Chapter 2
World’s Oil and Natural Gas Scenario

Abstract  Recent studies suggest that the earth’s crust may hypothetically hold 6,000 Billion Barrels of oil as its reserves, which also include 3,000 Billion Barrel un-recovered oil resource. However, owing to the complexities in geology associated with the reservoirs one can only indirectly get some inference about the quantum of reserves based on some probabilistic distribution. With 95% probability the world may touch ultimate recovery of 2,248 Billion Barrels. Owing to the non-encouraging scenario of oil production and likely higher cost of oil in future, may lead to search for alternative replacement to oil. The world gas reserves are estimated to the order of 10,000 Trillion Cubic Feet (TCF) out of which only 6,186 TCF are the proven reserves. The projected world natural gas consumption may reach to 158 TCF by 2030. This chapter provides an overview of present oil production, its consumption and future prospects.

2.1 Introduction

Oil, natural gas and coal form the main constituent of fossil fuel energy. These energy resources were formed millions of years ago as the consequence of decomposition of organic remains trapped in the sediments and subjected to high temperature and pressure conditions in the subsurface of the earth. Such temperature–pressure regimes prevail in the shallower part of the crust. The presence of high order of total organic content in the sediments under this regime over long periods of time would provide most likely sites for the formation of oil and gas. Large extent of the world (expect some deeper part of the oceans) has been explored to assess the oil resources and the most favorable geological structures have already been mapped where oil and gas are likely to be found. However, it has been noticed that the potential oil resources are unevenly distributed over the globe (Fig. 2.1). Most of the favorable locations of oil deposits are confined to former Soviet Union, Middle East and North Africa and Asia Pacific and some other regions of the world.
Hypothetically, estimated in place crude oil of the world are of the order of 6,000 billion barrel (B, barrel ~ 159 l) which includes the recoverable and non-recoverable oil in the reservoirs. From this about 3,000 BB could be technically recovered and produced. The quantum of recoverable oil is estimated based on the present geological information and technological development. The estimate of recoverable oil in region has three contributing components i.e. the cumulative production to given date, proven reserves and un-recovered resources (yet-to find) (Fig. 2.2, adopted from Wood et al. 2004). Based on the degree of uncertainty the oil reserves can be classified as proven and unproven. The proven reserves are “the estimated quantities of oil which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under current economic and operating conditions” (Lyons and Plisga 2005). The proven reserves are the estimates of oil resources, which are based on geological information and could be produced by the present day technology certainty (probability). In practice a probability of 90% is used to ascertain the quantum of proven reserves in a region (Gregory and Rogner 2004). Unproved reserves can be classified into possible reserves and probable reserves, based on the low order probabilistic distribution. Possible reserves are estimated with 50% probability and with assigned probability of 10% the quantum of probable reserve are estimated. In general, most early estimates of the reserves of an oil field are conservative and tend to grow with

**Fig. 2.1** Oil endowment (cumulative production plus remaining reserves and undiscovered resources) for provinces assessed. Darker green indicates more resources. The USGS world oil and gas assessment- Thomas S. Ahlbrandt, United States Geological Survey, Denver, CO, US Geological Survey Fact Sheet 062-03 (supersedes FS-070-00)
time. This phenomenon is called reserves growth. Governments can also withhold details of oil reserves for economic and national security reasons, are considered as strategic reserves. EIA estimates approximately 4.1 billion barrels of oil are held in strategic reserves. These reserves are generally not counted when computing a nation’s oil reserves.

Based on the technological aspect, the configuration of the geological structure and economical consideration, only a part of the oil can be produced from the oil in place. The ratio of the producible oil to oil in place is termed as the recovery factor. The recovery factor varies from 10 to 60 and even as high as 80. The recovery factor can be enhanced depending on the characteristics of the reservoir, technological development and on the investment. The producible oil also incorporates small quantum of undiscovered (yet-to-find) oil. The non-producible/unrecoverable oil pertains to the oil that cannot be recovered by present technology and economic consideration. These estimates may change as knowledge for the formation of oil grows, technology advancement and change in the economics scenario. The model estimate of USGS has a component of reserve growth, suggesting improving the recovery factor may enhance estimates of reserve. Primarily about 10–15% oil can be recovered by upward flow towards the surface of oil by its buoyancy. The recovery factory can be enhanced by means of injecting fluids and thereby increasing the pressure in the reservoir (secondary), and in the tertiary process by thermally heating oil by injecting steam and thereby reducing its viscosity. Chemical agents like surfactants can also be used to reduce the surface tension in the oil and allow the oil to flow easily to the surface. Other means is pumping gases like carbon dioxide in to the reservoir, which may either reduce the pressure or get mixed up with the oil and thereby reducing its viscosity and permits easy out ward flow to the surface. Such attempts may enhance the recovery factor to as high as 60%. With the

*Fig. 2.2* Different interpretations of a hypothetical 6,000 Billion barrel World Original Oil-in-Place resource base

*Source: http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2004/worldoil supply/oilsupply04.html*
introduction of 3-D seismic survey, demarcating the physical limits (geometry) of oil reservoir has become more reliable and the scope of drilling dry wells has substantially reduced. The time lapse 4-D seismic surveys not only provide locating oil reservoir more precisely but also helps in real time estimates of oil reserve quantum by the identification of oil-water contact. Advancement in drilling technology also helped prevention of blow outs. Logging while drilling (LWD) providing real time in situ measurement and thereby ascertaining the health of reservoir. Introduction of horizontal and target oriented drilling has resulted in improving the recovery enhancement. These advancements in technologies have enhanced recovery factor from 10 to 60% to as high 80% depending on the characteristics of the reservoir, technological development and the investment.

Figure 2.3 shows the pattern of oil reserves estimates based on the different confidence level (probability). The distribution suggest that with least confidence level, reserve estimate is significantly high, whereas with 95% confidence level the reserve quantum is appreciable low. With these probabilities the global reserve is estimated to be about 2,500 BB with 95% probability and 3,900 with 5% (possible reserves) probability respectively. Under the prevailing technological conditions a figure 2,500 BB reserve looks to be quite optimistic. However, experiences have shown that the estimate of oil made in the past is rather low. Improvement in the understanding the characteristics of reservoirs are leading to increase in the recovery of oil and thus growth in reserve estimates.

**Fig. 2.3** Schematic graph illustrating petroleum volumes and probabilities. Curves represent categories of oil in assessment. There is a 95% chance (i.e., probability, F95) of at least volume V1 of economically recoverable oil, and there is a 5% chance (F05) of at least volume V2 of economically recoverable oil.

*Source: pubs.usgs.gov/fs/fs-0028-01/fs-0028-01.html*
The present oil reserve estimates only take into consideration the cumulative figure of oil already produced and likely to be produced with present day technology and which is economically viable. In this regard it is considered as the conventional form of energy.

The OPEC members hold around 75% of world crude oil reserves. The countries with the largest oil reserves are, in order, Saudi Arabia, Iran, Iraq, Kuwait, United Arab Emirates (UAE), Venezuela, Russia, Libya, Kazakhstan and Nigeria (Fig. 2.4).

### 2.2 Oil Scenarios

The amount of oil in place is estimated by different methods. They are categorized in three categories, viz. volumetric, material in balance and production performance. Volumetric method provides the estimate of oil in the reservoir depending on the size, the physical properties of the host rock and the liquid content. The product of the size of the reservoir and the recovery factor determines the oil in reserve. The material in balance method relies on the quantum of petroleum already extracted and the prevailing physical conditions, such as pressure, temperature and pressure history to determine the quantum of reserve the reservoir holds. The production performance methods depend on the history of production of the reservoir. As the

![Image: World oil reserves by region](Fig. 2.4)

**Source:** [www.absoluteastronomy.com/topics/Oil_reserves](http://www.absoluteastronomy.com/topics/Oil_reserves)
production continues the rate of production will tend to decline. Based on the statistical analysis the pattern of decline in the production can be ascertained and strategies for production from the reservoir in future can be worked out.

The present oil reserve estimates have remained mainly unaltered. There have been no giant oil field discoveries after late 1960s. This is due to the fact that major oil fields tend to get explored easily. The estimated recoverable oil remained almost constant from around 1960s. This ultimately recoverable reserve of oil also incorporates the quantity of yet to find oil for estimating the total reserves, which can be put to production with some percentage of recovery factors. It is assumed that possibly around 2,000 BB can be recovered from existing oil in place. A periodical analysis based on the assumed ultimate recoverable oil 2,000 BB, suggests that the contributory elements to ultimate recoverable have been modified/re-categorized, the total quantum remaining unchanged since 1950 (Bentley 2002). The analysis indicated (Fig. 2.5) that as cumulative production has grown, the proved reserves have increased from 540 BB in 1970 to 1,050 BB in 1998. The quantum of yet-to-find resources have substantially contributed to the improvement in the proved reserves. This may suggest that estimates of proved reserves have been under quoted or due to part of probable and possible reserves estimates have been put in the proved reserve category with technological developments and thereby improving the recovery factor. The re-categorization leads to improvement in the estimates of proved reserves and with reserve/production ratio of 1998, the world’s oil production can sustain in future for two to three decades.

However, for most of countries around the world have shown decline in the production of conventional oil. Figure 2.6 gives the yearly production of oil from the major oil producing countries of the world. The quantum of oil which is likely to be produced including a appreciable quantum from deep water reservoirs, Polar Regions as well as liquids converted from natural gas reserves does not provide encouraging scenario for oil production in future. In US oil production has substantially come down from couple of decades. The Middle East, most prolific contribution to oil production also seems to be approaching peak production.

Figure 2.7 shows world wide consumption of oil (dark colours represents more consumption based on the reserve estimates during late nineties of the order 1,750 BB (www.globalresourcesplus.com/Petroleum_by_country.html). Most of oil producing countries except perhaps Middle East and Russia has already consumed more than half of their estimated oil reserves. In recent time it is being debated how long the conventional oil reserves are going to last. It is argued that global conventional supply is at political and physical risk (Bentley 2002). It is estimated that maximum oil reserves are still preserved in the Middle East. Under any political strain the Middle East may curtail its oil production and it would be quite difficult for other oil producing countries to substitute the shortfall resulting in higher cost and leading to turmoil in the international market. As most of the oil producing countries in the world have already crossed the peak limit of the oil production, the burden on Middle East countries will be immense to increase the production leading to the decline in their oil reserves (Bentley, 2002).
Fig. 2.5 A history of world oil: production, reserves, and yet-to-find in 1950, 1970 and 1998. 

Notes: excludes NGLs. Data in billion barrels (Gb). Assumes a conventional ultimate of 2,000 Gb, and calculates: Yet-to-find = \( \frac{1}{4} \) Ultimate Cumulative production 

Reserves: Reserves here are public domain proved reserves. (This makes the end-'98 yet-to-find somewhat misleading. The industry end-'98 figure for (proved+probable) reserves, excluding NGLs, is around 850 Gb, giving a yet-to-find, based on a 2,000 Gb ultimate, of about 300 Gb). Depletion curve: Exponential decline once 1,000 Gb has been produced.

Sources: Reserves data from BP Statistical Reviews, and as supplied by EDA Ltd. Production data pre-1965 from Campbell. NGL’s estimated
The consumer demand for crude oil has been increasing with annual rate in excess of 2%. This demand is even higher in the advanced Asian countries like China, India and South Korea owing to increase in transportation, using cars and trucks powered by internal combustion engines. Extensive analysis of demand-supply by petroconsultants, geologists has predicted that the oil production will peak with in a span of 20 years in the near future. Based on the King Hubbert (1973) and Gillette (1974) approach, USGS analyzed long term world supply data and predicted the nature of oil production scenario in the future. Figure 2.8 shows the pattern of annual demand production growth of 2% for different resource levels and with decline for reserve/production (R/P) ratio of 10. It is estimated that with 95%
probability the oil reserve is estimated to be of order of 2,248 GB and with demand growth rate of 2% the oil production will peak around 2026 touching a figure of around 42 BB per year, which eventually will decline sharply with assumed R/P ratio. The oil production will peak to about 52 BB in 2037 with estimated mean value of oil reserves. With lowest probability of 5% of oil reserve estimate the peak production will touch value of around 65 GB per year during 2047. Even with least probability of 5% the world oil reserve touch a figure of 3,898 BB and eventually decline very fast leading to severe energy crisis all over the globe.

### 2.3 Natural Gas

The present trend in oil consumption and its not encouraging prospects make natural gas a viable replacement for oil in near future. The decomposition of organic matter in oxygen-poor (anaerobic) conditions and aided by bacterial activity leads to the formation of natural gas. The presence of high content of organic matter in most of the young sediment basins may favor the generation of methane gas in such locales. The gas when formed diffuses in surrounding regions unless it is trapped by suitable geological structures. Commercial amounts of gas also can accumulate as a gas cap above an oil pool or, if reservoir pressure is sufficiently high, dissolved gas in the oil is derived from both land plants and marine organic matter. The gas found in nature is formed due to physical, chemical, biological and geological conditions prevailing in different at levels in the earth’s crust. Most of the methane gas is of biogenetic nature and formed at shallow levels of the crust, where biological and chemical processes dominate and is confined to swamps, lake beds and shallow marine environment. In the deeper parts of the earth
the physical parameters of temperature and pressure dominate the formation of thermogenic gas (see details – Chap. 1). Natural gas primarily comprises methane and ethane. Other gases like propane and butane may also be present in the natural gas and such mixture without presence of any liquid component is considered as dry natural gas. The inclusion of higher isotope elements such as pentane containing liquids at standard pressure and temperatures may be considered as natural gas liquids. Natural gas reserve may also contain non-hydrocarbon elements such as carbon dioxide, water vapor, hydrogen sulfide and such mixed gas is considered as wet natural gas. The wet gases are processed to remove the contaminants before the gases are used for normal purposes.

Gas is found abundant in nature; with its higher recovery rate, higher fuel efficiency and low order pollutant may work out to be a good future energy prospect. Natural gas remains the main energy resources for many industrial plants and the generation of electricity. Worldwide natural gas is third most prominent energy resource amounting to 23% of global energy consumption. It is expected that in future, industry will consume 40% of total gas production. In absence of good transport system for transporting the gas to industrial plants most of the gas associated with oil reservoirs is burnt at the wellhead. Owing to its low calorie content it has lesser priority than oil for its use as the energy source. In order of priority Russia, Iran, Qatar, Saudi Arabia and UAE have the highest gas reserves of the world. Russia is also highest gas producer of the world. Global gas reserves are abundant, but unevenly distributed (Fig. 2.9).

![Fig. 2.9 Global gas reserves. (Adopted from Ahlbrandt (2002))](image-url)
The projected estimated reserves of the world are of the order of 10,000 trillion cubic feet (TCF), out of which around 6,254 TCF are the proven reserves. Middle East and Eurasia hold almost three-quarter of world’s natural gas (Fig. 2.10), Russia, Iran and Qatar alone contributing 57% of this. It has been suggested that the quantum of gas reserves have not substantially improved over last couple of years. However, Iran and USA in recent times have added significantly to their reserves, followed by small incremental rise in the reserves in Indonesia, Kuwait, Venezuela and Libya (EIA 2009). Most of the reserves growth in USA during the last couple years has come from shale resources, outside USA there were not much serious attempts to exploit natural gas from the shale resources.

### 2.3.1 Natural Gas Scenario

The global market for gas is much smaller than for oil because gas transport is costly and difficult. Only about 16% of global gas production is internationally traded, with less than 4% of the trade accounted for by liquefied natural gas (LNG). However, in spite of the high cost of gas transportation and the remote location of potential future supply regions, increasing international trade in natural gas is expected. A significant portion of gas production by major gas producing countries is meant for export in the form of LNG. Middle East and Africa are likely to be main contributors for the supply of LNG in the coming future. These two countries are likely to have tremendous growth (~21 TCF) in the production of natural gas and especially in terms of LNG and may cover a bigger portion for the demand of gas from other countries (EIA 2008, 2009). Recent discovery in China and India may help these countries to reduce their import from other countries. The industrialized countries are the major gas importers, but the major gas supplies are located in the Former Soviet Union and the Middle East. Thus, similar to world

![Fig. 2.10 World Natural Gas Reserves by Geographic Region as of Jan 1, 2009](image)

**Source:** Worldwide look at reserves and production, “Oil and Gas Journal. 106(48), (Dec 22, 2008) pp 22–23
oil, the expanded use of natural gas by Europe and Japan will become increasingly
dependent on the world’s politically unstable regions. Canada provides most of the
natural gas imports to the United States.

The Organization of Economic Co-operation and Development (OECD) comprising mainly of developed countries (USA, Canada, Japan, South Korea and others) and Non-OECD (Russia, China, India and others) consumed around 104 TCF during the year 2006. The yearly world demand for natural gas is 104 TCF and likely to rise to 153 TCF in 2030. In the year 2006 the OECD countries consumed 52 TCF and non-OECD countries utilized 53 TCF. The consumption of natural gas by non-OECD countries is likely to surpass that of OECD countries, with 2.2 average annual growth almost twice that of 0.9% growth of OECD countries (Fig. 2.11). In the year 2006 OECD produced 38% of total natural gas production and consumed about 50% of the total gas production making them to depend heavily on imports from other countries. The projected production and consumption of natural gas by OECD countries is likely to fall during the year 2030 and their dependence on import of gas may likely to fall as projected during 2030. Russia is largest consumer natural gas in the list of non-OECD countries and by 2030 the gas consumption is likely to surpass that of oil and coal consumption. The non-OECD presently consumes about 9% of world gas production and which is likely to increase to 31% in the year 2030. Developing countries China and India are likely to heavily increase their consumption to match with the expected industrial growth. Presently China and India utilize very small percentage of gas towards their energy consumption and which is likely to show an increase of 5% in their consumption. In order to meet the growing demand of natural gas in the future a substantial increase in the production of gas is required. The non-OECD countries are likely to contribute significantly to world’s natural gas production. In the non-OECD countries the

![Fig. 2.11 World Natural Gas Consumption 1980–2030](http://www.eia.doe.gov.iea)
production is likely grow by 2.1% per year. On the contrast the OEBD countries will show smaller growth rate of 0.9% and may likely to add about 7 TCF to increase in global demand of 48 TCF during the period of 2026–2030. India and China is likely to double their production by 2030. However, the rate of consumption is also, increasingly sharply in the developing countries like China and India.

The study suggests that the Non-OCED countries will start consuming more gas in future. Like in the oil scenario most of the proven world gas reserves have already been consumed. With higher rate of recovery the peak production for many countries has already surpassed.

2.4 Unconventional Oil

The conventional form of oil contributes only a small percentage of the existing oil basket under the subsurface earth. The existence of other types of large petroleum deposits over vast areal extent have been identified. These oil reserves have slightly different physical characteristics and cannot be recovered from normal conventional techniques. The unconventional resources require greater than industry-standard levels of technology or investment to harvest and are termed as unconventional oils. The total amount of unconventional oil resources in the world considerably exceeds the amount of conventional oil reserves (Fig. 2.12). It is estimated that earth may hold about 45,000 BB of unconventional oil and about 1,000 BB can be recovered and put to production. This substantial fossil fuel energy resource may supplement and overcome the depleting conventional fossil fuels in the near future.

Unconventional fossil fuels have been put in four distinct groups, based on their higher density, viscosity and ratio of hydrogen and carbon in the oil. These oil types do not flow easily due to their high viscosities. They can be categorized in heavy and extra-heavy, bitumen and shale oil, depending on their specific gravity or American Petroleum Institute (API) gravity values. API values define the density of petroleum liquids compared to water. Petroleum liquids having lesser than 10

Fig. 2.12 World proven oil reserves
Source www.landartgenerator.org/.../date/2009/09
API value sinks in water and greater than 10 are lighter when compared to water. Most of the unconventional oils have lower API when compared to conventional oil. Oils are considered to be heavy, extra heavy or bitumen, when their API values range from 25 to 7 covers mobile and less mobile (bitumen) oils. The shale oil constitutes mainly of bitumen and primarily considered as source rock (Total 2006).

Most of unconventional oil deposits are confined to shallow portion of the crust and have been identified in many parts of the world. These deposits are considered as degraded products of conventional oil. It is being hypothesized that conventional oil field formed at deeper level migrated to shallower levels. In the shallower levels most of the lighter carbons were consumed due to biodegradable action by the bacteria, exposure to water and air, leaving the hydrocarbon containing carbon, asphaltenes and resins in the oil. They are contaminated by heavy metals, sulfur and nitrogen. These deposits are found mainly in unconsolidated permeable sands.

Oil sands, also known as tar sands, or extra heavy oil, are a type of bitumen deposit. The sands are naturally occurring mixtures of sand or clay, water and an extremely dense and viscous form of petroleum called bitumen. Depending on the viscosity of the heavy oils different types of methods are proposed for production. Heavier oils with comparable lower viscosity can be produced by injecting hydrogen (hydro-cracking) or depleting carbon content (cracking) of the heavier oils. The viscosity of the heavy oils decreases appreciably with increase in temperature. Steam is injected in the reservoir for the production of oil. Because of very high viscosity of the bitumen containing oil, normal treatment processes cannot be applied

Fig. 2.13  Worldwide heavy oil reserves by country
Source: Schlumberger open database; http://www.slb.com/services/industry_challenges/heavy_oil.aspx
for production of oil. The deposits present at shallow levels of the earth are mined along with host rock and treated in plants for recovery of oil. The heavy, extra heavy and bitumen oil deposits are found in large amounts in many countries throughout the world (Fig. 2.13, adopted from http://www.slb.com), but are found in extremely large quantities in Athabasca Oil Sands in Alberta, Canada and the Orinoco extra heavy oil deposit in Venezuela. These two countries produce around two-third heavy and extra heavy oil of the world. IEA estimates that earth may hold about six trillion barrels of heavy oil and from which about two trillion barrels is recoverable.

2.4.1 Shale Oil

Historically shale oil has been referred by many different names, such as cannel coal, boghead coal, alum shale, stellarite, albertite and kukersite. Some of these names are still used for certain type of oil shales. Shale oil is primarily a fine grained sedimentary rock containing lots of organic material (kerogen). The chemical decomposition of kerogen begins at temperature \(480–520^\circ\text{C}\). Appreciable quantity of oil can be extracted from these sediments. The extraction process requires mining of the rock and subjecting it to heat treatment (retorting) or from the chemical process of pyrolysis. Shale oil is likely to be present in many parts of world; the highest concentration is being in the USA. The estimated quantum of shale oil of the world is around 2.8–3.3 trillion barrels and small percentage of that can be recovered.

2.5 Unconventional Gas

Natural gas in most of the countries is being produced from conventional reservoirs. Except USA, most of the countries have not put serious efforts to look for the vast extent of gas trapped in complex geological environment. One way of defining unconventional gas is as ’natural gas that cannot be produced at economic flow rates nor in economic volumes of natural gas unless the well is stimulated by a large hydraulic fracture treatment, a horizontal wellbore, or by using multilateral wellbores or some other technique to expose more of the reservoir to the wellbore’ (Perry et al. 2007). Unconventional gas resources are likely to be present in tight gas sand, coal seams (coal bed methane) and in shale gas. Growing concerns about the green house effects and depleting oil scenario have necessitated USA to increase the gas production by proper understanding of the geological regimes and applying new techniques for the extraction of natural gas from unconventional resources. This has led to boosting of gas production in USA by the order of 30%. It is estimated that a total 32,000 TCF of natural gas to be present in coal bed methane, shale gas and tight gas sands (Rogner 1997; Kawata and Fujita 2001). During the last decade development of tight gas reservoirs have occurred in Canada, Australia, Mexico, Venezuela, Argentina, Indonesia, China, Russia, Egypt, and Saudi Arabia. Most of the recent
discoveries of giant gas field in United States are located in unconventional gas resources. Unconventional gas deposits are confined to low permeable reservoirs and mainly contain dry gas and are categorized based on their flow rates.

Unconventional gas also been associated with coal bed formation (coal bed methane) and is emerging as good resource potential for natural gas in near future (Detailed in Chap. 1). Other prominent gas resources which have been extensively reported in recent times are the presence of methane gas in form of gas hydrates.

### 2.5.1 Tight Sands

Tight sands are characterized by their low permeability because of compaction, the nature of the fine sediments, or pore space infilling. The tight sand reservoirs are mainly associated with compact rock types such as sandstones and limestones. It is assumed that tight sands occur in vast quantities world over but their quantum is not well defined. It is estimated that gas from tight sands contributes to about 30% of total domestic supply in the United States. The flow rates of tight sands are uneconomical and it takes special technologies to produce this unconventional resource. A great deal more effort has to be put into extracting gas from a tight formation. Several techniques exist that allow natural gas to be extracted, including fracturing and acidizing.

### 2.5.2 Shale Gas

Shale formations act both as source and reservoir for natural gas. The gas in shale is stored in pore spaces, in the fractures and absorbed gas. The presence of gas in different settings makes extraction of gas from the shale difficult. Abundant occurrences of shale gas have been reported from USA, Canada and Asia Pacific (Perry et al. 2007). It is expected world over about 16,000 TCF of natural gas may exist in the from shale formations. Hydraulic fracturing, horizontal and directional drilling techniques are being used to extract gas from the shale gas reservoirs.

### 2.5.3 Geopressed Zones

Geopressed reservoirs or aquifers occur in most parts of the world in the deeper parts of the earth. These zones/reservoirs are located in a higher pressure regime under the earth’s surface. These deep reservoirs/zones hold methane dissolved in hot (150–200°C) brine solutions. The natural gas present in the aquifer is under very high pressure hence the term ‘geopressure’. The reservoirs are formed when the water and methane gas present in the clay is squeezed out and percolates down in
the more porous sand and silt deposits due to the rapid compaction overlying clay beds. Subsequent sedimentations increase pressure conditions in the aquifer. The geopressurized reservoir zones are located at great depths, usually 3,000–6,000 m below the surface of the earth. The dissolved methane content is generally of the order of 30–80 cubic feet in one barrel of brine solution. The dissolved gas content in the geopressurized reservoir is appreciably low in comparison to normal liquid hydrocarbons under pressure. However, the occurrences of these zones over large extent make these deposits as possible future resource potential. The higher fluid pressure gradient in the reservoir may lead to easier recovery of gases when the reservoir is tapped.

The geopressurized zones provide three types of energy resources. They form unconventional gas reserves; the high pressurized fluids impart mechanical energy and the hot brine may provide geothermal energy. However, geopressurized zones are estimated to hold largest unconventional gas reserves of the world. Most of the geopressurized natural gas in the U.S. is located off Louisiana and Texas Gulf Coast region. In these regions most of the productive strata is confined to sand beds, which are interbedded with shale. The amount of natural gas in these geopressurized zones is uncertain. However, experts estimate that anywhere from 5,000 to 49,000 TCF of natural gas may exist in these areas. Given the current technically recoverable resources are around 1,100 TCF, geopressurized zones offer an incredible opportunity for increasing the nation's natural gas supply.

Emergence of new technology and proper understanding of mode of formation of unconventional oil/gas resources in recent times has provided some hope that these resources may compliment the conventional oil/gas reserves and thereby reduce the energy resource crunch in future. However, such efforts require large financial resources and unconventional oil/gas production economical viable for its production and utility. Even with probable abundant accumulations of unconventional form fossil fuel energy special types of processes, present economic conditions and political considerations may forbid extensive attempts to extract and utilize unconventional energy resources. The easier processes of recovery of conventional form fossil fuel energy and its economic still hold advantageous this over unconventional oil and gas resources. In this context unconventional form of oil and gas may not significantly add to present oil and gas reserve scenario. The present recession in the global market may make unconventional oil economical not viable source of energy in the near future.

### 2.6 Hydrogen

Hydrogen is being considered as viable source of energy carrier in the future. It can be used in any application in which fossil fuels are being used today. Hydrogen works as an energy carrier, and like electricity must be produced from other resources. Because hydrogen doesn’t exist on Earth as a gas, it must be separated from other elements. It can be produced from water by using a variety of energy
sources, such as solar, nuclear and as the by-product of chemical reaction and it can be converted into useful energy form efficiently and without detrimental environmental effects. The only by-product is water or water vapor. The utility of solar energy for separating hydrogen molecules from water may provide hydrogen as renewable source of energy carrier.

Most commonly used methods for producing hydrogen are the steam reforming and electrolysis. Steam reforming method is less expensive is commonly used for producing hydrogen from methane gas. About 90% of hydrogen produced in United States comes from steam forming method. The steam forming method emits high quantity of green house gases, which may lead to global warming. The electrolysis process is used to separate hydrogen atoms from water molecules. It is very expensive process and utilized only on smaller scale and as emergency standby.

It is suggested that usage hydrogen as energy may substantially reduce the greenhouse effect and thereby controlling global warming. Hydrogen can be used as a fuel in furnaces, internal combustion engines, turbines and jet engines, even more efficiently than fossil fuels, i.e., coal, petroleum and natural gas. Hydrogen can also be converted directly to electricity by the fuel cells, with a variety of applications in transportation and stationary power generation. It has been successfully demonstrated that light vehicles as well as buses as mode transportation can be run utilizing hydrogen energy. The National Aeronautics and Space Administration (NASA) is the primary user of hydrogen as an energy fuel; it has used hydrogen for years in the space program. Liquid hydrogen fuel lifts NASA’s space shuttles into orbit. Hydrogen batteries, fuel cells, power the shuttle’s electrical systems. The only by-product is pure water, which the crew uses as drinking water. Unfortunately the production of hydrogen from the renewable energy resources is extremely high and production of hydrogen from fossil fuels may lead to green house effects. The utility of hydrogen as energy resource needs large quantum of hydrogen and its conversion to energy requires planning and cost effective and its efficient transition to energy is quite complex processes. Such efforts require large capital and human endeavors for making this form of energy as alternative source of energy fruitful.

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