7 PETROLEUM ECONOMICS

LEARNING OBJECTIVE

After studying this chapter, you should be able to:

- Understand the concepts of petroleum economics
- Discuss the framework of petroleum economics
- Explain the business indicators of petroleum projects
- Describe the risk in petroleum economics
- Explore about the contribution of petroleum industry
- Learn about the crude oil demand and supply
- Describe the upstream petroleum industry
- Understand the midstream petroleum industry
- Discuss the downstream petroleum industry
- Understand the concepts of petro-retailing
- Learn about the future of petroleum
- Explore about the future of petroleum

KEY TERMS

This chapter features these terms which you should strive to do more research about:

Concessionary System	Bonus	Surface Fees
Royalty	Contractual System	Net Cash Flow (NCF)
Discounted Cash Flow	Net Present Value	Internal Rate of Return
Payback Period	Geological Risk	Facilities Risk
Political Risk	Economic Risk	Partner Risk
Industry Risk	Expected Monetary Value	Liquefied Petroleum Gas
Kerosene	Jet Fuel	Furnace Oil
Paraffins	Napthenes	Aromatics
Asphaltics	West Texas Intermediate	Brent Crude
Dubai Crude	Minas	Tapis
Bonny Light	Isthmus-34 Light	Field-by-Field Analysis
Oil Sands Mining	Oil Sands Surface Mining	Tailings

INTRODUCTION TO PETROLEUM ECONOMICS

Basically, there is an opportunity to profit. Companies are formed to exploit reserves, they perform due diligence, take into account risks and make a decision on whether or not to drill and produce. Investment can come from venture capital companies, private investment or equity raising. Petroleum products can be sold in several different markets such as options, futures contracts or directly through shares of a company.

Since 1900, the use of petroleum products has gone from 5% to 60% of market share of total energy products. The cause for this growth stems from several areas:

- Petroleum industry was incredibly successful at finding and manufacturing fuel
- Fluids are easier to handle than solids
- The advent of the internal combustion engine
- Economies of scale reduced the price of oil comparatively to other fuels
- Economic and military systems became progressively dependent
- Finally, one of the biggest influences has been the astronomical growth of motor vehicles – cars.

There has been an increase in both quantity and geographical diversity of oil. USA and Russia dominated the market in the early 20th Century accounting for 95% of oil on the market supplying around half a million barrels per day.

USA started gaining the majority of the market share in 1945 with 65% of oil supplied on the market. The total supply of oil had grown to seven millions barrels per day at this stage in history. Oil production continued at a rampant rate up until the 1970s to a rate of 65 million barrels per day due to massive discoveries in the Middle East.

Making the decision to invest in petroleum exploration and production projects is always a very complicated endeavor. These projects are impacted by many high risk factors associated with the petroleum industry, such as relatively high initial investment requirements, long term investment horizons (projects may take up to 20 years or more) and negative cash flow during the first few years, sometimes also during the last years of the project life. These factors, coupled with dangerously volatile price levels, makes the number of uncertainties in the data utilized in decision making to invest in petroleum projects very high, and this therefore weighs heavily on the minds of decision makers.

Most petroleum companies make the decision to invest in a certain petroleum project based on economic models, which are constructed as spreadsheets prepared by internal economists in the company or by external experts based on data available from different sources (such as petroleum engineers, geologists etc.). As a result, each petroleum company has developed its own economics model. These models are characterized by unclear definitions of input variables and the way they are related to the output parameters.

Therefore, to improve the decision making process in petroleum projects and to be able to face modern challenges, it is imperative to develop a robust solution to the petroleum economics model and the associated risks. The main objective of this dissertation is to introduce a unified framework to deal with this problem through the achievement of the following topics:

- Develop the characteristics of petroleum exploration and produce reliable project economics models.
- Determine, clearly and uniformly, the variables of the economics of petroleum projects. Include all relevant cost and revenue variables, their mathematical treatment and functional correlations.
- Develop a generalized economics model that can reflect the detailed and vast economics aspects of petroleum exploration and production projects including flexibility in fiscal regimes.
- Manage uncertainty of the data in the designed model, not only by the use of Monte Carlo simulation (as common in petroleum industry), but by applying some necessary complementary methods, i.e. fuzzy logic and probability theory.

FRAMEWORK OF PETROLEUM ECONOMICS

Life Cycle of Petroleum Projects

A successful petroleum project typically passes through six phases, as shown in below figure:

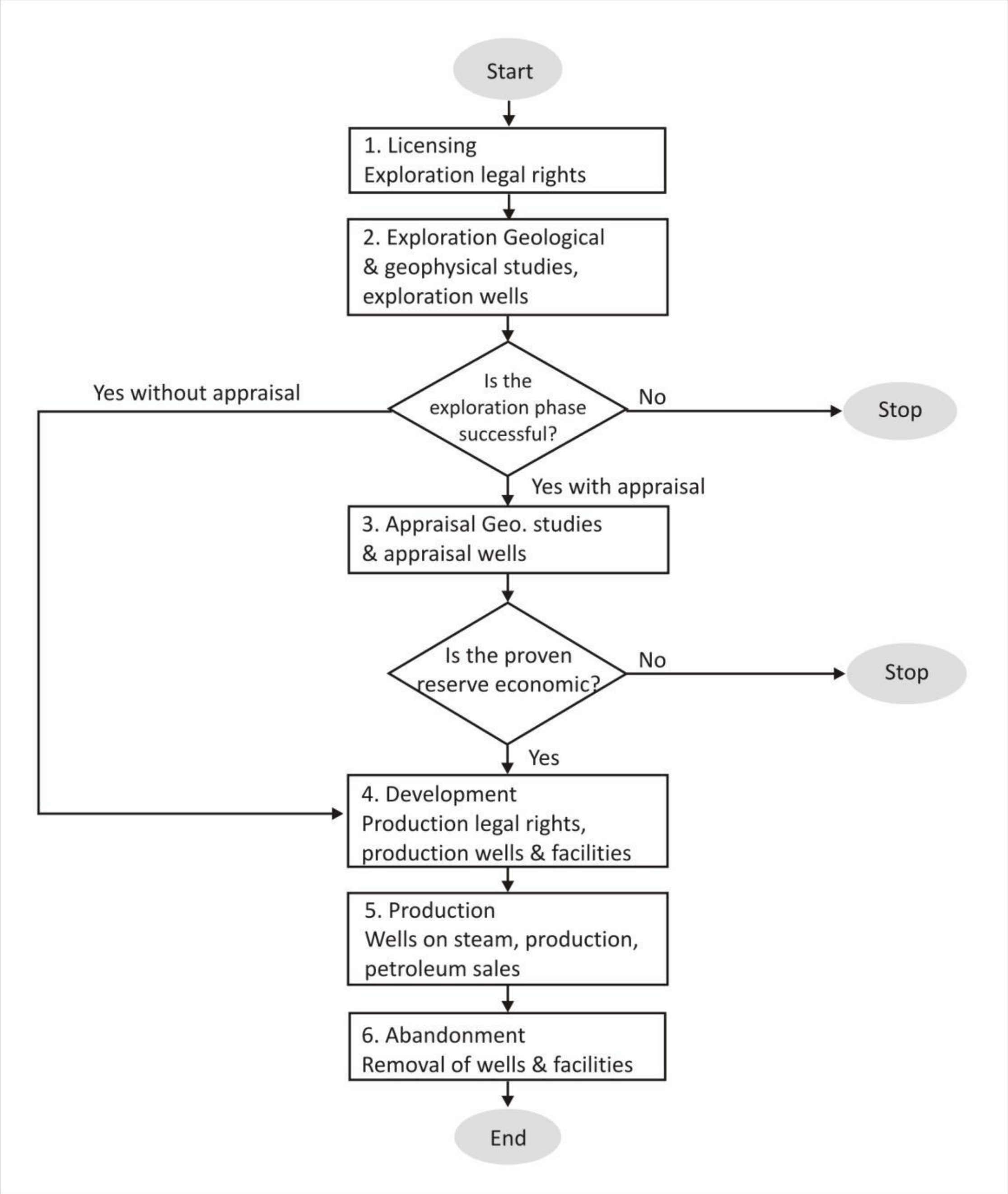

Figure 7.1: Life Cycle of Petroleum Projects

The first phase of the petroleum project is the **licensing phase.** Here, the petroleum company receives legal rights from the host government to explore petroleum in a specific area.

The second phase is the **exploration phase**, which aims to proof the existence of petroleum within the granted exploration license. In order to achieve this, several geological and geophysical studies are made and the collected data are analyzed and interpreted. If the likelihood of a sufficient quantity of petroleum is acceptable, one or more exploration wells will be drilled. If the wells are unsuccessful, the project will be stopped.

In case of successful exploration efforts, the **appraisal phase** begins with more geological studies and sometimes additional wells (appraisal wells), to be drilled in order to enhance the level of confidence in the volume of petroleum and the profitability of the project. If the discovered quantity of petroleum is economic, the decision will be made to proceed with the next phase.

The fourth phase is the **development phase.** Here, a field development plan is formulated and evidence on the technical and economic feasibility of the project is provided. On application by the petroleum company the exploration license will be converted to a production license by the government.

Then the development plan will be realized, the production wells will be drilled and the production facilities implemented. The development phase represents the phase of highest cost during the entire project life.

Once the production wells are completed and the facilities are commissioned, the fifth phase starts, the production phase. The production phase itself passes through three sub-stages as shown in below figure.

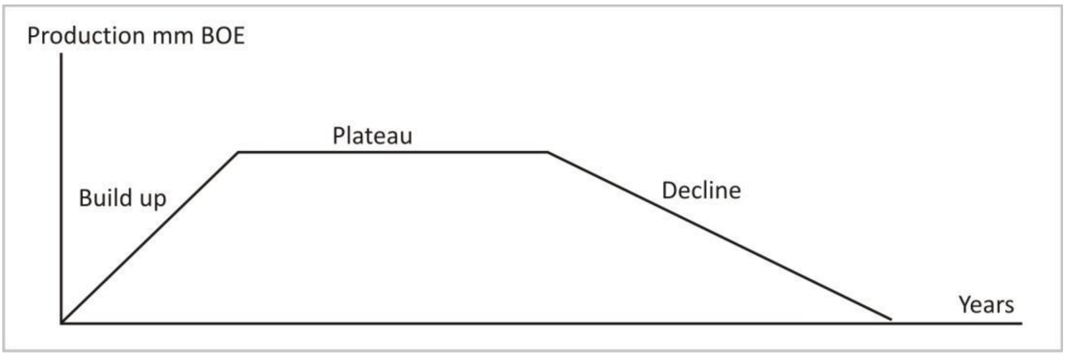

Figure 7.2: Typical Petroleum Production Curve

- ***Build up Stage:*** During this stage the wells are progressively brought on stream, which means that the production rises at a relatively constant rate until it reaches an anticipated level of production, when all wells are on stream.
- ***Plateau Stage:*** During this stage the production rate remains steady. The duration of the plateau phase may be difficult to estimate, especially for large fields with long production periods.
- ***Decline Stage:*** During this stage the production rate declines. This stage lasts longer than other stages of production.
- The sixth phase, the final phase in the petroleum project life, is the abandonment phase. This phase starts at the point when the revenue of the project no longer covers operating costs.

However, preparations for the abandonment phase usually start earlier than the actual year of abandonment.

Petroleum Exploration and Production Investment Rights

Petroleum resources are usually owned by governments and rarely by individual people such as in the case of private ownership of petroleum e.g. by farmers and landowners in the United States of America. Usually the governments (the so-called host governments) establish a national petroleum company to search for petroleum and to develop it. But due to the high risks and the expensive nature of investment in petroleum exploration and production the national oil company often requires help from international oil companies, the so called contractors. The contractors have the necessary capabilities and staff to search for petroleum and to extract it.

The host governments use licensing systems to distribute the exploration and production investment rights to the contactors. According to the licensing systems can be classified in two groups; open-door systems where interested contractors are allowed to submit a proposal with respect to specific areas at any time (mostly annual or bi-annual) and licensing rounds held as an auction or administrative process based on a set of criteria provided by the host governments.

Within all systems; a negotiation process starts between the contractor and the national petroleum company based on the petroleum law in the project country. The petroleum law usually defines the petroleum policy of the host government, the terms of petroleum contracts and the fiscal tools the government uses to capture an appropriate reward from the country's petroleum resources.

After negotiations, the host government signs a contract with the contractor. This contract organizes the relationship between the host government and the contractor. When the contractor includes a number of companies (partners), then the joint venture (group or consortium) between them is formalized by means of a so called joint operating agreement (JOA).

Contract Types of Petroleum Exploration and Production

Due to the negotiation of contract terms between the contractor and the host government, in a number of petroleum countries in the world, certain flexibility in petroleum contract types exists. Thus, a contract may have different terms compared to another contract in the same country. However, according to the ownership type of the petroleum resources, petroleum contracts are generally classified into two basic systems: Concessionary and contractual.

Concessionary System

The concessionary system or so-called royalty/tax system was the first system used in world petroleum contracting and it is used currently by around half of the petroleum producing countries worldwide, including the US, UK, France, Norway, Canada, Australia, New Zealand, Libya, and South Africa.

According to a concessionary contract, the host government transfers ownership of the petroleum resource to the contractor. The contractor pays all exploration, development and operating costs, so the government does not bear any risk during the project. Therefore a contractor gets the total petroleum production but he makes different types of payments which are identified in the laws and regulations of the host government.

The host government makes profit from the petroleum project under a concessionary contract by using one of the following fiscal tools:

- ***Bonus:*** A bonus is paid when predetermined events happen. For example, a signature bonus is paid by a contractor when a contract is signed or an exploration license is granted. A production bonus is paid when production is starting or a certain production level is reached in a field. In some countries these bonuses are deductible for tax purposes, whereas in others they are not.
- ***Surface Fees:*** The contractor may be required to pay annual surface fees to the host government, either in the exploration phase or/and in the production phase, based on the area over which the project extends.
- ***Royalty:*** A royalty is one of the most commonly used fiscal tools worldwide. It represents an amount paid by the contractor to the host government in cash or in kind. Royalties paid to a private party other than to a host government are called overriding royalties. Calculation principles are the same for both, the difference is only in who receives the payment. The implementation of a royalty rate differs from host government to host government. Some use a flat royalty rate while others use variable royalty rates. These variable rates can be calculated depending upon yearly production, cumulative production, petroleum price, or price and production together, etc.
- ***Tax on Profit:*** The contractor is subject to the profit tax laws in the investment country, in addition to other taxes such as those applied to export and import of the commodity. If the tax losses from one contract are used to offset the taxable profit of another contract in the same country, then the tax system used in this country is called tax consolidation or ring-fencing.

Contractual System

In the contractual system the host government retains the ownership rights on the petroleum and shares the petroleum production with the contractor in kind or in cash. The contractual system itself could be classified into production sharing contracts and service contracts.

Production Sharing Contracts

The first production sharing contract was established in Indonesia in 1950. This type of contract later became the prevalent contract type worldwide. In both the contractor and concessionary systems the contractor bears the risk of the investment and covers all financing issues, as well as carrying out all petroleum operations.

In exchange, the contractor gets an amount of petroleum for recovery of costs as well as an amount of petroleum which represents a share of the profits. The host government gets a share of the petroleum in addition to other fiscal tools, such as royalty and fees. The main fiscal tools to share the profit between the host government and the contractor (based on the production sharing contract) can be summarized as follows:

- ***Bonus:*** The basic concept of a bonus is similar in all contract types
- ***Royalty:*** The basic concept of a royalty is similar in all contract types
- ***Cost Recovery (Cost Petroleum):*** The contractor has the right to recover his costs by an appropriate proportion. Sometimes the cost recovery is restricted to a certain upper bound of the annual production, and this is called the cost recovery limit. When the revocable cost is not recovered in the year of occurrence due to the cost recovery limit, then it is generally allowed to be recovered in the following years.
- ***Sharing of Production (Profit Petroleum):*** Profit petroleum represents the part of the petroleum left after deduction of cost recovery and royalties. There are many ways to share this profit between the host government and the contractor. For example, profit of petroleum is split based on a fixed rate, or based on variable rates according to the daily production rate or cumulative production or production price etc.
- ***Tax:*** The tax on profit is calculated based on the remaining petroleum production after profit sharing, or is based on the contractor’s profit share. In some production sharing contracts the national oil company pays the profit tax on behalf of the contractor in order to encourage petroleum investments in the host government.

Service Contracts

Under a service contract, the contractor finances and carries out petroleum operations and receives fixed or variable fees for these services. This fee is generally paid in cash. Additionally, the contractor recovers his costs from the total revenue and pays taxes according to the tax laws in the host government.

As example of a service contract, a simplified Iranian service contract is shown in below figure.

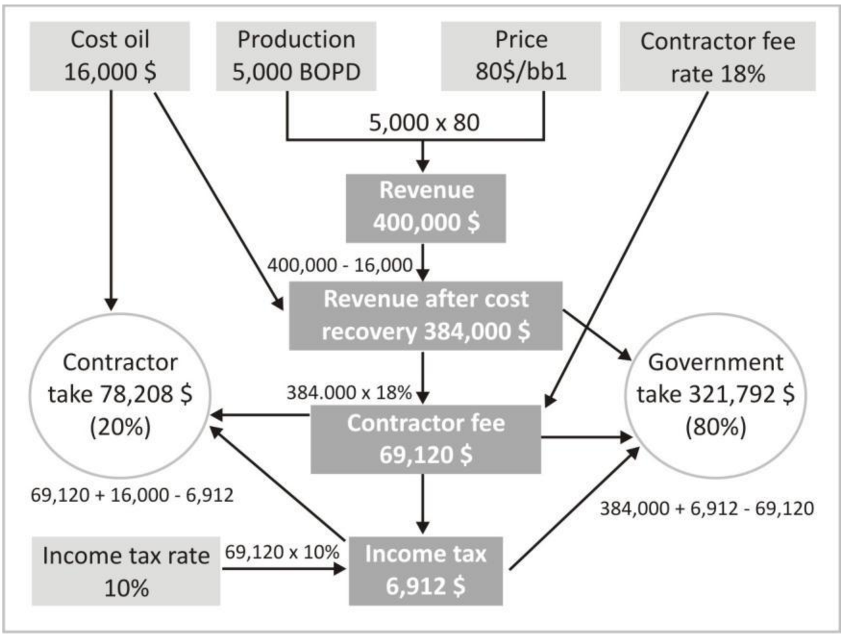

Figure 7.3: Iranian Simplified Service Contract based on one day Production

BUSINESS INDICATORS OF PETROLEUM PROJECTS

Key business indicators of petroleum projects present tools utilized in the improvement of the decision making process. The most common used indicators for evaluation of petroleum projects are net cash flow; discounted cash flow; net present value; internal rate of return and payback period.

Net Cash Flow (NCF)

The net cash flow of a project is defined as the cash remaining after covering all the expenses during one year or one period. In order to express the annual NCF associated with a petroleum project, the cash disbursements should be subtracted from cash receipts for the given period.

NCF = Cash Inflows (Revenue) – Cash Outflows (Cost)

Babusiaux & Pierru classified net cash flow as net cash flow before tax payments and net cash flow after tax payments; also operating cash flow generated only from petroleum sales and associated costs and other net cash flow generated from other unusual cash inflows or outflows such as asset sales or wastage.

A negative cash flow for one year is not necessarily bad for the total investment; it could mean that the company makes a large investment at this period which earns a high return later. For example, the first years of the petroleum project where a lot of money is paid for exploration and development but no reward is achieved.

To build the net cash flow, equation information is required from different sources. This information is summarized in below table.

Information Resources	Information Type
Petroleum Engineering	• Production Profiles • Reserves Type
Drilling Engineering	• Drilling and Completion Cost
Facilities Engineering	• Facilities Cost
Operating & Maintenance Engineering	• Operating Cost • Maintenance Cost
Human Resources	• Manpower Types and Numbers • Manpower Cost
Host Government	• Fiscal System (Tax, Royalty, etc.)
Corporate Planning	• Forecasts of oil and gas prices • Discount Rate, Inflation Rate, Exchange Rate, etc.

Revenues

Revenue arises from petroleum production sales (oil, gas or condensate) in addition to other activities such as money received from asset sales or interest on the provisions (abandonment, depreciation and others).

In order to calculate the revenue from petroleum sales, the prices should be predicted. For each project the price forecasts should be chosen depending on the expertise of the economist. Some choose a flat real price forecast; others choose flat rate money of the day price forecast etc. According to Jahn et al. (2008) – *"one can say that the petroleum industry analyses so far have been very bad at predicting future petroleum prices."*

Costs

In order to produce the petroleum there are two main types of costs: fiscal costs and field costs, which can be classified into four elements: exploration costs, development costs, operating costs and abandonment costs.

Exploration and development costs together are termed CAPEX, while the operating cost is called OPEX. The abandonment cost is considered to be a special category of cost because it is associated with environmental safety and does not produce any future profit for the company. It is also a very large cost component, and could be equal to or more than the development cost.

The allocation of field cost (CAPEX, OPEX) into elements differs from company to company, due to the variable nature of petroleum projects (e.g. different reservoir types) and the fiscal regime applied in the project (e.g. some host governments determine the cost which will be capitalized and the cost which will be depleted). By comparing several studies, for example it can be demonstrated in below figure how the field cost is classified.

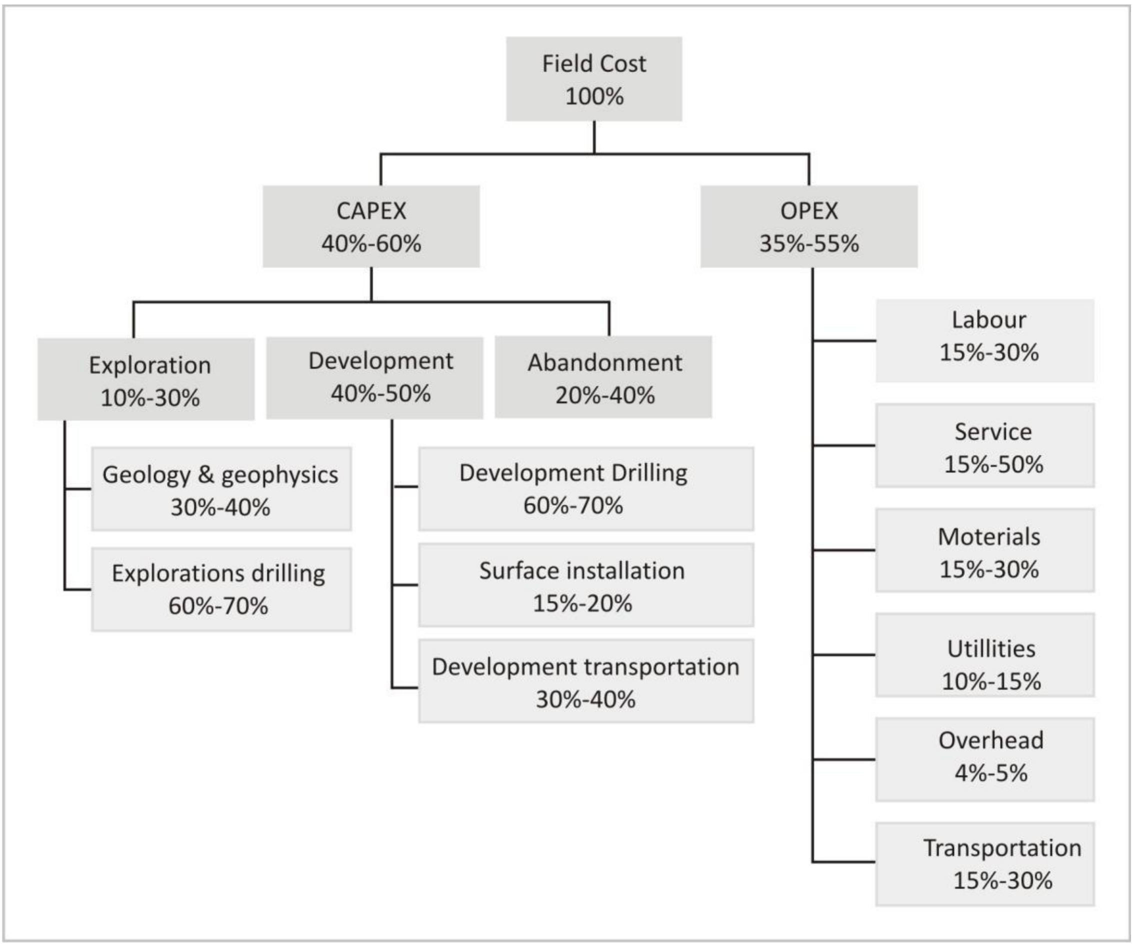

Figure 7.4: Structure of the Field Cost

Capital cost account for a minimum of 40% up to a maximum of 60% of field cost while the operating cost account for a minimum of 35% up to a maximum of 55%. The environmental nature of the project area plays a major role in determining the contribution of capital cost to the total cost.

For example, offshore petroleum projects require more equipment and facilities than onshore projects, and therefore the capital cost could account for up to 60% of the total cost. There is also an inverse relationship between the contribution of the cost of labor, materials and utilities and the contribution of operating service contracts cost.

Discounted Cash Flow

Discounted cash flow is a technique which translates the time value of money by discounting the future cash flow to a present value reference. The discounted cash flow (**DCF_a**) in the end of the year **a** is given as:

$$DCF_a = \frac{NCF_a}{(1+i)^a}$$

Where

NCF_a: Net cash flow at the end of year **a**

i: The discount rate

a: Number of the year **a** = 0,1,2…A

The above equation assumes that the cash flow has occurred at the end of the year. In reality cash flow transactions take place continuously or at least monthly. To deal with this fact, some economists use the mid-year discounted cash flow which is given as:

$$DCF_a = \frac{NCF_a}{(1+i)^{a-0,5}}$$

The discount cash flow at either end of year or mid-year is a significant key business indicator because it presents the base of calculation for other indicators.

Net Present Value

The net present value (NPV) value is the algebraic sum of discounted annual cash flows associated with the project. The NPV is given as:

$$NPV = \sum_{a=0}^{A} \frac{NCF_a}{(1+i)^a}$$

Where

NCF_a = Net cash flow at the end of year a

i: The discount rate

a: Number of the year a = 0,1,2…….A

When the NPV of an investment at a certain discount rate is positive, the project is acceptable. By evaluating mutually exclusive projects, the project with the highest NPV should be accepted.

A negative NPV indicates that the investment is not generating any earnings and the project should be rejected. If the NPV is zero, then the decision maker will be undecided because the investment is generating the same return as the alternative use of the money. The decision should then be based on other criteria, e.g. the degree of risk associated with each project.

The choice of a discount rate to be used to calculate the net present value is a matter of corporate policy. Some companies prefer a fixed discount rate over the project lifetime while other companies use a declining discount rate. However, there are some methods which can be used to determine the appropriate discount rate for a project, such as the weighted average cost of capital (WACC) method, which is one of the most commonly used methods. In order to finance new projects or assets, a debt or equity can be used. The weighted average cost of capital of a company is the average cost of both of these sources of financing weighted by their individual use, and is given as follows:

WACC = EF.CE + DF.CD(1-ETR)

Where

WACC: Weighted average cost of capital (%)

EF: Percentage equity financing (%)

CE: Cost of equity

DF: Percentage debt financing

CD: Cost of debt

ETR: Effective tax rate

Internal Rate of Return

The internal rate of return of a project is the value of the discount rate which equates the project's NPV to zero.

$$0 = \sum_{a=0}^{A} \frac{NCF_a}{(1+IRR)^a}$$

If the IRR is greater than the weighted average cost of capital then the NPV is positive, and if the IRR is less than the weighted average cost of capital then the NPV is negative. The NPV is equal to zero when the IRR is equal to the weighted average cost of capital.

Sometimes when a petroleum project has a nonconventional cash flow (negative, positive, negative) a dual rate of return may occur. In this case the IRR is a mix of rate of return and rate of reinvestment; other economic indicators must therefore be used to make investment decisions.

Payback Period

The payback of a project identifies the expected number of years which the company needs to recover its project investments. At this point, the cumulative net cash flow is equal to the total investment. The payback can be defined by using the following equation

$$\sum_{a=0}^{b} NCF_a \geq 0$$

Where b represents the payback point at which the cumulative net cash flow is positive for the first time in the project life.

When the project achieves a payback point, in principle it will then be a worthwhile investment. When evaluating mutually exclusive projects, short payback points are preferred over long ones. It is worth mentioning that the payback period alone cannot be used to make investment decisions because it does not take into account the cash flow after the recover point. However, it is a useful indicator to be used with other indicators to determine if the project is a favorable investment opportunity.

RISK IN PETROLEUM ECONOMICS

Risk Factors

Investments in the petroleum industry are made under significant risk circumstances, due to the nature of the exploration and production process. The volatility of petroleum prices also adds a high degree of risk to petroleum investments. These risk factors are the major reason which makes economic data imprecise for project evaluation. Generally, the risk factors are classified into geological risk factors and industry risk factors.

Geological Risk Factors

Geological risk factors play an important role in the exploration phase of a petroleum project. The key to success in this phase is the presence of an acceptable likelihood of commercial petroleum, which is based on the existence of four geological factors: presence of sufficient and mature source rock, presence and quality of reservoir rock, presence of a trap, appropriate timing of trap formation, migration and retention of hydrocarbons. These factors represent the most important geological risk factors in exploration, and become less important in the development and production phases.

Geological risk is the uncertainty due to incomplete data sets that are an intrinsic part of exploiting unseen reserves subsurface. We must make our best estimations and predictions about formations and pay areas. These predictions involve uncertainties that relate to material risk.

Facilities Risk

The materials used to transport and house the migration of petroleum products from reservoir to refining facilities must tolerate corrosive fluids and harsh environments. There is risk that these facilities may be damaged through a project life cycle resulting in loss of produced materials and loss of money.

Political Risk

Political risk arises from uncertainty in nations with regards to their rules, laws or legislation. If there is a change to a contract this can have a significant impact on the projected profitability of a project.

Economic Risk

Oil and gas as a commodity is incredibly volatile – and I mean that in a financial sense. In the past 10 years 2005 – 2015 we have seen the price of a barrel of oil rise from $50 to $150 down to $40 in 2009 back up to $120 and most recently down to $45 in 2015. This increases risk as with any financial instrument: the greater the volatility, the greater the uncertainty. Companies are also exposed to inflation and exchange rate fluctuations.

Partner Risk

Finally, partner risk arises from operations where two companies are involved, typically from joint ventures. Two companies may choose to work together to exploit a reservoir because of complimentary services or economies of scale.

Industry Risk Factors

Industry risk factors affect the exploration phase in addition to development and production phases. However the degree of impact may be higher in the final two phases. These factors include the location risk factor (infrastructure, environment, logistics etc.), technology risk factor (available technology, new technology), fiscal and political risk factors (stable or unpredictable) and business risk factors (petroleum prices, cost and the global economic situation).

Expected Monetary Value

Expected monetary value (EMV) is a technique to formulate the key business indicators (NPV or NCF), taking into account the probability of project success in order to deal with the risks surrounding the project. In general the EMV is given as:

EMV = Reward.POS – RiskedCost(1-POS)

Where,

Reward: Denotes net present value or the net cash flow.

POS: Probability of success

Risked Cost: Risked cost is the cost which the project could lose in the case of project failure. If the net present value represents the Reward then the discount risked cost must be used.

It is to be noted that the expected monetary value can be calculated for each phase in the life of a petroleum project, and it can then be used to draw a decision tree in order to improve the decision making process. If the EMV is positive then the project can be continued; otherwise the project should be terminated. By evaluating mutually exclusive projects, the project with the highest EMV should be accepted.

CONTRIBUTION OF PETROLEUM INDUSTRY

The petroleum industry is include the global processes of extraction, exploration, refining, transporting (often by pipelines and oil tankers), and marketing petroleum products.

The largest volume products of the industry are gasoline (petrol) and fuel oil. Petroleum (oil) is also the raw material for many chemical products, including solvents, pharmaceuticals, pesticides, fertilizers, and plastics.

The origin of the Indian oil & gas industry can be traced back to the late 19th century, when oil was first struck at Digboi in Assam in 1889. In view of the significance of the gas & oil sector for overall economic growth, the Government of India announced in 1954 that petroleum would be the core sector industry.

1954, petroleum exploration & production activity was controlled by the government-owned National Oil Companies (NOCs), namely Oil India Private Ltd (OIL) and Oil & Natural Gas Corporation (ONGC).India's refining capacity has more than trebled in the last 13 years. Reliance Industry is the first refinery industry in Jamnagar in 1999, India has an installed capacity of around 193.5 million tpa in April, 2011.

The growth is likely to continue with refining capacities expected to touch 255 million tpa by 2012-13 and 302 million tpa by 2017-18, with a slew of projects announced by both the private and public sector. Today, private sector accounts for 76.5 million tpa (around 39.5 per cent) and public sector oil companies account for close to 117 million tpa (around 60.5 per cent).

India is the 3rd largest energy and oil consumer in the world after China and the US. Oil and gas occupied approximately 35% share in India's energy consumption.

India is the fourth largest importer of liquefied natural gas (LNG) after Japan, South Korea, and China, accounting for 7.4% of the total global trade.

Import of crude oil during April-November 2017 stood at 144.7 MMT valued at approximately $ 51.1 bn, marking an increase of 9.31% in quantity terms and 15.3% in value terms compared to the same period of last year.

While, imports of petroleum products during April-November 2017 were 23.76 MMT valued at approximately $ 7.9 bn, which shows a decrease of 4.91% in quantity terms but an increase of 21% in value terms compared to the corresponding period of previous year.

- The demand for petroleum products is estimated to reach 244,960 MT by 2021-22
- India aims to reduce oil and gas imports dependence from 77 % to 67% by 2022
- Gas production will likely touch 90 bn cubic meters by 2040
- 100% FDI allowed in exploration activities of oil and natural gas fields under automatic route 49% FDI allowed in petroleum refining by the Public Sector Undertakings (PSU), without any disinvestment or dilution of domestic equity in the existing PSUs under automatic route

India has emerged as a Refinery Hub

India's current refining capacity stands at 247.5 MMPTA, comprising of 23 refineries – 18 under public sector, 3 under private sector and 2 in a joint venture. Indian Oil Corporation (IOC) is the largest domestic refiner with a capacity of 69.2 MMTPA. Top three companies – IOC, Bharat Petroleum Corporation (BPCL) and Reliance Industries (RIL) contribute around 65.5% of India's total refining capacity.

India has witnessed a steady increase in production as well as consumption of petroleum products over the years. The production of petroleum products stood at 231.9 MMT during 2016-17, 243.6 MMT during 2017-18 and is expected to reach 254.4 during 2019-20. While, consumption of petroleum products stood at 184.7 MMT in 2016-17, 194.6 MMT in 2017-18 and is expected to be 204.9 MMT in 2019-20.

The production of crude oil stood at 36.9 MMT during 2016-17, 36 MMT during 2017-18 and is expected to be 37.4 in 2019-20.

Product Profile

This section provides a brief description of the technology and production process. An understanding of these issues is critical as it helps understand industry structure.

Crude oil is a liquid mixture of hydrocarbons chemical compounds consisting roughly of six parts of carbon and one of hydrogen, both of which are fuels; it generally also carries small quantities of salts sulphur, oxygen, metals and nitrogen.

The principal products obtained from the crude oil are:-

- ***Petrol:*** Petrol is used to fuel internal combustion engines, mainly vehicular. It is early use as a killer of lice and their eggs has completely disappeared.
- ***Liquefied Petroleum Gas (LPG):*** LPG is mostly a combination of propane and butane. It is heavier than air, and liquefies under pressure. It is used as a household cooking fuel, vehicular fuel and refrigerant; 4 million vehicles are estimated to be powered by LPG in the world.
- ***Kerosene:*** Kerosene is also known as paraffin, is used as an illuminant and cooking fuel in India and other poor countries, and as a space heating fuel in industrial countries.
- ***Jet Fuel:*** It is used in jet planes, is closely akin to kerosene.
- ***Naphtha:*** Naphtha is used to make additives for high-octane petrol, and to make polymeric plastics and urea, a nitrogenous fertilizer.
- ***Lubricating Oil:*** It is consists of greases and viscous oils used to lubricate moving parts in automobiles, industry, railway engines and carriages and marine engines.
- ***Petroleum Coke:*** It is mostly used as fuel, but is also used to make dry cell batteries and electrodes.
- ***High-speed Diesel Oil:*** It is used in engines running at 750 revolutions per minute (rpm) or more. It is mostly used in diesel-powered vehicles.
- ***Light Diesel:*** It is used in the diesel engines running at lower speed – mainly irrigation pumps and generation sets.
- ***Furnace Oil:*** It is made by diluting residual fuel oil from refining with middle distillates such as diesel oil. It is used in bunkers, boilers, furnaces, heaters, or as fertilizer feedstock.

Uniqueness of Petroleum Industry

The petroleum industry is such an industry which has the largest earning capacity. The various petroleum products are diversified in a very wide range. The main functional areas of this industry are extraction of crude, refining of crude, processing and transporting. The main problem faced by the entire petroleum industry is the pollution problem.

The refining of crude oil creates huge pollution by producing various harmful gases. Another problem is of drilling mud. When the drilling work is done a huge amount of crude, water, soil mixture gets wasted. Here innovative and upgraded technology is required to minimize the wastage of petroleum.

The leakage and drainage problems are also one of the major barriers in case of refinery work. Good piping technology and proper drainage system is also very essential in this industry. One thing we must appreciate that India has very limited production of petroleum in comparison with demand scenario. In this condition the wastage is a critical issue which must be addressed properly.

No of Players

For India the corresponding body with the responsibility of exploration, production of oil and natural gases, their refining, distribution, marketing, import, export and conservation of various petroleum products and natural gases is the "Ministry of Petroleum & Natural Gas".

There are various public sector and other organizations under the ministry of petroleum & natural gas that are mainly responsible for all the above mentioned functions. These are listed below. These are the main players in this industry. For all the organizations The Government of India also has respective shares which are also listed below.

S.No.	Name of Organization	Government of India Share
1	Oil and Natural Gas Corporation Ltd. (ONGC)	74.14%
2	Indian Oil Corporation Ltd. (IOC)	78.92%
3	Hindustan Petroleum Corporation Ltd. (HPCL)	51.11%
4	Bharat Petroleum Corporation Ltd. (BPCL)	54.93%
5	GAIL (India) Ltd.	57.34%
6	Engineers India Ltd.	90.40%
7	Oil India Ltd.	98.13%
8	Biecoo Lawrie & Co. Ltd.	57.13%
9	Balmer Lawrie & Co. Ltd.	59.67%

Performance of Petroleum & Natural Gas Sector

The efficient and reliable energy supplies take very important role for maintaining a good growth level of the Indian Economy. The petroleum and natural gas takes a very vital role in this energy generation. The share of oil and gas in the energy consumption is about 45%.The entire picture will be clearer after analyzing the statistics of crude oil and natural gas production.

Crude Oil Production

The crude oil production in 1981 was 258.36 lakh tonnes. The growth story started and in 2001 it reached a production of more than 1000 lakh tonnes. This particular year witnessed a growth of 20.33%. Once again in the year 2007 the growth was 12.64% with a total production of 1465.51 lakh tonnes. In last two years we witnessed a comparatively lesser growth. In last year i.e. 2017 the total production was 1607.72 lakh tonnes with a growth of 2.99% over the year 2016. The constant increase of the green line in the production column shows the constant improvement of the crude oil production.

Natural Gas Production

During 2008-2009 natural gas production was 32.85 billion cubic meters (BCM) and for this period the target was 36.94 BCM. The data shows that there is an achievement of 89% of the target. For the next fiscal year the targeted production is 52.116 BCM, an increase of 15.176 BCM. The ministry of petroleum also forecast that the natural gas production will be doubled by the end of 12th Five Year Plan.

Production and Consumption of Petroleum Products

Presently the production of petroleum products is 152.68 million metric ton (MMT). There is an increase of 3.87% than of the last fiscal year's data. Currently the consumption is 133.400 MMT there is also a growth of 3.45% in case of consumption.

Import of Crude Oil

Financial year 2017-18 shows that import of crude oil has been 128.16 MMT. In last financial year the import was about 121.672 MMT. This shows an increase of 5.33% in quantity terms. Further analysis of the import data shows that the total growth of import of crude oil is 63% starting form 2001-02 and continuing up to 2018-19. In value terms total import of crude oil in 2017-18 was valued at Rs. 3,41,887 crore. This figure for the financial year 2016-17 was Rs. 2,72,699 crore. The increase is of 25.37%.

Key Issues in Petroleum Industries

The global economy is a dynamic and ever-growing one in spite of the high cost of energy. This in turn is forging the demand for petrochemicals. The strong growth in demand is not backed by a sufficient supply so the cost is still to come down. Operating rates of major petrochemical product segments are very high presently.

Problems faced by the India petrochemical industry:

- The manufacturing units mostly use outdated format of technology and are not able to produce optimally
- There is a requirement for the modernization of equipment
- Excise duty on synthetic fiber should be rationalized
- Anticipation of reservation on Small Scale Units
- Plastic waste to be recycled and the littering habits to be discouraged
- India requires advantage on feedstock, so the import cost has to be brought down
- The industry should have access to the primary amenities of infrastructure

One of the big issues is the difficulty in predicting the advance price, which will succeed in the market in the future months. Some indications are of course available with the futures prices prevailing in the exchanges. Some companies hedge their margins or crude prices by doing paper trading. The forward price is a vital input in the optimization process and can actually make the model for a particular product maximization based on its price.

Current Trends in Petroleum Industry

Petroleum has proven to be the most flexible fuel source ever discovered, situated at the core of the modern industrial economy. While the industry is strong, it is subject to some very significant stresses:

- Industry consolidation
- Global industrial expansion resulting in increased petroleum demand
- Tight supplies of economically extractable oil
- Political instability and terrorism
- High per-barrel price that accelerates development of alternative energies
- Safety and the need to protect workers in “hostile” environments
- Speed required establishing a presence in new markets
- Need to spread infrastructure risk among competitors

These stressors are causing oil companies to change the way they do business. From their cooperation with competitors to their massive investments in technology, from a renewed focus on safety and the environment to serious investigation of alternative fuels, these firms are reshaping the industry on:

- How they manage these changes and influences?
- How they view their real estate holdings?
- How they house the scientists and engineers who play a vital role in this transformation?

The challenges oil and gas companies face are having a significant impact on how they view their real estate holdings and what kind of workplaces they provide their employees. These are important issues since many companies in this sector have vast real estate holdings.

More and more these companies are managing these holdings from an enterprise-wide perspective, running their facilities like any other part of the business. They are realizing that facilities and furnishings can be a strategic tool for achieving the organization's business goals. That focus has several implications for the workplace.

Petroleum includes all petroleum-based products, such as gasoline, oil, diesel fuel, kerosene, refined cleaners, and solvents. Organizations involved in upstream (exploring and extracting) and downstream activities (refining and marketing) for these petroleum products are among some of the most profitable companies in the world.

Whether they are involved in upstream or downstream activities, whether they are public corporations or state-owned companies, players in the oil industry must operate within the context of significant issues and major trends that are shaping the long-term outlook for oil.

Oil companies public corporations and state and non-state-owned enterprises are faced with increasing demand for petroleum products due to global industrial expansion.

On the one hand, labors to get the "conservative" oil (produced from underground hydrocarbon reservoirs by means of production wells) have prompted oil companies to invest ever more heavily in technology and equipment. On the other, these firms have increased investments in producing "unusual" oil, including oil sands, shale oil, and extra heavy crude oil, some of which require additional processing to produce artificial crude.

To spread the risk of investing in costly technology, equipment, and processes firms are entering into joint-venture relationships designed to spread infrastructure risk among competitors in order for the entire industry to remain healthy. In some cases, firms have required mergers or acquisitions in order to expand resources for highly technical exploration and advanced production.

Other changes on the energy scene, particularly increasing prices for both oil and gas, are prompting several companies to take a broader view of their business. They are transforming themselves through investments in alternative energy sources, including solar, wind, biomass, geothermal energy, and fuel cell technology.

The realization that alternative fuels and renewable energy technologies will play an increasingly important role as a bridge between the current focus on hydrocarbons and the clean, cheap promise of hydrogen has prompted many oil companies to invest heavily in these areas.

CRUDE OIL CLASSIFICATION AND BENCHMARKS

Crude Oil Classification

For several decades now the crude oil or petroleum industry has classified the raw crude by the location from which it was extracted. In other words, oil is classified by geographic region. However, all oils from a particular region are not created equal.

Further classification of petroleum, derived from the density of the raw petroleum (API gravity) and its various non-hydrocarbon components (especially sulfur), is then added to the geographic designation. The end result of all this classification helps determine the price of a specific barrel of crude as well as how much demand there is for that particular oil.

In general, if the crude oil contains high levels of sulphur the petroleum classification is termed 'sour, if it has relatively low levels of sulphur the petroleum classification is termed 'sweet'. If the raw petroleum is of a high density then the petroleum classification is termed 'heavy' and if it is of a low density the petroleum classification is termed 'light'.

Density of oil is determined by the length of the hydrocarbons it contains. If it contains a great deal of long-chain hydrocarbons, the petroleum will be denser. If it contains a greater proportion of short-chain hydrocarbons it will be less dense.

Besides chain length, the ratio of carbon to hydrogen also helps to determine the density of a particular hydrocarbon. The greater the amount of hydrogen in relation to carbon, the lighter the hydrocarbon will be less dense oil will float on top of denser oil and is generally easier to pump.

The hydrocarbons in crude oil can generally be divided into four categories:

Paraffins

These can make up 15 to 60% of crude and have a carbon to hydrogen ratio of 1:2, which means they contain twice the amount of hydrogen as they do carbon. These are generally straight or branched chains, but never cyclic (circular) compounds. Paraffins are the desired content in crude and what are used to make fuels. The shorter the paraffins are, the lighter the crude is.

Napthenes

These can make up 30 to 60% of crude and have a carbon to hydrogen ratio of 1:2. These are cyclic compounds and can be thought of as cycloparaffins. They are higher in density than equivalent paraffins and are more viscous.

Aromatics

These can constitute anywhere from 3 to 30% of crude. They are undesirable because burning those results in soot. They have a much less hydrogen in comparison to carbon than is found in paraffins. They are also more viscous. They are often solid or semi-solid when equivalent paraffin would be a viscous liquid under the same conditions.

Asphaltics

These average about 6% in most crude. They have a carbon to hydrogen ratio of approximately 1:1, making them very dense. They are generally undesirable in crude, but their 'stickiness' makes them excellent for use in road construction.

When considering the petroleum classification it is important to consider the fact that the overall classification will have an effect on the value, not just the physical properties. For example, petroleum with a geographical classification from one region of the world may be expensive to transport to another region of the world regardless of the suitability of the raw petroleum as an overall substance.

In general, lighter crude commands a higher price because it contains more hydrocarbon chains that can be easily refined to make gasoline and diesel, which are in high demand. The lower the sulphur content, the higher the price as well because low-sulfur, sweet crude requires less refining.

Classification of petroleum also indicates the best use for a particular field of petroleum. One oil type is not necessarily “better” than another, but rather the different types are useful in different applications. Light crude oil is preferable for refining into gasoline as it produces a far higher yield than heavy.

In a similar fashion, sweet petroleum is often more desirable than sour petroleum as its use will cause far less impact on the environment in the form of harmful emissions as it is burned. These basic classifications of petroleum are further enhanced by a full molecular description gained through a crude oil assay analysis.

Crude Oil Benchmarks

Benchmark oils are used as references when pricing oils. There are approximately 161 different benchmark oils, of which the main three West Texas Intermediate, Brent Crude, and Dubai Crude. Crude oil is the most actively traded commodity and is bought and sold in “contracts.”

A contract trades in units of 1,000 barrels of oil and benchmarks help to determine the price of a barrel of oil in a contract.

West Texas Intermediate

WTI is probably the most famous of the bench mark oils. It is light, sweet crude with an API gravity of 39.6 degrees. That gives it a specific gravity of 0.827, which means that at 60 degrees Fahrenheit, WTI is only 8/10 as heavy as water. It contains 0.24% sulfur and is refined in the Midwest. It comes from the Southwestern United States

Brent Crude

Brent Crude, named after a goose, comes from the North Sea. It is light, sweet crude with an API gravity of 38.06 and a specific gravity of 0.835, making it slightly “heavier” than West Texas Intermediate. The sulfur content is 0.37%.

The price of Brent Crude is used to set prices for roughly 2/3 of the world’s oil. It is mostly refined in Northwest Europe and is also called Brent Blend, London Brent, and Brent petroleum. The Brent field is located in the East Shetland Basin, halfway between Scotland and Norway.

Dubai Crude

Dubai Crude is light and sour, with an API gravity of 31 degrees and a specific gravity of 0.871. Its sulfur content is 2%, making it 6 times sourer than Brent Crude and 8 times sourer than West Texas Intermediate. It is generally used for pricing oil that comes from the Persian Gulf. Dubai Crude is also known as Fateh. Its importance comes not only from its quality, but also from the fact that it was the only freely traded oil from the Middle East until recently.

OPEC Reference Basket (ORB)

This is not specific crude, but rather is a weighted average of petroleum that comes from OPEC countries. There are currently 11 different oils combined into the ORB. It averages API gravity, with the present combination, of 32.7 degrees and has a sulfur content of 1.77%. It was recently changed to reflect the average quality of crude oil in OPEC Member Countries. The change decreased the API and increased the sulfur content of the basket.

Minas

Minas oil is also referred to as Sumatran Light and comes from the island of Sumatra. It is light, sweet crude. The API gravity is approximately 35 and the specific gravity is 0.8498. It has a sulfur content of only 0.08%. It is produced at a rate of approximately 420,000 barrels per day.

Tapis

Tapis is often referred to as the “World’s Costliest Oil” and comes from a single field in Malaysia. Its value comes from the fact that WTI and Brent Crude are difficult and expensive to export to Asia and because it is of extremely high quality. Tapis has an API gravity of 45.2 degrees and a sulfur content of 0.0343%. These are exceptional numbers, indicating that Tapis is very light and very sweet. Unfortunately, output from the Tapis field has been falling steadily since 1998.

Bonny Light

Bonny light comes from Nigeria and is light, sweet oil. It has an API gravity of 32.9 and a sulfur content of 0.16%

Isthmus-34 Light

This is sour crude with and API gravity of 33.74 degrees and a sulfur content of 1.45%. It is produced in Mexico. Though Mexico is not a part of OPEC, this oil was once part of the OPEC Reference Basket. It was removed in from the ORB when it was changed in 2005.

CRUDE OIL DEMAND AND SUPPLY

Crude Oil Demand

World oil consumption will top 100 million barrels per day (bpd) in the next three months, putting upward pressure on prices, although emerging market crises and trade disputes could dent this demand, the International Energy Agency said.

The Paris-based IEA maintained its forecast of strong growth in global oil demand this year of 1.4 million bpd and another 1.5 million bpd in 2019, unchanged from its previous projection.

"As we move into 2019, a possible risk to our forecast lies in some key emerging economies, partly due to currency depreciations versus the U.S. dollar raising the cost of imported energy. In addition, there is a risk to growth from an escalation of trade disputes," the agency said.

The United States and China have imposed a series of tariffs on each other's goods since May that have unnerved equity markets, while a rising U.S. dollar has put emerging market currencies under pressure, raising the energy bill for some of the world's largest oil importers.

Demand from nations not in the OECD group of industrialized countries, led by China and India, is expected to rise by 1.1 million bpd to 51.6 million bpd this year and by 1.2 million bpd to 52.8 million bpd next year, the IEA said.

Global demand will hit a high of 100.3 million bpd in the final quarter of this year, before moderating to 99.3 mln bpd in the first quarter of next year, the agency said.

In its monthly report, the agency left its forecast for global demand growth for 2018 and 2019 unchanged from last month at 1.3 million b/d and 1.4 million b/d, respectively, as weaker economy is largely offset by lower oil prices.

Oil demand is slowing in several non-OECD countries as the impact of higher year-on-year prices is amplified by currency devaluations and slowing economic activity.

Non-OECD oil consumption should increase by 950,00 b/d in 2018, and the pace will accelerate to 1.1 million b/d in 2019. Notably, IEA's non-OECD demand forecast for 2019 has been revised down by 165,000 b/d compared to a month ago.

Asia remains the main source of growth, contributing 900,000 b/d in 2018 and 820,000/d in 2019, with China and India the dominant markets. IEA expected total oil demand growth in China to be 495,000 b/d in 2018, followed by a slower rate in 2019 of 380,000 b/d. Indian oil demand growth has more than doubled in 2018 to 255,000 b/d, although IEA expected a modest slowdown in 2019 to 215,000 b/d.

OECD demand is expected to increase by 355,000 b/d in 2018, slowing to 285,000 b/d in 2019.

OECD Americas oil demand is projected to increase by 445,000 b/d in 2018, supported by harsh weather conditions in the first quarter of this year, as well as booming industrial activity and the start-up of petrochemical projects in the US.

The strong year-on-year increase in oil prices seen in 2018 is, however, affecting gasoline demand, which is forecast to contract by 30,000 b/d in 2018. More ethane crackers coming on stream and recently lower oil prices should continue to support OECD Americas growth of 200,00 b/d in 2019.

OECD Europe's demand is less robust, and, after growth of 230,000 b/d year-over-year in this year's first quarter, there were declines of 100,000 b/d and 65,000 b/d in the second and third quarter. For the year, demand is set to decline by 5,000 b/d on very weak gas oil and naphtha deliveries, but a more favorable price environment is expected to support growth of 145,000 b/d in 2019. OECD Asia Oceania oil demand will post small declines in both 2018 and 2019.

History of Oil Prices

Given the critical role played by crude oil, events in the oil market have a major impact on overall economy. Over the past 50 years, oil prices have moved in a wide range, but lacked any meaningful trend. As shown in below figure, between 1945 and 1972, oil prices, as measured by West Texas Intermediate (WTI), were essentially flat and ranged from $2 to $3 a barrel.

Then, the world economy faced two major oil shocks in 1973-74 and 1979-80, both of which were largely due to cutbacks in OPEC production. In 1973-74, oil prices rose from $2-3 a barrel to about $11-12 a barrel and then in 1979-1980 they spiked up again to about $39 a barrel. During both oil shocks, the US and much of the global economy moved into recession and unemployment rates rose sharply.

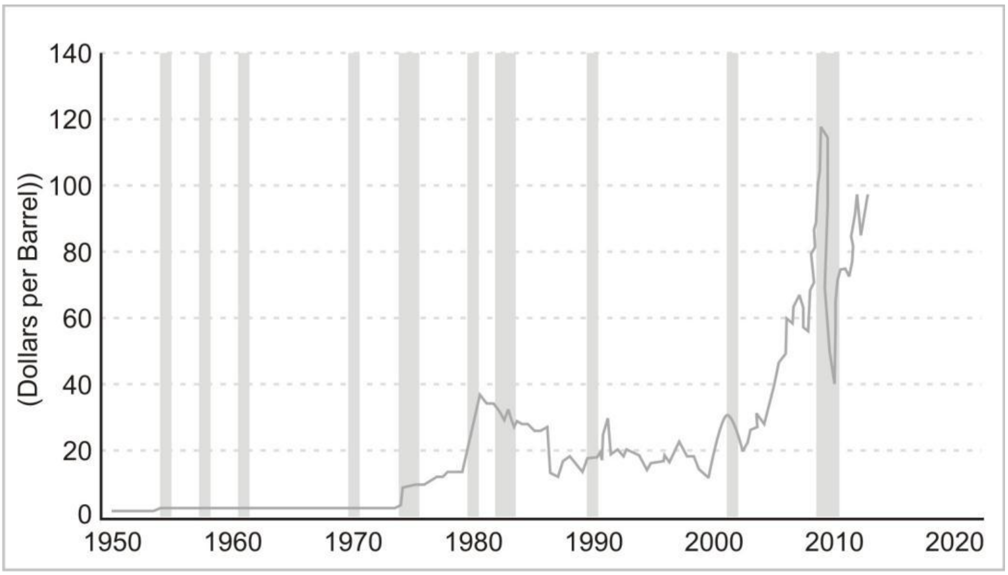

Figure 7.5: Spot Oil Prices – West Texas Intermediate

Oil prices peaked in April 1980 at $39.50 a barrel and then steadily declined for almost 20 years, until they bottomed out in December 1998 at $11.28 a barrel. This 20-year period of fall in prices set the stage for the price surge over the past decade.

Investments in the oil industry became unprofitable and there was no longer much of an incentive for consumers to conserve energy. As a result, oil companies cut back on their capital budgets and oil rig counts and drilling activity fell sharply. The relatively low price of oil at the pump encouraged consumers to buy less fuel-efficient vehicles and bigger homes. Crude prices starting edging up again at the end of 1990's, but the upward price spike did not become noticeably pronounced until late 2003, with oil prices rising sharply between 2003 and 2008 and reaching a peak of over $130 a barrel in July 2008.

The deepest and longest global recession in the post-World War II period that began in December 2007 and lasted through the middle of 2009, dramatically reduced oil demand and oil prices. Prices for WTI fell from over $130 a barrel in the summer of 2008 to a low of $31 in December 2008.

Despite sluggish recovery in advanced countries and record levels of inventories, oil prices trended upwards since the recession ended in 2009 and touched over $100 a barrel by the spring of 2012. Oil prices are now at levels that are well above those experienced prior to the global recession. Oil prices (WTI) averaged around $56 a barrel in 2005 and $66 a barrel in 2006 at a time when the global economy was expanding at a rapid rate. The question is why are oil prices so high given the sluggish rate of growth in the overall global economy?

Supply Side: Issue of Peak Oil

No one expects the global economy to run out of oil anytime soon. The concern is that the upward trend in oil production, that has been evident over the past century, will reach a point of maximum production and then decline. The question is, when will global oil production peak and how will it affect the global economy?

The date when peak production occurs is a source of much debate among participants in the energy market. Peak oil refers to the point at which a given oil field reaches peak production, after which production will fall, no matter how many new wells are drilled.

The ideas underlying peak oil were developed by a Shell geologist, M. King Hubbert (Hubbert, 1956). Back in 1956, Hubbert reviewed the production history of a number of oil fields in the US. He predicted that US oil production would peak in the 1970s, and he called the top within a few months.

Since then, crude oil production has been declining in the US, despite the large discovery of oil made on the North Slope of Alaska in the late 1970s. Applying the same methods to global production, proponents of Hubbert predict that global production should peak in the next few years. Most of today's peakists base their forecast on Hubbert's curve, which is a bell shaped curve representing exponential growth and decline in production.

Hubbert's curve shows that oil production rises and falls as a direct function of remaining oil reserves. In other words, production can increase until the cumulative production uses up half the total reserves in the field and then production begins to decline. What is critical in the analysis is the halfway point. Once half of the oil is used up we have reached a point of no return and production will decline no matter how much new technology is applied or additional drilling occurs.

Analysis of Global Oil Reserves

The key to Hubbert's peak and the time at which production begins to decline is the level of global oil reserves. We have been consuming oil for over 100 years and have over this period pumped out approximately 1 trillion barrels of oil according to the International Energy Agency (IEA). Current production uses about 31 billion barrels per year.

How much oil is left is thus the key question. If we have extracted half of all the oil that has ever existed, we are, by most definitions of the issue, at or past the peak. Obviously, a larger reserve base implies a later peak date than a smaller one. Here is where there is considerable debate among geologists and oil analysts. The peak oil debate revolves around four important issues regarding oil reserves:

- Amount of oil left to produce.
- Quality of remaining reserves.
- Geographic distribution of remaining reserves.
- Field-by-field analysis.

Amount of Oil

On the issue of the amount of oil remaining, no geologist or analyst knows exactly how much oil exists under the earth or how much can be extracted. Instead, all the reported numbers are essentially informed estimates based on probabilities. In fact, reserve definitions vary by country, making comparisons between them essentially useless.

Reserves in a given oil field are classified in a number of categories. The news media nearly always uses the proven reserve figures and omits other categories. By definition, proven reserves are those that can be recovered with reasonable certainty using current technology and current prices. These are often classified as P-90 reserves since there is a 90% probability they will be extracted over the life of the field.

The oil field will also have additional quantities of probable and possible reserves; these are recoverable with a probability of over 50% and under 50%, respectively, from the estimated total volume of oil-in-place in the field. The probable and possible reserves are undeveloped since they are unprofitable to produce at current prices and technology.

Finally, there are unconventional reserves, which include heavy oils, tar sands and oil shale. Processing these reserves is expensive and requires different production methods. While some consider recoverable reserves to be fixed by geology, in reality, their accessibility as energy source is more dictated by technology and oil price changes. In other words, economics is as important as geology in coming up with reserve estimates since a proven reserve is one that can be economically developed.

As technology improves and prices increase, probable and possible reserves are reclassified as proven. This process often leads to a situation where the level of proven reserves in an oil field trends upwards over time in spite of the ongoing extraction of oil from the field.

This will occur as the rate of extraction is offset by the conversion of probable and possible reserves to the category of proven. In addition, proven, probable and possible reserves represent only a portion of the oil in place in a given field since it is impossible to recover all the oil and gas.

The recovery factor (reserves to oil in place) may change over time in response to improved technology and higher prices. Below table provides an estimate of ultimately recoverable reserves (a category that includes proven and probable reserves from discovered fields) as estimated by various sources.

Table 7.1: Estimate of Oil Reserves (Trillions of Barrels)

	Ultimately Recoverable Reserves
British Petroleum	1.6
Campbell	1.0
Exxon	3.2
International Energy Agency	1.3
Nashawi Kuwait University	1.2
Oil and Gas Journal	1.3
United States Geological Services	2.3

Thus, the world supply of oil is not only determined by geology, but also by an interplay of economics, technology and most critically important in today's environment, geopolitics. Given the above, the concern is not that we will soon run out of oil in a direct sense. The consensus among most geologists is that we still have about 7-9 trillion barrels of oil-in-place left. The question, is how many of those barrels can be recovered? And, what will be the cost?

Most advocates of peak oil believe about 1 trillion barrels of oil are left. If true, that will put us at or beyond the peak since about 1 trillion barrels have been already produced and production must, therefore, decline. Other geologists estimate ultimately recoverable conventional reserves as high as 3 trillion barrels with another 2 trillion barrels of unconventional oil.

Of course, the higher reserve figures yield a much later oil peak, with the USGS numbers suggesting a peak around 2037. A recent study by researchers at Kuwait University estimated that the world could ultimately produce 2,140 billion barrels of oil, with 1,161 billion barrels remaining to be produced at 2005 end. This suggests a peaking of production in 2014.

Reviewing the other reserve estimates suggests that the claim that oil production has already peaked seems premature. If the more optimistic assessments hold up, we should have at least another decade or two of rising production, especially if production from unconventional reserves increases as expected.

But, even assuming that the peak occurs as late as 2040, a crisis is in the making and preparation must soon begin for the difficult adjustment process of finding reasonable options and alternative energy sources. What is important to understand is that the level of reserves available is not the only factor to consider when creating an effective long-term global energy strategy and oversimplifies the peak oil argument.

Quality of Oil

Quality of oil reserves is also critical due to its impact on the cost of extracting and refining oil. The highest quality, light sweet crude, is easy to find and cheapest to produce and refine. But, most geologists, according to the IEA and US Geological survey, believe that most of the high quality crude oil has already been discovered and its production in existing oil fields is set to decline.

Replacing it will be one of several lower, heavier grades of crude (often containing sulfur) that are more expensive to extract and refine. Compounding the problem, it is getting more expensive to discover such new deposits worldwide.

For example, recent discoveries of large quantities of crude oil offshore in Brazil and in the Gulf of Mexico involve extremely costly deep water drilling in waters over 2 miles deep. Furthermore, unconventional energy sources such as oil sands in Canada and Venezuela are expensive to produce and refine and have significant environmental costs. All this suggests that oil prices cannot help but trend upwards in the years ahead as cost of production rises.

Geographic Distribution

Finally, most of the world's proven reserves are found in the OPEC region. The Middle East accounts for over 54% of the world's reserves based on data from British Petroleum (2011) and the International Energy Agency (IEA, 2010). The rest of OPEC has 23% of reserves with Venezuela and Nigeria containing 15% and 3%, respectively.

Most of these OPEC reserves are found in countries with high geopolitical risks. Non-OPEC reserves account for 23% of the world total with proven reserves in the US estimated at 2% of total. Exploration, development and production costs are much higher in the non-OPEC region. Most of the fields in the non-OPEC region are mature and in decline.

Field-by-Field Analysis

The rate of change in output from maturing oil fields is critical in assessing the point of peak production. The IEA has compiled a database containing production profiles on the world's 798 largest oil fields. This database includes all 54 of the super-giant fields (proven reserves greater than 5 billion barrels) and 263 of the 320 giant fields (proven reserves greater than 500 million barrels).

The bulk of global oil production comes from a small number of super-giant and giant fields. The IEA shows that the 20 largest fields in the world produce over 19 million barrels per day (mbd) or about a quarter of the oil produced in 2008. In addition, the percentage of global production from super-giant and giant fields has grown as a share of total production and accounted for about 60% of global production in 2008 compared to around 56% in 1985.

The IEA in an intensive field-by-field study found that 580 of the 798 largest oil fields are at peak or past peak in production. Output in 2008 at 16 of the 20 largest oil fields was below their historic peak. Most of the world's largest fields have been in operation for many years and few large discoveries have been made in recent years except for those in high cost deep offshore waters.

The average annual rate of decline in these 580 fields is 5.1%. This is equal to 3.6 mbd, based on 2008 levels of global production. The rate of decline can be slowed through the deployment of new secondary and enhanced recovery techniques, but this is extremely capital intensive and significantly increases the cost of producing a barrel of oil.

The problem is that once production exceeds its peak, it is difficult to slow the rate of decline even if large investments are made. In fact, peak oil analysis suggests that the rate of decline will accelerate once oilfields exceed peak production. A key implication of the analysis is that future supply must not only meet rising demand, but also offset the loss of capacity from existing fields as they mature. In fact, loss of capacity will have a more important impact on future supply needs than the increase in demand.

In summary, what the oil reserve data suggests is that we are not running out of oil per se, but that we are running out of high quality low cost oil and large-scale investment in future energy supply is needed to offset large declines in global production capacity.

Changing Composition of Global Demand

Perhaps, the most important development on the demand side of the oil market is the rising importance of emerging market economies. Below tables 2 and 3 provide historic consumption data for 1980 to 2010 and projections out to 2030.

Historic Data

What is evident in the data is that the composition of global oil demand is rapidly changing. Mature economies in the US, Europe and Japan still account for over half of global consumption, but their share are declining. The share of oil consumption in advanced countries has declined from 62.2% in 1980 to 49.9% in 2010. What is happening is that most of the growth in the demand for oil is coming from emerging/developing countries.

Due to a combination of rapid economic growth and an expanding manufacturing and transport sector, emerging economies are quickly cornering a larger pie of global oil consumption. Growth in manufacturing and vehicle ownership is the most important driver of oil demand in these countries.

It is not surprising that the booming emerging economies have posted robust oil demand. This is especially true of China and India, with their GDPs growing at an annual rate of around 10% and 8%, respectively, over the past 5 years, with no reasonable expectation of a slowdown. From the historic oil consumption data provided in Tables 2 and 3, following observations are made:

- As is shown in above figure, oil price rose significantly in the decade of 1970s. Oil consumption responded to these price hikes with a lag as there was virtually no growth in global oil demand between 1980 and 1990. Oil demand rose from 64.8 mbd in 1980 to only 67.0 mbd in 1990. Demand in mature economies declined by 400,000 mbd over this 10 year period.
- Between 1990 and 2000, global oil demand rose by 9.6 mbd as economic growth worldwide was relatively strong. Despite the robust increase in demand, both nominal and inflation-adjusted oil prices declined through most of the decade and bottomed out in late 1998.
- What was striking in the oil market in the decade of the 1990s was the sharp contraction in oil consumption in the former Soviet Union from 8.1 mbd in 1990 to 4.3 mbd in 2000.
- Global oil consumption grew at a rapid rate between 2000 and 2010 despite the deep 2007-09 recession. Between 2000 and 2010, demand for oil increased by 9.4 mbd from 76.6 mbd in 2000 to 86.0 mbd in 2010.
- Most of growth in oil demand between 2000 and 2010 has been due to growth in consumption in emerging economies. Between 2000 and 2010, oil consumption in emerging economies rose by 11.2 mbd accounting for all of the incremental growth in global demand over this period. In contrast, consumption in advanced economies declined by 2 mbd.
- China alone increased consumption by 4.4 million barrels per day between 2000 and 2010. Demand in India and the rest of Asia rose by 2.6 mbd from 2000-10.
- Changes in the price of oil are largely determined by incremental growth in demand. Emerging economies, given their rapidly expanding consumption, will increasingly account for most of the overall incremental demand growth for oil and thus become one of the primary determinants of oil price.

Table 7.2: Global Oil Consumption by Region (Million barrels per Day)

	1980	1990	2000	2010	2015	2030
Mature Economies						
USA	17.4	17.0	19.7	19.0	20.6	21.6
Europe	14.6	14.2	14.6	14.1	14.3	14.8
Japan	4.9	5.3	5.5	4.4	4.3	4.5
Other*	3.3	3.4	5.1	5.4	5.8	6.2
Total Mature	**40.3**	**39.9**	**44.9**	**42.9**	**45.0**	**47.1**
Former Soviet Union	**9.5**	**8.1**	**4.3**	**4.5**	**5.0**	**5.5**
Emerging Economies						
China	2.0	2.3	4.7	9.1	11.1	16.6
India	0.7	1.2	2.3	3.3	3.7	5.1
Rest of Asia	4.0	4.1	6.4	8.0	9.1	10.9
Latin America	5.0	5.6	6.8	7.8	8.4	9.6
Middle East	2.0	3.7	4.9	7.1	7.5	9.0
Africa	1.3	2.1	2.3	3.3	3.5	4.1
Total Emerging	**15.0**	**19.0**	**27.4**	**38.6**	**43.3**	**55.3**
Total World	**64.8**	**67.0**	**76.6**	**86.0**	**93.3**	**107.9**

Table 7.3: Change in Demand by Region (Million Barrels Per Day)

	Changes in Consumption 2000-10 (mbd)	Projected Changes in Consumption 2010-30 (mbd)
Advanced Economies		
USA	-0.7	2.6
Europe	-0.5	0.7
Japan	-1.1	0.1
Other	0.3	0.8
Total Mature	**-2.0**	**4.2**
Former Soviet Union	**0.2**	**1.0**
Emerging Economies		
China	4.4	7.5
India	1.0	1.8
Rest of Asia	1.6	2.9
Latin America	1.0	1.8
Middle East	2.2	1.9
Africa	1.0	0.9
Total Emerging	**11.2**	**16.7**
Total World	**9.4**	**21.9**

Demand Projections

Global oil demand is projected to increase from 86.0 mbd in 2010 to an estimated 93.3 mbd in 2015 and an estimated 107.9 mbd in 2030 based on projections made by the US Department of Energy. The US Energy Information Administration forecast is essentially a consensus forecast and is consistent with projections made by the International Energy Agency (IEA) and most private analysts.

Oil consumption in the emerging economies will increase by an estimated 16.7 mbd between 2010 and 2030 and account for most of the growth in global oil consumption. Oil consumption is expected to increase by 4.2 mbd in advanced economies over this period. China alone will increase its consumption by 7.5 mbd between 2010 and 2030 accounting for over 34% of the global increase in oil demand.

Growing vehicle ownership will play a key role in oil demand growth. Of the projected increase in oil use over 2010-30, 62% occurs in the transportation sector. Statistical studies by EIA and IEA indicate that demand for motor vehicles rises rapidly once per capita income exceeds $3,000.

A growing portion of the population in China and India is now approaching this threshold level of per capita income and thus both countries will experience a significant surge in rates of motor vehicle ownership. In summary, the growing absolute size and importance of demand in emerging economies will have a major impact on price trends in the oil market.

Production: Non-OPEC Supply

Growth in non-OPEC oil supplies has played a significant role in the erosion of OPEC's market share over the past three decades. Production surged in Alaska, the North Sea, South America and Mexico and recently in Africa. Many of these oil fields are now aging and production is expected to decline. It is non-OPEC supply that will experience the impact of peak oil.

Table 7.4: Non-OPEC production (Million Barrels Per Day)

	2000	2010	2015	2030
US/Canada	11.1	13.3	14.6	18.2
Mexico	3.5	2.9	2.3	1.5
Europe	5.8	4.5	3.5	3.1
Former Soviet Union	10.7	13.2	14.6	17.4
Africa	2.5	2.6	3.0	3.5
Latin America	3.6	4.8	6.2	8.9
Rest of World	9.0	10.4	10.5	10.4
Total Non-OPEC (Includes Unconventional)	**46.2**	**51.7**	**54.7**	**63.0**
Unconventional Production	1.3	4.8	6.2	11.7
Total Non-OPEC Less Unconventional	**44.9**	**46.9**	**48.5**	**51.3**
Total Less Unconventional and Former Soviet Union	**34.2**	**33.7**	**33.9**	**33.9**

Above Table 4 provides supply projection for Non-OPEC countries to 2030 based on EIA estimates. The forecast assumes that conventional production (outside the former Soviet Union) stays essentially flat through 2030 as effects of peak oil become evident. Oil production increases due to growth in the former Soviet Union and gains in nonconventional production.

The EIA assumes significant growth in non-conventional production with production increasing from 4.8 mbd in 2010 to 11.7 mbd by 2030. It is important to point out that unconventional production is capital intensive, expensive to produce and with large environmental impacts. The extent to which these unconventional resources will be utilized hinges on the price of crude and the cost of mitigating their impact on environment. Oil markets will be adversely impacted if either former Soviet Union or unconventional production fall s below expectations.

Growing Dependence on OPEC

Comparing the demand forecast provided in Table 2 with non-OPEC supply projections in Table 4, we can calculate the residual demand for OPEC oil. This is the amount of oil OPEC must produce to close the gap between global demand and non-OPEC supply. The results are provided in Table 5. Most long-term projections of oil supply and demand simply assume that OPEC production is a residual that will be available to meet market demand.

Table 7.5: Growing Dependence on OPEC (Million Barrels Per Day)

	2000	2010	2015	2030
Global Demand	76.6	86.0	93.3	107.9
Less Non-OPEC Supply	46.2	51.7	54.7	63.0
Need for OPEC Oil	**30.4**	**34.3**	**38.6**	**44.9**

The need for OPEC oil will grow from 34.3 mbd in 2010 to 44.9 mbd in 2030. These amounts to a significant increase in OPEC output over a 20-year period. Most of the production increases will occur in the highly politically unstable Middle East.

Essentially, the above analysis indicates that OPEC countries must find the equivalent production capacity of another Saudi Arabia over the next 20 years. Such a sizeable expansion in oil production capacity will prove to be a daunting challenge for OPEC producers and will require a huge financial investment in both oil capacity and the infrastructure to transport it.

Implications of Dependence on OPEC

The growing projected reliance on OPEC production has the following implications:

- Oil is a global market, therefore, once non-OPEC production peaks and demand continues to grow, there will be strong upward pressure on oil prices.
- Despite the two price shocks in 1973-75 and 1979-1980, oil prices, after adjusting for inflation, have been essentially flat for the past 40 years with no clear trend. This is about to change. Over the next few decades, oil prices are expected to trend upwards and do so well above the inflation rate.
- The world currently has little surplus oil capacity. According to EIA, spare global capacity is at its lowest in 30 years. Tight capacity is likely to be an ongoing characteristic of the oil market in the future, given the expected slowing in non-OPEC production.
- With little spare capacity, oil prices will be highly volatile and will respond quickly to any sudden change in demand or supply.
- There are major questions as to whether OPEC countries or countries in the former Soviet Union will have the required financial wherewithal and technology to expand oil production to meet global market needs. This will create further uncertainty in the oil market.
- Much of OPEC's production is in countries with high geopolitical risk. With a growing reliance on OPEC oil, a speculative risk premium will be a permanent feature in the oil market.
- The threat is especially acute in Venezuela, where nationalistic policies could lead to a sharp drop in foreign investment and in output. At risk are foreign oil company’s plans to finance the commercial development of an estimated 235 billion barrels of extra-heavy oil found in the Orinoco Belt.

Supply Issue: Need to Offset Production Declines

Global oil production must expand over the next two decades not only to meet the expected increase in demand, but also to offset declining production in existing oil fields. As we noted earlier, many of the largest oil fields have been producing oil for decades and are likely to be close to a production peak and an eventual decline.

The IEA (2008) estimated that oil production from existing oil fields is declining at an annual rate of 5.1%. Given this rate, the question is how much capacity must be added between 2010 and 2030 just to offset the production declines.

IEA (2010) data estimated global oil production capacity in 2010 at 85 mbd. With no addition to reserves, global production capacity will decline to 31.4 mbd by 2030 assuming an annual rate of decline of 5.1%. Thus, gross capacity of 53.6 mbd must be added by 2030 to compensate for declining production in existing fields. This estimate is probably conservative since the rate of decline is likely to accelerate over the next two decades.

Impact of Price Elasticity

The key unknown in the above projections is the eventual responsiveness of global demand and non-OPEC supply to higher prices. In economics jargon, we are referring to the concept of the elasticity of demand for and supply of oil. Elasticity measures responsiveness of consumption and production of oil to changes in its price. In other words, the coefficient of elasticity measures the extent to which consumption growth will slow and production will rise in response to higher prices.

Estimates of the demand and supply price elasticity for oil vary widely, but consensus shows that elasticity rises significantly with time as both businesses and consumers make adjustments in their spending habits and production decisions.

Economic theory predicts that over longer periods, oil demand and supply should be highly responsive to price (a high level of elasticity). Historic data completely supports this prediction. In fact, the decades of 1970s and 1980s provided a perfect test of this theory.

Consistent with economic theory, the high price of oil in the 1970s was followed by a surge in non-OPEC investment and production in the 1980s. At the same time, following the 1979-1980 price shock, demand for oil stagnated for over 10 years.

Surprising to many analysts, the global economy expanded at a healthy rate in the 1980s with essentially no growth in oil demand (energy efficiency improved dramatically). What the data clearly shows is that in response to the higher oil price, there was a sharp slowdown in growth in demand for oil in the 1980s while its supply rose.

These results are just as predicted by economic theory and indicate a high value for the long run elasticity of demand and supply. Understanding the concept of elasticity has important implications for the future outlook of the oil market. Forecast in Tables 2 and 3 assumes that oil prices rise at the inflation rate through 2030 (real price of oil is unchanged). If oil prices were to rise at a faster rate (not an unreasonable assumption), projection of future global demand will be considerably lower, and at the same time, higher production is likely from non-OPEC sources.

The global demand and non-OPEC supply imbalance will be considerably less, as will be the need for OPEC production. The important point to understand is that higher the oil price, the more important is the elasticity effect. This means that demand will expand at a slower rate and supply will expand at a faster rate in response to the higher price of oil. This, in turn, will limit the extent to which oil prices rise (because of lower demand and higher supply).

Conclusions and Implications for Oil Prices

The oil market is undergoing fundamental changes. On the supply side, global oil production is likely to peak in the next few decades. The exact peak date is difficult to determine, but a careful analysis of global oil reserve data suggests it could occur as early as 2014 or as late as 2040. The impact on global oil supplies will be dramatic even if peak production occurs at a later date since global production capacity is already falling due to aging of oil fields.

On the demand side, growth in oil consumption will come entirely from emerging countries, with little growth in demand in advanced countries. Thus, pressure to add to oil production capacity is coming from both supply and demand sides of the oil market. Table 6 summarizes the amount of new oil production capacity that must be added globally by 2030 to meet growing global demand and to offset production declines.

Table 7.6: Estimated Needs for New Oil Producing Capacity (Million Barrels Per Day)

Additional Oil Capacity need to	2010 – 2030
Meet Global Demand	21.9
Replace loss of capacity due to aging of fields	53.6
Total	**75.5**

The results show that oil production capacity must increase by a staggering 75.5 mbd by 2030 to meet demand growth and replace depleted supply. This capacity increase is more than twice the level of current OPEC production. In fact, as shown in the above table, the loss of capacity will have more important impact on future supply needs than the increase in demand.

What makes the situation even more challenging is that peak oil analysis indicates that the rate of decline will accelerate with the increase in the age of oil fields. If this prediction is correct and peak production occurs in the next few years, there will be an even greater need to discover more oil to offset the larger declines in production.

In addition, most new capacity coming on stream will be of lower quality, more difficult to refine, with higher production costs and located in countries with high geopolitical risk. Given the need to replace a significant and growing amount of capacity and the growing demand from emerging economies, oil prices should rise considerably over the next two decades.

UPSTREAM PETROLEUM INDUSTRY

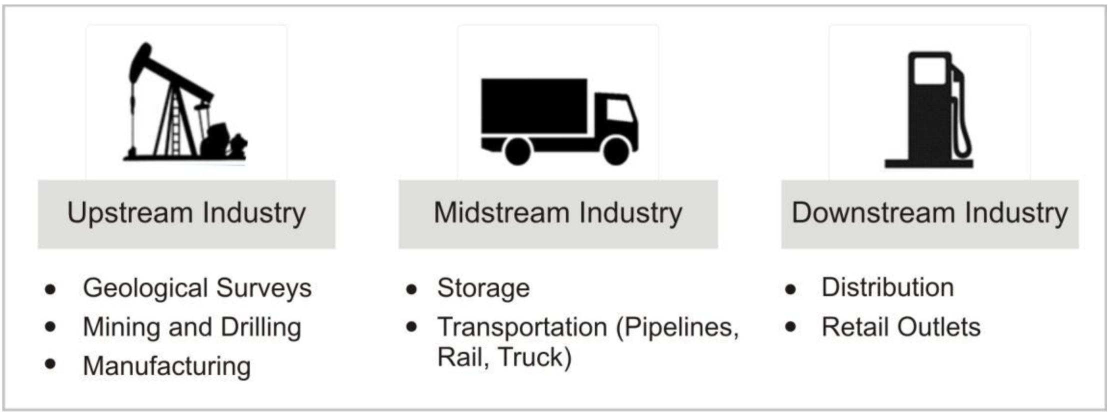

Figure 7.6: Representation of Upstream; Midstream and Downstream Industry

Upstream industry is the portion of the oil and natural gas industry that is responsible for finding crude oil and natural gas deposits, along with producing them. Upstream industry is sometimes known as the exploration and production or E&P sector. This part of the petroleum industry includes all activities that happen out in the field including drilling wells, trucking supplies, and mining oil sands. In addition, it includes planning and preparation – including environmental studies and engineering plans.

The different sectors within the upstream industry include:

- Offshore Drilling
- Oil Sands Mining

- Supply and Service
- Manufacturing
- Seismic Surveys
- Geological Surveys
- Reclamation

Offshore Drilling

Figure 7.7: An Offshore Drilling Rig

Offshore drilling is the process of extracting petroleum from reserves located beneath the Earth's oceans instead of reserves located on the mainland. Offshore oil rigs have developed greatly over the past years, and have become gigantic structures that house hundreds of people at a time. Some facilities sit on towers that go to depths of 1220 meters below the surface, larger than any skyscraper ever conceived of.

Why is it needed?

Recently, offshore drilling has increased in popularity as a result of the large amount of oil and other petroleum products used worldwide each day. The IEA estimates that in 2016 the worldwide consumption of oil and liquid fuels will be 96 million barrels per day - working out to over 35 billion barrels a year.

To meet this demand for fossil fuels, petroleum companies are faced with the task of searching in more remote locations to discover new reserves. Since oceans cover almost 3/4ths of the Earth's surface, a large amount of the oil and natural gas reserves around the globe are located beneath water.

Drilling Process

The process of drilling for oil and natural gas under seas is much more challenging than drilling on land. Extraction, transportation, and environmental protection are all comparatively more difficult with offshore drilling than with traditional wells. In an attempt to make this process more simple, petroleum companies have developed offshore oil platforms to aid in this extraction.

Once the offshore drilling platform is built, some method of extracting the oil and gas from beneath the ocean and moving it to the surface without losing it must be developed. To drill without water flowing into the hole or having the entire oil surge up into the ocean, a subsea drilling template is used.

This template is simply a large metal box with holes in it that is used to guide the drilling process and marks the site of each production well. Once the locations of the drilling sites are marked with this template, the drilling process can begin. To drill these wells, a number of 9 meter drill pipes are connected to form a large drill string used to reach deep into the Earth's crust.

Once connected, this string of drill pipes is connected to a device that spins it around, and using the drill bit connected at the bottom of the drill string the pipes grind down into the Earth's surface. This drilling process can take a long period of time, lasting anywhere from weeks to months. During this time, if the bit becomes dull and needs replacement the equipment is moved to the ocean floor in a tube known as a marine riser.

As the borehole moves deeper into the ground, a stream of drilling mud is sent to the drill bit, and then moves back up to the platform. This mud is vitally important to the drilling process as it provides lubrication for the drill bit, seals the wall of the well, and controls pressure inside of the well. Any rock particulates broken off during the drilling process are brought up to the surface, suspended in the drilling mud.

A filtration system on the platform filters the mud before sending it to the ocean floor again. Drilling itself happens in phases, with a length of the well drilled and then lined with metallic casing. Each phase of drilling creates a portion of the well with a smaller diameter, each portion lined with casing. Once drilled and cased, a packer is sent down the well which expands and ensures the well is sealed.

Although drilling mud helps to control the high pressure experienced when drilling, there is a significant risk of blowout. To prevent this from occurring, drilling rigs are equipped with a blowout prevention system on the seafloor. These systems act by sealing the well with hydraulic rams if pressurized petroleum pushes up the well, moving expelled fluids into containment systems to prevent pollution.

Extraction Process

Once the well has been drilled, the final portion of casing known as the production casing is installed. This casing ends in a cap that closes the well, allowing the flow of petroleum into the well to be controlled. Explosives are sent below ground to crack this production casing at a variety of depths to allow oil and gas to enter the well in a controlled manner and move to the surface at a reasonable pressure.

When first drilled, the pressure from the reservoir is enough to send fluids to the surface, but as this pressure declines pumps may be needed. Sometimes, water or gas is pumped into the reservoir, increasing the reservoir pressure and allowing petroleum to flow again. In some cases, steam is sent down a well to heat the petroleum, increasing its pressure.

Since the liquid that is brought up to the platform is a mixture of crude oil, natural gas, water, and sediments, some drilling platforms contain full production facilities to separate this mixture. Although most refinement occurs onshore, some companies use converted oil tankers to treat and store oil at sea. Once some initial treatment has occurred, undersea pipelines and oil tankers transport the oil and natural gas to storage and treatment onshore.

Oil Sands Mining

Oil sands extraction is the process of removing oil sand from the ground and extracting bitumen from it. This bitumen is later upgraded into a synthetic crude oil that can be separated into usable fractions through fractional distillation. There are two main methods that can be used to extract bitumen from this oil sand:

- ***Oil Sands Surface Mining:*** In this method, large amounts of oily sand are dug out of the ground and the bitumen is separated from it afterwards through mechanical and chemical processing.
- ***In Situ Oil Sands Mining:*** This is a process used to extract bitumen from oil sand that is buried deeply below the ground. In this process a well is drilled into a deposit and steam is injected into the formation to allow bitumen to become less viscous and flow out of the well. This removes the desired bitumen but leaves the sand in place.

Oil Sands Surface Mining

Surface mining is a technique used to obtain bitumen from oil sands where the oil sands deposits are located fairly close to the surface. If the reserves are shallow enough, earth moving equipment can dig out oil sand for processing. These deposits must be within 75 meters of the surface to be mined in this fashion. Resources recoverable by this type of extraction are estimated to be 65 billion barrels in Alberta.

Currently, around 500 square kilometers of the oil sands deposit in Northern Alberta is undergoing surface mining, which is only 3% of total oil sands.

Figure 7.8: A Caterpillar 797 Truck Used in the Extraction of Oil Sands for Hauling the Extracted Sand

Process

To excavate the oil sand, large trucks use scoops (some with scoops as large as a two-car garage) to collect the oil sand and move it to a cleaning facility. These trucks and scoops are enormous in size (this can be seen in above and below figures). This collection step is known as extraction. In total, two tonnes of oil sand must be obtained and processed with 2-4 barrels of water to produce single barrels of oil equivalent |barrel of crude oil in its synthetic form.

After extraction, the sand must be separated from the bitumen before the bitumen can be upgraded and refined. The first step in this separation is known as conditioning. In this step, large pieces of oil sand are broken up and the oil sand is mixed with water. Hydro-transport pipelines stir the mixture and move it to the extraction facility. This begins to break bonds holding the bitumen, water, and sand together.

Figure 7.9: A Bucyrus rope shovel loading oil sands material into a Caterpillar truck. For an idea of the size of this shovel, the truck being loaded in this image is the same as the truck in above Figure.

The next step is separation, where hot water and the water-oil sand mix is fed into a vessel where three components separate out. In this vessel, there is usually some kind of diluting chemical. Bitumen froth floats on top, with sand sinking to the bottom and a combination of bitumen, sand, clay, and water in the middle.

This takes approximately 20 minutes and separates the thick bitumen from the sand. The non-bitumen component that remains is composed of sand, water, fine clays, and minerals. This leftover component is known as tailings and is then sent to tailings ponds to allow the sand to settle out. The sand-water mixture is pumped into tailings ponds.

The secondary separation then occurs, and air is injected into the middle component in a floatation tank. This promotes the creation of more bitumen froth in an attempt to obtain more bitumen. This froth is heated and air bubbles are removed to allow pumps to operate efficiently.

The next step in the process is froth treatment where the bitumen froth has solids and water removed from it. The bitumen here is diluted with naphtha and sent to a series of settlers and centrifuges which allow particles to settle and be removed. Two types of centrifuges are used, the first being the scroll centrifuge which removes larger particles and the disc centrifuge which removes finer material. This material is sent to tailings ponds. At this point the bitumen has small water content and contains few solids and extraction is complete. At this point it can be upgraded and refined.

Environmental Concerns

The environmental impacts of oil sands development have been an issue for a long period of time. Many of these potential impacts can be connected to the disruption of the surface as a result of surface mining and the processing of the bitumen extracted. Some of the concerns include:

- ***Climate and Air:*** Emissions from oil sands production are greenhouse gas-intensive as it takes more effort to make the bitumen usable, and these emissions are a growing problem as oil sands production increases.
- ***Water:*** Oil sands extraction, especially through surface mining, uses a large amount of water to separate the bitumen from sand particles even with recycling efforts.
- ***Tailings:*** Tailings are a direct result of the processes necessary to separate bitumen from oil sand and is not necessary with in-situ mining techniques. As tailings volumes continue to grow, the issues associated with them will increase. These ponds can be toxic, can seep, and can prove dangerous to aquatic organisms.
- ***Land and Wildlife:*** Although more reclamation and restoration efforts are being promoted, the complete restoration of wetlands may never occur and the boreal forest cannot be restored to its native state following the closure of a mine. The disturbance of ecosystems with increased oil sands production resulting in more territory being mined can harm birds and other wildlife.

In Situ Oil Sands Mining

Oil sands deposits that are greater than 75 meters below the ground surface are usually extracted without removing the overlying rock and dirt. This is known as in situ oil sands mining. Oil sands deposits are usually split into two types of deposits. Shallow deposits are located within approximately 75 meters of the ground surface and are extracted using surface mining methods. Deep deposits are located at least 75 meters below surface level.

The fossil fuel being mined in oil sands deposits is bitumen which is a type of low-quality crude oil. Bitumen is used to make synthetic crude oil. Crude oil is important to make various products like gasoline, kerosene, and plastic. In Alberta alone, 80% (or 135 billion barrels) of the oil sands are located in these underground deposits and specific techniques such as SAGD are necessary to access these deposits.

The formation of oil sands is slightly different than the formation of a conventional oil deposit. Like all oil, the bitumen in the oil sands formed from an accumulation of organic material that was buried under sediment. Over millions of years the heat and pressure on this matter increased, causing bacteria to break it down in an oxygen-poor environment.

At this point, instead of dispersing throughout the geological formation, the fossil fuel adheres onto sand grains, creating oil sand deposits. Within the oil sands are fine clay particles, along with other minerals such as assorted metals and sulfur.

Extraction Methods

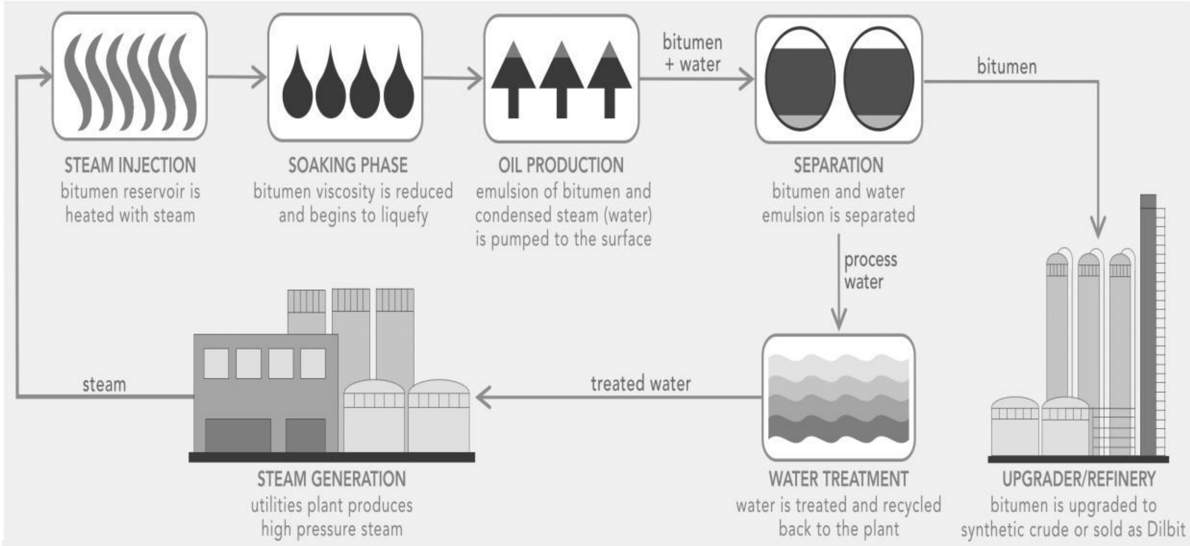

Figure 7.10: In-Situ Bitumen Extraction Process Overview

There are several different methods to extract bitumen from in situ deposits. Regardless of what type of extraction method is used, it must be able to reduce the viscosity of the bitumen so that it can freely flow and it must provide some way of recovering the bitumen from the deposit (above figure). Generally, the three methods that can be used to reduce the viscosity of the bitumen are the addition of steam, solvents, or thermal energy.

The one of the most common methods used for in situ recovery is steam assisted gravity drainage (below figure). Two wells are drilled, approximately 5 m apart. Steam injected into the top well causes the bitumen to become fluid enough that it flows into the other well and can be pumped out of the ground. Two benefits of this method of extraction exhibits is that tailings ponds are not a necessity as sand remains in the ground and less water is used to create the oil. One barrel of crude oil in its synthetic form only requires half a barrel of water.

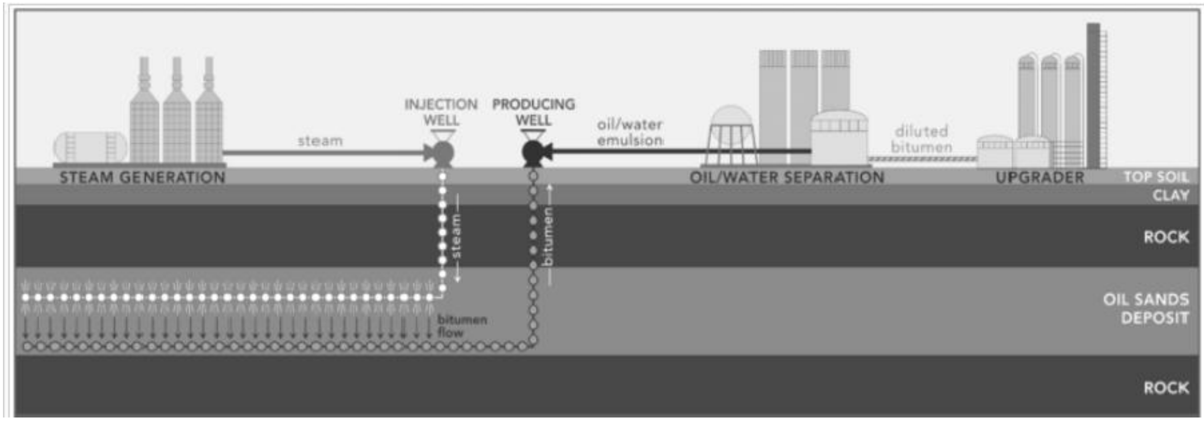

Figure 7.11: In-Situ Extraction: System Assisted Gravity Drainage

The other common method is cyclic steam stimulation (below figure). A single well is drilled and used to inject steam into the bitumen deposit. The steam is kept under high pressure for multiple days to weeks, allowing the reservoir soak up the steam to make the bitumen more fluid. The bitumen/steam mix is then pumped up the same well to the surface.

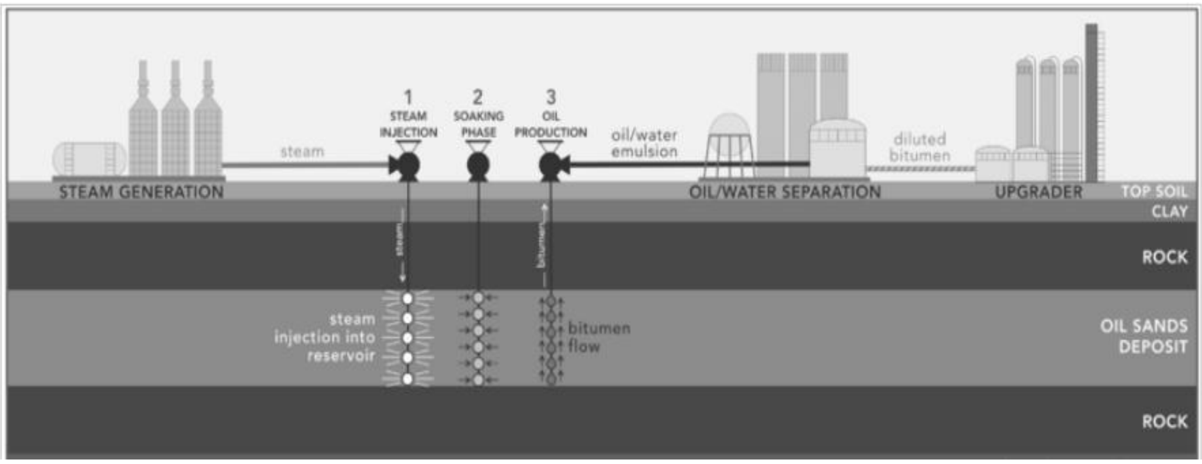

Figure 7.12: In-Situ Bitumen Extraction: Cycle Steam Stimulation

Steam assisted gravity drainage and cyclic steam stimulation is not the only ways to extract bitumen from underground deposits, but they are the most widely used. Other options include Toe-to-Heel Air Injection, Vapour Extraction Process, and an Electro-Thermal Dynamic Stripping Process.

Environmental Impacts

- One of the biggest benefits of utilizing in situ mining techniques is that there are no tailings ponds required, as the sand remains in the ground with only bitumen extracted.
- However, the amount of water used can be an issue (even if it's less than conventional oil extraction), with one barrel of synthetic crude oil requiring half a barrel of water for its extraction. Although up to 90% of the water used during extraction is recycled and used again, there is still some water disposal that occurs. This water can be fresh or brackish, and may contain a variety of pollutants.
- Depending on how this water is disposed of, it could contaminate clean groundwater deposits or harm plant and animal life around the deposit.
- In addition, the volume of water used is an issue because there are concerns with how much water residential areas need and how much is being taken from mutual sources for in situ use.
- Emissions are also an issue when it comes to anything involving the production of fossil fuels. The emissions of carbon dioxide for bitumen development and pre-processing are about 110 kg per barrel – three times the amount for a barrel of crude oil.
- The in situ extraction operations account for about half of this – around 60 kilograms of carbon dioxide per barrel of bitumen.
- The consumption of natural gas to produce the steam used in these operations is considered to be an issue as it releases emissions associated with natural gas. These emissions can range from carbon dioxide to carbon monoxide and sulfur compounds depending on the purity of the gas.

Environmental Impacts of Upstream Petroleum Industry

There are several environmental impacts that can be connected to various upstream petroleum activities.

- There are a wide variety of emissions released into the atmosphere as a result of activities such as flaring. This reduces air quality and increases greenhouse gas emissions.
- Some of these emissions include benzenes, particulate matter, acid emissions, methane, and carbon dioxide.
- 2013 estimates report that the upstream oil and gas sector contributed 20% of the sulfur oxide (SOx) emissions, 23% of the nitrogen oxide emissions (NOx), and 29% of the volatile organic compound emissions in Canada.
- Moreover, water quality and negative environmental effects from land use are a concern with upstream industry.

- The use of fracking fluids when drilling wells is a concern in terms of groundwater contamination and the extensive water use in oil sands extraction are potentially problematic.
- As well, the disruption of habitats can arise from development of extraction sites.

MIDSTREAM PETROLEUM INDUSTRY

Midstream industry is the portion of the oil and natural gas industry that is responsible for the processing, storage, and transportation of products such as crude oil, natural gas, natural gas liquids, and sulfur.

Midstream industry is responsible for linking far-spread petroleum producing areas and population centers where consumers are located. Transmission pipeline companies are included in the midstream petroleum industry. In places like Canada, oil sands upgrading is a part of midstream industry.

The different sectors included in midstream industry are:

- Pipelines
- Transportation
- Upgraders and Refineries

Oil Refinery

An oil refinery is an industrial plant where crude oil is separated into a variety of different, useful substances through a variety of chemical separation steps. After extraction from the ground, processing at oil refineries is the second step in the production of different petroleum products.

This second step in the production of petroleum products is considered to be a portion of the midstream oil and gas industry. Different petroleum products that are obtained at an oil refinery include products such as diesel, gasoline, and heating oils.

In Canada, there are currently 12 companies that run refineries. Most of these companies generally run a single refinery and sell product locally, but a handful of companies own more than one refinery and distribute product worldwide.

Of the 19 total refineries in Canada, 16 are able to extract a full range of petroleum products, while others produce a limited number of products. Some of these limited products include asphalt plants and petrochemical plants. In these various oil refineries, a number of processes occur in specialized equipment to produce desired fractions of crude oil. These steps are outlined below.

Refining Steps

Since crude oil is a mixture of a large number of hydrocarbons that each has their own specialized, individual uses, it must be separated into these individual components. The process of oil refining separates this thick, crude oil into different useful substances in an oil refinery through a number of steps:

Fractional Distillation

Crude oil enters the refinery through a series of pumps and first stops at a heater. In this heater, the crude oil is heated to around 370°C. After the crude oil has been heated and is vaporized, it travels to a distillation tower. Inside these towers the vaporized crude oil is separated into fractions by utilizing their different boiling points.

As the vaporized crude oil travels up the tower, fractions with different boiling points condense at different levels, separating different components of the oil. Lighter fractions like butane and propane are collected at the top with heavier fractions collected at the bottom.

Chemical Processing

Some newer refining processes use chemical process on some fractions to create different fractions in a process called conversion. These processes can break long hydrocarbon chains into shorter ones.

In a vessel known as a hydrocracker, heavier petroleum fractions are exposed to heat and pressure in the presence of a catalyst to break up long hydrocarbon chains. This is useful as it converts some of the heavier fractions into more useful fractions, such as gasoline, jet fuel, and propane.

Treating

The separated fractions from the fractional distillation process are treated and cleaned to remove contaminants such as sulfur. The process of removing sulfur from petroleum products is known as de-sulfurization. This allows the fuels to burn more cleanly and efficiently.

Blending

After separated fractions have been cleaned, they can be mixed together in special proportions to make desired products. For example, mixing of different products can create gasoline with different octane ratings.

Storage

Finally, mixed products are stored on-site until they are delivered to distribution areas. As well as making these petroleum products, refineries also treat the waste created in the processes of extracting the different products to minimize air and water pollution.

What's in a Barrel of Oil?

In refineries, unprocessed crude oil is separated into a variety of different useful products. Although crude oil is not useful by itself, when separated a large number of useful hydrocarbons are obtained, primarily gasoline, diesel fuel, heating oil, jet fuel, kerosene, and propane.

In addition to this, crude oil yields other important products such as natural gas liquids, petrochemical feedstock, petroleum coke, heavy fuel oil, asphalt, lubricating oils, naphthas, and waxes. Because all of these useful products are obtained through the refining process, the refining of oil is an incredibly important step in the oil and gas industry.

Environmental Impacts

Pollution

The refining process releases a number of different pollutants into the atmosphere including sulphur dioxide, nitrogen oxides, volatile organic compounds, particulate matter, carbon monoxide, and benzene in addition to a number of greenhouse gases. In a refinery, the major sources for air pollution are in the catalytic or thermal cracking steps, at the catalytic reformer, at the desulphurization step, and from storage vessels.

Many of the pollutants listed above are harmful to humans and can cause permanent damage. Damage can include respiratory problems - such as asthma, coughing, chest pain, and bronchitis - as well as skin and eye irritations, headaches, and cancers.

Pipeline

Piping, or the pipeline, represents the most common way that the oil begins the process of being transported and distributed. To accomplish this, vast networks of pipelines need to be constructed and maintained. There are many potential obstacles involved in the piping of oil because it typically needs to travel long distances. Some of the most common hurdles include:

Compressor Stations/Pump Stations

Getting the oil and gas to travel the long distances to the downstream refinery locations requires extreme amounts of compression. Even with high amounts of pressure the pipeline routes need compression/pump stations at intervals to keep the flow moving.

Geopolitical

Since the oil does travel so far it is not at all uncommon for it to travel through multiple countries. Thus building and maintaining the pipeline will require successfully navigating these political waters, getting the right permits and other paperwork done, keeping the pipeline in compliance with local regulations, and negotiating taxes.

In addition to these potential complications, other standard logistical issues will arise that typically occur when a company needs to operate in a foreign country. For instance the company will need to pay for travel expenses and other accommodations for key personnel which will be traveling to the foreign country, or it will need to figure out a successful strategy of employing local workers, or a hybrid approach.

Terrain

The pipeline will need to travel across a wide variety of different terrains. For instance it may begin its journey on flatlands, but need to travel across mountainous regions, through deserts, swamps, or frozen land. This wide variety of different terrain types will require unique considerations with regard to the pipeline's construction and maintenance.

Maintenance

As mentioned above, the challenge of maintaining the pipeline is one of the most crucial aspects of piping. It is imperative to prevent the pipes from cracking or bursting because not only would such an accident be extremely expensive, it would also be devastating to the environment, and could also cause significant problems in terms of supply and demand. As stated the nature of geopolitical affairs and terrain conditions may make proper maintenance even more complicated.

Secondary Logistics

After the initial pipeline transfer of the oil, additional transportation and storage may be necessary before the oil is ready to be processed and distributed in the downstream sector of the industry. This additional transportation may take several different forms such as:

- ***Trucking:*** The oil may be trucked over highways and roads to various facilities and processing plants. One advantage of trucking is that it allows the oil to travel to nearly any destination even if there is not a port or rail line nearby.
- ***Barge:*** Often the oil will be transported by barge or other seafaring vessel. This can be a very time consuming process, but it is the most efficient way for the oil to travel over oceans and other large bodies of water.
- ***Rail:*** Oil is often transferred over land by rail providing a cost effective and efficient option of transporting a large amount of oil quickly.

Due to the highly varied ways in which the oil is transported as well as the many different challenges it faces during its journey, there are quite a few different business sectors involved in the midstream phase. The companies provide the services and materials which make the midstream transportation and storage possible. While this list is certainly not exhaustive, a few of the major ones include:

- Pipeline Developers
- Rail Providers (including Big Rail and Short-line)
- Rail Car Suppliers
- Trucking Companies
- Barge Companies
- Terminal Developers and Operators
- Trans-loading Providers
- Gathering and Processing Companies
- Logistics Companies
- Technology Providers

Midstream is the Conduit between Upstream and Downstream

The Midstream sector of the oil industry has a major economic impact on a varied array of people, companies, and even countries worldwide. It is a huge, vital sector which successfully handles one of the most difficult logistical challenges in the world. In addition to the economic contribution of the business itself it is also important to keep in mind what the midstream sector is actually accomplishing.

Ultimately the midstream sector provides an integral link between the upstream and downstream sectors. This in turn makes it possible for the end consumers to purchase the goods and utilize the services that they are dependent upon. Given the far reaching nature of the oil industry, and the vast number of different products that it contributes to, it is obvious why the industry continues to grow and consumption is at an all-time high.

DOWNSTREAM PETROLEUM INDUSTRY

Downstream industry is the portion of the oil and natural gas industry that is responsible for the refining, distributing, and retail of petroleum products. This portion of industry includes oil refineries, petrochemical plants, petroleum products distributors, and natural gas distribution companies. Downstream industry provides numerous products such as jet fuel, gasoline, diesel, synthetic rubber, plastics, pesticides, pharmaceuticals, natural gas, and propane.

The different sectors within the downstream industry include:

- Distributors
- Retail Outlets (like Petrol Stations)
- Production Plants

The Downstream sector of the oil industry is actually the one that provides the closest connection to everyday consumers. As such it is also perhaps the easiest of the three for many people to relate to. In the Downstream sector crude oil arrives at processing plants where it is refined and eventually turned into various products which will then be sold and distributed.

Products

Some of the products commonly associated with the downstream sector include:

- Liquefied Petroleum Gas (LPG)
- Liquefied Natural Gas (LNG)
- Gasoline
- Diesel Oil
- Jet Fuel
- Heating Oil
- Other Fuel Oils
- Propane
- Asphalt
- Synthetic Rubber
- Plastics
- Petroleum Coke
- Lubricants
- Pharmaceuticals
- Antifreeze
- Fertilizers
- Pesticides
- Natural Gas

As indicated above the distribution of natural gas is also one of the fundamental attributes of the downstream sector. The term “natural gas” is probably one that is common to most people; however, it is often not fully understood just what natural gas is. Natural gas is a mixture of methane with other hydrocarbon gases. It is flammable and as the name implies it occurs naturally in underground sites, often in close proximity with petroleum.

Due to its flammable nature, natural gas plays a very important role as both a heating source and also in the production of electricity. Natural gas can also be processed to play a role in the transportation industry and in the production of fertilizer.

Though the term "natural" may lead people to assume that the gas is in its natural state by the time it reaches homes and other final locations, this is not correct. Before it can be used, natural gas must be processed to remove water and other impurities. In fact this is very much where the Downstream phase does its work since it is in this sector that natural gas in rendered usable and then distributed.

Liquefied Natural Gas

Liquefied natural gas is natural gas that has been condensed and liquefied. This is typically done to make the transport and storage easier. For instance, liquefied natural gas takes up a volume of about 1/600th that of regular natural gas. Thus it is much more efficient to transport and store in its liquid form.

This is especially true when it needs to travel over areas where pipelines do not exist. However, in order to accomplish the liquefaction process the natural gas must be exposed to very cold temperatures, typically about −260 °F. It must also be stored in cryogenic tanks. These requirements make it expensive and therefore not cost effective in a lot of commercial settings. Once the liquefied natural gas reaches its destination it will typically be converted back to gas.

Other Industries

Figure 7.13: Downstream Storage Tank

One thing that many people do not realize is that while the Downstream sector is one of the three fundamental parts of the oil industry, by extension this sector also provides a major role in quite a few other industries and areas of life as well. This is because the products refined and produced go on to be used in ways that may not seem intuitive at first glance.

For instance, it is obvious to most people that the fuel produced in this sector will be crucial for the transportation industry and the power industry. However, what may be less readily obvious is that the downstream sector also influences industries such the medical industry through the role it plays in the production of pharmaceuticals and medical equipment.

In addition, the downstream sector produces plastics which are one of the most pervasive materials in just about every industry. In fact the majority of goods from all industries will use plastics in their packaging or manufacturing.

The agricultural industry is also affected by the downstream sector. As stated above natural gas plays a big role in the production of fertilizers. Pesticides are also produced with the aide of the oil industry. Finally the farm equipment itself is likely to run on the fuel produced in the downstream sector.

Logistics

The Downstream sector must also deal with an array of challenges in terms of distribution, transportation and other logistics. The processed natural gas and oil products must be transported to the various places where it will be sold, used, or redistributed. This will typically involve the use of conventional transportation methods such as trucking, rail shipment, or boat shipment. However, because of the unique nature of natural gas it is also very common for it to be transported using an extensive network of pipelines.

As is obvious from the list of goods above, as well as the other topics discussed in this article, the products created in the Downstream sector are products nearly everyone in developed nations will come into contact with daily.

They make up the fabric of our society and without their ready availability our quality of life would be drastically different. The number of jobs created by this industry is also very considerable and in that way the downstream sector has an even greater role to play in the economy. All these reasons combined add up to make the downstream sector an extremely important part of everyday life.

Environmental Impacts of Downstream Petroleum Industry

There are several environmental impacts that can be connected to various downstream petroleum activities.

- Distribution activities can be heavily reliant on fossil fuels, which can result in more greenhouse gas emissions to the atmosphere. These emissions include carbon dioxide, sulfur oxides (SOx) and nitrogen oxides (NOx); along with occasional releases of hazardous materials such as solvents or groundwater contamination from production.
- 2013 estimates report that the downstream oil and gas sector contributed about 5% of the sulfur oxide (SOx) emissions, 1% of the nitrogen oxide emissions (NOx), and 2% of the volatile organic compound emissions in world. These values are significantly lower than the emissions for upstream industry.
- Moreover, since distribution is a component of downstream oil and gas, the possibility of leaks exists.
- Gasoline stations are particularly notorious for emitting volatile organic compounds.

PETRO-RETAILING

In petroleum sector, India is also showing early signs of aligning with global trends in petro-retailing with forces working as depicted in below figure. The market is becoming dynamic because of the changing need and expectations of the customers and entry of new players. Moreover, as per the global trend, the market is slowly moving towards increasing revenue from non-fuel related and further intensifying the competition within the companies to garner maximum market share.

Some of the Forces responsible for bringing changes in the business of petro-retailing are:

- Customer Churning
- Changing Customers' Needs and Expectations
- New players -and increased competition for market share
- Squeeze of Margins and Profitability

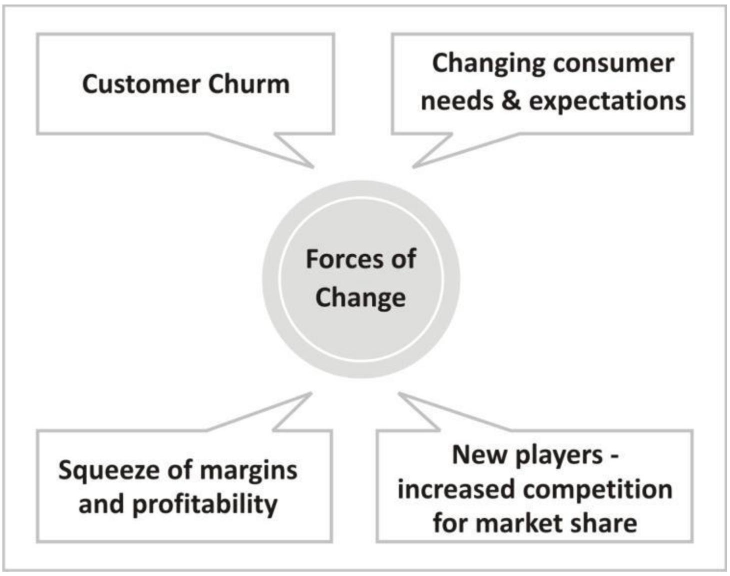

Figure 7.14: Factors Influencing the Change in Petro-Retailing

However, looking at the CRM models as disposed by leading oil companies, it was obvious that they were following a common approach to the CRM business models. The below figure indicates that to have a common experience shared across the company, companies were looking at the uniform offerings, formats and locations to comer the customer loyalty and these were being aided from the four pillars of brand , technology, operations and overall organizational philosophy.

Figure 7.15: CRM Models in Petroleum Industry

New CRM Initiatives in Petro-Retailing

Retail Branding

Over the years, customer was faced with the dilemma of visiting the same company store but with different philosophy for each store. The services, delivery and the approach for each of the company stores were different and therefore, customers were patronizing the service delivery and not the companies.

Over the years, this philosophy has confused the customers about the service parameters of the individual companies. Consequently, companies have adopted a strategy of "Retail Store brands branding', which has influenced the CRM efforts.

Loyalty Based Card Program

PSU Companies biggest leap in building consumer loyalty was to run a powerful card based loyalty programme with various card products such as Credit Card/Debit Card/Smart Cards/Fleet Cards etc. The coalition loyalty programme offered rewards event to cash customers. In addition, the members were also given an option to accumulate points at other coalition member establishments.

These gives value up to 5% rewards on spends - for petrol/diesel fills, lubricants, car servicing, for tyres, batteries & accessories and for grocery purchased at respective company outlets. With this card, customers were roped into buying process on cards and offered cash back when even thinking any credit on buying was a distant dream.

The cards were provided in easy denominations for uploading the amount on the card and are debited on purchase of fuels, which then could be redeemed at any participating Retail outlet for petrol, diesel, premix fuel, lubricants, servicing, tyres, batteries and accessories. Similarly, to facilitate the large fleet operators, many prepaid card for Fleet Owners, which has eliminated all cash transactions en-route, wherever the customers are taking fuel on Highways. Using this card the fleet owner can tracks vehicles through web based tracking system, simultaneously earning attractive & non-stop rewards on purchases. Using Web based technology, the Driver has to place the card on the reader and enter his PIN number.

The information of the Vehicle location is conveyed to controlling company office, from where it is incorporated on the Web server and the vehicle owner can access the information. One card per vehicle is issued with preset limits - daily & fortnightly to take care of the driver's fuel purchases en-route. The card is debited only after the fuel is delivered avoiding any pilferage by the driver and restoring the confidence of the vehicle owner.

Similarly, co-branding of credit cards by the oil companies, e.g. HPCL and ICICI BANK, BPCL and Standard Chartered, IOC and Citibank etc. in various categories of customer's economic strata. The features of tariffs co-branded card were the unique opportunity to save on fuel and services purchased from petrol pumps.

At a time when banks were charging up to 2.5% of the surcharge on fuel purchased thru cards, this co-branded card with special waiver of the 2.5% surcharge on fuel purchases, highly attractive reward points and free fuel in exchange of the reward points, and was first among the category. Along with this card came 'Mileage Schemes' with discounts, accumulation and redeem-emption benefits. These cards were valid internationally, which could act like a credit and debit card, again with varied features.

The latest in the loyalty card is the 'i-mint loyalty card' wherein six leading brands HPCL, ICICI Bank, AirTel, Indian Airlines, Lifestyle and Make my trip.com have joined hands to launch India's first Coalition Loyalty and Consumer Rewards Program. This card was only added to consolidate reward earnings in a single loyalty account. These points can be redeemed not only for fuel but also against a wide array of products and services. During 2005-06, 2.6 million loyalty card customers were enrolled taking the total number to over 5 million as on 31.03.06.

Quality Assurance

HPCL took several initiatives, many of them, first in the industry towards quality assurance under the banner of "Good Fuel Promise" at the Retail outlets. Addition of Mobile labs for carrying out surprise checks at the outlets restored customer confidence in the fuel quality they received making them attached to the retail outlet more significantly.

Another milestone was the continuance surveillance audit at over 4000 outlets every quarter has resulted in remarkable improvement in the quality and service standards at the outlets. ISO certification was done to standardize the quality levels of service. Customer Satisfaction Index (CSI) survey was another step undertaken by the Regional Offices as a mechanism to receive customer feedback.

Besides this, media campaign supported such efforts on the field's activities for making customer aware by the company across the country. This has created trust and confidence in customers.

Leveraging on Technology to Enhance Quality

Retail Automation

Companies like HPCL pioneered the concept of e-fuel stations in India, having fully automated over 40 Retail outlets in western regions as a test case. Quality Assurance through Quality control is an international practice. Retails Automation focuses on monitoring the stocks, sales and inventory controls at Retail outlets by capturing, collating and analyzing all the transactions electronically. This resulted in availability of fuel at all stations which was contrary to the thinking a few years ago.

Vehicle Management System

As a step towards ensuring quality of products during transportation to the Retail outlets, Companies have taken the pioneering step to monitor tank truck movements on real time basis through a technology based Vehicle Management System (VMS). Installation of this system on company owned tank trucks engaged for transporting MS/HSD has resulted in more productivity and better availability of fuel across stations. The benefits though indirectly, are accruing to the customer in the form of timely supplies.

New Visual Retail Identity

In response to customer demand, PSU oil Companies were the first to introduce the concept of New Visual Retail Identity to give attractive look and appearance to its Retail outlets as per world-class standards, which stand out in the Oil industry. The concept of Physical ambience as marketing tools was the premise of this project. Customer remembers the logo and the service as a brand recall.

Rural Initiative

As part of rural initiative; companies promoted a new concept of collaborating the rural distribution channels in rural India to keep pace with the customer orientation. Other than fuel, seeds, pesticides and fertilizers were also being sold to the farmers through "Kisan Vikas Kendras" set up at these outlets. This resulted in generating the additional revenue for the company leading to improvement in performance of the outlet and attaching the company with customers at the grass-root level.

Non Fuel Business

Market research had proved and already mentioned that there are certain non-fuel offerings that customers demand at fuel outlets. Companies grabbed this opportunity through various national tie-ups and helped in generating additional revenues in addition to delivering customer needs. Now, companies are focusing to collaborate with the best in class brands in the relevant categories.

Many companies are now in agreement with brands like Cafe Coffee Day, Crossword Book Stores, Music World, Subway, Pizza Comer and e-Ticketing for Air Deccan and Spice Jet, kingfisher, Indian Airlines, MacDonald's, Dominos, Nirula, etc. and efforts are being made to expand the number of partners by entering into tie-up with reputed International brands.

Training/Motivation of Dealers & Dealer-men

People are integrated part of any delivery mechanism. Other than the physical ambience of the outlets, companies worked on, training Centers for "in-house" training programs were developed at prominently located company-owned model retail outlets in each Region for training dealers/dealer-men on a regular basis.

The key person between the service delivery and the customer is the deliveryman stationed at the petrol pump. Oil Companies have understood that over the years, this person's behavior has stagnated to similar working conditions and needs to be attended.

Dealer-men training "customer first" workshops were conducted covering over a lakh dealer men on all India basis in various training programmes held by profession agencies towards modification of behavior. This "In-sit-U" training program has become a regular feature of the customer-oriented workshops at micro-level of operation.

"Reward and Recognition" is part of any Customer driven organization. Companies also embarked on such activity and coined the scheme "Spot & Reward", which aims at giving immediate recognitions for the good world by the dealer men.

THE FUTURE OF PETROLEUM

Most experts seem to agree that if the world has not already reached peak petroleum production, then it will do so within the next 20 years. Elsewhere on the site it is explained that peak oil does not mean that petroleum reserves have run out, but that the maximum rate of petroleum extraction has been reached and that subsequent methods of extraction cannot increase the rate further.

Over time, the total rate of petroleum output will decrease. This naturally leads people to question what the future will look like. Several scenarios are possible and it seems that all of them will come true to some degree or another, rather than any single one of them coming true alone.

Heavy Oil and Oil Shale

Efforts have already been made to extract oil that was once considered uneconomical to produce. As the world supplies of light, easily extractable crude oil continue to decrease and demand continues to increase, the price people are willing to pay for a barrel of crude will increase as well. As a result, heavier oil that was once uneconomical to extract due to high upfront costs has become profitable to produce.

Countries like Canada and Venezuela and United States all sit atop extremely large deposits of heavy oil and oil shale. In fact, it is estimated that there is more heavy oil in Venezuela then there is petroleum in the entirety of the Middle East. Canada is currently the world's leading producer of heavy oil and it is estimated that the heavy crude in Canada is enough to supply the entire world at current demand for well over 200 years. Of course, the vastness of the supply is only one of the considerations of extracting heavy oil.

Production methods for heavy oil are discussed elsewhere, but the two things they have in common are decreased energy returned on energy invested and it increased impact on the environment. While world demand for petroleum continues to rise, there has recently been competing interests from environmental lobbies concerned about the long-term impact of extracting heavy crude.

Environmental concerns arise not just from the direct impact of the environments, but also from the fact that the decreased energy returned on energy invested for heavy oils means that they produce more greenhouse gases and other pollutants than do same quantities of lighter crudes. In other words, the extraction and use of heavy oil is expected to exacerbate the problem of carbon dioxide and greenhouse gas emissions throughout the world.

What is clear is that heavy oil production will be necessary in the near future unless there is a drastic decrease in demand for petroleum. While techniques are being developed to help reduce the impact of extracting heavy oil on the environment, there is little doubt that utilization of this resource will have substantial negative impact. For this reason, conservation has become more important than ever. The less oil the world uses, then the less the environment is impacted both from current and future oil production activities.

Conservation efforts are less about concern over running out of oil than they are about concern of increasing use of oil. Environmentalists point out that time and money being spent on research and development for the extraction of heavy oil could be better invested into developing alternative energies.

Electricity

Because the transportation industry is responsible for using 70% of all crude oil produced, there has been great effort in the last two decades to produce an electric vehicle capable of performance similar to that of petroleum powered vehicles. While there are major obstacles to overcome, recent advances have seen mileage ranges increased from less than 100 to well over 200 miles.

The major factors holding back the mainstream production of electric vehicles are the cost of batteries, the production and recycling of batteries, and the time that it takes to charge a battery. In other words, the only thing holding back electric vehicles is how they store electricity when the vehicle is not in use. A cheap, efficient, reliable alternative to current batteries would make electric vehicles instantly practical.

Many proponents of electric powered vehicles point to hybrid vehicles as the logical bridge between petroleum vehicles and vehicles that rely 100% upon electricity. Hybrid vehicles offer the benefits of unlimited mileage obtained from gasoline while increasing fuel economy through the employment of electric motors as well.

These hybrid vehicles are slowly but surely progressing from a disproportionate amount of reliance on petroleum to increased reliance on electricity through techniques like adding solar panels, regenerative braking, and plug-in capabilities (allowing them to be charged through the electrical grid rather than by running their petrol motors).

It is worth pointing out that while electric vehicles can reduce petroleum use, the source of electricity used to charge their batteries is of critical importance. If that energy does not come from clean, renewable resources, then the problem is simply being shifted from one location to another and is not being solved.

Proponents are clear that the success of electric vehicles also depends upon the implementation of renewable resources for the generation of the majority of electricity. Technologies like solar, wind, hydro, and geothermal are all being investigated and have met with various levels of success throughout different regions of the world.

Future of Indian Petroleum Industry

The future of Indian petroleum industry has good potential but it needs developmental activities in this sector to strengthen itself.

The world at present is experiencing a lot of changes of mammoth proportions. The Petroleum Industry in India is one of the harbingers of huge economic growth. The arena for business has now gone global since trade boundaries are fast dissolving. These developments present India with tremendous opportunities in the future to be one of the major players in the export of petrochemical intermediaries.

Today, India imports more than 70% of its oil requirements. The search for more oil led India to sift through the international markets comprising of the emerging energy-trading countries - China, Russia, and Iran. India has made new partnerships with Venezuela, Burma, Middle East nations, and Pakistan.

The long-term energy strategies of India have to emphasize on the methods of using energy effectively and efficiently, and to enhance energy self-sufficiency. To lift the Indian economy to enhanced economic standards innovation, diplomacy, creativity, and vision are the need of the hour.

India has to compete for conventional energy sources and for that there must be developmental activities for energy efficient buildings and vehicles. The main problems with the Petroleum Industry in India are related to infrastructural developments. The lack of proper storage facilities, enhancements in refining capacities, and fluctuating import prices plays important role in the development of the sector.

The target of improvement for the growth of the economy for India should be in the area of the petrochemical sector. The need for intermediary products for the manufacturing of the end use products is an important sector to tap in. With the per capita consumption for the petrochemical products in India being low and the production of these products being high, India may become one of the leading exporters of such intermediary products.

The future of Indian petroleum industry depends on:

- Demand for petroleum is growing in leaps and bounds
- Shifting focus to more production of olefin - ethylene, propylene, butadiene etc.
- Price and availability of crude oil and gas as feedstock would still be critical factors
- The demand of the end products would affect the demand of the intermediary products

POINTS TO REMEMBER

- USA started gaining the majority of the market share in 1945 with 65% of oil supplied on the market. The total supply of oil had grown to seven millions barrels per day at this stage in history.
- Oil production continued at a rampant rate up until the 1970s to a rate of 65 million barrels per day due to massive discoveries in the Middle East.
- Making the decision to invest in petroleum exploration and production projects is always a very complicated endeavor. These projects are impacted by many high risk factors associated with the petroleum industry, such as relatively high initial investment requirements, long term investment horizons (projects may take up to 20 years or more) and negative cash flow during the first few years, sometimes also during the last years of the project life.
- These factors, coupled with dangerously volatile price levels, makes the number of uncertainties in the data utilized in decision making to invest in petroleum projects very high, and this therefore weighs heavily on the minds of decision makers.
- Most petroleum companies make the decision to invest in a certain petroleum project based on economic models, which are constructed as spreadsheets prepared by internal economists in the company or by external experts based on data available from different sources (such as petroleum engineers, geologists etc.).
- The concessionary system or so-called royalty/tax system was the first system used in world petroleum contracting and it is used currently by around half of the petroleum producing countries worldwide, including the US, UK, France, Norway, Canada, Australia, New Zealand, Libya, and South Africa.
- The contractor may be required to pay annual surface fees to the host government, either in the exploration phase or/and in the production phase, based on the area over which the project extends.
- A royalty is one of the most commonly used fiscal tools worldwide. It represents an amount paid by the contractor to the host government in cash or in kind. Royalties paid to a private party other than to a host government are called overriding royalties.
- In the contractual system the host government retains the ownership rights on the petroleum and shares the petroleum production with the contractor in kind or in cash.
- Geological risk factors play an important role in the exploration phase of a petroleum project. The key to success in this phase is the presence of an acceptable likelihood of commercial petroleum, which is based on the existence of four geological factors: presence of sufficient and mature source rock, presence and quality of reservoir rock, presence of a trap, appropriate timing of trap formation, migration and retention of hydrocarbons.
- Political risk arises from uncertainty in nations with regards to their rules, laws or legislation. If there is a change to a contract this can have a significant impact on the projected profitability of a project.
- Finally, partner risk arises from operations where two companies are involved, typically from joint ventures. Two companies may choose to work together to exploit a reservoir because of complimentary services or economies of scale.
- LPG is mostly a combination of propane and butane. It is heavier than air, and liquefies under pressure. It is used as a household cooking fuel, vehicular fuel and refrigerant; 4 million vehicles are estimated to be powered by LPG in the world.
- Kerosene is also known as paraffin, is used as an illuminant and cooking fuel in India and other poor countries, and as a space heating fuel in industrial countries.
- Benchmark oils are used as references when pricing oils. There are approximately 161 different benchmark oils, of which the main three West Texas Intermediate, Brent Crude, and Dubai Crude. Crude oil is the most actively traded commodity and is bought and sold in "contracts."

- Brent Crude, named after a goose, comes from the North Sea. It is light, sweet crude with an API gravity of 38.06 and a specific gravity of 0.835, making it slightly “heavier” than West Texas Intermediate. The sulfur content is 0.37%.
- Dubai Crude is light and sour, with an API gravity of 31 degrees and a specific gravity of 0.871. Its sulfur content is 2%, making it 6 times sourer than Brent Crude and 8 times sourer than West Texas Intermediate.
- Oil sands extraction is the process of removing oil sand from the ground and extracting bitumen from it. This bitumen is later upgraded into a synthetic crude oil that can be separated into usable fractions through fractional distillation.
- Surface mining is a technique used to obtain bitumen from oil sands where the oil sands deposits are located fairly close to the surface. If the reserves are shallow enough, earth moving equipment can dig out oil sand for processing.
- Midstream industry is the portion of the oil and natural gas industry that is responsible for the processing, storage, and transportation of products such as crude oil, natural gas, natural gas liquids, and sulfur.
- An oil refinery is an industrial plant where crude oil is separated into a variety of different, useful substances through a variety of chemical separation steps. After extraction from the ground, processing at oil refineries is the second step in the production of different petroleum products.
- Piping, or the pipeline, represents the most common way that the oil begins the process of being transported and distributed. To accomplish this, vast networks of pipelines need to be constructed and maintained.
- The Midstream sector of the oil industry has a major economic impact on a varied array of people, companies, and even countries worldwide. It is a huge, vital sector which successfully handles one of the most difficult logistical challenges in the world.
- In addition to the economic contribution of the business itself it is also important to keep in mind what the midstream sector is actually accomplishing.
- Downstream industry is the portion of the oil and natural gas industry that is responsible for the refining, distributing, and retail of petroleum products. This portion of industry includes oil refineries, petrochemical plants, petroleum products distributors, and natural gas distribution companies.
- Downstream industry provides numerous products such as jet fuel, gasoline, diesel, synthetic rubber, plastics, pesticides, pharmaceuticals, natural gas, and propane.