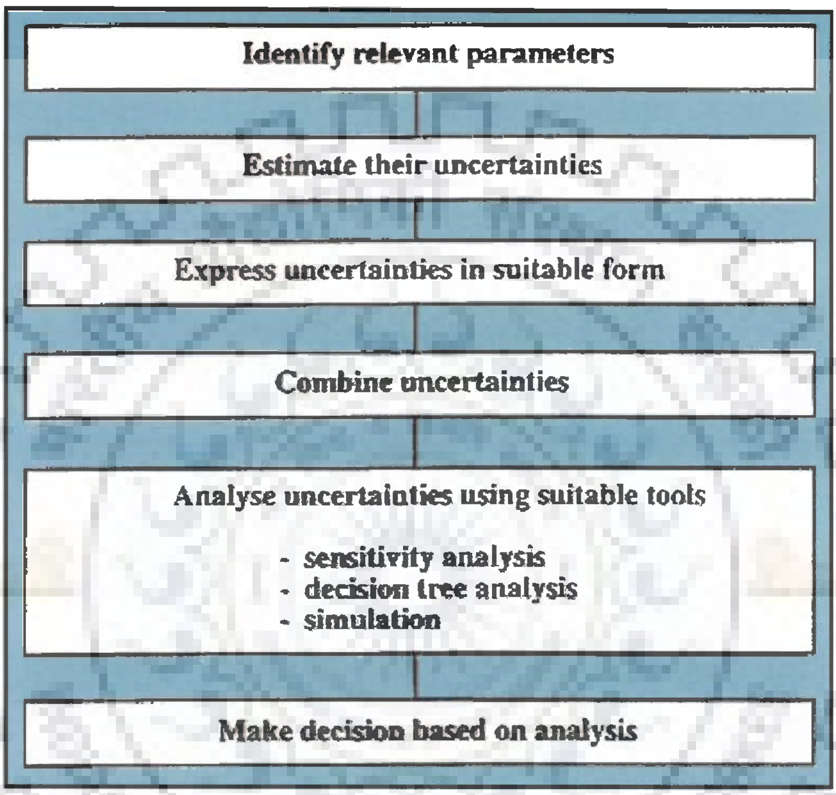


Figure 6.6 Schematic of approach to manage uncertainties

(Adapted from Cook, 1999)

6.6.1 Combining Uncertainties

To make recommendations on investment opportunities many of the uncertainties need to be combined. Some of these variables will be independent, such as fiscal system and well productivities, and some will be dependent, such as economically producible reserves and oil price. Monte-Carlo simulation and the parametric methods are main methods of combining uncertainties, with the treatment of dependency between variables.

6.6.2 Monte Carlo Simulation

Monte Carlo Simulation (Figure 6.7) is frequently employed to evaluate the numerous interrelated risks. The use of Monte Carlo simulation tools in the petroleum industry is now common among the more sophisticated hydrocarbon exploration and production organisations. It is being used for probabilistic assesment of prospect inventory, resource and reserves volumes.

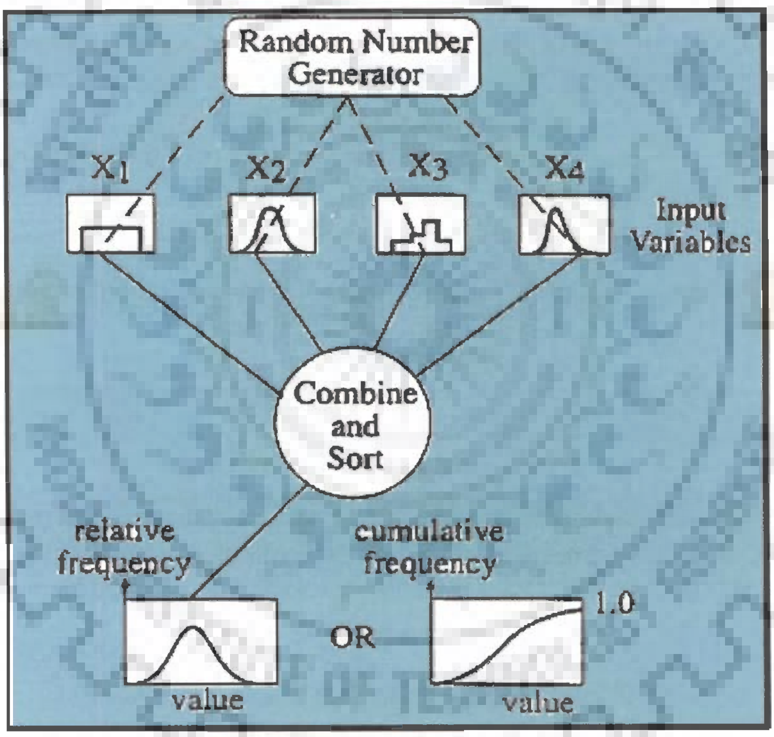


Figure 6.7 Monte Carlo Simulations

(Adapted From Cook, 1999)

The Monte Carlo Simulation brings probability in to the picture of risk estimation. This statistical technique addresses the question, “if something happens, then what is the range of possible outcome. It yields probability versus value relationships for key parameters (Bailey, et al 2000).

6.6.3 Parametric Method

It is used as an alternative to Monte Carlo simulation, because of its simplicity and its ability to identify the sensitivity of the result to the input variables. This allows a ranking of the variables in terms of their impact on the uncertainty of the result.

6.7 Tools used to Quantify Risk

The three main tools used for quantifying risk are

- sensitivity analysis
- decision tree analysis
- simulation

6.7.1 Sensitivity Analysis

Sensitivity analysis is a technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This technique is used within specific boundaries that will depend on one or more input variables, Sensitivity analysis is a way to predict the outcome of a decision if a situation turns out to be different compared to the key prediction(s). The sensitivity analysis and tornado analysis are two separate methods that help in understanding which of the uncertain inputs (e.g., the price of oil) drive the uncertainty in conceived models.

6.7.2 Decision Analysis Methods

The decision analysis methods provide new and more comprehensive ways to evaluate and compare the degree of risk and uncertainty associated with each investment choice (Ikoku (1985). It leads to provide the decision maker with a clearer insight of potential profitability. The decision analysis technique will provide decision maker a better understanding of risk and uncertainty, which may supplement the judgment of professionals. The decision analysis methods are employed for maneuvering in normal business environment. Kjemperud (2003), suggests following schema for the decision process –

1. Understand alternatives and the risk these alternatives involve
2. Evaluate the potential consequences perceived in the situation
3. Assess the uncertainties involved in the decision
4. Recombine the judgments to develop a consistent strategy

6.7.3 Portfolio Theory

The Portfolio Theory is another tool used to find out how multiple assets can be combined in such a way that risk is minimized for any given level of expected return (Bailey, et al 2000). The portfolio theory brings consistency to decision making process (O'Connor, S.J.)

6.7.4 Expected Monetary Value

The Expected Monetary Value (EMV) has been suggested by Johnston (1994) and Kjemperud (2003) to evaluate or quantify aspects of risk. Expected Value combines quantitative probabilities (estimates) with each alternative. The parameter is computed as the sum of the mathematical product of the probability of each outcome times the value of that outcome for all possible outcomes. According to Seba (2003), the EMV analysis requires the identification of two or more outcomes for each alternative. However, the outcomes identified must include all possible outcomes for the alternative being evaluated. Each of the possible outcomes must have some finite likelihood of occurring, but none can be certain of happening. The assigned probabilities must be proportional to the likelihood of that individual event's occurrence, and sum of all such probabilities must add up to one (Seba, 2003).

If R_1, R_2, R_3, ……represent the possible numerical outcomes of a decision situation, and P_1, P_2, P_3……represent the corresponding probabilities that each of the R's will occur, then in general

$$\text{Expected value} = (R_1 * P_1) + (R_2 * P_2) + (R_3 * P_3) + \text{------}$$

$$\text{where: } P_1 + P_2 + P_3 + \ldots\ldots = 1$$

According to Kjemperud (2003) the total success probability can be computed as

$$SP = Pexpl. * Pdev. * Pfiscal * Ppol. * Pecon.$$

Kjemperud (2003) has suggested following computations for EMV

$$EMV=(R*SP)-(RC*(1-SP))$$

Where, R = Reward = Net Present Value (NPV), SP= Success Probability, RC= Risk Capital = Bonuses, Dry Hole Cost, G&G etc.

Following example (Table 6.5) illustrate the methodology to quantify political risk (Johnston (1994). It takes in to consideration the possible scenarios visualized for a hypothetical exploration venture. It is assumed that the exploration effort may be affected by varying degree (moderate to substantial) political unrest and there are possibilities for expropriation of asset. The relative weight attached to the various possible outcome is also depicted. The example suggests that despite chances of political unrest and expropriation of asset the project is worth pursuing. The methodology may also be expressed in the form of decision tree.

Possible outcome	**Present Value ($ MM)**	**Probability (%)**	**EMV ($ MM)**
Unsuccessful Exploration Effort : $50 MM Work Program	- 50	70	- $ 35
Large discovery Moderate Political unrest	700	5	35
Large discovery Substantial Political unrest	500	5	25
Moderate discovery Moderate Political unrest	350	6	21
Moderate discovery Substantial Political unrest	250	6	15
Large discovery Assets expropriated during development work	-150	4	-6
Moderate discovery Assets expropriated during development work	-100	4	-4
		100	$ 51

Table 6.5 Quantifying Political risk

(Adapted from Johnston, 1994)

The EMV technique does not reduce the uncertainty in the investment decision. It simply expresses the degree of ignorance concerning the decision consequences in a quantitative manner while providing the benefit of furnishing numerical value for the decision maker.

As per Johnston (1994), except the geological dimension (which lead to volume of crude oil) almost all the elements that affect the investment decision are or can be influenced by the government and the nature of the business climate offered to the industry. Johnston (1994) says that the geological risk begins to diminish after discovery, and the political and financial risks intensify.

6.8 Methodologies to account for risk and uncertainty in E&P

Risks have been qualitatively or quantitatively evaluated. For any petroleum exploration and development project following types of risks need to be quantified or assessed (Ikoku, 1985).

i. Risk of a dry well.
ii. Political and economic risk.
iii. Risk related to future oil prices.
iv. Risk of size of catch which may not compensate the exploration cost.
v. Environmental risk.

It calls for risk analysis approach to economic evaluation as proposed by Newendorp (1975) (Figure 6.8).

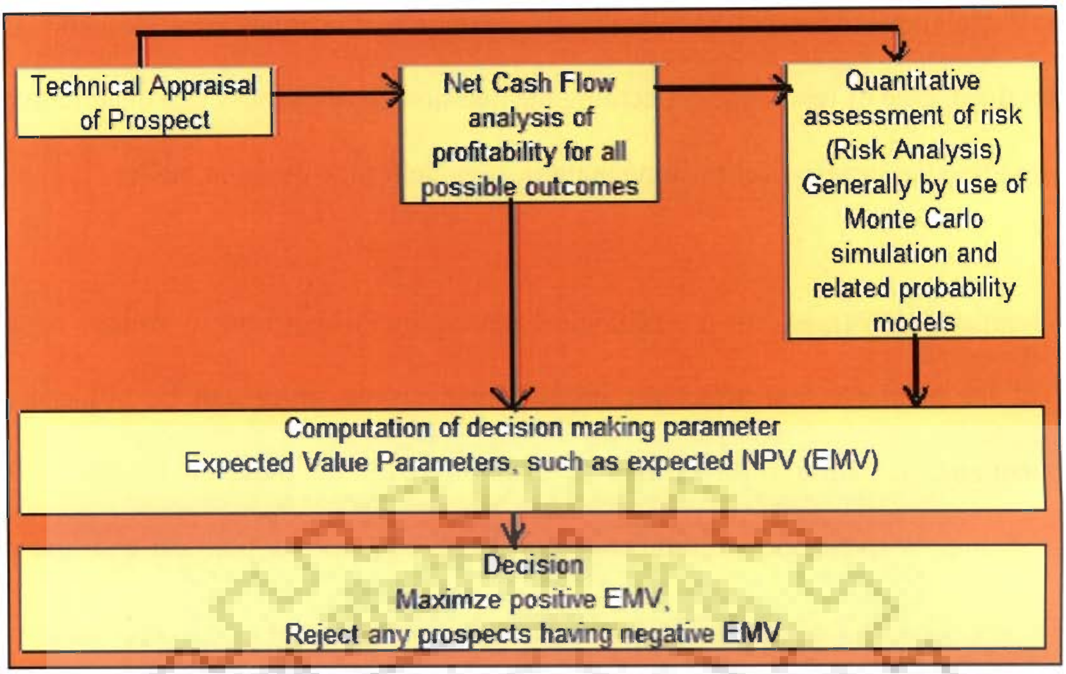


Figure 6.7 Approach to account for risk and uncertainty (After Newendorp, 1975)

Adapted from Ikoku, C.U (1985)

6.9 Conclusions

The decision to opt any business opportunity needs thorough evaluation for risk and uncertainty. The application of decision analysis framework approach is critical to screen any overseas acreage. The study has revealed that the strategy should be designed to focus the countries having favorable investment climate, optimum unrisked economic return. Thus the understanding of risk and uncertainty will facilitate in evaluation of the potential consequences perceived in each business situation, assess the uncertainties involved in the decision and develop a consistent strategy. The capital investment decision making based on sound understanding of risk and uncertainties will have favorable implications on petroleum resource exploration and development business. This chapter has discussed at length the decision analysis concepts and procedures associated with decision making under uncertainty and risk. It provides comprehensive understanding for the bidder to decide the destination which suits their investment strategy for such kind of high risk business. The understanding thus developed will constitute a ground for designing the model and methodology for globalization strategy which are discussed in subsequent chapters.

CHAPTER 7

DEVELOPMENT OF MODEL

FOR SLECTION OF GLOBAL DESTINATION FOR CRUDE OIL

7.1 INTRODUCTION

Petroleum investment decisions require a decision making. But, decision making is becoming more and more difficult because decision problems are not well-structured problems that are easy to solve by intuition or experience supported by relatively simple calculations. The problem becomes more complex because of the globalization of the economy and linkage with various environmental, social, and political issues. Not only that the decision making is done for the future, which is always uncertain. Thus the decision has to cope with uncertainty in order to rationally manage various risks. This chapter is the description of an attempt to model the parameters discussed in earlier chapters which are generally understood to affect the decision of a business entity in screening the global destinations for venturing in to the business of exploration and production of crude oil. The model is expected to integrate relevant knowledge and large amount of data, the complex relationship between variables, the characteristics of the resulting mathematical problems, and requirements for comprehensive problem analysis. This task motivates the development of model including model specification, data management, data defining parameters, and documentation of the whole modeling process (Makowski, 2005).

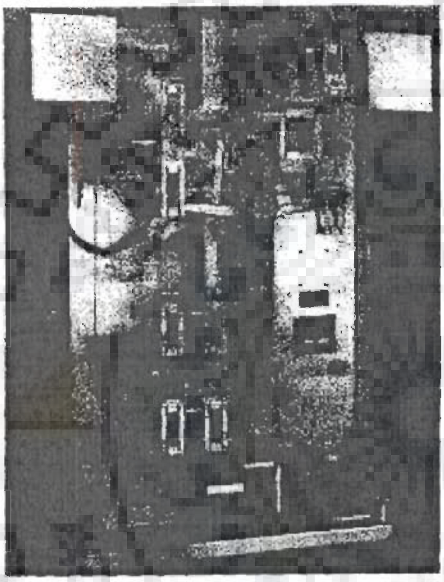
7.2 NEED OF A MODEL

The process of rational decision making require a representation of the relationships between decisions and outcomes i.e. the consequences of applying a decision; understanding the uncertainties related to various representation of such relationships; an assessment of various risks related to implementing the decisions; a procedure for selecting the best decision; and an assessment of the consequences of implementing any decision. However, it may not be possible to attempt to deal with all these issues for any given decision problems. In fact there are large number of methods and corresponding tools for each of these issues. Moreover, different decision problems and their associated decision making process have different characteristics which call for focusing on implementing a selection of methods and tools. Thus, it may be agreed that a model based decision making will be worth taking up for such investment. Furthermore, it may be said that coping with uncertainty and risk for these kind of complex decision making situation is a complex problem. There is a wealth of knowledge and experience that can contribute to rational risk management. Modeling has been able to solve various problems and thus have been intensively developed over the last few decades and for this reason the need of mathematical model in decision making has been emphasized (Makowski, 2005). A simple example may illustrate the issue. Let us take an example of decision to be taken by an individual to buy a car. From a methodological perspective this is a multi criteria problem of selection from a small set of alternatives. The alternatives are rather well defined and criteria are easily interpreted by a person making the decision. There are several methods supporting decision making in such situations, and the problem is typically solves using intuition and experience rather than any analytical tool. The same problem may be solved in a different way by different persons, and the same person may take very different decisions which he/ she can not explain using the criteria that are believed to completely define the tradeoffs. Different solutions to the same problem which, are believed to be the best exhibit that even for the simple decision problem it may be impossible to precisely define a set of criteria and tradeoffs between them. The decision may be taken without using any analytical tool, intuition and experience alone can not be used for the analysis of solutions to complex problems. Therefore, decision makers need to somehow integrate knowledge from the various areas, and this can be efficiently done only by using model (Makowski, 2005).

Each model represents a part of knowledge that is relevant for analysis of the problem. Thus, a model is valid for a specific purpose. In order to define a purpose for modeling one need to analyze if and how a model can constitute to finding a better solution – that can be found without a model. This, in turn implicitly sets the requirement for a selection of input and output variables. Because of the success of modeling in problem solving, various modeling prototypes have evolved depending upon the variables and the relationship between variables with an aim to best represent different problems by a structured approach. Each model represents knowledge, expectation, methodology, and modeling tools targeted to solve particular problem (Makowski, 2005).

7.3 MODEL DEFINED

A model is the medium between data and understanding (McLaughlin, 1995). Boumal (2003) defines model as a representation of a theory, or part of a theory, often for the purpose of illuminating cause and effect relationship. Boumal (2003) expresses that his notion of a 'model' is familiar to children, scientists and economists and they use the term in much the same way. An illustration of A.W. Philips, the famous engineer-turned-economist who discovered the Philips Curve can exemplify this statement. Philips constructed a working model of the determination of national income in a simple economy in using colored water flowing through pipes. This model graced the basement of the London School of Economics. But, in general economist consider models to be developed with paper and pencil rather than with hammer and nails.



The Phillips Machine
The late Professor A. W. Phillips, while teaching at the London School of Economics in the early 1950s, built this machine to illustrate Keynesian theory. This is the same theory that we will explain later in this book, using words and diagrams, but Phillips's background as an engineer enabled him to depict the theory with the help of tubes, valves, and pumps. Economists, on the whole, tend not to be very good plumbers; only Phillips and Irving Fisher before him used water and pipes to build models of this sort. Most economists rely on paper and pencil instead. But the two sorts of models perform the same function: They simplify reality in order to make it understandable.

Wikipedia defines model as a pattern, plan, representation, or description designed to show the strictures workings of an object, system, or concept. A model may also refer to abstractions, concepts, and theories. An abstract model refers to an abstraction or conceptual object used in the creation of a predictive formula, a causal model, is an abstract model that uses cause and effect logic, and a mathematical model, is an abstract model that uses mathematical language. According to Wikipedia, "an abstract model (or conceptual model) is a theoretical construct that represents something, with a set of variables and a set of logical and quantitative relationships between them. Models in this sense are constructed to enable reasoning within an idealized logical framework about these processes and are an important component of scientific theories. Idealized here means that the model may make explicit assumptions that are known to be false (or incomplete) in some detail. Such assumptions may be justified on the grounds that they simplify the model while, at the same time, allowing the production of acceptably accurate solutions."

The purpose of a model is to provide an argumentative framework for applying logic and mathematics that can be independently evaluated (for example by testing) and that can be applied for reasoning in a range of situations. Abstract models are used primarily as a reusable tool for discovering new facts, for providing systematic logical arguments as explicatory or pedagogical aids, for evaluating hypotheses theoretically, and for devising experimental procedures to test them. Reasoning within models is determined by a set of logical principles (McLaughlin, 1995). In some cases, abstract models can be used to implement computer simulations that illustrate the behavior of a system over time. The automated use of modeling has been identified as a significant issue in the creation of artificial intelligence.

7.3.1 Structure of models

A conceptual model is a representation of some phenomenon, data or theory by logical and mathematical objects such as functions, relations, tables, stochastic processes, formulas, axiom systems, rules of inference etc. A conceptual model has a set of expressions in the model which are intended to denote some aspect of the modeled object. Typically a model will refer only to some aspects of the phenomenon in question (McLaughlin, 1995).

7.4 MATHEMATICAL MODEL

A mathematical model is an abstract model that uses mathematical language to describe the behavior of a system. Eykhoff (1974) defined a mathematical model as a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form. Very often mathematical models are used to analyze a system to be controlled or optimized. A mathematical model usually describes a system by a set of variables and a set of equations that establish relationships between the variables. The values of the variables can be practically anything; real or integer numbers, boolean values or strings, for example. The variables represent some properties of the system, for example, measured system outputs often in the form of signals, timing data, counters, event occurrence (yes/no). The actual model is the set of functions that describe the relations between the different variables (McLaughlin, 1995).

7.4.1 Building blocks of a model

There are six basic groups of variables: decision variables (also known as independent variables, input variables, state variables, exogenous variables (also known as parameters or constants variables), random variables, and output variables. The variables are not independent of each other as the state variables are dependent on the decision, input, random, and exogenous variables. Furthermore, the output variables are dependent on the state of the system (represented by the state variables). Objectives and constraints of the system and its users can be represented as functions of variables or state variables. The objective functions will depend on the perspective of the model's user. Depending on the context, an objective function is also known as an index of performance, as it is some measure of interest to the user. Although there is no limit to the number of objective functions and constraints a model can have, using or optimizing the model becomes more involved (computationally) (McLaughlin, 1995).

7.4.2 Classifying mathematical models

Mathematical models can be classified in several ways, some of which are described below.

1. Linear vs. nonlinear: Mathematical models are usually composed by variables, which are abstractions of quantities of interest in the described systems, and operators that act on these variables, which can be algebraic operators, functions, differential operators, etc. If all the operators in a mathematical model present linearity, the resulting mathematical model is defined as linear. A model is considered to be nonlinear otherwise. In a mathematical programming model, if the objective functions and constraints are represented entirely by linear equations, then the model is regarded as a linear model. If one or more of the objective functions or constraints are represented with a nonlinear equation, then the model is known as a nonlinear model (McLaughlin, 1995).

2. Deterministic vs. probabilistic (stochastic): A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables. Therefore, deterministic models perform the same way for a given set of initial conditions. Conversely, in a stochastic model, randomness is present, and variable states are not described by unique values, but rather by probability distributions (McLaughlin, 1995).

3. Static vs. dynamic: A static model does not account for the element of time, while a dynamic model does. Dynamic models typically are represented with difference equations or differential equations (McLaughlin, 1995).

4. Lumped parameters vs. distributed parameters: If the model is homogeneous (consistent state throughout the entire system) the parameters are lumped. If the model is heterogeneous (varying state within the system), then the parameters are distributed. Distributed parameters are typically represented with partial differential equations (McLaughlin, 1995).

Mathematical modeling problems are often classified into black box or white box models, according to how much a priori information is available of the system. A black-box model is a system of which there is no a priori information available. A white-box model (also called glass box or clear box) is a system where all necessary information is available. Practically all systems are somewhere between the black box and white-box models, so this concept only works as an intuitive guide for approach (McLaughlin, 1995).

Usually it is preferable to use as much a priori information as possible to make the model more accurate. Therefore the white-box models are usually considered easier, because if one has used the information correctly, then the model will behave correctly. Often the a priori information comes in forms of knowing the type of functions relating different variables. Very often the parameters have to be estimated through some means before one can use the model (McLaughlin, 1995).

In black-box models one tries to estimate both the functional form of relations between variables and the numerical parameters in those functions. With a priori information one could derive a set of functions that probably could describe the system adequately. If there is no a priori inform, one may try to use functions as general as possible to cover all different models. Neural networks are a black-box models, which usually do not assume anything the incoming data (McLaughlin, 1995).

7.5 CONSTRUCTING A MODEL

In order to construct a model, it is necessary to proceed from known to unknown, or at the very least from the better known to less well known. Data and information are not equivalent. In fact Data = Information + Error. To construct a model, it is necessary to proceed from the known to the unknown or, at the very least, from the better known to the less well known. There are two approaches, depending upon whether it is the information or the error that is better known. In the first case, the model is designed to utilize the known properties of the embedded information to extract the latter and leave the error behind. This approach is commonly employed with stochastic data. Alternatively, if the error is the better known, the model is designed to operate on the error, filtering it out and leaving the information behind. This approach is nearly universal with deterministic data.

7.6 MODEL EVALUATION

An important part of the modeling process is the evaluation of an acquired model to know if a mathematical model describes the system well. A common approach is to split the data into two parts; training data and verification data. The training data are used to train the model, that is, to estimate the model parameters. The verification data are used to evaluate model performance. Assuming that the training data and verification data are not the same, we can assume that if the model describes the verification data we then the model describes the real system well (McLaughlin, 1995).

7.7. REQUIREMENT OF MODEL FOR GLOBALIZATION STRATEGY TO RANK COUNTRIES FOR PETROLEUM BUSINESS

The globalization of the world economies, and in particular the internationalization of petroleum business, have expanded and diversified investment possibilities, leading to numerous new opportunities accompanied with diverse risks. Globally firms resort to strategic and tactical investment decisions in overseas E&P opportunities involving significant capital diversification investment. Profitability, risk and growth guide overseas investment decisions. Selection of overseas investment opportunities are critical for a firm because of uncertainty in identifying and quantifying the attendant risk- geological, commercial, social and political as well as return on investment. Consequently, there has been growing interest in obtaining reliable ranking of countries for investment in crude oil exploration and production business. There is a growing concern to screen and rank overseas investment opportunities in terms of decisive factors which drive an explorer in deciding their overseas business destination for exploration and production of crude oil consists of country risk (economic, social and political), fiscal terms, various tax systems, technical prospectivity as defined by geology, local markets, and infrastructure.

Annually, several countries in the world offer acreage for exploration and development. The countries provide information about technical aspects of the acreage, i.e. tentative oil-gas potential of the acreage on offer, the contract terms or fiscal arrangements, and the tax laws. The investment decisions for such projects follow the fundamental factors applicable to any project and the project economics is worked out and consideration is given to geo-political and other factors (Surya et al 2008). The investor often negotiates the contract terms to work out a logical division of profit (Daniel Johnston, 2000). Mostly, from the operator's perspective, economic measures such as the present value and rate of return indicating the expected profitability from the venture hold key importance. There are several sources of uncertainty related to geological information, production forecast, investment, etc. A realistic idea of reserve estimate is never possible leading to further uncertainty in estimates of production profile. Even more difficult is predicting price of crude oil and gas, cost likely to be incurred, and demand-supply situations. These impact the decision to lease and investment planning. But, these computations alone may jeopardize the business, because of other risk elements which need attention of decision makers during the computation process. These factors, which, are generally not taken into consideration while making the strategic investment decisions in any overseas acreage are country risk elements comprising of economic, social and political factors, the fiscal system etc. In overseas investments after the establishment of project on techno-economic considerations, thorough due diligence which includes country entry risk assessment is carried out perfunctorily as a part of preliminary project planning (Surya et al 2008). Such studies identify potential risk factors and assign a relative degree, and the recommendations serve as a sanity check for decisions already taken based on knowledge and instinct (Surya et al 2008). Mostly the detailed country risk assessment which may unravel the impending factors to failure of the project is not carried out and even the modest risk assessment exercises made during project evaluation in isolated cases do not get logged for future reference (Surya et al 2008). Thus, a need is being felt to overcome these limitations and develop a tool which encompasses majority of risk factors affecting global petroleum investment decisions and which can be used to screen and rank business opportunities at an early stage of decision making.

Beyond doubt, the upstream petroleum business is complex, and further complex is the process to select country (ies) for investment in exploration and development of crude oil and gas. Globally firms make significant capital investment in overseas E&P opportunities. Globalization is nothing new to oil and gas industry and companies of all sizes now participate in international venture (Bagge, 2005). The primary objective of any company is not merely to produce oil and gas but rather to make profit (Ikoku, 1995). In general, a company acquires license or enters into a contractual arrangement with the government or private operator to explore and/ or exploit crude oil- gas, or develop a field without owning the resources. Only the companies which exercise sound economic judgment use sophisticated evaluation techniques can survive in this business (Ikoku, 1995). The economic analysis may provide a basis to select or reject an investment opportunity. But, the decision to invest or not in overseas venture hinges on inherent uncertainty in identifying, quantifying, and integrating in pervasive framework the risks related to geological, commercial, social, political and various other aspects.

The resolution to opt for overseas E&P investment opportunity depend on the technical prospectivity (TP), the ease of doing business in that country (EODB), fiscal rank/ fiscal index (FI), global competitiveness index (GCI) as well as country risk (CR). we describe such decision for resolving overseas venture by a numerical value called Globalization Index (GI) as a function of TP, EODB, FI, GCI, and CR.

In order to rank countries, and to obtain Globalization Index (GI), we have applied modeling techniques to model these parameters by applying nonparametric approach using Alternating Conditional Expectation (ACE) alogorithm and the Abductive network based on self –organizing Group Method of Data Handling (GMDH).

In parametric regression, a model is fitted to data by assuming a functional relationship. However, it is always not possible to identify the underlying functional construct amongst dependent and independent variables. Nonparametric regression technique offer much more flexible data analysis tools for exploring the underlying relationships between dependent and independent variables. In this work we adopt non parametric approach for estimating optimal transformations of risk parameters to obtain the maximum correlation between observed variables. It does not require *a priori* assumptions of a functional form and the optimal transformations are derived solely based on data set. We have made an attempt to apply an iterative procedure involving “Alternating Conditional Expectation” (ACE) algorithm to construct a functional relationship between independent variables (predictors) – TP, EODB, FI, GCI, and CR to find dependent variable (response) - GI. As no functional relationship can be assumed between GI and TP, EODB, FR, GCI, and CR, non-parametric transformation may lead to some plausible solution that is derived from the data sets of dependent and independent variables.

Another attempt has been made to develop an automated analytic framework which can quantify without user intervention, the weight or degree of influence of various elements of risk (technical, economic, social, and political) associated with any acreage. To achieve this objective the modeling approach employing Group Method of Data Handling (GMDH) to model the system events in terms of various exogenous defined parameters leading to ranking of countries for petroleum exploration and production business has been developed.

7.8 KEY PARAMETERS FOR SELECTING OVERSEAS DESTINATION

7.8.1 Variable selection criteria and the selected variables

The selection of variables for estimating a country's worth for attracting overseas investors in petroleum exploration business is based on norms like - the significance of variables, the availability of uniform data sets for countries. Extensive literature and data review has lead authors in selecting the set of variables for inclusion in their model.

Based on the criteria of importance, accessibility and consistency we have resolved to incorporate country specific variables e.g. technical prospectivity represented by crude oil reserves, country risk (incorporating economic, social and political risks), fiscal terms, ease of doing business, and corruption in the country in our model. The variables are defined on a scaled interval and are based on estimates/ measurements provided by various agencies. The list of variables that have been considered in this work is provided in Table 7.1.

7.8.1.1 Technical Prospectivity (TP)

The reserves of crude oil has been considered to represent the technical prospectivity of any country. According to the Society of Petroleum Engineers (SPE) and World Petroleum Congress (WPC) "reserves are those quantities of petroleum which are anticipated to be commercially recovered from known accumulations from a given date forward (1997)." The higher the values of these variables, the more likely the country are to be exploration worthy. The estimates of reserves provided by British Petroleum (2008) have been taken to represent technical prospectivity or exploration worthiness of a country.

7.8.1.2. Country Favorability Index (CFI)

The computed value of current year data for "Reserves-to-production ratio" (R/P) has been used as a dummy variable to represent the Country Favorability Index. The R/P ratio is derived by following equation with data taken from estimates of reserves provided by British Petroleum (2008).

$$\text{R/P Ratio} = \frac{\text{Current Year Remaining Reserve}}{\text{Current Year Production}}$$

The ratio depicts the length of time that those remaining reserves would last if production were to continue at that level.

7.8.1.3 Ease of Doing Business (EODB)

The ease of doing business refers to the degree of ease by which a business entity can start and do business in a country. The index has been developed by World Bank (2005) and it ranks economies by an indicator which is calculated on the simple average of country percentile rankings on aspects like - starting a business, dealing with licenses, employing workers, registering property, getting credit, protecting investors, paying taxes, trading across borders enforcing contracts, and closing a business.

7.8.1.4 Fiscal Ranking (FR)

Exploration for petroleum occurs on the basis of concessions, leases, or contracts granted by governments. The terms and conditions of such arrangements are established by law or negotiated case by case. One important aspect of the arrangements is the fiscal terms and conditions—these include bonuses, rentals, royalties, production sharing arrangements, carried interest provisions, corporate income taxes, and special taxes. Together, all the payments to government required under a petroleum arrangement can be called a "fiscal system." In some countries, a single fiscal system applies to the entire country; in others, a variety of fiscal systems exist. Khelil (1995) has ranked fiscal system of oil-producing areas as very favorable, favorable, average, tough and very tough. Van Meurs (1997) has provided star ranking of countries according to their fiscal system. The ranking provided by Van Meurs (1998) has been used in our study.

7.8.1.5 Country Risk (Economic, Social and Political) (CR)

Country risk is a major factor for global investors. There are several studies focused to analyze and rank countries according to the economic, social and political risk (Harvey et al, 1996). In this work, we have used the index provided by KOF (Dreher, Axel; 2006) referred as KOF index. The KOF Index measures the three main dimensions: economic, social, political and calculates an overall index. The sub-indices data on economic integration refer to actual economic flows like - trade (in percent of GDP), Foreign Direct Investment (in percent of GDP), portfolio investment (in percent of GDP), income payments to foreign nationals (in percent of GDP), and economic restrictions represented by - hidden import barriers, mean tariff rate, taxes on international trade (in percent of current revenue), capital account restrictions. The data on political engagement takes in to consideration factors like - embassies in country, membership in international organizations, participation in un security council missions; and the data on social globalization takes into consideration data on personal contact, data on information flows, and data on cultural proximity.

7.8.1.6 Corruption Perception Rank (CPR)

Corruption constitutes country specific risk factor which is likely to have significant impact on the decision of investor in selecting overseas business destinations. The Corruption Perception Rank (CPR) provided by Transparency International has been taken into consideration.

Following is an attempt to make use of the Alternating Conditional Expectation (ACE) and Abductive Network (AN) to rank petroleum producing countries in order of the favorability for global investors by taking in to consideration all factors which may affect the global business. The ranking will facilitate investment decisions in overseas exploration and exploitation business.

7.9 MODELING METHODOLOGY

7.9.1 Application of ACE in Estimation of Globalization Index

Most commonly, "Globalization Index" can be estimated from different parameters impacting it by using either empirical relationship or some form of statistical regression: parametric or non parametric. The empirical models may not be applicable in regions having environments endowed with different kinds of risk categories and risk elements, without making adjustments to exponents in the models. Statistical regression has been proposed as a versatile solution to the problem of estimation. Conventional statistical regression has generally been done parametrically using multiple linear or nonlinear models that require a priori assumptions regarding functional forms. In recent years, nonparametric regression techniques such as Alternating Conditional Expectation (ACE) (Duolao Wang et al (2004); Kukreja J.P, (2009), Sum, C. C., et al (1995); Sum, C. C., et al (1999); Verma C. P et al (Dec. 2005) and Verma C. P et al (2008); Xue, G., et al. (1997); hybrid soft computing systems viz. Artificial Neural Networks (ANN) and Group Method of Data Handling (GMDH) (Negi, J K and Prasad U S (2005), Prasad U.S et al. (2006), have been introduced to overcome the limitations of conventional regression methods. In the following paragraphs, an attempt is made to apply the alternating conditional expectation (ACE) algorithm for estimation of Globalization Index from the different parameters impacting it.

7.9.2 The ACE Algorithm

The method of ACE originally developed by Breiman and Friedman (1995) and refined by Xue, et al (1997) is intended to alleviate the main drawback of parametric regression. In nonparametric regression a – priori knowledge of the functional relationship between the dependent variable y and independent variables $x_1, x_2, \ldots, x_n$ is not required. In fact, one of the main results of such regression is determination of the actual form of this relationship.

A model predicting the value of y from the values of $x_1, x_2 \ldots x_n$ is written in the generic form $y = f^{-1}(z)$

where $z = \sum z_i$ and $z_i = f_i(x_i)$

The procedure for this approach is given by

(i) Calculate the data transform :

$$z_i = f_i(x_i) \quad i = 1,2, \ldots\ldots, n$$

(ii) Calculate the transform sum :

$$z = \sum z_i, \; i = 1, 2, \ldots\ldots, n$$

(iii) Calculate the inverse transform :

$$y = f^{-1}(z)$$

Given n observation points, we wish to find the best transformation functions $f_1(.)$, $f_2(.)$, …………, $f_n(.)$, but not as algebraic expressions, rather as a relationships defined point wise. The method of ACE constructs and modifies the individual transformations to achieve maximum correlation in the transformed space. Graphically this means that the plot of $z = \sum z_i$ against $z' = f(y_{measured})$ should be as near to the 45° straight line as possible. The resulting individual transformation are given in the form of a point by point and/or table, thus in any subsequent application (graphical or algebraic) interpolation is needed to obtain the transformed variables and to apply the inverse transform to predict y. Naturally, the smoother the transformation the more justified and straightforward the interpolation is, therefore, some kind of restriction on smoothness is built into the ACE algorithm. In other words, based on the concept of conditional expectation, the correlation in transformed space is maximized by iteratively adjusting the individual transformations subject to a smoothness condition.

The strength of ACE can be appreciated by the following synthetic example as provided by Xue et al (1997), where these authors have discussed an example to illustrate how the ACE algorithm can be used to identify the functional relationship between dependent and independent variables.

Function Identification. Following synthetic example discussed by Xue et al (1997) is considered to illustrate the effectiveness of ACE algorithm. A data set with 200 observations are simulated from the following model:

$$y_i = \exp[\sin(2\pi x_i) + \varepsilon_i/2] \ (1 \leq i \leq 200) \ \ldots\ldots\ldots\ldots (1)$$

where x_i is drawn from a uniform distribution U(0,1) and ε_i is independently drawn from a standard normal distribution N(0,1). Figure 7.1.A is a scatter plot of y_i vs. x_i. The plot itself does not reveal a functional relationship between the dependent and independent data observations. In this situation, the direct use of parametric regression is impossible.

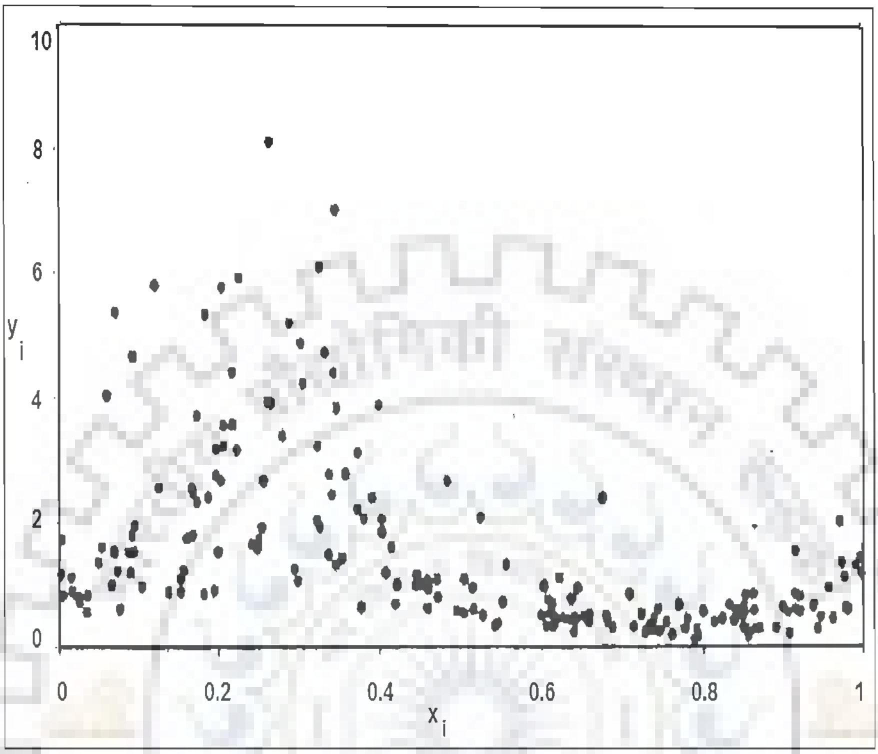


Figure 7.1.A Scatter plot of y_i vs. x_i simulated from bivariate model $y_i = \exp[\sin(2\pi x_i) + \varepsilon_i /2]$, where x_i is drawn from uniform distribution U(0.1), and ei is independently drawn from normal distribution N (0,1).

Rearranging equation 1 as

$$\ln (y_i) = \sin(2\pi x_i) + \varepsilon_i /2 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The optimal transformations of dependent and independent variables can be identified in following forms:

$$\theta^*(y_i) = \ln(y_i)$$

$$\theta^*(x_i) = \sin(2\pi x_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Substituting equation 3 into equation 2 results in

$$\theta^*(y_i) = \theta^*(x_i) + \varepsilon_i/2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

To demonstrate that the ACE algorithm can estimate these optimal transformations, the algorithm has been applied to the synthetic data set. Figures 7.1.B and 7.1.C show the optimal transformations of y_i and x_i derived by ACE.

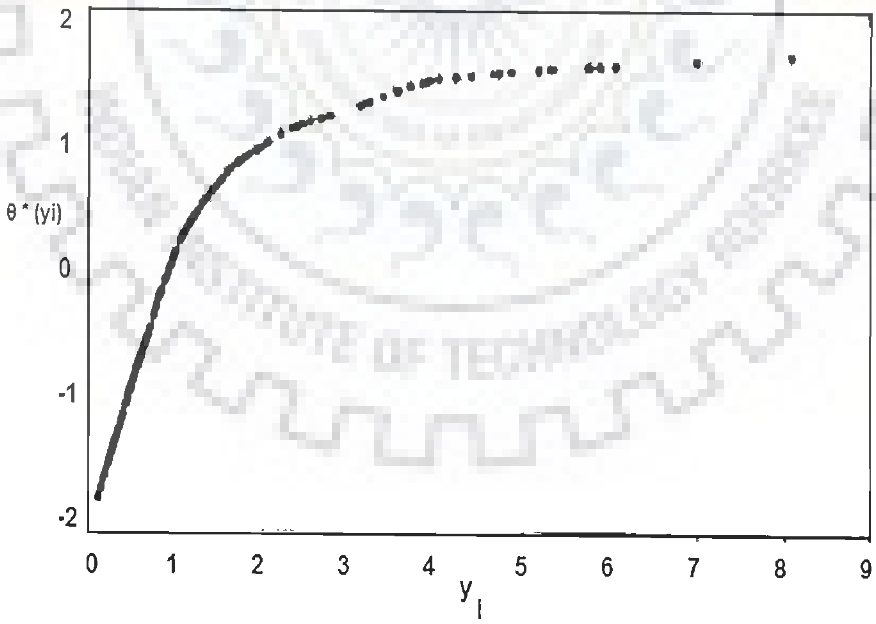


Figure 7.1.B – Optimal transformation of y_i by ACE

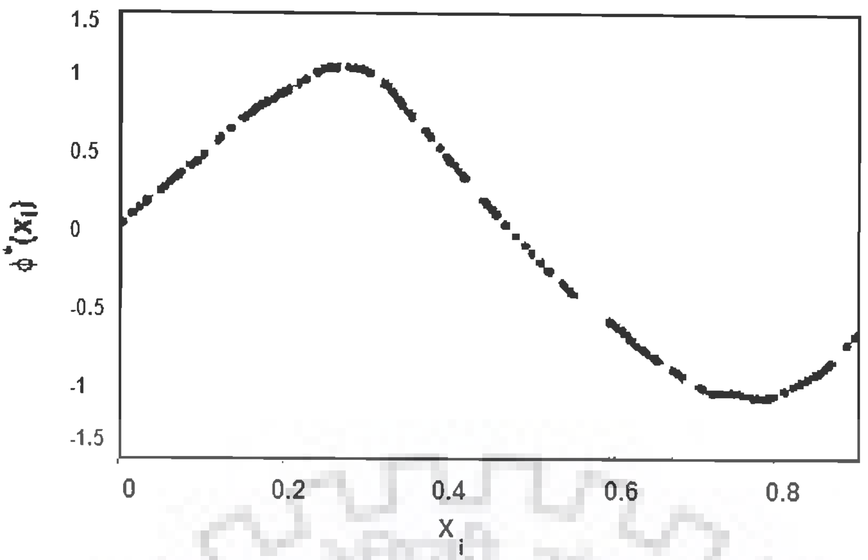


Figure 7.1.C Optimal transformation of x_i by ACE

Clearly, ACE is able to identify logarithmic function as the optimal transformation of the dependent variable and sine function as the optimal transformation of the independent variable. Figure 1.D shows a plot of $\theta * (y_i)$ vs. $\phi * (x_i)$. A linear regression on the transformed data yields

$$\theta * (y_i) = 1.093 \; \phi * (x_i) \, , \qquad (5)$$

which is a very close estimate of $\theta * (y_i) = \phi * (x_i)$, indicating that the transformations are, indeed, optimal.

It is observed that the original y_i and x_i are preprocessed to satisfy a zero mean for both y_i and x_i and a unit variance for y_i before the ACE transformations. Hence, the optimal transformations estimated by ACE, as shown in Figures7.1.B and 7.1.C, do not have the exact numerical relations as in equation 3.

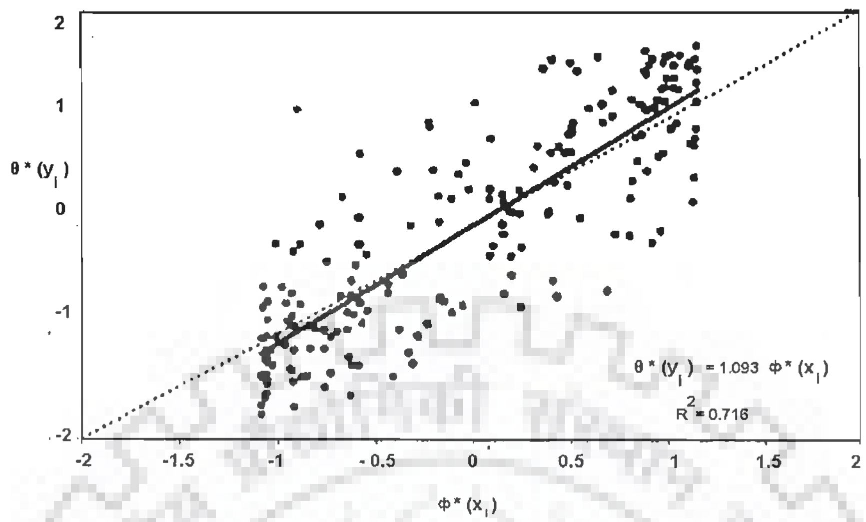


Figure 1.D Optimal transformation of y_i vs. optimal transformation of x_i by ACE.

The solid straight line represents linear regression of the data.

7.10 NUMERICAL MODEL DEVELOPMENT

The five country specific parameters (independent variables) (Table 7.1) have been taken in to consideration to work out the Globalization Index (dependent variable) - Technical Prospectivity (TP) represented by reserves of crude oil, the Composite index for Country Risk (CR) after Harvey et al, 1996, Ease of Doing Business (EODB) index provided by the World Bank, Fiscal Rank (FR) provided by Van Muers, and Corruption Perception Index (CPI) provided by Transparency International. The KOF Index of globalization has been used as a proxy to provide data for dependent variable i.e. Globalization Index (GI).

Country	Independent variables and their data source in brackets						
	KOF Index of Globalization, (Dreher, Axel (2006)	Technical Prospectivity represented by Oil - Gas Reserves (Oil & Gas Journal)	Country Risk (Harvey et al, 1996)	Ease of Doing Business (World Bank)	GCI 2006 Rank (World Economic Forum)	Fiscal Rank/ Index (Van Muers)	Corruption perception index (Transparency International)
	KOF_GI	**TP**	**CR**	**EODB**	**GCI**	**FR/ FI**	**CPI**
Argentina	64.12	2.320	70	101	69	2	93
Australia	80.91	1.437	82.5	8	19	76	9
Austria	91.6	0.062	84	30	17	29	11
Brazil	59.6	11.243	62.5	121	66	20	70
Canada	87.49	178.792	83	4	16	52	14
Chile	69.91	0.150	79.5	28	27	198	21
Colombia	52.3	1.542	68	79	65	232	59
Czech Rep.	84.46	0.015	82	52	29	60	46
Denmark	84.27	1.328	87.5	7	4	147	4
France	87.71	0.158	82	35	18	63	18
Germany	82.48	0.367	84.5	21	8	57	16
Greece	74.94	0.007	75	109	47	48	54
Hungary	81.15	0.102	72.5	66	41	39	41
India	49.7	5.848	69	134	43	187	74
Indonesia	51.31	4.301	69.5	135	50	285	134
Italy	80.61	0.622	77	82	42	33	45
Japan	64.22	0.059	86	11	7	73	17
Malaysia	75.81	3.000	80.5	25	26	148	44
Netherlands	89.15	0.106	86	22	9	91	10
New Zealand	73.46	0.053	83.5	2	23	58	3
Nigeria	52.97	35.876	52.5	108	101	98	146
Norway	77.75	7.705	87	9	12	240	8
Pakistan	52.35	0.289	59.5	74	91	13	147
Peru	57.12	0.930	60	65	71	49	75
Philippines	59	0.139	67.5	126	48	71	126
Poland	78.22	0.096	78	75	34	37	62
South Africa	62.45	0.016	76.5	29	45	142	51
Spain	82.52	0.158	74	39	28	4	23
Thailand	56.87	0.291	77	18	35	144	65
Turkey	63.45	0.300	62.5	91	59	66	60
United States	80.83	21.757	83	3	6	47	22
Venezuela	53.75	79.729	66.5	164	88	313	141

Table 7.1 Data used to workout Globalization Index

7.10.1 Multiple Linear Regression Model

Figures 7.2 to 7.7 show scatter plot of GI (KOF) vs. TP, CR, EODB, GCI, FR, CPI respectively. A multiple linear regression of GI on individual independent variables results in maximum correlation R^2 0.6139 with CPI and minimum correlation R^2 0.0046 with TP.

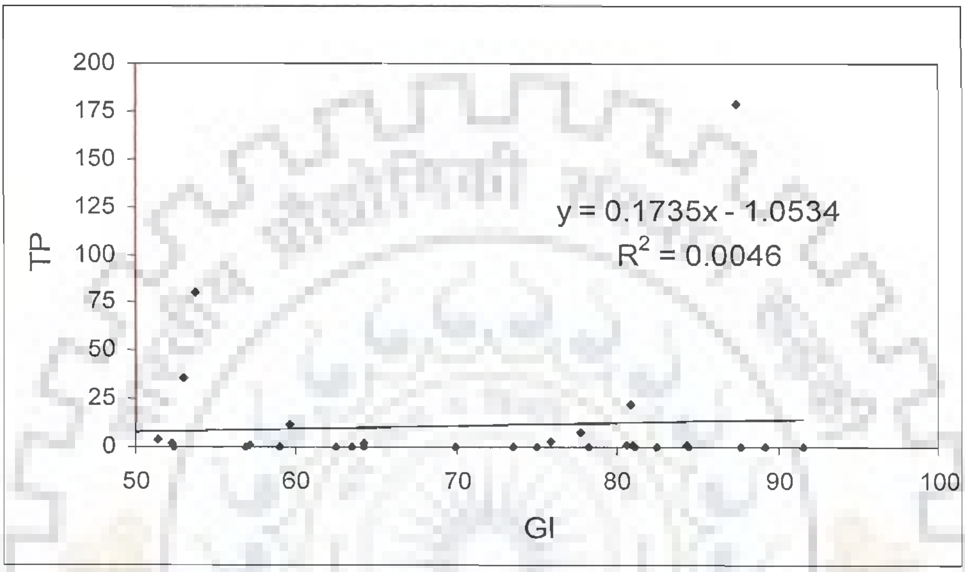


Figure 7.2 Scatter plot of GI vs.TP

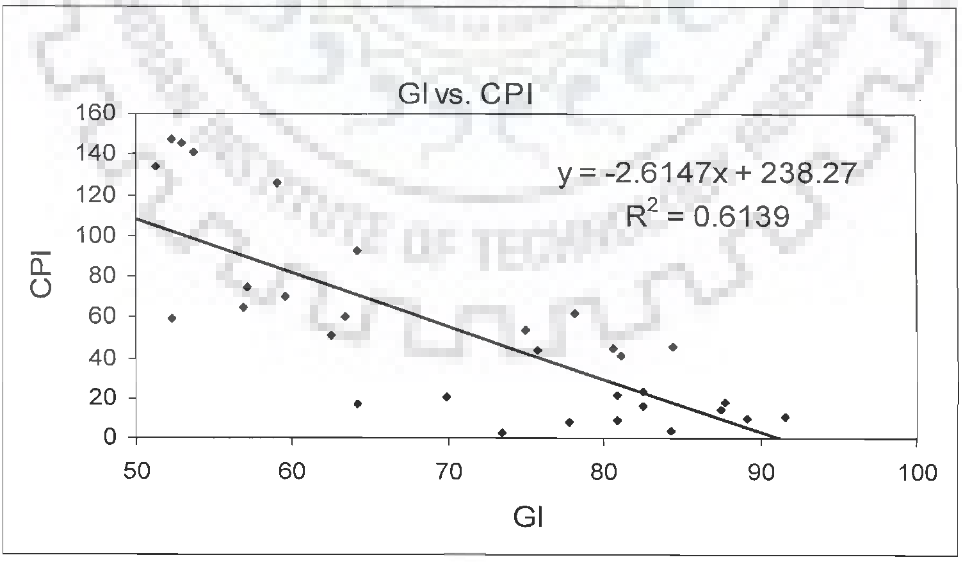


Figure 7.3 Scatter plot of GI vs. CR

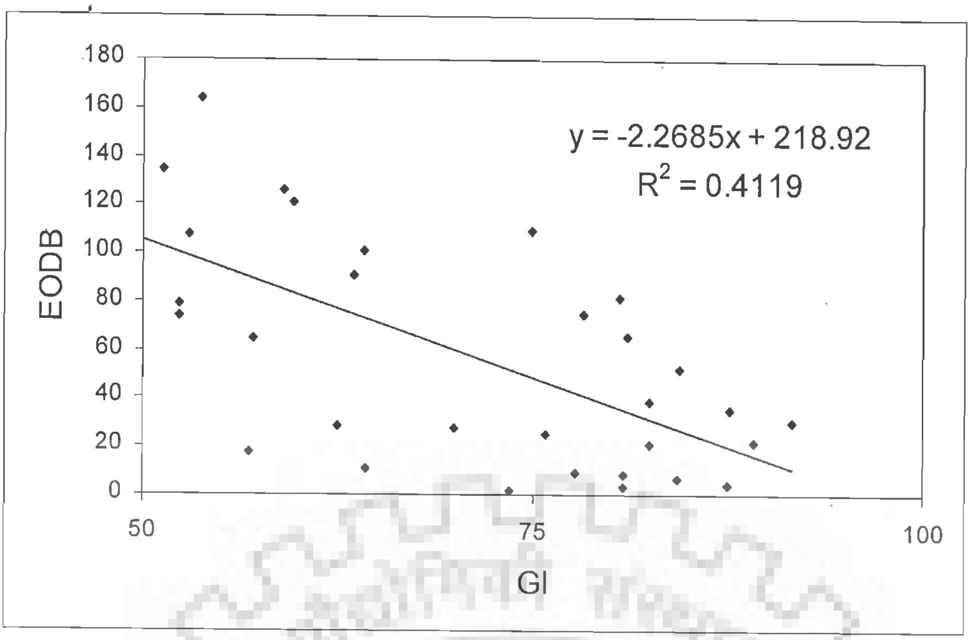


Figure 7.4 Scatter plot of GI vs. EODB

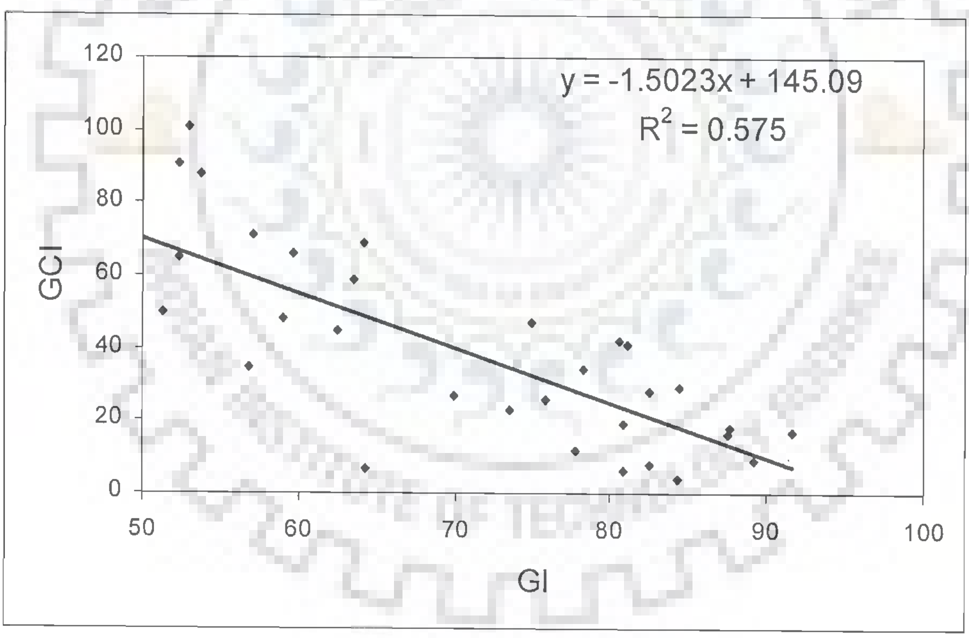


Figure 7.5 Scatter plot of GI vs. GCI

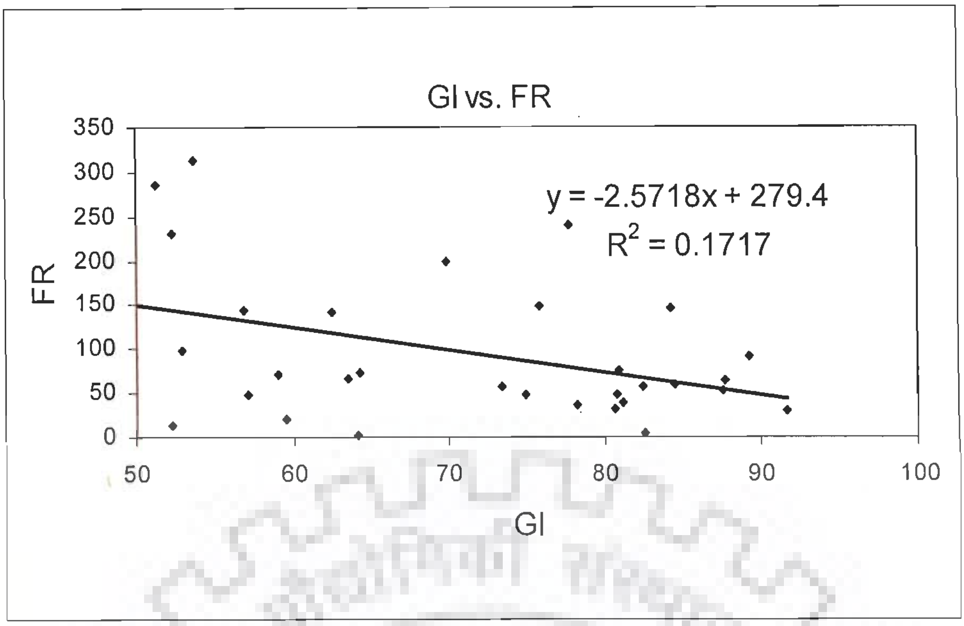


Figure 7.6 Scatter plot of GI vs. FR

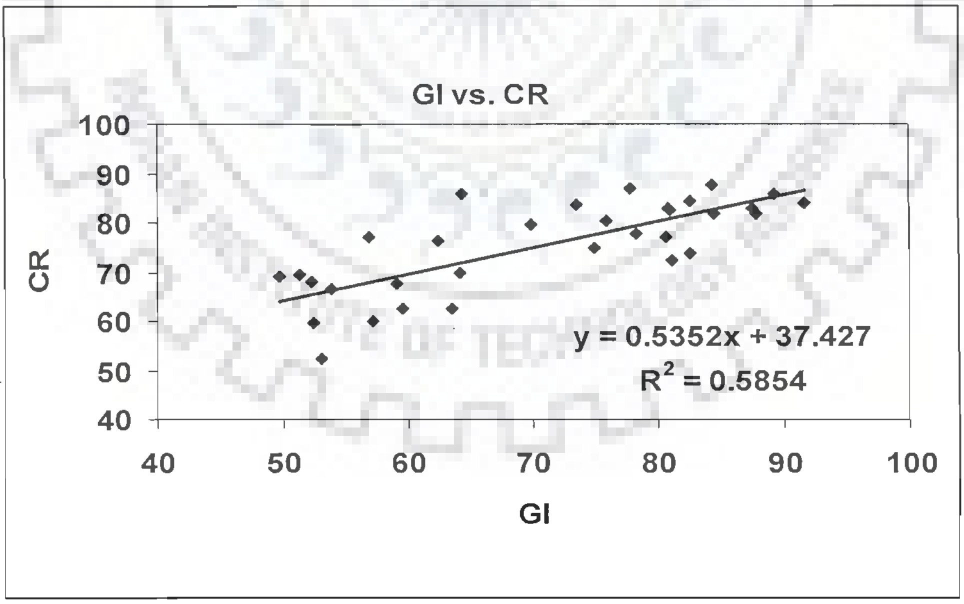


Figure 7.7 Scatter plot of GI vs. CR

Such low correlation of GI with individual variables are not unusual for such complicated problem. The conventional multiple linear regression model for GI is

$$GI = 0.513\ TP + 0.992\ CR + 0.057\ EODB + 0.048\ GCI - 0.0663\ F - 0.111\ CFI, \text{ with } R^2 = 0.79. \quad \ldots\ldots\ldots(6)$$

This linear regression model will be compared with ACE derived model.

7.10.2 Model from ACE

Six variables (TP, CR, EODB, FR, GCI and CPI) are used to predict GI based on ACE algorithm. The optimal transformations for GI and selected six independent variables were obtained through ACE. The sum transformations of these six independent variables has been constructed. Finally GI has been estimated from these variables for a country where GI is unknown using the following equation derived by ACE.

$$K\_GI = -3.1576E\text{-}01\ SumTr^2 + 1.2682E\text{+}01\ SumTr + 7.1717E\text{+}01 \quad \ldots\ldots\ldots(7)$$

where,

$$Sum\_Tr = CR\_Tr + EODB\_Tr + FR\_Tr + TP\_Tr + GCI\_Tr + CPI\_Tr$$

$$CR\_Tr = 8.8757E\text{-}04x^2 - 6.4039E\text{-}02x - 3.3999E\text{-}01;\ x = CR \quad \ldots\ldots\ldots(8)$$

$$EODB\_Tr = -1.8872E\text{-}04x^2 + 3.4091E\text{-}02x - 9.6804E\text{-}01;\ x = EODB \quad \ldots\ldots\ldots(9)$$

$$FR\_Tr = 1.7753E\text{-}05x^2 - 8.9505E\text{-}03x + 5.9538E\text{-}01;\ x = FR \quad \ldots\ldots\ldots(10)$$

$$TP\_Tr = -1.3012E\text{-}04x^2 + 6.5249E\text{-}03x - 2.1056E\text{-}02;\ x = TP \quad \ldots\ldots\ldots(11)$$

$$GCI\_Tr = 1.7132E\text{-}05x^2 - 1.5378E\text{-}02x + 5.2131E\text{-}01;\ x = GCI \quad \ldots\ldots\ldots(12)$$

$$CPI\_Tr = 3.7019E\text{-}05x^2 - 1.4466E\text{-}02x + 5.6312E\text{-}01;\ x = CPI \quad \ldots\ldots\ldots(13)$$

Using transform established in equation (7), globalization index can be estimated. Figures 7.8 to 7.14 illustrate the optimal transform for individual variables and final sum transform for prediction of GI.

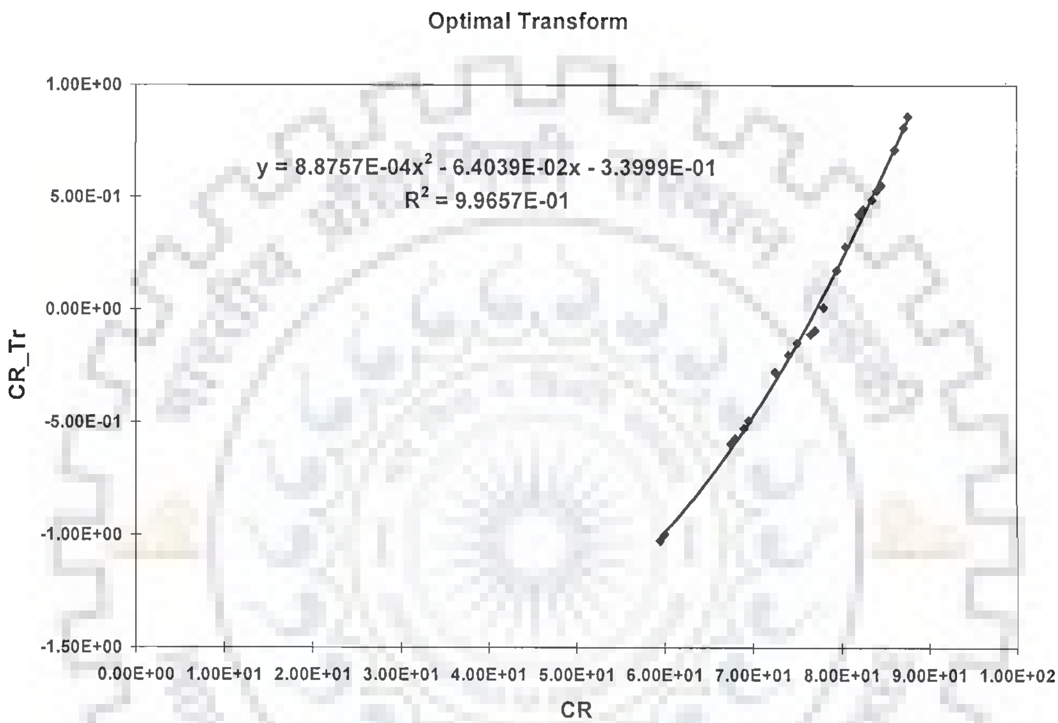


Figure 7.8 Optimal Transform CR vs. CR_TR

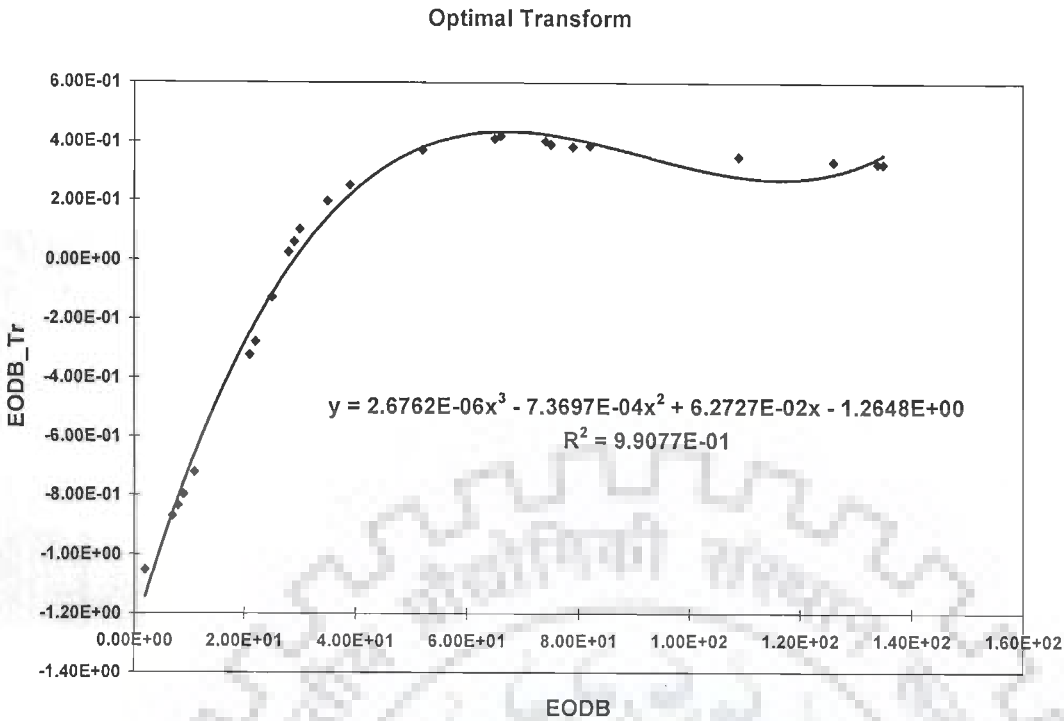


Figure 7.9 Optimal Transform EODB vs. EODB_TR

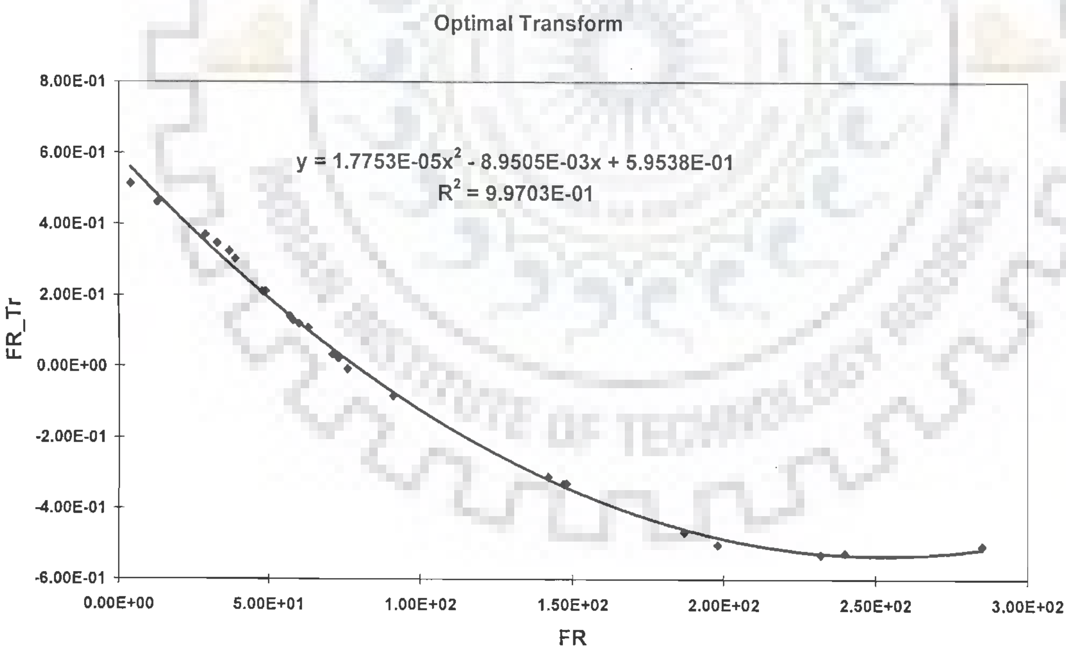


Figure 7.10 Optimal Transform FR vs. FR_TR

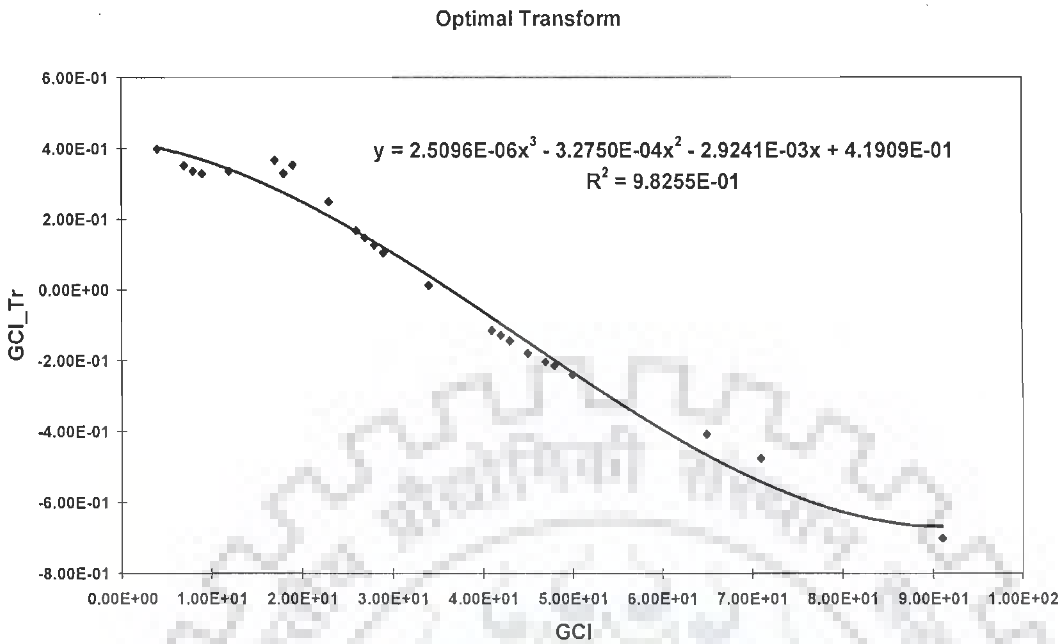


Figure 7.11 Optimal Transform GCI vs. GCI_TR

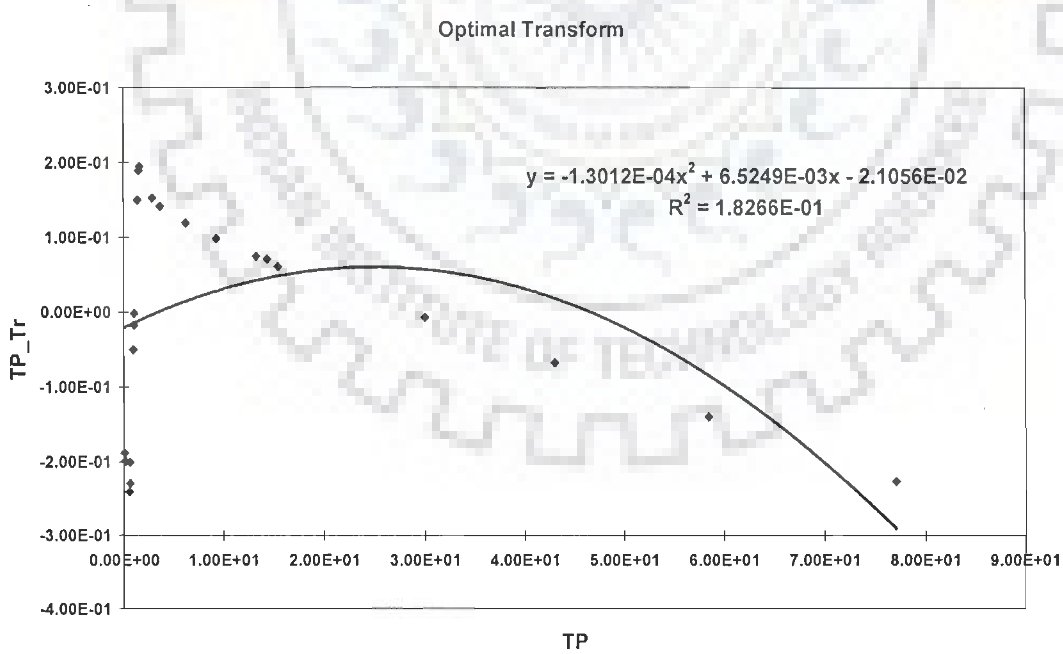


Figure 7.12 Optimal Transform TP vs. TP_TR

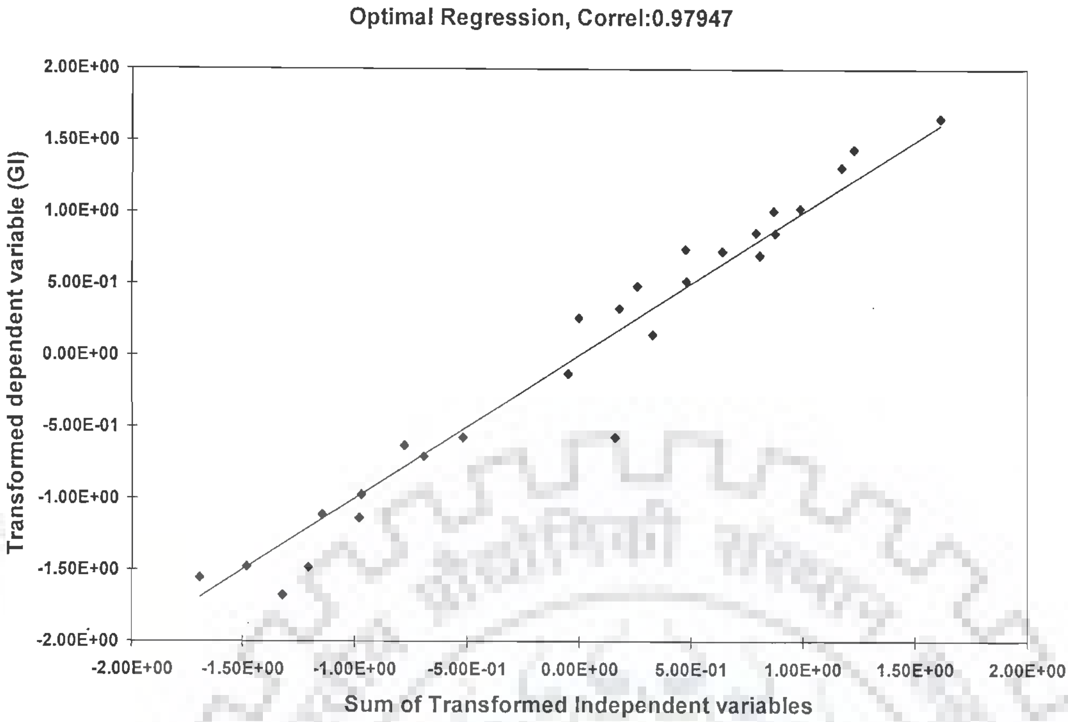


Figure 7.13 Optimal Regression

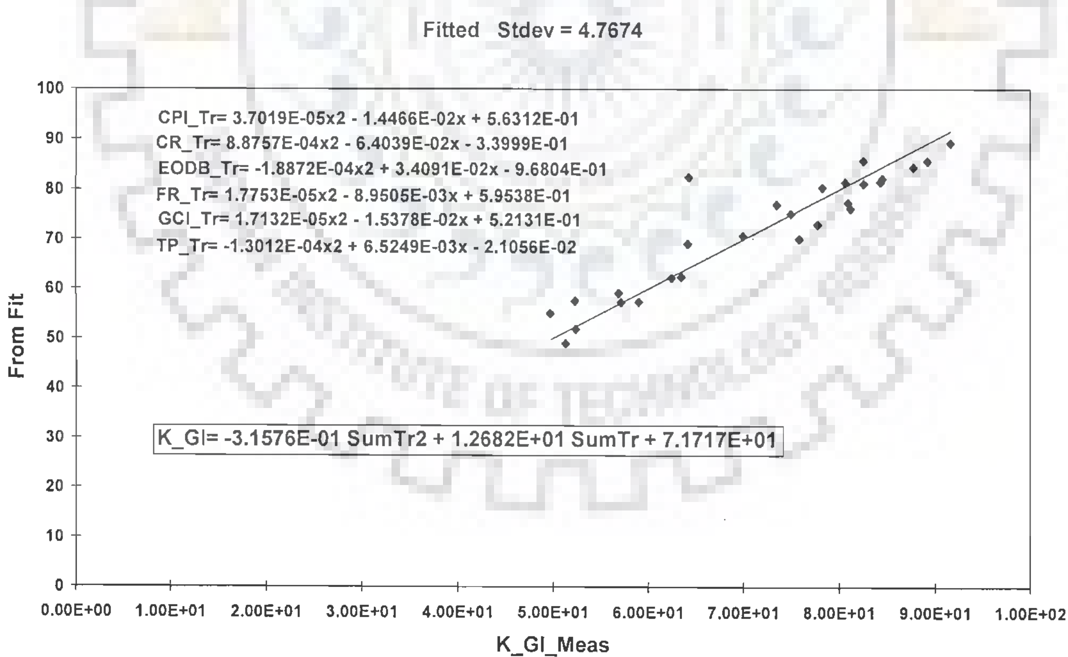


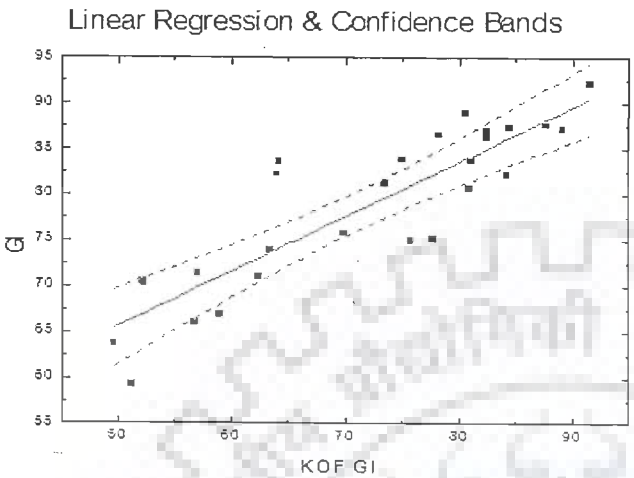
Figure 7.14 GI Measured vs. GI from Fit

Table 7.2 illustrates that despite some minor differences there is general agreement between the proxy values of GI and ACE derived values, indicating thereby that ACE is able to reveal the average characteristics of GI and provide a reliable basis for overseas venture screening. A comparison has been attempted (Table 7.2) between the estimated GI for ranking overseas crude oil-gas destination against the KOF Index which has been used as proxy.

Country	**KOF GI**	**GI (Derived)**	**Country**	**KOF GI**	**GI (Derived)**
Argentina	64.12	82.14	Japan	64.22	83.54
Australia	80.91	80.71	Malaysia	75.81	74.94
Austria	91.6	92.15	Netherlands	89.15	87.09
Chile	69.91	75.73	New Zealand	73.46	81.10
Colombia	52.3	70.40	Norway	77.75	75.08
Czech Rep.	84.46	87.31	Pakistan	52.35	70.14
Denmark	84.27	82.04	Peru	57.12	71.34
France	87.71	87.53	Philippines	59.00	66.90
Germany	82.48	86.99	Poland	78.22	86.48
Greece	74.94	83.78	South Africa	62.45	70.98
Hungary	81.15	83.70	Spain	82.52	86.17
India	49.7	63.59	Thailand	56.87	65.99
Indonesia	51.31	59.18	Turkey	63.45	73.86
Italy	80.61	88.94			

Table 7.2. Globalization Index derived by ACE

The linear regression and confidence bands of KOF globalization index and derived globalization index is depicted in Figure 7.15.



Parameter	Value	sd
KOF GI	35.72961	4.67102
GI	0.59813	0.0644

R = 0.88051

SD = 4.26518, N = 27

P = 1.3944E-9

Figure 7.15 Linear regression and confidence bands of KOF Globalization Index and GI

It is pertinent to mention that ACE algorithm reveals that GCI is the most dominant factor. followed by EODB. Further it can be seen that conventional multiple linear regression (equation 6) results in correlation R^2 = 0.79, whereas ACE derived model results in correlation of R^2 = 0.98.

7.10.3 Analysis and observations

Variation in KOF globalization index and the globalization index derived by application of ACE for several countries have been observed. It indicates impact on globalization index of factors like technical prospectivity, fiscal index, etc. which has been used to derive Globalization Index.

Argentina has KOF GI and GI of 64.12 and 82.14 which can be explained by lower ease of doing business (EODB) (Table 7.3).

Country	Possible Reason for difference
Argentina (64,82)*	Low EODB
New Zealand (73,81), Peru (57,71), Poland (78,86), Japan (64,83), Spain(82,86), and Turkey (63,73)	Low technical prospectivity
Chile (69,75), South Africa (62,70), and Thailand (56,65)	Low technical prospectivity, Low rank Fiscal Index
Colombia (52,70)	Lower rank Fiscal Index
Greece (74,83), Philippines (59, 66)	Low technical prospectivity, EODB
India (49,63)	Low EODB, FI, GCI
Indonesia (51,59)	Lower rank Fiscal Index, EODB and High CPI
Pakistan (52,70)	Low technical prospectivity, Low TP, EODB, GCI and High CPI

*Note: * Figures in bracket represent (KOF GI, Ace Derived GI)*

Table 7.3 Suggested reason(s) for variation in GI derived and KOF GI

The inferior GI in respect of KOF GI for New Zealand, Peru, Poland, Japan, Spain, and Turkey can be explained by the low technical prospectivity; for Chile, South Africa and Thailand it can

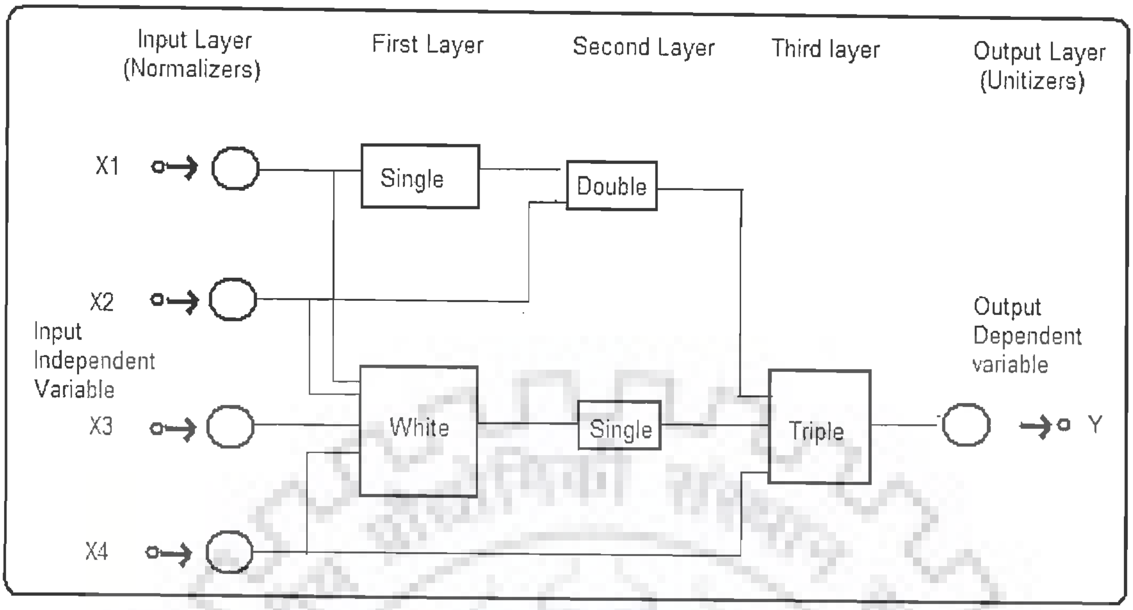


Figure 7.16. A typical abductive network model showing various types of functional elements

(After: Osman et at.; 2002)

i. A white element which consists of a constant plus the linear weighted sum of all outputs of the previous layer, i.e.:

$$\text{White output} = W_0 + W_1X_1 + W_2X_2 + W_3X_3 + \ldots\ldots\ldots W_nX_n$$

where X_i are inputs to the elements and W_i are the elements of weights.

ii. Single, double, and triple elements which implement a second or third degree polynomial with all possible cross terms for one, two or three inputs respectively, for example:

$$\text{Double Output} = W_0 + W_1X_1 + W_2X_2 + W_3X_1^2 + W_4X_2^2 + W_5X_1X_2 + W_6X_1^3 + W_7X_2^3.$$

The first step in solving a problem with AIM is acquiring a database of input-output solved examples for training and evaluating the model. The database is randomly split into a training set of N_t examples and an evaluation set of N_e examples. AIM uses the training set to synthesize the model network layer by layer until no further improvement in performance is possible or present limit on the number of layer is reached. Performance of the derived model is then evaluated using evaluation set.

The AN modeling tool uses optimization criteria to automatically workout network size and connectivity, element types and coefficients, and automatically selects influential input parameters. These lead to diminished user intervention (Osman et al 2002). The GMDH is a multi-phase polynomial regression and each phase leads to minimization of the error. The iteration stops automatically when the model responds to training data and work satisfactorily with new data. The input-output relationship is expressed in high degree polynomial forms.

In this study GMDH has been applied in a novel way to rank petroleum-bearing countries in terms of relative worthiness for upstream petroleum business taking in to dependent factors like oil-gas reserves; fiscal system; and economic, social, political indices, etc .

As discussed earlier in the chapter, the decision to opt for investment in overseas crude oil and gas exploration and production opportunity depend on the technical prospectivity (TP) of the acreage on offer, the ease of doing business (EODB) in that country, attractiveness of fiscal terms (FR) offered, degree of corruption in that country (CPI) and the country risk (CR). It has been proposed earlier in this chapter to describe such decision for resolving overseas venture by a numerical value called "Globalization Index" (GI) and in functional form it can be written as follows.

$$GI = f\,(TP, EODB, FR, CP, CR)$$

We have applied Abductive Networks approach which is based on self-organizing Group Method of Data Handling (GMDH), to obtain GI. The data used for deriving the ranking of countries is provided in Table 7.1. The total 31 data records used to develop Globalization Index (GI) prediction model. Each data record (as mentioned in the case of ACE) consisted of TP, EODB, GCI, FI, and CR as input (predictor) variables and GI as output (response) variable (Figure 7.17).

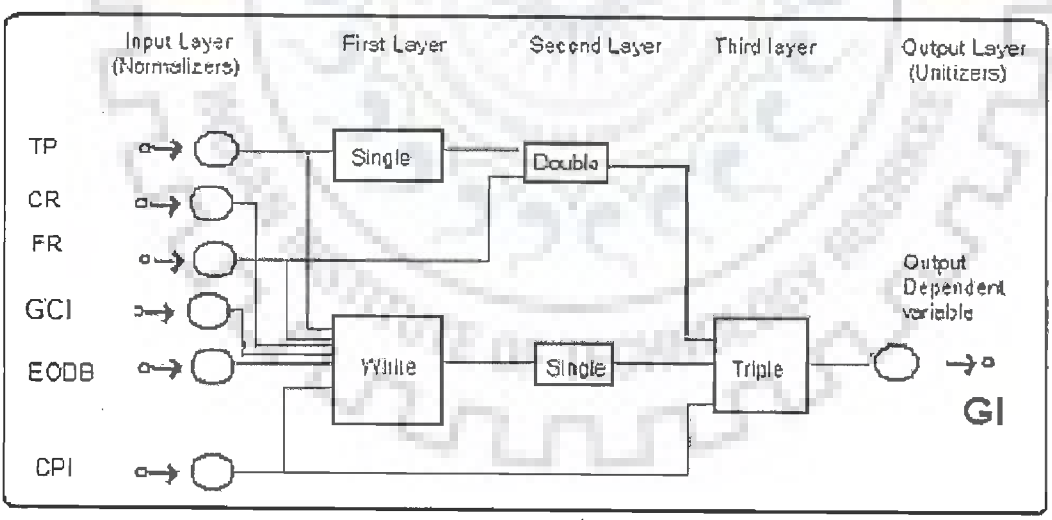


Figure 7.17 Abductive network model showing input and output layers

(Modified After: Osman et al 2002)

Out of the 186 data points 60 were randomly selected to train each model and 126 to test the model to evaluate its efficacy. The output of the abductive network thus developed shows an excellent agreement between the measured and predicted values when interpreted in the light of impact being made by various exogenous parameters like fiscal terms, country risk etc. on the dummy GI value indicate that developed model has satisfactorily generalized the relationship between GI and input variables.

7.10.5 Comparison with Model developed using ACE

The countries have been ranked with values of GI obtained by ACE and GMDH (Table 7.4). On comparison of ranking of countries evaluated with ACE derived values in the light of observation of country related data it is observed that both models are competitive.

Country	Ranking obtained by applying GMDH	Ranking obtained by applying ACE
Iran	1	1
United Arab Emirates	2	3
Russian Federation	3	4
Venezuela	4	2
Nigeria	5	5
Canada	6	9
USA	6	7
China	7	13
Algeria	8	11
Mexico	8	11
Brazil	9	12
Norway	9	15
Argentina	10	15
Australia	10	16
Chad	10	6
Oman	10	10
United Kingdom	10	17
Ecuador	11	7

India	11	9
Indonesia	11	8
Malaysia	11	12
Peru	11	13
Colombia	12	12
Denmark	12	14
Gabon	12	8
Italy	12	9
Trinidad & Tobago	12	14
Tunisia	12	10
Egypt	13	15
Romania	13	13
Thailand	14	18

Table 7.4 Comparison of Ranking obtained by application of ACE and GMDH

7.11 Conclusion

The petroleum exploration and production business which during the past few decades has taken a truly global dimension calls for judicious selection of overseas destination for investment. It is more so because of multitude of associated risk elements which may jeopardize the business interests. Undoubtedly, petroleum industry these days has to work in an environment of intense competition, tough fiscal terms, and countries with high-risk. Accordingly, some measures are adopted by investors to mitigate that risk. The strategic intent of business entities is guided by the philosophy - the target country possess sizable petroleum volumes, has reasonable success rate of petroleum exploration and provides terms that are favorable for the nature of high-risk exploration. These factors combined with stable political condition, predictable regulation, reasonable tax rates and a well-defined legal system will make the country attractive. Business entity tries to venture in countries, which has favorable mix of these factor conditions. These factors do not have apparent mathematical relationship amongst themselves and defy any functional relationship to provide an empirical value which can lead to an index for ranking global destinations.

A better approach may be to screen the opportunity for inherent risk prior to making investment. It calls for ranking of countries for petroleum exploration and production business to guide the business decisions. The simplest model may be to develop a matrix of weighted risk factors. But, it may not be possible to assign the logical weights to various dependent variables which are potential risk elements and impact the business decisions. Even the degree of impact of various parameters on the business decision is not known. Therefore, to devise a tool incorporating all major risk factors with relative weights assigned to deduce ranking of countries for global petroleum business required an approach which avoided the a priori underlying assumptions about relationship between the rank and influencing factors deriving that rank.

In this chapter, we have explored the application of nonparametric approaches, called ACE and GMDH as tools for data analysis and building correlations. The transformations derived by ACE can facilitate physically based function identification during multiple regression, and this sets ACE (also GMDH) apart from other parametric approaches, such as ANN, which often work as "black box". The strength of these methods lie in their ability to incorporate multiple and mixed variables, both continuous and categorical in correlations. Our result shows that ACE and GMDH can improve GI prediction under different risk embedded global environment.

The rank thus obtained by ACE and GMDH technique satisfy the merit of impacting factors to the country ranking, suggesting that the techniques can be used for such purpose with reasonable degree of confidence. However, as is true of other such prediction tools, although ACE and GMDH provides a fully automated approach for estimating relative rank of countries for global petroleum exploration business, it is not meant to exclude heuristic reasoning based on experience gained in analyzing the potential of global venture. Moreover, it should be realized that success of the ACE and GMDH modeling tool, like any other methods, relies on the quality and volume of the data.

CHAPTER 8

GLOBALIZATION STRATEGY

8.1 INTRODUCTION

On the eve of Word war I, Churchill made a historic decision to shift the power of British Navy Ship from coal to oil. He intended to make the fleet faster than it German counterpart. But the switch also meant that the Royal Navy would rely not only on coal from Wales, but on in secure oil supplies from what was then Persia. Energy security thus became a question of national strategy. Churchill's answer? " Safety and certainty in oil lie in variety and variety alone. Since Churchill's day, the key to energy security has been diversification. This remains true, but, a wider approach is now required that takes in to account the rapid evolution of the global energy trade, supply chain vulnerabilities, and the integration of major new economies in to the world market (Daniel, 2006). Thus, diversification with integration is the message of present day global economic system.

The world economy is undergoing a transformation. There is a pragmatic shift in business from government regulated to market driven. The oil market is one example of this trend as it has moved away from bilateral contracts or government relationships between specific buyers and producers to a global market system based on competitive bidding through the commercial dealings of a wide number of players. It leads to an open, transparent competitive global market for crude oil (Lee, 2008). Crude oil is a truly global community (Gluck, 1990) and the world oil market is inherently global. No single country can exempt itself from the interdependence of that market. The first interdependence is that of trade, stemming from the geographical dispersion of supply and demand. There is another form of interdependence which is between resource owners (host governments) and producers (the international oil companies). Diversification of supply, security of the supply system and integration with world market is important (R5). The major obstacle to the development of new crude oil supplies is not related to exploration and exploitation but also the international affairs, politics, decision making by government, energy investment and new technological development. Furthermore, for oil producers, the implications are more complex, because the cheapest resources may not be found in the world's safest location and thus the explorer has to weigh the costs against the risk.

The complexity of technical, economic and corporate environment in which exploration business is carried out stipulates that the choice of a strategy is so complex that it can not be decided by thumb rule, intuition or faith. The business entity is required to understand the business environment and key information to develop a strategic model.

Therefore a strategy depicting the objectives, resources, and policies that will guide business processes for securing crude oil asset overseas over a period of time to achieve sustainable growth is required. This chapter deals with the theoretical construct to the strategy formulation for crude oil security by acquiring overseas acreage.

8.2. GLOBALIZATION DEFINED

Globalization is a process unfettered by territory (Reid, 2000). It represents the increasing interests of the world economy, based on drivers of change. These drivers of change include – international trade (lower trade barriers and more competition); financial flows (FDI, technology transfer, licensing, portfolio investment, and debt), communications and populations nobilities, especially of labor. Globalization is both the construction of a set of interrelationships and a process of change. There is an increasing integration of global financial markets, leading to the increasing speed of business transactions and the rapid pace of technological changes. Under this scenario, each nation has to decide how to engage in globalization process and strategy.

8.3 WHY GLOBAL BUSINESS FOR PETROLEUM EXPLORATION

An understanding of factors which motivates petroleum industry world wide to develop interest in foreign operations is required. This would facilitate in reviewing and designing globalization strategy to secure crude oil. Following describes the motivating factor for business entity to resort global business in exploration and exploitation of crude oil.

8.3.1 Economic Factors

The economic factors viz. the exploration cost or cost of finding crude oil and gas, followed by its production, transportation, refining and marketing strongly influence and guide petroleum industry. The petroleum industry intends to focus those areas where these costs are minimal. The upstream companies mostly tries to enter in to global business to get crude oil and gas at a better economic rate of return as compared to domestic resources. The principal economic factors that greatly influence the business decisions are capital and operating expenses which must provide profitable revenue from crude oil per dollar of investment.

8.3.2 Location advantage

The are other reasons which influence the decision to secure crude oil reserves overseas may be to have it at a relatively geographically convenient location from the point of view of exploration and exploitation. Moreover, the feeling world over is that there is an end to find techno-economically viable crude oil at convenient locations because the days of "elephant discovery" is over. Thus, the obvious choice for a company would be to make a best bargain of choice amongst the technically suitable alternatives. The ideal would be the location having a tradeoff between technical, economic, and logistics. The firm need to adopt a strategy which would be most suitable for the country's objective and company's vision and mission.

8.3.3 Obtaining equity crude oil

The inherent risk of failure to strike crude oil in hitherto unexplored and under-explored locations (domestic or foreign) prohibit explorers to enter in to such business where the business game is techno-economically both unreliable and uneconomic. The operator looks overseas to search for petroleum reserves where economic crude oil volume can be located with existing resources. These constitute factors which lead companies and countries to evince interest in exploring for crude oil abroad.

8.4 GLOBALIZATION STRATEGY FOR E&P BUSINESS

The strategy to enter any foreign country requires scanning of several factors, the mode of entry and to do business may vary from country to country depending on their petroleum legislation, terms of offering petroleum exploration licenses etc. Business entities competing for exploration and production acreage overseas visualize an operative relationship between their international strategy, its implementation and success.

8.4.1 SELECTION OF GLOBAL DESTINATION

Deciding a global destination requires knowledge and acumen to critically examine the overseas destination, not only to estimate the gain, but also to weigh risk vs. reward taking in to account the uncertainty. Various economic yardsticks must be considered to verify the return from the venture, taking in to consideration the geological, engineering and economic data as well as physical environment to delve in to range of probabilities. Otherwise it will be a short-run and ad-hoc arrangement. The globalization strategy and decisions are interdependent, requiring iterative planning process and decision-making as per feedback at intermediate loops of hierarchal planning. The constituent plans for selecting an overseas destination requires a response about the petroleum potential of foreign target country, the objective and goals envisaged to be fulfilled in that target, the entry mode and business strategy for functioning in that country. It may call for an institutional arrangement requiring transfer of technology and/ or occupying management position(s). In order to secure equity oil the entry mode may be licensing, service contract, technical agreements, acquisitions and joint ventures. But, whatever be the entry mode it is obvious that in the present era of competition for global crude oil acreage, the essence of strategy should be to perform activities differently than rivals do (Porter, 1996).

8.4.2 THE GLOBAL STRATEGY PROCESS

The global strategy is guided by the organizational strategy and national policies. The premise is to understand the present, consolidate our plan for next few years, and foster a realistic plan to reach that destination after scanning the risks and uncertainties in the path and finally execute the plan (Figure 8.1).

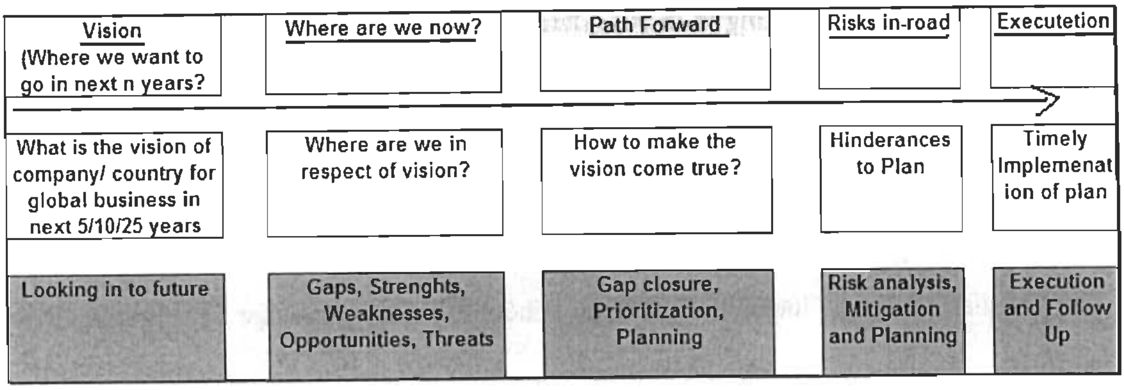


Figure 8.1 The Globalization Process (Adapted from Lee, 2008)

The strategy to secure overseas crude oil asset by any business entity is often presented as an effort to treat the acreage world over as an identical business destinations, differentiated by 'size of catch' and geopolitical risk. But, the overseas acreage acquisition is plagued with technical, environmental, political or business related risks. An integrated strategic framework is required which takes in to cognizance the various risks and rewards to screen and rank global business opportunities for crude oil acreages. There is a requirement to examine the return from the global acreage and formulate strategy to secure profitable ventures.

The exploration strategy adopted by any company for its domestic acreage may not hold true for global operations. In global operations the acreage is acquired under set of stipulated conditions. Therefore, the strategy to explore is well defined before the acquisition of assets. The critical strategic issue involved in global scenario is making right choice of country and the acreage, the former involve more non-technical and later technical aspects. The business entity needs to devise a strategy having unique mix of both aspects for competitive advantage. The setting of objectives, strategic planning, and managing of day-to-day operations in any business requires assessment of present day as well as prediction of the future external environment. The external environment refers to economic conditions, technological progress, competitive strategies, demography, culture, government, and regulatory measures (Kobrin, 1988). It stems from the fact that the improper understanding of the current scenario may lead erosion of competitive position, legal problems, or regulatory pressures and ultimately to failure of business. The strategic analysis process involves the comprehensive understanding of the environment milieu involving both non-technical and technical components. The technical environment analysis will involve understanding of the exploration history of the country or acreage available. It will lead to understand the degree of exploration in that country – mature, sub-mature, pre-mature, as well as past success and failure. The non-technical environmental analysis will involve understanding of various risk factors like political, economic and social; foreign investment in the country, infrastructure as well as other firms operating in that country (Quick , 1983a).

8.4.2.1 Technical Environmental Analysis

It calls for understanding the volume of resources, reserves, reserve to production ratio, reserve replacement ratio, the exploration and development status, past success history, production profiles, and kind of petroleum product likely to be produced. There should be a knowledge about the availability of infrastructure like pipelines, gathering stations, various installations, transportation and communication networks.

8.4.2.2 Social Risk Assessment

The social evaluation of target exploration acreage needs attention prior to entering into business deal. The increasing awareness and involvement of society necessitates attention being paid by companies to the social environmental issues, because these issues if not addressed properly may be disastrous to the business. "Social Risk Management" is a system designed to assist industry, business and government decision makers in managing the external environment (Quick, 1983a).

8.5 HOW FIRMS GLOBALIZE FOR E & P OPPORTUNITIES?

Firms resort to enter overseas crude oil exploration and production business through investment in these activities. The investment is primarily targeted to acquire crude oil through exploitation of resources at profit and utilize the opportunity to expand petroleum business activity in that country. The investor thus derives benefit of entry in overseas petroleum exploration to diversify its business in upstream and/or downstream activities. It facilitates the firm to establish itself overseas and exploit superior degree of competitive advantage, which may or may not be possible if an overseas business is secured by contractual arrangements. But these entry modes via investment are capital intensive and require greater commitment. Such commitment exposes the firm to greater degree of economic, social and political risks. The crude oil exploration business requires substantial start-up costs, long pay back periods, and cost of disinvestment as well as abandonment. The decision to invest is highly risky if the investor has no previous experience about that country; and the proposal normally should be after structured scrutiny of the following prior to decision making.

- Is the foreign investment proposal in question worth pursuing?
- Is the business climate in that country favorable?
- Does the past experience corroborate stable investment climate in future.
- What will be the return on investment?
- What is the country risk?

The first and foremost issue in overseas investment is the decision to investigate any overseas projects because it requires investment of time, money and human resource (Figure 8.2). It is followed by the evaluation of investment climate under prevailing economic, social and political scenario and in feasible future and its impact on profitability of project over the planned duration. Identification of critical risk factors of the present investment climate and assessment of likely future scenario holds key importance. Most of these risk factors are due to the political system and government. Thus, an assessment of political risk may provide plausible answer to question of investors regarding maintenance of status quo of business rules over the projects time horizon. The judgmental evaluation of socio-political system may hold the key.

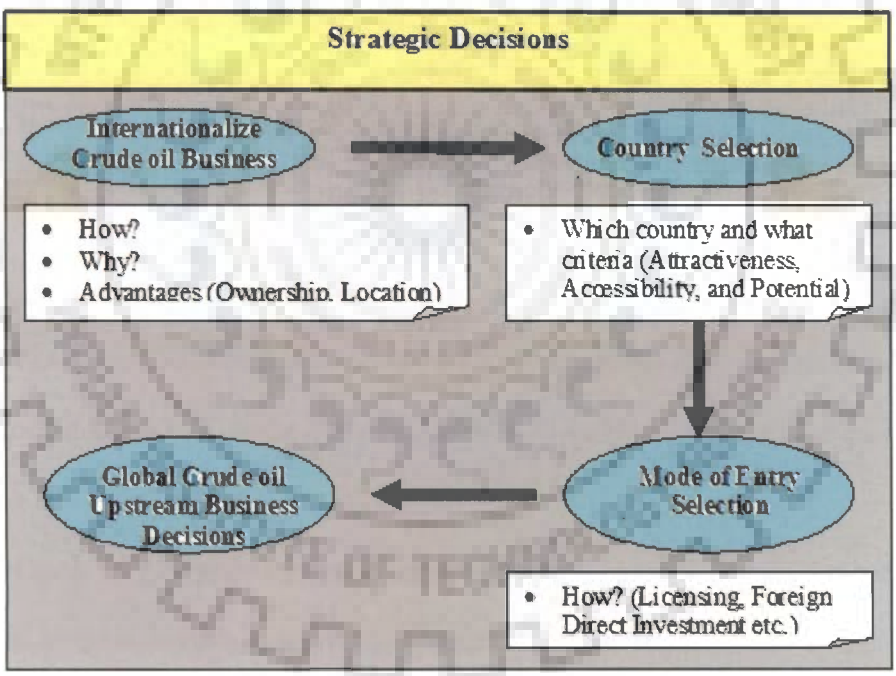


Figure 8.2 Strategic decision Flow Process

Once the investment climate from the point of view of political risks is found favorable, next step calls for economic evaluation of the project, taking into consideration the various risk factors, and the analysis of pre-condition or expectation set forth by the government from overseas firm. The last factor may call for joint negotiation between firm and local government.

8.5.1 Assetizing the money and monetizing the assets

Occasionally, a firm may opt to invest in overseas crude oil exploration and production venture by acquiring the business of another firm overseas. Such approach also calls for scrutiny of business proposal as in the case of overseas investment and provides faster access to producing properties of the acquired firm. Two conflicting situation is encountered in case of acquisition one based on the premise of core competence and another monetization.

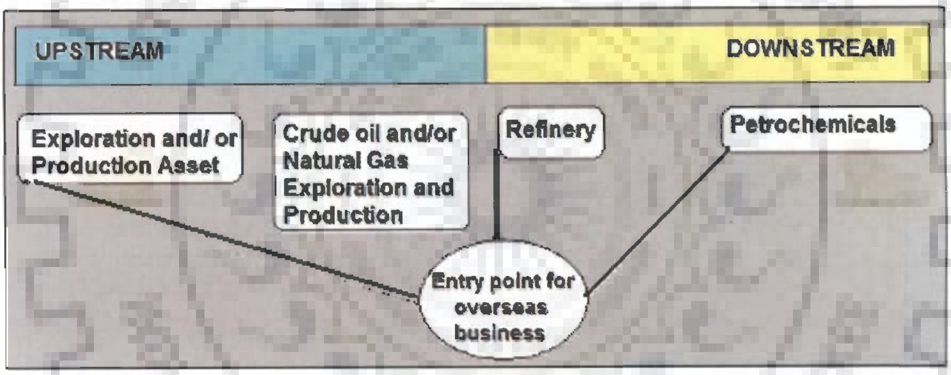


Figure 8.3 Petroleum business spectrum and entry points for overseas business

The petroleum business operation from upstream to downstream may be acquired overseas and each allows the investor for diversification in overseas (Figure 8.3). In most general terms, if the acquisition is in the same business domain (upstream or downstream) then diversification is considered to be a better business proposal as opposed to one in which business entity acquires overseas asset by investment in sector other than its activity - upstream to downstream or vice-versa. The philosophy behind such an argument is based on the premise of core competence of the investor firm. If the investors is having core competence in upstream and it acquires an upstream asset overseas, the firm can manage the business in a better way due to its core competency. But, another hypothesis postulates that if a firm engaged in upstream business acquires the downstream asset, it can monetize the asset quickly and get earlier economic returns on investment. The upstream business is accompanied with risk and uncertainty of striking hydrocarbon and the acquisition of upstream business may lead to partial or complete failure in exploration game leading to loss, even though the domain of business activity is parallel to core competence of investor. As opposed to it, the downstream business has lesser degree of risk. Following alternative scenario exists

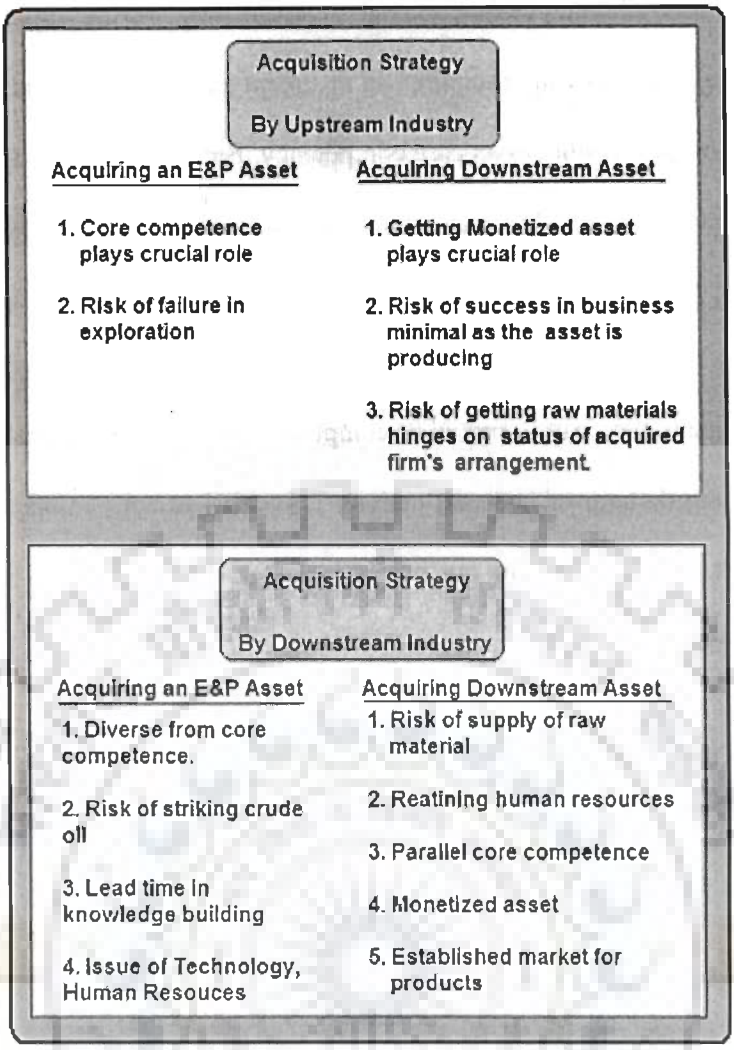


Figure 8.4 Acquisition strategy

- The raw material for running the downstream industry (refining and petrochemical) is obtained from internal resources of target firm which the firm deciding to invest overseas wants to acquire,
- The target firm is only owning the engineering installations and gets raw material from other domestic exploration and production firm over which it may or not have control,

- The target firm only owns the engineering installation and gets raw material from other overseas exploration or production firm, over which it may or may not have control. The supplier of raw material like crude oil for refinery likely to be acquired by the firm may not be guaranteed of supply during project life cycle because it may or may not have or be able to establish identical business relation with the supplier of raw material (crude oil). The investor need to ascertain that the requisite resources for refining are available or will be available after acquisition. The acquisition of downstream industry leads to have monetized asset with no lead time required to have crude oil supply, gain control over production or operation, and thus quicker return on investment. But, it has inherent risk for acquiring company/ country especially with regard to retaining manpower, and to ensure supply of crude oil.

Thus overseas acquisition may provide crude oil or refined product at an early date (thus concomitant Return on Investment (ROI) as compared to that when an exploration asset is acquired and the exploration process is started from scratch. But, the strategy of acquisition of producing property or downstream industry will provide ROI if and only if the project is economically viable after acquisition or made viable by the investor. The lead time for ROI will depend upon the duration of time required by the investor to cast the acquired project in to the mold of its priorities.

The acquisition of downstream (refining) industry has other potential advantage e.g. low overall costs than establishing a refinery from scratch. After all refined product like petrol, diesel, kerosene etc. will be required for energy security. But, the investor need to do thorough due diligence of property to be acquired.

8.5.2 Evaluating Country

There are more than hundred petroleum producing countries and several would be potential candidate for securing crude oil. An initial screening is required to determine which countries may be potential candidate for thorough investigation for the purpose of crude oil exploration and production business. The countries need to be evaluated in terms of relevant variables and employing standardized evaluation techniques. A flow chart depicting conceptual framework has been envisaged (Figure 8.5). The evaluation begins with (i) selecting the criteria for preliminary screening and elimination of countries, followed by (ii) fixing the criteria with weights for evaluation of countries and finally (iii) finally evaluation of countries.

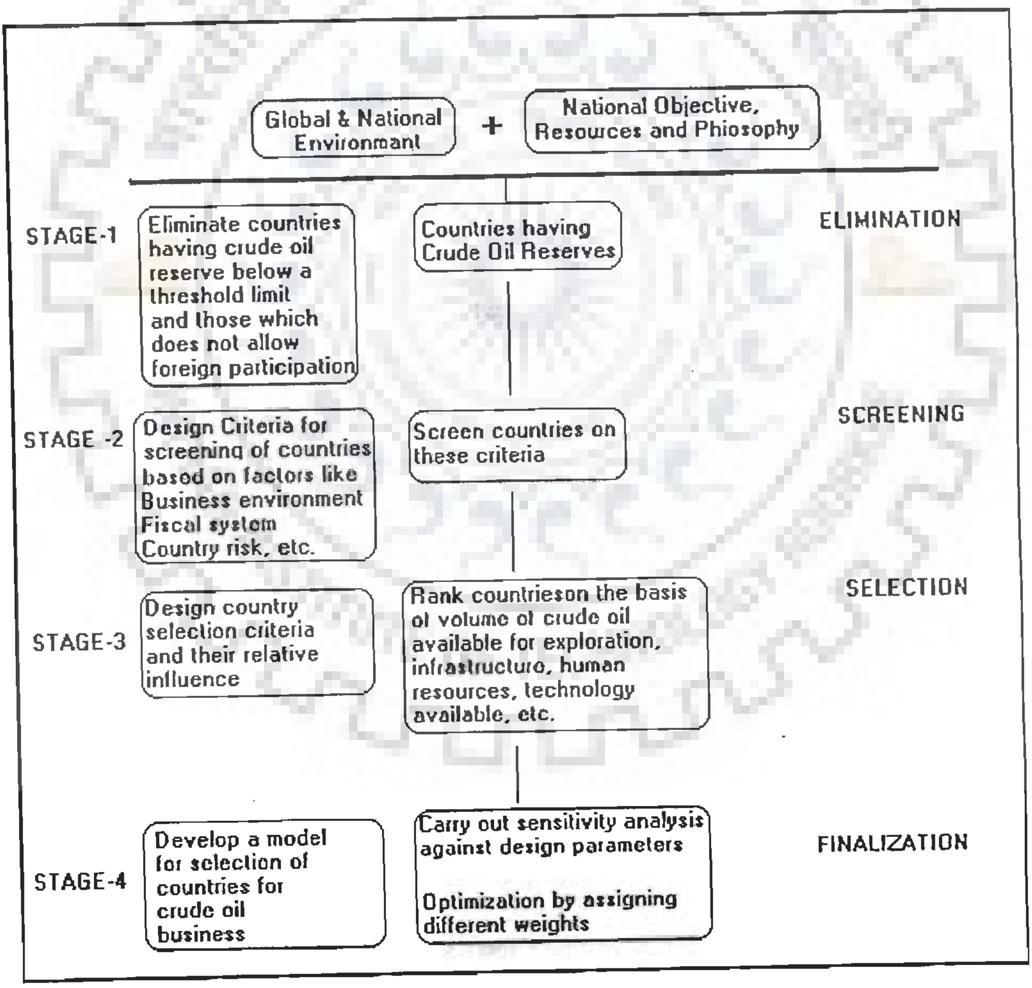


Figure 8.5 Flow chart for country screening criteria

The first stage (stage-1) lead towards applying go-no-go criteria to exclude some oil bearing countries and narrow down the list of select countries for further evaluation purpose as a candidate for crude oil business. The next stage (stage-2) aims at designing criteria for further screening of countries and assigning weights to these criteria. These criterion include technical prospectivity or volume of crude oil available for exploration, the country risk (economic, social and political) and operating expenses. Next stage requires assigning weights to these parameters based on the perception of country specific risks (economic, social, and political) finding degree of corruption, operating expenditure etc. These weights may be judged by standard procedures. The exercise leads to initial ranking of countries. The next stage calls for sensitivity analysis to find out the impact of key decisive indices and their implications on the ranking of countries.

8.6 Overseas investment decision processes

The overseas oil-gas investment venture is targeted to maximize the value to the owners. It calls for managing risk though integration of techno-commercial expertise and decision-making ability to amalgamate technical recommendations with business decisions. The resolution to invest or not-to-invest is driven by business decisions, but directed by technical as well. Thus, the pivotal issue is to establish technical and economic risk tolerances by amalgamating technical and economic factors to encounter the risk.

Technical and economic risk mitigation requires combining technical and economic information into business decisions to decide the chance of gain or loss in investment venture. Petroleum techno-economic analyses need to be carried out for any prospect. It requires estimation of hydrocarbon reserves, cost estimation etc. to find out the associated risk in the business opportunity.

Probabilistic in-place volume of crude oil for the prospect is to be derived through Monte-Carlo simulation. The input parameters used for Monte-Carlo simulation are as Minimum, most likely and maximum of prospect are, net pay thickness, porosity, saturation of hydrocarbon, specific gravity of hydrocarbon, pressure, temperature, formation volume factor, and recovery factor. The P-90, mean and P-10 of in-place volume and reserves for the prospect are computed. The mean reserve sizes are considered for techno-economic evaluation. In the most simple scenario standalone economics for the prospect is being worked out. Production profile for mean reserve size in each variant is being generated. The lifecycle cost under different scenarios, development, infrastructure and operating costs is being computed taking the applicable rates. The total estimated life cycle cost (Exploration & Appraisal, Development, Operating, and Abandonment) for different scenarios are worked out. The economic evaluation (NPV and IRR) is worked out considering applicable fiscal terms and conditions of the prospect. EMV analysis is carried out for the prospect taking in to consideration the chance of success and exploration cost. Sensitivity analysis for the prospect is carried out. Based on these analyses the viability of the prospect under different scenarios is worked out.

According to Johnston (1994), the business decision requires a trade-off between geological condition vis-à-vis fiscal terms and political conditions. As per Johnston, "the most obvious geotechnical aspects of exploration are field sizes and success ratios. Targets must be large and just how large they must be depends on costs and fiscal terms. Sometimes countries are compared on the basis of barrels of oil discovered per wildcat. The question is, will past statistics provide some insight? Just how meaningful historical information is in regard to success ratio and size of discoveries depends on the maturity of an area and other factors. If all the major structures have been drilled, then past is certainly not the key to the future."

Johnston suggests that, "Costs are critical. With maturity and infrastructure development in a given province, costs often come down. This is particularly true with exploration and transportation costs, which are highest for the first field development in an area." ...."while geological risks begin to diminish after discovery, political and financial risks intensify. Bargaining power of the contractor begins to diminish also. .... Once a resource project becomes commercial, bargaining power really begins to shift. The large investments for the development phase of petroleum operation start out as a source of strength for contractor. By the time production commences, capital investment is a sunk cost, and facilities installed in a foreign country can represent a significant source of vulnerability to the contractor."

8.7 GLOBAL EXPLORATION STRATEGIES

The organization participating in global exploration business need to adopt and implement strategies to spread the risk. It necessitates the company to understand the global business environment, scale of capital involvement and thus formulate overseas exploration strategies in a manner that it is in confirmation with organization's goal, objectives and business strategies.

8.7.1 Environmental Analysis

The first component in strategic analysis calls for understanding the global environment in which crude oil exploration and production business of the firm will take place. Strategic planning requires that this environment be properly understood, it may lead to disastrous result. The environmental analysis leads to scanning of exploration history, degree of exploration maturity of the concession, and field size distribution, as well as remaining sizes likely to be discovered from this time onward. An understanding of social environment of the area where petroleum exploration business is likely to take place is also required. The review of available native resources (human skill, technology, knowledge etc.) facilitates an appraisal of preparedness to succeed in global crude oil exploration business environment.

8.7.2 Situation Audit

The situation audit attempts identify the company's strengths and weaknesses with regard to its technical, financial and human resource to carry out exploration business. The analysis of firm's strengths and weaknesses help in designing corporate strategic goals.

8.7.2 Competitor Analysis

The competitor analysis identifies strengths of competing firms for use in strategic planning. This is especially true for Indian and Chinese enterprises. In most of the bid rounds in recent past the companies from these two countries were competitors.

8.8 Managing Environments

The information gathered by environmental analysis will help in risk management and designing as well as evaluating exploration strategies. Businesses face the risk that governments may take actions that reduce the firm's value. This is particularly true of firms that do business in multiple countries. Political risk refers to a action by the government that diminishes the value of a firm. It may include

- Confiscation i.e. the taking of property without compensation.
- Expropriation i.e. government takes property without compensation
- Nationalization i.e. involves government taking over a firm's assets with compensation. However usually the compensation paid does not represent the true value of the firm.

- Contract repudiation or frustration.
- Unfair regulatory practice.
- Currency inconvertibility.
- War be it civil war or war with another country.

The management of political risks calls for understanding the host country government. Two strategies can be used to manage political risk namely the integrative strategy and the defensive strategy. The integrative strategy requires to make the foreign firm part of the social and economic fabric of the host country which may make it difficult for the government discriminate the firm. The foreign company need to adopt the strategy of localization like hiring host nationals. The defensive strategy aims to reduce dependence on local economy.

In order to address the legal environment of risk the foreign firm should understanding diverse legal systems to manage the risk. It is more important when it comes to liability risks. Different country have different legal system and it requires thorough understanding.

8.9 CORPORATE STRATEGIES

There are as many strategies in petroleum business as the number of companies operating in exploration, development, and production activities of crude oil and natural gas. The way any company does business is evidenced in their strategy and the factors that make the company follow that strategy. The strategies of national oil companies may not be articulated or known outside the company. But, the public companies disclose their strategies to investors. It is observed that no categorization may be sufficiently descriptive to encompass all possible cases. Very often, the categories may change as internal (staffing, assets, successes, failure, etc.) and external (oil price, markets, interest rates, etc.) circumstances vary during the course of business cycle and following broad classification is suggested (Kaiser et al, 2006).

- No specialty,
- Geographic specialty,
- Technological specialty,
- Low cost specialty, and
- Risk specialty.

Companies may specialize within a single category or simultaneously pursue projects that fall within two or more categories.

8.9.1 No specialty

These strategies are commonly carried out by the large integrated companies. It allows these companies to ensure that failure in one or more areas is compensated by success elsewhere. Oil and gas companies that hold geographically diverse assets across all parts of the business spectrum are less vulnerable to specific events than companies that hold assets in one part in one geographic region. Breadth of operations allows companies to reduce the volatility of their return on investment and reduce their cost of capital. Integrated oil and gas companies tend to have lower volatility of their return on investment than independent companies.

8.9.2 Geographic specialization

It allows a company to minimize overhead expense and develop a regional expertise which may lead to reduced drilling and development cost in the region. Each country provides different opportunities for investment which depend on technical, economic, and political factors; the core competencies of the company and their strategic goals; and specific geopolitical and socioeconomic circumstances. But, this strategy may restrict upside potential when reserves begin to decline.

8.9.3 Technological specialization

These strategies may take various forms and allow companies to capitalize on in-house technical strengths or to specialize in specific areas such as onshore/offshore, shallow water/deepwater, oil/gas, geologic and working interest plays, and mature assets.

8.9.4 Low cost strategies

It allows companies to explore without large financial backing and to farm out acreage after adding value to the asset, or to purchase marginal (end-of-life) property for production and acreage opportunities.

8.9.5 Risk strategies

It involves confining activities to ventures that have a defined risk-reward level. High risk projects are expected to have high rewards, low initial cost, and low government take. Low risk projects are more likely to occur in proven producing areas and will have lower rewards because of less favorable government terms and smaller available prospects.

8.10 EVALUATION OF STRATEGIES FOR INDIA

India makes significant FDI. Efforts to secure crude oil from global petroleum provinces constitute major national policy issue and involve sizable dollar investment. The environmental milieu which has a pivotal role in selecting global location for business comprises political risk, economic conditions, protectionism policies especially tariff, cartelization, quota restrictions and the concern for corruption. The premise is to select a country which satisfies all the counts of the decisive factors, which drive petroleum explorer to an overseas exploration destination- country risk, fiscal terms, technical worthiness, and availability of market as well as developed infrastructure; that country wants foreign investors and provides favorable fiscal terms.

The global business strategy in the case of investment or acquisition should be articulated on the premise that can deal with the nuances of risk elements and identify the positive and negative elements associated with the candidate prospects, thus, rank the objective opportunities.

8.10.1 Joint Ventures

Joint Ventures (JV) constitute one of the investments mode for securing equity in an existing crude oil producing asset or starting a crude oil exploration and production from scratch. The venture with local/ domestic partner leads to sharing of country risk. The domestic partner has the knowledge about the technical aspects of candidate prospects for crude oil exploration as well as the domestic business environment. The foreign investor thus has lesser risk of entering an overseas area scanning the business environment and can start the project with little or no experience about threat country. The strategy for not-so-open economies therefore should be to opt for joint venture with domestic company, even if the option exists for sole venture entry. Even in technologically starved countries the investor may think of entering as a joint venture partner and extend technology to the domestic partner for execution of requisite exploration business. Such a strategy will create a kind of trust and mutual dependence between partners and the foreign investor can have the opportunity to exercise decisive control on the business, even if it has the minority partnership. Thus the strategic element is to have right choice of joint venture partner. It should look in to the aspect of the global business strategy of investor firm, it's expectation from JV partner in overseas and how this strategy will fit into the whole international business strategy of the investor be low technical prospectivity as well as fiscal rank, for Columbia it can be low fiscal rank, for Greece and Philippines it may be low technical prospectivity and ease of doing business.

Although ACE provides a fully automated approach for estimating optimal transformations, it is not meant to exclude heuristic reasoning based on experience gained in analyzing the potential of overseas venture. It should be emphasized that success of the ACE algorithm, like any other regression methods, relies on the quality of the data and underlying association between the dependent and the independent variables.

7.10.4 Application of GMDH – based Abductive networks

Experience with Artificial Neural Network (ANN) has revealed a number of limitations for the technique. One such limitation is the complexity of the design space. With no analytical guidance on the choice of many design parameters the developer often follows an ad hoc, trial and error approach of manual exploration that mutually focuses on just a small region of the potential search space.

An alternate modeling approach is that helps to overcome many of the limitations of ANN is based on the self-organizing Group Method of Data Handling (GMDH). GMDH type algorithm (Farlow, 1989) can automatically synthesize adequate model that embody the inherent structure of complex and highly nonlinear systems. Abductive network based on GMDH modeling approach have been used for modeling and classification in a number of fields including nature forecasting Abdel-Aal et al (2006b); medical diagnostic Abdel-Aal et al (2006a); credit evaluation Summers (1996), marketing Kim et al. (1966); and soil and agriculture Pachepsky et al (1999), Further information on GMDH can be found in GMDH website www.gmdh.net.

The GMDH is a formalized paradigm for iterated polynomial regression capable of producing high-degree polynomial model in effective predictors. The process is evolutionary in nature, using initially simple (myopic) regression relationships to derive more accurate representations in the next iterations. The algorithm selects polynomial relationships and input combinations that minimizes the prediction error in each phase. Iteration is stopped automatically at a point in time that strikes a balance between model complexity for accurate fitting of training data, and model simplicity that enables it to generalize well with new data. It is seen that the algorithm has three main elements: estimation, selection, and stopping. The algorithm applies abduction heuristics for making decisions concerning some or all of these three aspects.

Practical implementations of the GMDH paradigm take the form of abductive or polynomial networks. The Abductory Induction Mechanism (AIM) tool (1990) automatically synthesizes mathematical model from relationships it finds in the training data. It does so by trying out all potential relationships of linear, multiple and polynomial regressions on various combinations of existing variables and builds a network of various types of numerical functional elements based on prediction performance as shown in Figure 7.16. The used version of AIM supports the following main functional elements (Osman et at., 2002):

company. The expectation from JV partner by investor include the convergence of synergism in philosophy and principle in exploration and exploitation as well as the pooling of resources, mutual trust and continued support over the project's time frame.

8.10.2 Production Sharing Contact

According to Andreas et al 2002, a production sharing agreement is a contractual agreement under which the state awards an investor for a certain period of time an exclusive right to search, prospect and extract mineral resources from a specific acreage. The investor undertakes the obligation to carry out these works for these works for the stated period of time, at its own expense and bearing all the risks. Thus the foreign oil or gas company acts as a contractor for the host country in developing its oil or gas resources and receives a share of the production at rates specified in a contract to recoup its costs and make a profit.

The global business strategy of any firm entering overseas business to secure crude oil by bidding in to get acreage via Production Sharing Contact (PSC) can not be defined by any strategic rule because the choice to secure business interest does not lie with the investor. In majority of the cases the investor participates in the bid rounds announced by the National Oil Company (NOC) of the country, or tries for equity participation in farm-in opportunities. In these cases the terms for participation by global investor is decided by the host government or company offering farm-in opportunities. Thus, contrary to strategy formulation to decide entry mode for global marketing, the option to enter in global crude oil business defies any such strategic formulation.

8.10.3 Strategic alliance

It is a preferred mutual deal between firms intended at achieving competitive advantage for each partner. Alliances enable firms to have wide geographical presence, share risk, and pool skills. However, such arrangement is plagued with uncertainty regarding conduct of partners. The firms entering in to alliance need to have a strategic fit between their internal disposition (strength and weakness) as well as external milieu (opportunity and threat). Once the firm decides to enter in to strategic alliance it should address the process and key issues like – partner solicitation, due diligence, valuations, partner trade-offs, structure and governance of alliance, capital access, negotiation and finally the documentation.

According to the Resource Based view, the commonsense for alliance is the value-creation capability when the resources of each business entity are pooled. The instances for alliance formation suggest that factors which incite forging of alliance are technological needs, environmental uncertainty, internationalization and several other motives. The critical resources of firms suffice as an indicator for alliance formation.

India may consider entering in to strategic alliance with countries/ companies for petroleum exploration and exploitation. The resource characteristics of Indian entity will be antecedent for alliance formation and the structural pattern may be worked out based on extent and character of pooling of resources by each partner. The critical part played by technological preparedness and edge of Indian firms engaged in petroleum business leads to the belief that the key to success will lie in the creation of collaborative advantage through strategic alliance. The integration of technological resource, human capital as well as India offering the scientific understanding and domain expertise to explore and exploit overseas province may foster strong strategic alliance between India and target overseas destination in petroleum sector. The petroleum sector in that country may tie-up with companies, if there were need for technologies. It would seek technical alliances with companies to gain access to technologies that have proved difficult for it to develop on its own, and for the development of skills and expertise in offshore petroleum exploration in which India is conversant. Strategic decisions of pooling (of Indian skill and technology) as well as sharing (of petroleum) will not be driven by the evaluations of its present circumstances, but, also expectations about the future outcome. The target country will embrace amplified opportunity to exploit petroleum resources as well as gaining from opportunities for learning of tacit and embedded skills as well as gaining access to technologies.

8.10.4 Legal provisions

In the event of entering in competitive bid to obtain a petroleum concession or lease by national oil company's farm-in offer or government sponsored bid-rounds it is to be recognized that bidding on concessions abroad is more complex and needs understanding of impacting factors on return on investment like bonus, royalty, division of net profits in the case of a strike of commercial quantities, the right of a national oil company to participate in the business, and other risk factors generally associated with any global business. According to Dunlap (1961), the geographic limits of area, primary term of lease and extensions if any, and type of permit or contract, the bonus and rentals payable needs to be spelled out clearly at the time of entering in to agreement and signing of award. Different types of permits or contrasts are usually required for exploration and appraisal of prospects, development drilling, and production and refining. The agreement should define the right to relinquish or surrender, or assign or transfer the contract to third parties an exploration permit, concession, or even a producing property, and its liability if it opts to surrender or relinquish. The condition to convert an exploration permit to a lease or concession for development drilling and production needs documentation. The contract must define in detail the products on which royalty is to be paid, the method of measuring these products and determining their value, the `geographic location at which their value is to be determined; any exclusions such as the use of natural gas for pressure maintenance, the responsibility of the grantee is in transporting and handling the products, etc. The contract will require special consideration and care for drafting the clauses pertaining to taxes. A very important consideration is the stability of the tax regulations with respect to the time period covered by the contract. Due care is to be taken for drafting the rules to be followed in making such conversions. Very often the petroleum legislation stipulates an obligation to supply domestic demand for petroleum by the operator to have energy at reasonable cost. Therefore, countries that do not have an established domestic supply of petroleum require that domestic needs be met before any is exported.. Besides these provisions and conditions set forth in contract the employment of nationals ratios that must be adhered to between national and foreign employees), labor laws, and repatriation of capital and earnings needs consideration (Dunlap, 1961).

8.11 RECOMMENDATION

Based on the considerations of above discussions following strategy is strategy is recommended.

8.11.1 Strategic Process

The Indian companies should plan a budget as an expression of a company's plans and objectives. The capital budgeting process will require the establishment of the level of funds available for investments in projects as per the ranking of projects and the availability of funds. The ranking may vary from one organization to another with various techniques and criteria employed in ranking investment opportunities. The criteria that are typically used in ranking investment opportunities include payback, net present value, discounted return on investment, internal rate of return, and profit on investment. The investment opportunities may be graded according to the criteria which reflect the goals and strategies of the organization. The methodology suggested in this thesis may be of help in ranking the opportunities. Once the ranking is done for available opportunities, the selected business proposal will require licensing strategy.

8.11.2 Licensing policy

In order to enter in to any overseas exploration business following issues need to be considered – Prospectivity, Ranking (with respect to resource potential), Crude oil or gas, Exploration maturity, Data coverage, Infrastructure, Environment restrictions, an idea whether it is disputed or sensitive areas, Fiscal Terms and Work obligations as well as Block size and shape.

The prospectivity refers to the fields in production, volumes of petroleum produced, discovered and undiscovered (Figure 8.6 and 8.7). This volume has time connotation and exploration as well as exploitation maturity of any province may be understood *a priori* from these sizes. The undiscovered and discovered volume refers to the exploitation and exploration opportunity. The input of resource (Technology, Human capital, Money etc) will improve the discovered volume and shrink the undiscovered component.

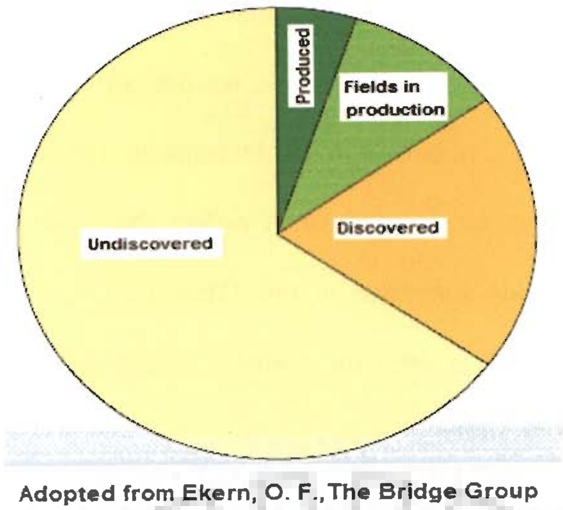


Figure 8.6 Petroleum volumes and prospectivity

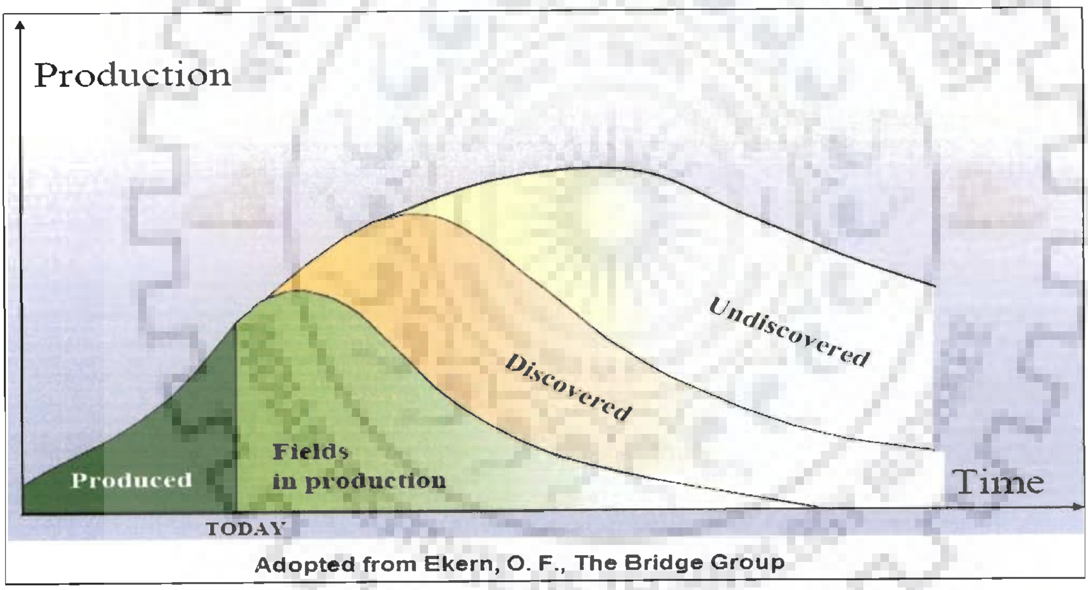


Figure 8.7 Petroleum volumes and prospectivity

An idea of the resource assessment of crude oil and natural gas resource base of the acreage/ field/ block will lead to the resource likely to be available for exploration and exploitation. This resource will lead to an estimation of risked mean recoverable hydrocarbon volumes.

These recoverable volumes of crude oil and gas will provide the reasonable degree of confidence in estimating the oil and gas that may be found, provided that the basins are explored efficiently Figure 8.10 (Ekern, 2005).

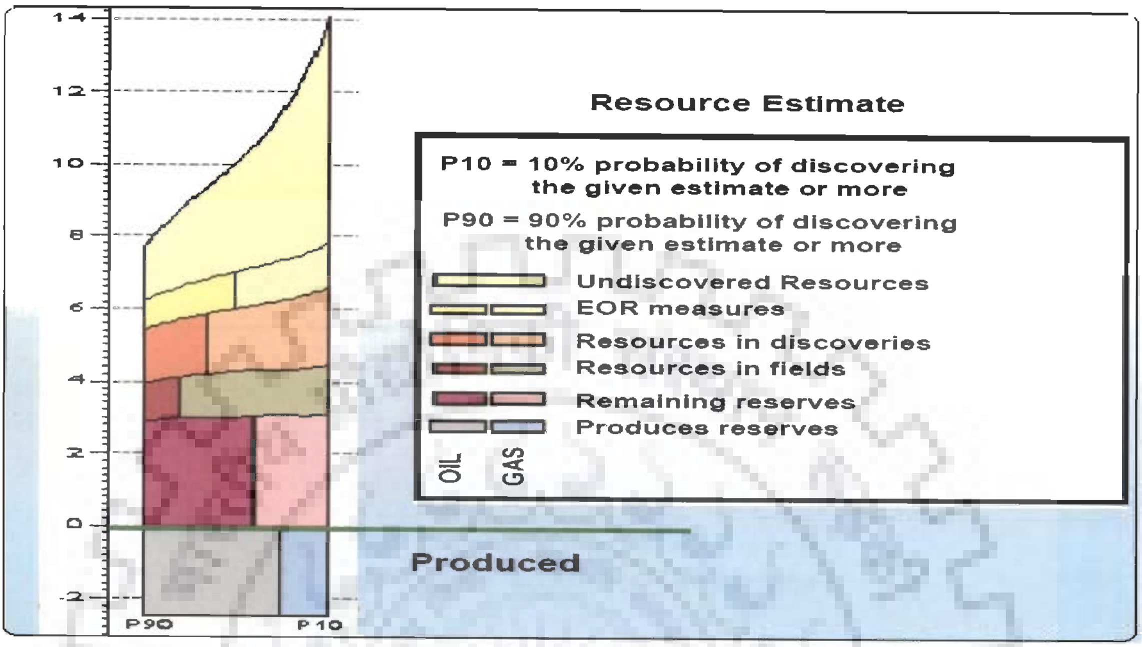


Figure 8.10 Licensing Strategy and Mechanisms

(Adopted from: Ekern, 2005)

These estimates will provide an idea about investments in fields and discoveries in the planning phase for exploration of this undiscovered resources and subsequent investments desired during field development, and production as well as supply chain and logistics. The ranking of basins within the country perspective viz. explored, unexplored, or frontier as well as scanning of geological environments for prior understanding of limitations imposed by geology of the area need to be addressed, because the cost and technical requirements differ for basins in onland, offshore, marshy areas. It will facilitate a company to model its strategy accordingly. In case of winning a bid for a acreage or prospect which is reasonably explored, the company may enter into the exploration production value chain at an early date post award of contract (Figure 8.10) and the production can be expected earlier.

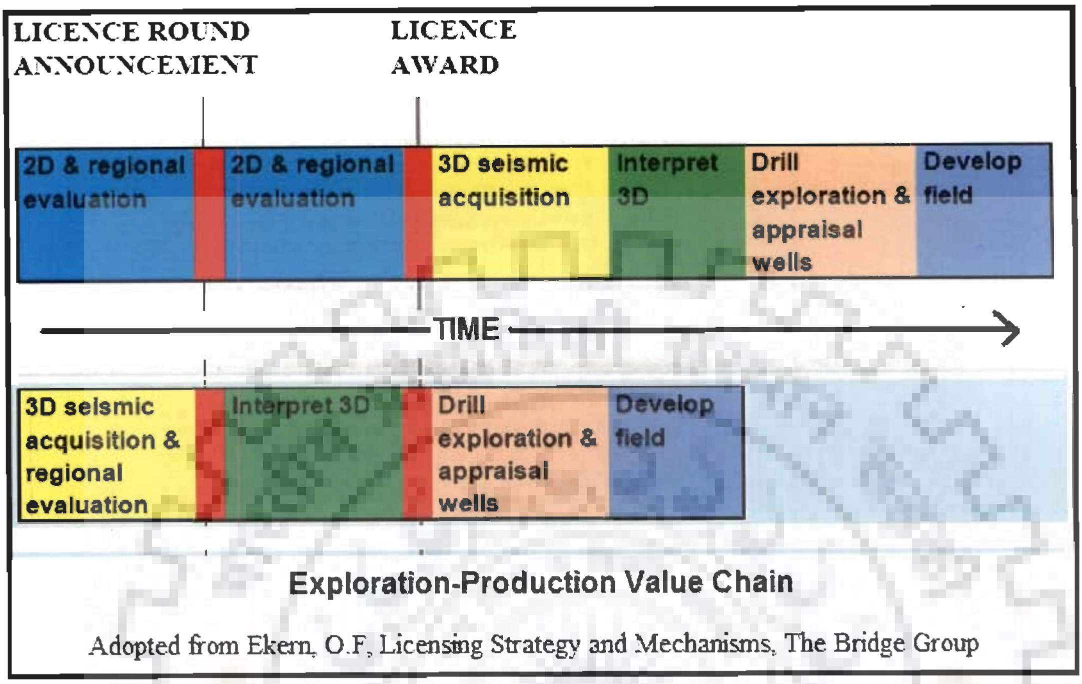


Figure 8.10 The Phase in exploration and production

In a field with no prior exploration input, there is substantial investment in generating the scientific data to substantiate the volume and locale of petroleum. But, in a reasonably explored province these costs are substantially lower, because of availability of data. The availability of infrastructure like existing production facilities, pipelines, etc. will facilitate project planning and cost analysis. In frontier provinces the technical data is not available and the company will have to spend resources (time, money, human resources) to gather requisite data for exploration. Therefore, the duration and input in phases 'A', 'B' and 'C' (figure 8.10 and 8.11) may be condensed or enlarged. These scenarios will have impact on project economics.

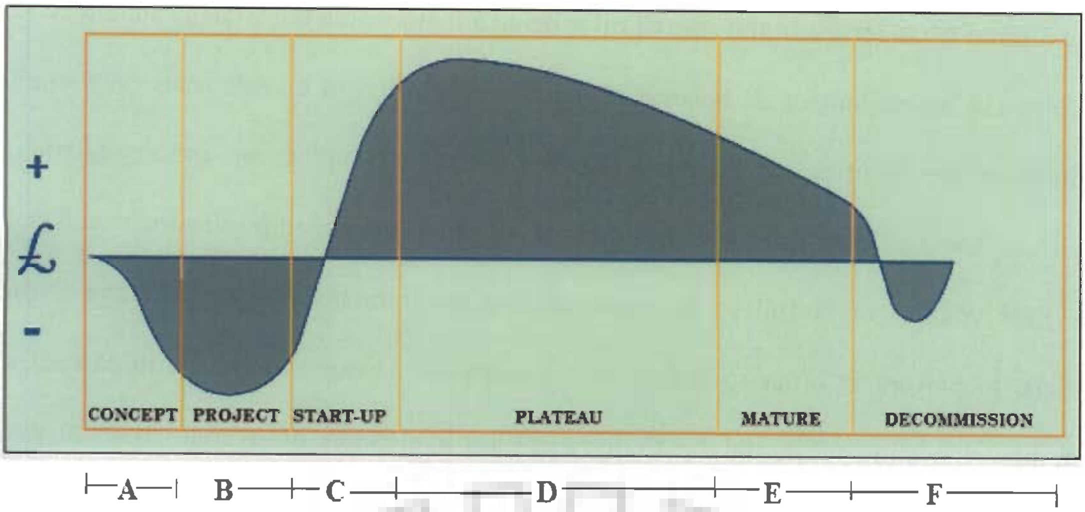


Figure 8.11 Field Life -Profit & Loss
(Adopted from Ekern, 2005)

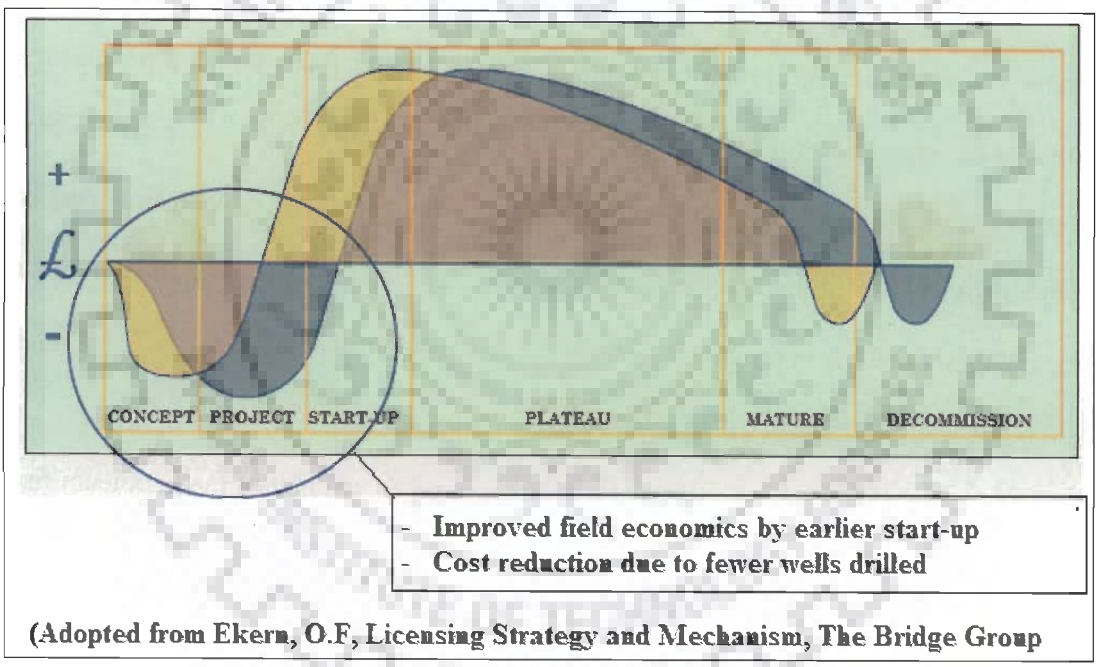


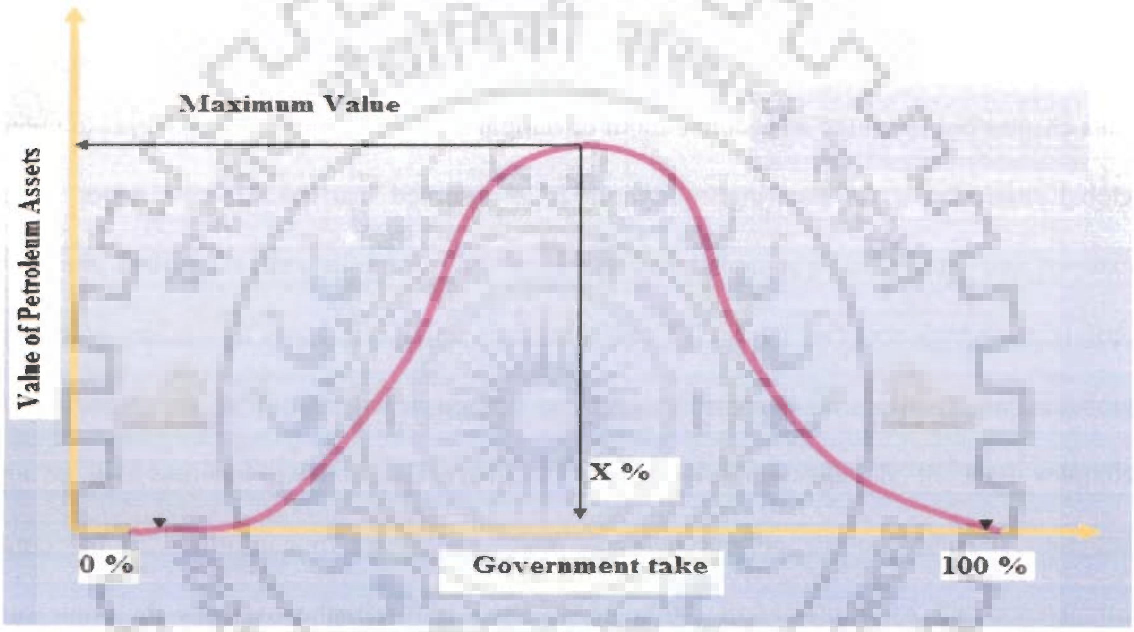
Figure 8.12 Field Life -Profit & Loss

Therefore, an Indian firm needs to exercise appropriate licensing strategy. The strategy must focus on screening of projects with block or acreage definition in terms of its technical and non-technical parameters especially the exploration maturity, the number and sizes of blocks available, the likely work program to explore and exploit the blocks, the phasing of activity, and the offered fiscal terms. In the case of offer being a mature area the strategy should be to have complete assessment of all balance resources. Very often in mature areas only small accumulations are on offer and these are resource critical for exploration and exploitation, and will require additional infrastructure to be developed if the existing infrastructure is not in the near vicinity or is full to its capacity. The governments provide lucrative fiscal conditions to players in order to entice them toward the acreage. Similarly, in case of a proven play the strategy should be to have careful evaluation of overall potential and identification of key prospects, as well as the long-term activities to be accomplished for exploration and exploitation.

The strategy for a hitherto unexplored area will require identification of resource potential and main uncertainties. The initial exploration strategy should focus both on prospectivity and information gathering for planning the future course of action. Thus a step-wise activity build-up will facilitate successful screening and selection of acreage in new areas. It may call for geo-analog studies to help facilitate planners and decision makers about the exploration efforts and their outcome in provinces having identical geological setup.

The Indian company needs to acquire a comprehensive understanding of the petroleum fiscal systems of the focus country so as to maximize the value of asset. Recognizing the fact that fiscal terms of a country and the political stability have a huge impact on the country's prospectivity, Indian firm should adopt a strategy to focus countries with fiscal system which provide a balance between the 'government take' and "contractor's share after payment of taxes and royalty etc.

As per Johnston (1994), the degree of favorability of geological condition compensates for the fiscal systems and country risk is one of the major considerations in international operations. Political scenario of any country makes it attractive for overseas business entity, because it leads to stable or fluctuating policies, tax regime etc. Even the overseas business entity fear the risk of nationalization or expropriation exists.



Adopted from Ekern, O.F, Licensing Strategy and Mechanism, The Bridge Group

8.13 The value of petroleum asset vis-à-vis Government take

The contract area and the block/acreage size as defined in bid or offer document need to be properly understood. These are important to avoid any future dispute arising out of contiguous fields or part of the fields falling in different blocks.

Human Resource Management

Indian companies must learn to exploit their size and scope, their pool of talented human resource to combine tangible and intangible assets for developing a new model of competitive advantage. The companies must realize the direct link between their profitability and large pool of talented professionals and overcome the barriers of internal complexity. The strategy should be to develop and mobilize the unique intangibles, knowledge and relationships to create value propositions (Bryan, 2005).

8.12 CONCLUSION

This chapter has provided an account about development of strategy for Indian firms to enter global environment for securing equity oil. It is observed that the strategic issues - the external and internal environmental factors, demanding domestic market, limited alternate option, and burgeoning fuel import bill calls for astute action. Strategies for the turnaround in globalization initiatives for crude oil business are desired. It will require an understanding of complex issue of globalization for crude oil security. The overseas business will be an integrated business to the present business practice; will be in conformity to the core competence and by implementing strategic diversifications in the overseas for crude oil business, Indian players can have a strong portfolio of profitable businesses. It will lead towards novel efforts in the Indian energy scenario with thrust on import substitution (minimization). The dividend of this globalization effort will start pouring in. The initiative will make allowance for availability of increased volume of crude oil at competitive prices.

Indian companies intending to enter into crude oil exploration and exploitation business overseas may acquire concession either directly from national government of the country where concession is located or through national oil company of the country, or enter in to business as partner to any other business entity operating in that country. These alternative approaches can be adopted depending on the petroleum concession law of the target country. The scouting, scanning, and screening of opportunity should be carried out with due consideration of all risk factors and a well drafted legal agreement must be entered in to prior to joining the business. The company need to work out project economics, cost benefit analysis, and above all quantification of values derived by adopting measures and arriving at energy security by minimizing or removing all together the import dependence, which has been a matter of serious concern and only a strategic intent can make serious and desired impact.

CHAPTER 9

CONCLUSION

9.1 INTRODUCTION

In this chapter, the major findings and contributions of the present study are summarized. The limitations of the study and scope of further research have been discussed. The global energy scenario with particular focus on crude oil has been analyzed. A review of Indian energy scenario with particular reference to crude oil has been attempted.

India is aggressively looking for acquiring crude oil and natural gas exploration and production acreages globally. The growth in demand of crude oil, the declining domestics reserve, low new reserve addition, global geopolitical scenario, environmental protection measures, growing economy and rapid population growth pose a threat and challenge to India. The country is trying to obtain secure, reliable, safe and at reasonable price the crude oil sources to fuel the economy. It imports crude oil from various countries. The country has secured crude oil reserves from overseas by participating in the exploration and production business of crude oil. The thrust areas identified for crude oil and natural gas security by the Government of India calls for accelerated domestic exploration, securing equity oil, diversification of sources for crude supplies, developing strategic storage and globalization measures to bring equity oil and gas form abroad by investing in equity abroad. But, the scouting, scanning, screening of global opportunities requires understanding of technical, economic, political and other parameters which impact business decisions. Therefore, it seems imperative to develop globalization strategy for crude oil security. Keeping these facts in view, the present study was carried out with the following objectives:

1. To understand the global and Indian crude oil scenario, scanning of global environment, and assessment of options for India to secure crude oil by participating in upstream business in a foreign country.
2. To identify the relevant key parameters like technical prospectivity, fiscal system, country risk etc. which should be considered to select overseas destination and formulate business strategy to acquire stake in crude oil production and thus making effort towards crude oil security.
3. To model the parameters to rank countries and thus formulate approach towards the globalization strategy for acquiring crude oil from overseas.
4. To conceptualize methodology for scouting, scanning and screening of global investment opportunities in exploration and production of crude oil.

9.2 SUMMARY OF THE WORK DONE

The global exploration environment, sources of crude oil as well as concern of crude oil security have been discussed. Indian energy scenario and India's concern for crude oil security are thoroughly. Evaluation of efforts towards crude oil security by India, both within and outside the country has been critically assessed.

The present research has developed a general understanding and the importance of crude oil as an energy source. It is observed that the strategies adopted by nations for crude oil security include intensive exploration of domestic province by national as well as foreign companies, import of crude oil, and secure equity oil from overseas.

In order to enter in to overseas upstream business, globally companies resort to various modes of entry. Description of various factors which affect the strategy to enter in to overseas business for crude oil exploration and production is discussed in detail. There are various technical and non-technical uncertainties that may impact the degree of attractiveness of crude oil assets to an overseas investor. These factors like, business environment, petroleum regulations and fiscal terms, availability of infrastructures, currency and credit risks, likelihood of strikes, acts of terrorism; fear of expropriation, and risks to the health, safety, and environment etc. have been studied. The role and impact of these factors for assessments of E&P assets has been analyzed. The study has revealed that these elements have critical importance and they affect the economic viability and thus attractiveness of petroleum assets to global investors.

A need has been identified for conceptualization and development of model and methodology to steer globalization strategy for venturing in to overseas business of crude oil exploration and exploitation. Accordingly an effort has been made to model these parameters to screen global destinations and develop a strategy for Indian companies to undertake overseas crude oil exploration business and obtain share of crude oil for India's crude oil security. The model is expected to rank the crude oil bearing countries in order of attractiveness for overseas business and is envisaged to facilitate the decision makers in deciding a strategy for selection of global opportunities. Based on these ranking and other factors which impact global business, propositions for globalization strategy have been made.

9.3 SIGNIFICANT RESEARCH CONTRIBUTIONS AND KEY FINDINGS

The study reveals that the technical prospectivity of an acreage which is generally believed to hold prime importance by business entities have but lesser degree of bearing on success of global business of petroleum exploration. On the contrary, various factors like country risk (economic, social and political), business environment, fiscal system and corruption have significant impact. The ranking of countries on the basis of their technical prospectivity should not be the binding parameters for taking up that country for exploration and exploitation of crude oil business.

The thesis has contributed in development of a model incorporating these technical and non-technical parameters. The model will facilitate to rank countries in order of attractiveness. The rank thus derived will facilitate in assessment of that country by any company interested in undertaking into global business for crude oil. It will help decision makers to select overseas opportunities for exploration and exploitation of crude oil.

9.4 IMPLICATION OF PRESENT RESEARCH

Petroleum exploration business is weighed down with risk and uncertainty. To participate in overseas equity participation countries need to do judicious selection of global opportunities. It involves assessment of alternate options and weighing up of risk and reward for each opportunity. The model and methodology will facilitate in evaluation of the target country taking into consideration these risk elements.

9.5 LIMITATIONS OF THE PRESENT STUDY

This thesis has dealt with the model and methodology for scouting, scanning, and screening of global opportunities for upstream crude oil business. The development of model and its validation require comprehensive dataset. The statistical model has been developed based on data obtained from public domain data base. The data pertaining to all risked parameters are not available for all countries. Furthermore, as is true with any model, the decision of end user should not be based on the model only, but also on the judgment based on experience.

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Annexure - i

Table 1.1 Crude Oil Proved reserves (Data Source: BP Statistical Review 2008)

	At end of1987 Thousand million barrels	At end of 1997 Thousand million barrels	At end of 2006 Thousand million barrels	At end of 2007 Thousand million tonnes	At end of 2007 Thousand million barrels	Share of total	R/P ratio
US	35.4	30.5	29.4	3.6	29.4	2.4%	11.7
Canada	11.7	10.7	27.7	4.2	27.7	2.2%	22.9
Mexico	54.1	47.8	12.8	1.7	12.2	1.0%	9.6
Total North America	**101.2**	**89.0**	**70.0**	**9.5**	**69.3**	**5.6%**	**13.9**
Argentina	2.2	2.6	2.6	0.4	2.6	0.2%	10.2
Brazil	2.6	7.1	12.2	1.7	12.6	1.0%	18.9
Colombia	1.9	2.6	1.5	0.2	1.5	0.1%	7.4
Ecuador	1.6	3.7	4.5	0.6	4.3	0.3%	22.5
Peru	0.5	0.8	1.1	0.1	1.1	0.1%	26.4
Trinidad & Tobago	0.6	0.7	0.8	0.1	0.8	0.1%	14.1
Venezuela	58.1	74.9	87.0	12.5	87.0	7.0%	91.3
Other S. & Cent. America	0.6	1.1	1.3	0.2	1.3	0.1%	25.2
Total S. & Cent. America	**68.1**	**93.4**	**111.0**	**15.9**	**111.2**	**9.0%**	**45.9**
Azerbaijan	n/a	n/a	7.0	1.0	7.0	0.6%	22.1
Denmark	0.4	0.9	1.2	0.1	1.1	0.1%	9.8
Italy	0.7	0.8	0.8	0.1	0.8	0.1%	17.6
Kazakhstan	n/a	n/a	39.8	5.3	39.8	3.2%	73.2
Norway	6.6	12.0	8.5	1.0	8.2	0.7%	8.8
Romania	1.3	0.9	0.5	0.1	0.5	◆	12.4
Russian Federation	n/a	n/a	79.3	10.9	79.4	6.4%	21.8
Turkmenistan	n/a	n/a	0.6	0.1	0.6	◆	8.3
United Kingdom	5.2	5.2	3.6	0.5	3.6	0.3%	6.0
Uzbekistan	n/a	n/a	0.6	0.1	0.6	◆	14.3
Other Europe & Eurasia	61.7	68.0	2.2	0.3	2.1	0.2%	12.8
Total Europe & Eurasia	**75.8**	**88.0**	**144.1**	**19.4**	**143.7**	**11.6%**	**22.1**
Iran	92.9	92.6	138.4	19.0	138.4	11.2%	86.2
Iraq	100.0	112.5	115.0	15.5	115.0	9.3%	*
Kuwait	94.5	96.5	101.5	14.0	101.5	8.2%	*
Oman	4.1	5.4	5.6	0.8	5.6	0.5%	21.3
Qatar	4.5	12.5	27.9	3.6	27.4	2.2%	62.8
Saudi Arabia	169.6	261.5	264.3	36.3	264.2	21.3%	69.5
Syria	1.7	2.3	3.0	0.3	2.5	0.2%	17.4
United Arab Emirates	98.1	97.8	97.8	13.0	97.8	7.9%	91.9
Yemen	1.1	1.8	2.8	0.4	2.8	0.2%	22.7
Other Middle East	0.1	0.2	0.1	^	0.1	◆	10.9
Total Middle East	**566.6**	**683.2**	**756.3**	**102.9**	**755.3**	**61.0%**	**82.2**

Algeria	8.6	11.2	12.3	1.5	12.3	1.0%	16.8
Angola	2.0	3.9	9.0	1.2	9.0	0.7%	14.4
Chad	-	-	0.9	0.1	0.9	0.1%	17.2
Rep. of Congo (Brazzaville)	0.7	1.6	1.9	0.3	1.9	0.2%	23.9
Egypt	4.7	3.7	3.7	0.5	4.1	0.3%	15.7
Equatorial Guinea	-	0.6	1.8	0.2	1.8	0.1%	13.2
Gabon	1.0	2.7	2.0	0.3	2.0	0.2%	23.8
Libya	22.8	29.5	41.5	5.4	41.5	3.3%	61.5
Nigeria	16.0	20.8	36.2	4.9	36.2	2.9%	42.1
Sudan	0.3	0.3	6.6	0.9	6.6	0.5%	39.7
Tunisia	1.7	0.3	0.6	0.1	0.6	♦	16.7
Other Africa	1.0	0.7	0.6	0.1	0.6	0.1%	10.2
Total Africa	**58.7**	**75.3**	**117.1**	**15.6**	**117.5**	**9.5%**	**31.2**
Australia	3.2	4.0	4.2	0.4	4.2	0.3%	20.3
Brunei	1.6	1.1	1.2	0.2	1.2	0.1%	16.9
China	17.4	17.0	15.6	2.1	15.5	1.3%	11.3
India	4.4	5.6	5.7	0.7	5.5	0.4%	18.7
Indonesia	9.0	4.9	4.4	0.6	4.4	0.4%	12.4
Malaysia	3.3	5.0	5.4	0.7	5.4	0.4%	19.4
Thailand	0.1	0.3	0.5	0.1	0.5	♦	4.1
Vietnam	^	1.2	3.3	0.5	3.4	0.3%	27.5
Other Asia Pacific	0.8	1.2	0.9	0.1	0.9	0.1%	11.0
Total Asia Pacific	**39.8**	**40.4**	**41.0**	**5.4**	**40.8**	**3.3%**	**14.2**
TOTAL WORLD	**910.2**	**1069.3**	**1239.5**	**168.6**	**1237.9**	**100.0%**	**41.6**
of which: European Union	9.0	8.8	6.9	0.9	6.8	0.5%	7.8
OECD	119.1	113.4	89.5	11.9	88.3	7.1%	12.6
OPEC	676.0	818.7	935.3	127.6	934.7	75.5%	72.7
OPEC 10	574.0	702.3	811.2	110.8	810.7	65.5%	70.9
Non-OPEC £	174.7	184.1	176.2	23.6	175.0	14.1%	14.3
Former Soviet Union	59.5	66.5	128.0	17.4	128.1	10.4%	27.4

Legend

* More than 100 years. ^ Less than 0.05. ♦ Less than 0.05% n/a not available

£ Excludes Former Soviet Union, includes Angola.

Notes: **Proved reserves of oil** - Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

Reserves-to-production (R/P) ratio - If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that level.

Source of data – The estimates in this table have been compiled using a combination of primary official sources, third-party data from the OPEC Secretariat, World Oil, Oil & Gas Journal and an independent estimate of Russian reserves based on information in the public domain. Canadian proved reserves include an official estimate of 21.0 billion barrels for oil sands 'under active development'. Reserves include gas condensate and natural gas liquids (NGLs) as well as crude oil.

Table 1.2. World Natural gas Proved reserves (Data Source: BP Statistical Review, 2008)

	At end of 1987 Trillion cubic metres	At end of1997 Trillion cubic metres	At end of 2006 Trillion cubic metres	At end of 2007 Trillion cubic feet	Trillion cubic metres	Share of total	R/P ratio
US	5.30	4.74	5.98	211.08	5.98	3.4%	10.9
Canada	2.69	1.81	1.62	57.55	1.63	0.9%	8.9
Mexico	2.12	1.80	0.39	13.01	0.37	0.2%	8.0
Total North America	**10.11**	**8.34**	**7.99**	**281.65**	**7.98**	**4.5%**	**10.3**
Argentina	0.69	0.68	0.45	15.54	0.44	0.2%	9.8
Bolivia	0.14	0.12	0.74	26.13	0.74	0.4%	54.7
Brazil	0.11	0.23	0.35	12.89	0.36	0.2%	32.3
Colombia	0.10	0.20	0.12	4.41	0.13	0.1%	16.2
Peru	0.34	0.20	0.33	12.54	0.36	0.2%	*
Trinidad & Tobago	0.30	0.52	0.48	16.95	0.48	0.3%	12.3
Venezuela	2.84	4.12	5.10	181.87	5.15	2.9%	*
Other S. & Cent. America	0.15	0.15	0.07	2.51	0.07	◆	21.0
Total S. & Cent. America	**4.67**	**6.21**	**7.64**	**272.84**	**7.73**	**4.4%**	**51.2**
Azerbaijan	n/a	0.84	1.26	45.13	1.28	0.7%	*
Denmark	0.07	0.11	0.12	4.10	0.12	0.1%	12.6
Germany	0.38	0.26	0.16	4.84	0.14	0.1%	9.6
Italy	0.30	0.27	0.09	3.14	0.09	0.1%	10.0
Kazakhstan	n/a	1.87	1.90	67.20	1.90	1.1%	69.8
Netherlands	1.77	1.79	1.32	44.07	1.25	0.7%	19.4
Norway	2.29	3.65	2.89	104.57	2.96	1.7%	33.0
Poland	0.16	0.16	0.11	3.99	0.11	0.1%	26.4
Romania	0.20	0.37	0.63	22.18	0.63	0.4%	54.4
Russian Federation	n/a	45.17	44.60	1576.75	44.65	25.2%	73.5
Turkmenistan	n/a	2.71	2.67	94.22	2.67	1.5%	39.6
Ukraine	n/a	0.98	1.03	36.24	1.03	0.6%	54.0
United Kingdom	0.64	0.77	0.41	14.55	0.41	0.2%	5.7
Uzbekistan	n/a	1.63	1.74	61.60	1.74	1.0%	29.8
Other Europe & Eurasia	39.25	0.45	0.44	15.31	0.43	0.2%	39.4
Total Europe & Eurasia	**45.06**	**61.02**	**59.37**	**2097.89**	**59.41**	**33.5%**	**55.2**
Bahrain	0.20	0.14	0.09	3.00	0.09	◆	7.4
Iran	13.92	23.00	27.58	981.75	27.80	15.7%	*
Iraq	1.00	3.19	3.17	111.95	3.17	1.8%	*
Kuwait	1.21	1.49	1.78	63.00	1.78	1.0%	*
Oman	0.27	0.54	0.69	24.37	0.69	0.4%	28.6
Qatar	4.44	8.50	25.64	904.06	25.60	14.4%	*
Saudi Arabia	4.19	5.88	7.07	253.03	7.17	4.0%	94.4
Syria	0.13	0.24	0.29	10.17	0.29	0.2%	54.7
United Arab Emirates	5.68	6.06	6.11	215.07	6.09	3.4%	*
Yemen	0.11	0.48	0.49	17.23	0.49	0.3%	-
Other Middle East	^	^	0.05	1.73	0.05	◆	18.5
Total Middle East	**31.18**	**49.53**	**72.95**	**2585.35**	**73.21**	**41.3%**	*

Algeria	3.16	4.08	4.50	159.45	4.52	2.5%	54.4
Egypt	0.31	0.93	2.05	72.85	2.06	1.2%	44.3
Libya	0.73	1.31	1.49	52.80	1.50	0.8%	98.4
Nigeria	2.41	3.48	5.22	186.99	5.30	3.0%	*
Other Africa	0.79	0.82	1.20	42.84	1.21	0.7%	*
Total Africa	**7.39**	**10.62**	**14.46**	**514.92**	**14.58**	**8.2%**	**76.6**
Australia	1.07	1.48	2.49	88.64	2.51	1.4%	62.8
Bangladesh	0.35	0.30	0.39	13.77	0.39	0.2%	24.0
Brunei	0.33	0.39	0.33	12.11	0.34	0.2%	28.0
China	0.89	1.16	1.68	66.54	1.88	1.1%	27.2
India	0.55	0.69	1.08	37.26	1.06	0.6%	35.0
Indonesia	2.37	2.15	2.63	105.94	3.00	1.7%	45.0
Malaysia	1.49	2.46	2.48	87.40	2.48	1.4%	40.9
Myanmar	0.27	0.28	0.54	21.19	0.60	0.3%	40.8
Pakistan	0.63	0.60	0.85	30.02	0.85	0.5%	27.6
Papua New Guinea	0.09	0.43	0.44	15.36	0.44	0.2%	*
Thailand	0.18	0.21	0.33	11.65	0.33	0.2%	12.7
Vietnam	^	0.17	0.22	7.77	0.22	0.1%	28.5
Other Asia Pacific	0.23	0.41	0.37	13.02	0.37	0.2%	21.9
Total Asia Pacific	**8.45**	**10.73**	**13.82**	**510.69**	**14.46**	**8.2%**	**36.9**
TOTAL WORLD	**106.86**	**146.46**	**176.22**	**6263.34**	**177.36**	**100.0%**	**60.3**
of which: European Union	3.75	3.85	2.94	100.26	2.84	1.6%	14.8
OECD	17.19	17.05	15.79	556.89	15.77	8.9%	14.4
Former Soviet Union	38.90	53.44	53.46	1890.24	53.53	30.2%	67.7

LEGEND

* More than 100 years. ^ Less than 0.05. ◆ Less than 0.05%. n/a not available.

Notes: **Proved reserves of oil** - Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

Reserves-to-production (R/P) ratio - If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.
Source of data - The estimates in this table have been compiled using a combination of primary official sources and third-party data from Cedigaz.

Table 1.3 World Proved Reserves: Oil, Natural Gas and Oil plus Oil Equivalent Gas

Data Source: BP Statistical Review, 2008

COUNTRY	OIL		NATURAL GAS			TOTAL OIL AND GAS	
	Oil: Proved reserves at end 2006 Thousand million barrels	Share of total	Natural Gas: Proved reserves at end 2006 Trillion cubic metres	Billion cubic metres	million barrels oil equivalent	(OIL + Oil Equivalent Gas) at end 2006 Million barrels	Share of total %age
USA	29.9	2.5%	5.93	0.59	3.73	29925.73	2.48
Canada	17.1	1.4%	1.67	0.17	1.05	17093.76	1.41
Mexico	12.9	1.1%	0.39	0.04	0.24	12908.64	1.07
Total North America	**59.9**	**5.0%**	**7.98**	**0.80**	**5.02**	**59928.13**	**4.96**
Argentina	2.0	0.2%	0.42	0.04	0.26	1971.82	0.16
Brazil	12.2	1.0%	0.74	0.07	0.47	12182.47	1.01
Colombia	1.5	0.1%	0.35	0.03	0.22	1506.32	0.12
Ecuador	4.7	0.4%	0.12	0.01	0.08	4664.01	0.39
Peru	1.1	0.1%	0.34	0.03	0.21	1078.47	0.09
Trinidad & Tobago	0.8	0.1%	0.53	0.05	0.33	809.33	0.07
Venezuela	80.0	6.6%	4.32	0.43	2.71	80014.71	6.62
Other S. & Cent. America	1.3	0.1%	0.07	0.01	0.04	1269.79	0.11
Total S. & Cent. America	**103.5**	8.6%	**6.88**	0.69	4.33	103496.93	8.57
Azerbaijan	7.0	0.6%	1.35	0.14	0.85	7000.85	0.58
Denmark	1.2	0.1%	0.08	0.01	0.05	1157.37	0.10
Germany	0.0	0.0%	0.16	0.02	0.10	0.10	0.00
Italy	0.7	0.1%	0.16	0.02	0.10	735.48	0.06
Kazakhstan	39.8	3.3%	3.00	0.30	1.89	39829.89	3.30
Netherlands	0.0	0.0	1.35	0.13	0.85	0.85	0.00
Norway	8.5	0.7%	2.89	0.29	1.82	8500.77	0.70
Poland	0.0	0.0	0.10	0.01	0.07	0.07	0.00
Romania	0.4	♦	0.63	0.06	0.40	448.40	0.04
Russian Federation	79.5	6.6%	47.65	4.77	29.97	79570.09	6.58
Turkmenistan	0.5	♦	2.86	0.29	1.80	547.80	0.05
Ukraine			1.10	0.11	0.69	0.69	0.00
United Kingdom	3.9	0.3%	0.48	0.05	0.30	3870.30	0.32
Uzbekistan	0.6	♦	1.87	0.19	1.18	595.18	0.05

Other Europe & Eurasia	2.2	0.2%	0.45	0.05	0.28	2179.70	0.18
Total Europe & Eurasia	**144.4**	**12.0%**	**64.13**	6.41	40.34	144437.53	11.95
Bahrain			0.09	0.01	0.06	0.06	0.00
Iran	**137.5**	11.4%	28.13	2.81	17.69	137507.69	11.38
Iraq	**115.0**	9.5%	3.17	0.32	1.99	115001.99	9.52
Kuwait	**101.5**	8.4%	1.78	0.18	1.12	101501.12	8.40
Oman	**5.6**	0.5%	0.98	0.10	0.62	5572.62	0.46
Qatar	**15.2**	1.3%	25.36	2.54	15.95	15222.95	1.26
Saudi Arabia	**264.3**	22%	7.07	0.71	4.45	264255.45	21.87
Syria	**3.0**	0.2%	0.29	0.03	0.18	3000.18	0.25
United Arab Emirates	**97.8**	8.1%	6.06	0.61	3.81	97803.81	8.09
Yemen	**2.9**	0.2%	0.49	0.05	0.31	2850.31	0.24
Other Middle East	**0.1**	♦	0.05	0.01	0.03	76.99	0.01
Total Middle East	**742.7**	**61.5%**	**73.47**	7.35	46.21	742793.17	61.47
Algeria	**12.3**	1.0%	4.50	0.45	2.83	12272.83	1.02
Angola	**9.0**	0.7%	0.00	0.00	0.00	9035.00	0.75
Chad	**0.9**	0.1%	0.00	0.00	0.00	900.00	0.07
Rep. of Congo	**1.9**	0.2%	0.00	0.00	0.00	1905.00	0.16
Egypt	**3.7**	0.3%	1.94	0.19	1.22	3721.22	0.31
Equatorial Guinea	**1.8**	0.1%	0.00	0.00	0.00	1805.00	0.15
Gabon	**2.1**	0.2%	0.00	0.00	0.00	2146.00	0.18
Libya	**41.5**	3.4%	1.32	0.13	0.83	41464.83	3.43
Nigeria	**36.2**	3.0%	5.21	0.52	3.28	36223.28	3.00
Sudan	**6.4**	0.5%	0.00	0.00	0.00	6402.00	0.53
Tunisia	**0.7**	0.1%	0.00	0.00	0.00	690.90	0.06
Other Africa	**0.6**	0.1%	1.21	0.12	0.76	614.89	0.05
Total Africa	**117.2**	**9.7%**	**14.18**	1.42	8.92	117180.95	9.70
Australia	**4.2**	0.3%	2.61	0.26	1.64	4228.38	0.35
Bangladesh	0.00	0	0.44	0.04	0.27	0.27	0.00
Brunei	**1.1**	0.1%	0.34	0.03	0.21	1105.21	0.09
China	**16.3**	1.3%	2.45	0.24	1.54	16272.84	1.35
India	**5.7**	0.5%	1.08	0.11	0.68	5693.36	0.47
Indonesia	**4.3**	0.4%	2.63	0.26	1.66	4302.66	0.36
Malaysia	**4.2**	0.3%	2.48	0.25	1.56	4201.56	0.35
Myanmar	**1.0**	0.1%	0.54	0.05	0.34	1000.34	0.08
Pakistan			0.80	0.08	0.50	0.50	0.00
Papua New Guinea			0.44	0.04	0.27	0.27	0.00
Thailand	**0.5**	♦	0.30	0.03	0.19	453.19	0.04
Vietnam	**3.3**	0.3%	0.40	0.04	0.25	3250.25	0.27
Other Asia Pacific	**1.0**	0.1%	0.34	0.03	0.21	1010.36	0.08
Total Asia Pacific	**40.5**	**3.4%**	**14.82**	1.48	9.32	40519.19	3.35
TOTAL WORLD	**1208.2**	**100.0%**	**181.46**	18.15	114.14	1208355.91	100.00

Table 1.4 World Proven Reserves (2004) and Undiscovered Resources (2000)

Region	Oil – Billion barrels (Bbbl)			
	Proven Reserves	Undiscovered Resources		
		F95	F5	Mean
USA	22,446	60,500	94,700	75,600
North America	40,268	67,302	252,190	146,091
FSU	79.4	35,601	225,654	115,985
Middle East and North Africa	743.4	73,286	423,178	229,882
Asia Pacific	35.9	8,726	58,653	29,780
South Asia	5,735	1,032	6,957	3,580
Central and South Africa	102.6	20,090	230,727	105,106
Sub-Saharan Africa and Antarctica	64,529	26,783	124,447	71,512
Europe	14.8	6,339	45,407	22,292
Total World	1,293	239,159	1,376,213	724,228
Region	**Gas – Trillion cubic feet (Tcf)**			
	Proven Reserves	Undiscovered Resources		
		F95	F5	Mean
USA	183	392,600	697,600	526,900
North America	252	413,044	1,051,199	681,399
FSU	1,967	429,164	3,246,740	1,611,262
Middle East and North Africa	2,565	425,371	2,607,896	1,369,933
Asia Pacific	392	109,068	746,044	379,339
South Asia	64	30,518	248,647	119,610
Central and South Africa	386	96,168	1,087,521	487,190
Sub-Saharan Africa and Antarctica	200	83,474	439,436	235,290
Europe	187	44,706	733,412	312,365
Total World	6,112	1,631,513	10,160,895	5,196,388

Data Source: (Radler, 2005; USGS, 2000).

Source: Kaiser et al, 2006

Table 1.5 World Undiscovered Oil Resources, 2000 (Thousand Million Barrels)

Country	Onshore	Offshore	Total
USA		85.9	
Canada	1.0	1.8	2.8
Mexico	7.7	12.9	20.6
North America			
Argentina	2.0	1.3	3.2
Brazil	*	45.7	46.7
Colombia	5.1	-	5.1
Ecuador	0.8	0.2	1.0
Peru	1.8	1.5	3.3
Trinidad & Tobago	*	0.7	0.8
Venezuela	15.6	4.1	19.7
South & Central America			105.1
Denmark	-	0.1	0.1
Italy	0.4	*	0.4
Norway	-	12.9	12.9
Romania	1.1	-	1.1
United Kingdom	*	6.3	6.3
Europe			22.3
Azerbaijan	0.2	6.1	6.3
Kazakhstan	7.9	13.2	21.1
Russian Federation	66.3	11.1	77.4
Turkmenistan	0.5	6.3	6.8
Uzbekistan	0.1	*	0.1
Former Soviet Union			116.0
Iran	39.7	13.5	53.1
Iraq	45.1	-	45.1
Kuwait	1.6	2.2	3.8
Oman	3.4	-	3.4
Qatar	1.6	2.0	3.6
Saudi Arabia	75.8	11.2	87.1
Syria	1.3	-	1.3
United Arab Emirates	4.4	3.3	7.7
Yemen	3.3	*	3.3
Middle East			229.9
Algeria	7.7	-	7.7
Angola	0.5	14.0	14.5
Cameroon	0.5	1.0	1.5
Republic of Congo	0.2	5.6	5.8
Egypt			
Gabon	0.9	7.3	8.2
Libya	6.6	1.7	8.3
Nigeria	15.4	22.2	37.6
Tunisia	1.7	0.5	2.2
Africa			71.5
Australia	0.2	4.8	5.0
Brunei	0.1	1.7	1.8
China	10.4	1.8	12.1
India	0.8	1.8	2.6
Indonesia	2.2	5.2	7.4
Malaysia	0.1	3.0	3.0
Thailand	-	0.1	0.1
Vietnam	-	*	*
Asia Pacific			32.4
TOTAL WORLD			724.2

Data Source: (USGS, 2000).

Note: ‡Excludes Former Soviet Union, *Less than 0.05%, n/a: Not available.

Source: Kaiser et al, 2006

Table 1.6 World Undiscovered Natural Gas Resources, 2000 (Trillion cubic feet)

Country	Onshore	Offshore	Total
USA		419.9	
Canada	15.6	8.9	24.5
Mexico	20.5	28.7	49.3
Total North America			
Argentina	21.8	14.9	36.7
Brazil	0.2	194.2	192.4
Colombia	10.1	-	10.1
Ecuador	0.3	0.2	0.6
Peru	1.9	4.4	6.3
Trinidad & Tobago	1.1	30.7	31.8
Venezuela	60.3	41.0	101.2
Total S. & Cent. America			487.2
Denmark	-	0.8	0.8
Italy	13.0	14.3	27.3
Norway	-	183.0	183.0
Romania	5.4	-	5.4
United Kingdom	*	23.3	23.4
Total Europe			312.4
Azerbaijan	1.6	65.9	67.4
Kazakhstan	38.6	33.7	72.3
Russian Federation	398.0	770.8	1,168.7
Turkmenistan	142.4	65.3	207.7
Uzbekistan	12.8	2.3	15.0
Total Former Soviet Union			1,611.3
Iran	176.2	138.4	314.6
Iraq	120.0	-	120.0
Kuwait	2.8	3.1	5.9
Oman	32.4	1.3	33.7
Qatar	17.5	23.6	41.1
Saudi Arabia	625.1	55.9	681.0
Syria	5.1	-	5.1
United Arab Emirates	28.5	16.0	44.5
Yemen	21.4	0.5	21.9
Total Middle East			1,370.0
Algeria	46.5	2.5	49.0
Angola	1.4	41.3	42.7
Cameroon	1.8	3.8	5.6
Republic of Congo	0.5	16.9	17.4
Egypt			
Gabon	2.8	21.5	24.3
Libya	12.8	8.3	21.1
Nigeria	55.1	68.1	123.2
Tunisia	4.9	2.3	7.1
Total Africa			235.3
Australia	3.4	106.0	109.4
Brunei	0.4	12.0	12.4
China	82.1	3.6	85.8
India	13.1	17.2	30.3
Indonesia	43.4	64.3	107.7
Malaysia	0.4	49.7	50.2
Papua New Guinea			
Thailand	-	4.7	4.7
Vietnam	-	0.8	0.8
Total Asia Pacific			498.9
TOTAL WORLD			5,196.4

Data Source: (USGS, 2000).

Note: ‡Excludes Former Soviet Union, *Less than 0.05%, n/a: Not available

Source: Kaiser et al, 2006

Table 1.7 Oil Production and Consumption Among Primary Producing Countries (2004)

Country	Production (1,000 barrels daily)	Consumption (1,000 barrels daily)	Production-Consumption (1,000 barrels daily)
USA	7241	20517	-13276
Canada	3085	2206	879
Mexico	3824	1896	1928
Total North America	**14150**	**24619**	**-10469**
Argentina	756	393	363
Brazil	1542	1830	-288
Colombia	551	223	328
Ecuador	535	140	395
Peru	93	153	-60
Trinidad & Tobago	155		155
Venezuela	2980	577	2403
Other S. & Cent. America	152	1424	-1272
Total S. & Cens. America	6764	4739	2025
Azerbaijan	318	91	227
Denmark	394	189	205
Italy	104	1871	-1767
Kazakhstan	1295	192	1103
Norway	3188	209	2979
Romania	119	212	-93
Russian Federation	9285	2574	6711
Turkmenistan	202	98	104
United Kingdom	2029	1756	273
Uzbekistan	152	120	32
Other Europe & Eurasia	496	12705	-12209
Tocal Europe & Eurasia	17583	20017	-2434
Iran	4081	1551	2530
Izaq	2027		2027
Kuwait	2424	266	2158
Oman	785		785
Qatar	990	84	906
Saudi Arabia	10584	1728	8856
Syria	536		536
United Arab Emirates	2667	306	2361
Yemen	429		429
Other Middle East	48	1354	-1306
Tocal Middle East	24571	5289	19282
Algeria	1933	242	1691
Angola	991		991
Cameroon	62		62
Chad	168		168
Rep. of Congo (Brazzaville)	240		240
Egypt	708	566	142
Equatorial Guinea	350		350
Gabon	235		235
Libya	1607		1607
Nigeria	2508		2508
Sudan	301		301
Tunisia	69		69
Other Africa	92	1839	-1747
Tocal Africa	9264	2647	6617
Australia	541	858	-317
Brunei	211		211
China	3490	6684	-3194
India	819	2555	-1736
Indonesia	1126	1150	-24
Malaysia	912	504	408
Thailand	218	909	-691
Vietnam	427		427
Other Asia Pacific	184	10786	-10602
Tocal Asia Pacific	**7928**	**23446**	**-15518**
TOTAL WORLD	**80260**	**80757**	**-497**
Of which OECD	20732	48777	-28045
OPEC	32927		32927
Non-OPEC ‡	35916		35916
Former Soviet Union	11417	3729	7688

Source: (British Petroleum, 2005). ‡Excludes Former Soviet Union

Data Source: (British Petroleum, 2005). ‡Excludes Former Soviet Union

Source: Kaiser et al, 2006

Approximate conversion factors

Crude oil*	To				
	tonnes (metric)	kilolitres	barrels	US gallons	tonnes/ year
From	Multiply by				
Tonnes (metric)	1	1.165	7.33	307.86	–
Kilolitres	0.8581	1	6.2898	264.17	–
Barrels	0.1364	0.159	1	42	–
US gallons	0.00325	0.0038	0.0238	1	–
Barrels/day	–	–	–	–	49.8

*Based on worldwide average gravity.

Products	To convert			
	barrels to tonnes	tonnes to barrels	kilolitres to tonnes	tonnes to kilolitres
	Multiply by			
LPG	0.086	11.6	0.542	1.844
Gasoline	0.118	8.5	0.740	1.351
Kerosene	0.128	7.8	0.806	1.24
Gas oil/ diesel	0.133	7.5	0.839	1.192
Residual fuel oil	0.149	6.7	0.939	1.065

Natural gas and LNG	To					
	billion cubic metres NG	billion cubic feet NG	million tonnes oil equivalent	million tonnes LNG	trillion British thermal units	million barrels oil equivalent
From	Multiply by					
1 billion cubic metres NG	1	35.3	0.90	0.73	36	6.29
1 billion cubic feet NG	0.028	1	0.026	0.021	1.03	0.18
1 million tonnes oil equivalent	1.111	39.2	1	0.805	40.4	7.33
1 million tonnes LNG	1.38	48.7	1.23	1	52.0	8.68
1 trillion British thermal units	0.028	0.98	0.025	0.02	1	0.17
1 million barrels oil equivalent	0.16	5.61	0.14	0.12	5.8	1

Units	
1 metric tonne = 2204.62 lb.	
= 1.1023 short tons	
1 kilolitre = 6.2898 barrels	
1 kilolitre = 1 cubic metre	
1 kilocalorie (kcal) = 4.187 kJ = 3.968 Btu	
1 kilojoule (kJ) = 0.239 kcal = 0.948 Btu	
1 British thermal unit (Btu) = 0.252 kcal = 1.055 kJ	
1 kilowatt-hour (kWh) = 860 kcal = 3600 kJ = 3412 Btu	
Calorific equivalents	
One tonne of oil equivalent equals approximately:	
Heat units	10 million kilocalories
	42 gigajoules
	40 million Btu
Solid fuels	1.5 tonnes of hard coal
	3 tonnes of lignite
Gaseous fuels	See Natural gas and LNG table
Electricity	12 megawatt-hours
One million tonnes of oil produces about 4500 gigawatt-hours (=4.5 terawatt hours) of electricity in a modern power station.	

Source: British Petroleum Statistical Review, 2008

2007 KOF Index of Globalization*

	country	Globalization Index
1.	Belgium	91.96
2.	Austria	91.60
3.	Sweden	89.89
4.	United Kingdom	89.29
5.	Netherlands	89.15
6.	France	87.71
7.	Canada	87.49
8.	Switzerland	85.53
9.	Finland	84.84
10.	Czech Republic	84.46
11.	Denmark	84.27
12.	Ireland	83.09
13.	Portugal	83.06
14.	Spain	82.52
15.	Germany	82.48
16.	Singapore	82.14
17.	Hungary	81.15
18.	Australia	80.91
19.	United States	80.83
20.	Italy	80.61
21.	Poland	78.22
22.	Norway	77.75
23.	Malaysia	75.81
24.	Greece	74.94
25.	Luxembourg	74.18
26.	New Zealand	73.46
27.	Slovak Republic	72.58
28.	Estonia	72.11
29.	Israel	70.83
30.	United Arab Emirates	70.39
31.	Russian Federation	69.91
32.	Chile	69.91
33.	Croatia	69.30
34.	Slovenia	68.82
35.	Iceland	67.75
36.	Bulgaria	65.51
37.	China	65.26
38.	Korea, Rep.	64.82
39.	Jordan	64.74
40.	Japan	64.22
41.	Argentina	64.12
42.	Malta	63.78
43.	Kuwait	63.51
44.	Turkey	63.45
45.	Romania	63.34
46.	Lithuania	63.30
47.	Jamaica	62.87
48.	Cyprus	62.48
49.	South Africa	62.45
50.	Ukraine	61.83
51.	Uruguay	61.79
52.	Latvia	61.62
53.	Bahrain	60.93
54.	Brazil	59.60
55.	Philippines	59.00
56.	El Salvador	58.03
57.	Panama	57.58
58.	Peru	57.12
59.	Thailand	56.87
60.	Ghana	56.01
61.	Mexico	55.49
62.	Costa Rica	55.00
63.	Ecuador	54.50
64.	Egypt, Arab Rep.	54.18
65.	Honduras	53.99
66.	Namibia	53.79
67.	Venezuela, RB	53.75
68.	Saudi Arabia	53.69
69.	Nigeria	52.97
70.	Morocco	52.93
71.	Pakistan	52.35
72.	Colombia	52.30
73.	Tunisia	51.81
74.	Zambia	51.76
75.	Dominican Republic	51.72
76.	Oman	51.67
77.	Nicaragua	51.63
78.	Indonesia	51.31
79.	Trinidad and Tobago	50.79
80.	Paraguay	50.33

	country	Economic Globalization
1.	Luxembourg	98.49
2.	Singapore	95.14
3.	Ireland	94.88
4.	Belgium	92.33
5.	Estonia	92.05
6.	Netherlands	90.18
7.	Austria	88.65
8.	Sweden	88.52
9.	Portugal	86.81
10.	United Kingdom	86.12
11.	Bahrain	85.21
12.	Finland	84.62
13.	Czech Republic	84.46
14.	Hungary	84.34
15.	Chile	83.97
16.	France	83.95
17.	Malta	83.41
18.	Canada	83.09
19.	Israel	83.07
20.	Iceland	82.54
21.	Spain	82.36
22.	Switzerland	82.02
23.	New Zealand	81.21
24.	Italy	79.17
25.	Latvia	78.65
26.	Panama	78.38
27.	Australia	77.89
28.	Lithuania	77.29
29.	Cyprus	77.28
30.	Denmark	77.04
31.	Slovenia	76.08
32.	Trinidad and Tobago	75.58
33.	Jamaica	75.02
34.	Croatia	74.82
35.	Malaysia	74.70
36.	Greece	74.09
37.	Poland	73.64
38.	Botswana	73.43
39.	United States	73.00
40.	Germany	72.58
41.	Bulgaria	71.76
42.	Norway	70.85
43.	Slovak Republic	70.17
44.	Nicaragua	68.44
45.	Guyana	68.16
46.	El Salvador	67.46
47.	Uruguay	65.13
48.	Papua New Guinea	64.58
49.	Costa Rica	64.55
50.	Belize	63.87
51.	South Africa	63.78
52.	Turkey	63.64
53.	Oman	63.40
54.	Romania	62.18
55.	China	61.21
56.	Colombia	61.16
57.	Philippines	60.91
58.	Peru	60.73
59.	Jordan	60.38
60.	Brazil	60.16
61.	Venezuela, RB	60.16
62.	Korea, Rep.	60.12
63.	Kuwait	59.78
64.	Namibia	59.22
65.	Mexico	58.95
66.	Thailand	58.48
67.	Japan	58.36
68.	Argentina	58.30
69.	Ecuador	57.71
70.	Dominican Republic	57.43
71.	Zambia	56.46
72.	Uganda	56.29
73.	Tunisia	55.73
74.	Ghana	55.55
75.	Ukraine	55.20
76.	Russian Federation	54.96
77.	Mali	54.93
78.	Nigeria	54.50
79.	Barbados	52.46
80.	Albania	51.66

	country	Social Globalization
1.	Austria	93.10
2.	Singapore	92.49
3.	Belgium	90.66
4.	Netherlands	89.98
5.	Denmark	88.92
6.	Sweden	88.52
7.	Switzerland	88.43
8.	United Kingdom	87.88
9.	United Arab Emirates	86.91
10.	Canada	86.64
11.	Czech Republic	85.52
12.	Iceland	84.98
13.	Norway	84.64
14.	France	84.22
15.	Finland	83.91
16.	Germany	83.56
17.	Australia	82.78
18.	Kuwait	79.75
19.	Luxembourg	79.29
20.	Israel	79.28
21.	Slovak Republic	79.17
22.	Portugal	77.86
23.	United States	77.82
24.	Ireland	77.65
25.	Hungary	77.65
26.	Spain	77.59
27.	Malta	76.22
28.	Poland	74.92
29.	Estonia	73.75
30.	Italy	73.16
31.	New Zealand	73.13
32.	Bahamas, The	71.92
33.	Slovenia	71.78
34.	Saudi Arabia	71.33
35.	Cyprus	70.39
36.	Malaysia	70.36
37.	Greece	70.04
38.	Latvia	69.51
39.	Russian Federation	66.23
40.	Croatia	65.15
41.	Jamaica	64.85
42.	Costa Rica	62.29
43.	Lithuania	62.07
44.	Bahrain	61.60
45.	Mauritius	61.41
46.	Oman	59.84
47.	Jordan	58.90
48.	Ukraine	57.79
49.	Panama	57.76
50.	Fiji	55.73
51.	Bulgaria	55.04
52.	Barbados	55.02
53.	Korea, Rep.	54.67
54.	Japan	54.01
55.	El Salvador	53.99
56.	Belize	53.84
57.	Argentina	53.73
58.	Chile	53.25
59.	Uruguay	52.65
60.	Nicaragua	51.75
61.	Mexico	50.97
62.	China	50.84
63.	Romania	50.67
64.	Honduras	50.30
65.	Dominican Republic	50.26
66.	Colombia	49.69
67.	Gabon	49.18
68.	Venezuela, RB	48.70
69.	Namibia	48.57
70.	Ecuador	48.28
71.	South Africa	47.81
72.	Turkey	47.46
73.	Guatemala	47.39
74.	Ghana	46.79
75.	Morocco	46.68
76.	Trinidad and Tobago	46.67
77.	Guyana	46.35
78.	Thailand	45.92
79.	Philippines	45.74
80.	Paraguay	44.85

	country	Political Globalization
1.	France	98.06
2.	United States	96.11
3.	Russian Federation	96.04
4.	United Kingdom	95.76
5.	Canada	94.85
6.	Germany	94.61
7.	Sweden	93.82
8.	Italy	93.55
9.	Austria	93.51
10.	Belgium	93.37
11.	China	92.06
12.	Egypt, Arab Rep.	91.81
13.	India	90.24
14.	Spain	89.99
15.	Poland	89.41
16.	Denmark	87.47
17.	Argentina	87.47
18.	Japan	87.37
19.	Turkey	86.72
20.	Netherlands	86.51
21.	Finland	86.51
22.	Brazil	86.41
23.	Korea, Rep.	86.27
24.	Switzerland	86.13
25.	Nigeria	85.79
26.	Portugal	85.50
27.	Malaysia	85.39
28.	Pakistan	85.12
29.	Romania	83.57
30.	Greece	83.32
31.	Czech Republic	82.90
32.	Australia	82.35
33.	South Africa	82.12
34.	Hungary	81.88
35.	Jordan	79.37
36.	Morocco	77.88
37.	Indonesia	77.48
38.	Norway	77.19
39.	Ukraine	76.97
40.	Kenya	75.90
41.	Philippines	75.87
42.	Algeria	75.61
43.	Senegal	75.52
44.	Chile	74.91
45.	Ireland	74.76
46.	Tunisia	74.02
47.	Peru	73.36
48.	Bulgaria	72.27
49.	Thailand	70.75
50.	Uruguay	70.59
51.	Bangladesh	70.59
52.	Ghana	70.20
53.	Croatia	67.77
54.	Slovak Republic	66.20
55.	Iran, Islamic Rep.	63.85
56.	New Zealand	63.19
57.	Zambia	62.92
58.	Bolivia	62.48
59.	Sri Lanka	60.99
60.	Cote d'Ivoire	60.31
61.	Tanzania	59.91
62.	Ecuador	59.20
63.	Cameroon	57.90
64.	Mexico	57.33
65.	Paraguay	57.26
66.	Nepal	56.69
67.	Benin	56.29
68.	Guatemala	55.93
69.	Slovenia	54.42
70.	Niger	53.94
71.	Namibia	53.92
72.	Venezuela, RB	52.28
73.	Mali	52.22
74.	El Salvador	50.92
75.	Congo, Dem. Rep.	49.49
76.	Singapore	48.92
77.	Togo	48.26
78.	Saudi Arabia	47.87
79.	Dominican Republic	45.98
80.	Lithuania	45.72

Source: Axel Dreher (2007)