UNIT 3 WORLD SCENARIO OF CONVENTIONAL ENERGY SOURCES

Structure

3.1 INTRODUCTION

In this unit you will be introduced to the world scenario of conventional energy sources. We will provide a comprehensive discussion and analysis of global energy resources, international energy markets, and international energy forecasts for the first quarter of the 21st century, conventional energy sources.

Energy is the key for continuing development and growth of any country in this world. Currently the natural source of consumable energy mostly comes from petroleum, gas and coal. With limited source of conventional energy it is required to develop alternate energies to maintain growth and development.

Coal fueled the industrial revolution in the 18^{th} and 19^{th} century. With the advent of the automobile, airplanes and the spreading use of electricity, oil became the dominant fuel during the twentieth century. The growth of oil as the largest fossil fuel was further enabled by steadily dropping prices from 1920 until 1973. After the oil shocks of 1973 and 1979, during which the price of oil increased from 5 to 45 US dollars per barrel, there was a shift away from oil. Coal, natural gas, and nuclear energy became the fuels of choice for electricity generation and conservation measures increased energy efficiency. From 1965 to 2008, the use of fossil fuels has continued to grow and their share of the energy supply has increased. From 2003 to 2008, coal, which is one of the dirtiest (most polluting) sources of energy, was the fastest growing fossil fuel.

Objectives

After studying this unit, you should be able to

- know the world scenario of conventional energy sources

- explain solar energy
- describe the fossil fuel
- explain how to use Nuclear power

3.2 SOLAR ENERGY

In 2005, total worldwide energy consumption was 500 Exajoules $\left(=5\times10^{20}\,\mathrm{J}\right)$ with 80-90% derived from the combustion of fossil fuels. This is equivalent to an average energy consumption rate of 16 TW $\left(=1.6\times10^{13}\,\mathrm{W}\right)$.

Most of the world's energy resources are from the sun's rays hitting earth - some of that energy has been preserved as fossil energy, some is directly or indirectly usable e.g. via wind, hydro or wave power. For the whole Earth, with a cross section of 127,400,000 Km², the total energy rate is 1.740×10^{17} W , plus or minus 3.5%. This 174 PW (1 PW = 10^{15} W) is the total rate of solar energy received by the planet; about half, 89 PW, reaches the Earth's surface.

While it is not possible to capture all the solar energy falling on the Earth's surface, capturing less than 0.02% would be enough to meet the current energy needs. Barriers to further solar generation include the high price of making solar cells and reliance on weather patterns to generate electricity. Also, solar generation does not produce electricity at night, which is a particular problem in high northern and southern latitude countries; energy demand is highest in winter, while availability of solar energy is lowest. Globally, solar generation is the fastest growing source of energy, seeing an annual average growth of 35% over the past few years. Japan, Europe, China, U.S. and India are the major growing investors in solar energy. Advances in technology and economies of scale, along with demand for solutions to global warming, have led photovoltaics to become the most likely candidate to replace nuclear and fossil fuels.

The percentage distribution of Worldwide energy supply.

(http://en.wikipedia.org/wiki/U.S. Department of Energy) is as follows :

- Oil = 38%
- Gas = 23%
- Coal = 23%
- Hydroelectric = 6%
- Nuclear = 6%
- Solar, wind, geothermal, biomass = 1%

3.3 FOSSIL FUEL

The twentieth century saw a rapid twentyfold increase in the use of fossil fuels. Between 1980 and 2004, the worldwide annual growth rate was 2%. According to the US Energy Information Administration's 2006 estimate, (http://en.wikipedia.org/wiki/Energy_Information_Administration), the estimated 15TW total energy consumption of 2004 was divided as given in Table 3.1. It may be seen that fossil fuels were supplying 86% of the world's energy.

Table 3.1 : World Energy Supply

Fuel Type	Power in TW ($1\ TW = 10^{12}\ W$)	Energy/year EJ ($1\ EJ = 10^{18}\ J$)
Oil	5.6	180
Gas	3.5	110
Coal	3.8	120
Hydroelectric	0.9	30
Nuclear	0.9	30
Geothermal, wind, solar, wood	0.13	4
Total	**15**	**471**

3.3.1 Coal

Coal is the most abundant fossil fuel. This was the fuel that launched the industrial revolution and has continued to grow in use. Coal is the fastest growing fossil fuel and its large reserves would make it a popular candidate to meet the energy demand of the global community, short of global warming concerns and other pollutants. According to the International Energy Agency the proven reserves of coal are around 909 billion tonnes, which could sustain the current production rate for 155 years, although at a 5% growth per annum this would be reduced to 45 years, or until 2055.

For the XI Plan, Ministry of Power/Central Electricity Authority (CEA) has indicated a coal based capacity addition plan of 42,625 MW (24110 MW in Central Sector, 15165 MW in State Sector and 3350 MW in private sector) with a coal based generation programme of 733.3 BU (Billion Units) in 2011-12. 16^{TH} electric Power Survey projected energy requirement of 975 BU in 2011-12. This excludes generation from captive plants. After considering the likely capacity addition during XI Plan and going by the trend that around 70% of the projected energy requirement to be coal based, working group assessed that the most likely coal based generation in the terminal year 2011-12 of the XI Plan could be of the order of 690 BU. Further considering the current trend of specific coal consumption of 0.70 Kg/KWh the coal requirement for power sector utilities works out to 483 mt in 2011-12 (Report of the working group on COAL and LIGNITE for formulation of eleventh five year plan (2007-12), Government of India, Ministry of Coal, Shastri Bhavan, New Delhi).

In absolute terms, the demand is projected to increase from an anticipated off-take of 460.00 mt in 2006-07 to 731.10 mt in 2011-12, i.e. an incremental demand of 271.10 mt. Of the projected demand of 731.10 mt, the demand of power sector utilities is 483 mt which is about 66%. Including the demand for power captive at 57.06 mt, the share of power sector in the projected demand works out to about 74%. The demand of steel sector at 68.5 mt forms 9.4% of the projected demand. The share of cement sector is 4.4% and that of sponge iron sector is about 4%. The balance 8.2% is for bricks and others sectors.

In overall terms, the gap between the projected demand of 731.10 mt and the projected domestic availability of 680 mt works out to 51.10 mt in 2011-12. This comprises of 40.85 mt of coking coal and 10.25 mt of thermal coal. This requirement would need to be met from imports. Further increasing

production from captive blocks to bridge the gap also remains as a distinct possibility. This emphasises the need of energy conservation.

Different perspective demand scenarios are available from reports of the Expert Committee on coal sector reform, Integrated Energy Policy and Draft Coal Vision Document for 2025. The regional projection for generation and coal consumption, furnished by CEA at the end of Eleventh Plan is given in Table 3.2.

Table 3.2 : Regional Projection for Generation and Coal Consumption

	Projected Generation (BU)		Projected Coal Demand (Mt)	
Region	At the end of X Plan (2006-07)	At the end of XI Plan (2011-12)	At the end of X Plan (2006-07)	At the end of XI Plan (2011-12)
Northern	118.7	170.3	89.0	133.0
Western	134.8	222.3	104.0	165.0
Southern	83.5	130.0	60.0	91.0
Eastern and N.E.	91.8	210.7	69.0	153.0
Total	428.8	733.3	322.0	542.0

The above requirement of coal given by CEA for the coal based power projects in the XI Plan is based on the following assumptions :

- The coal demand/requirement has been arrived at by taking PLF (Plant Load Factor) at 85%. For new capacity the PLF has been taken at 40% in the first year.
- Normative coal requirement has been indicated as 5000 Tonne per MW/Year.

The year-wise coal requirement (for power generation) in the XIth Five Year Plan as projected **by CEA** is given in Table 3.3.

Table 3.3 : Year-wise Coal Requirement

Year	Existing Plants (as on 31.3.07)	New Plants (in XI Plan)	Total
XIth Plan	Mt	Mt	Mt
2007-08	359	10	369
2008-09	365	25	390
009-10	385	44	429
2010-11	423	60	483
2011-12	467	75	542

Table 3.4 : Region-wise Year-wise Break-up of Coal Requirement

Year	Northern Region	Western Region	Southern Region	Eastern & North East Region	Total
XI Plan	Mt	Mt	Mt	Mt	Mt
2007-08	94.0	124.0	63.0	88.0	369.0
2008-09	98.0	134.0	66.0	92.0	390.0
2009-10	109.0	146.0	72.0	102.0	429.0
2010-11	123.0	155.0	79.0	124.0	483.0
2011-12	133.0	165.0	91.0	151.0	542.0

Mt = Million Tonnes

Trend of electricity generation and coal consumption for consecutive plan periods are given in Table 3.5.

3.5 : Electricity Generation and Coal Requirement

Year	Power demand projected by TERI (BU)	Actual/ projection Generation (BU)	Coal demand projected by TERI (MT)	Consumption/ requirement projected by CEA (MT)	Specific Coal Consumption Kg/Unit	
					TERI projection	Actual/ projection
2001-02	373.45	341.3	266.70	240.4	0.714	0.704
2005-06	511.44	405.37	335.50	279.53	0.656	0.689
2006-07	544.03	428.8	356.82	322.0	0.656	0.751
2011-12	738.15	733.3	462.25	542.0	0.626	0.739

Mt = Million Tonnes; BU = Billion Units

Following points emerge out from the above table :

1. Actual generation had been invariably less than the demand projected by TERI, CEA has been envisaging generation at XI Plan almost at the level of demand projected by TERI.
2. Going against the forecast of TERI and actual trend, specific coal consumption is kept at a much higher level to arrive at coal requirement figure.
3. Out of the projected capacity addition of 42,625 MW, about 30% power plants consuming 29% coal are located at a distance of more than 1000 Kilometer distance. Besides another 3% capacity addition would be on the basis of imported coal. Specific coal consumption of these capacity additions would be substantially less than the national average. Mix of capacity addition and coal requirement is given in the Table 3.6.

3.1 After examining different projections, Sub-group assessed total demand of coal in the terminal year of XI Plan (2011-12) as 731.10 Million Tonnes, 662.60 Mt non-coking coal and 68.50 Mt coking coal. Against this demand the production projection for the terminal year of XI Plan is 680.0 Mt out of which 27.65 Mt and 652.35 Mt would be coking and non-coking coal production respectively. This leaves a gap of 51.10 Mt in 2011-12 comprising of 40.85 Mt of coking coal and 10.25 Mt of thermal coal.

Table 3.6 : Assessed demand vis-à-vis Indegeneous supply projection (Million Tonnes)

Year	Demand			Indegeneous Supply			Gap(-) / Surplus(+)		
	Coking	Non-Coking	Total	Coking	Non-Coking	Total	Coking	Non-Coking	Total
2011-12	68.50	662.60	731.10	27.65	652.35	680.00	-40.85	-10.25 *	-51.10

3.3.2 Oil

The structure of primary energy consumption in India shows that coal (51%) dominates as the major energy source. Hydrocarbons (45%) is the next available energy provider of the nation. Natural gas is fast emerging as an alternative; it meets around 9% of the primary energy needs. Considering the global trend of shift in energy mix from oil to gas, the share of gas in consumption pattern, in the Indian context, is also likely to increase gradually in the days to come. Currently, India's consumption (111.9 MMT in 2005-06) of petroleum products is only about 1/5th of world's average per capita consumption.

The hydrocarbon industry has been passing through very turbulent and challenging times for the last few years. The increasingly stringent environmental regulations, emergence of natural gas and soaring crude prices have thrown up challenges to the oil industry on one hand and opportunities on the other hand, such as gas business. Although natural gas is now being used as transport fuel the liquid fuels have traditionally remained the mainstay of hydrocarbon industry. There has been emphasis and quest for cleaner alternatives and CNG has emerged as an alternative fuel.

Demand for Petroleum Products

Various groups have estimated long-term demand projections for oil for the country from time to time. Some of the main projections are contained in:

- India Vision 2020,
- India Hydrocarbon Vision 2025,
- Energy Information Administration (EIA) and
- International Energy Agency (IEA).

While the projections by IEA and EIA are based on lower GDP growth rates and are in the range of 230 MMT to 264 MMT, India Hydrocarbon Vision (IHV) 2025 projects the demand for the year 2025 in the range of 235 MMT to 368 MMT. The worldwide oil reserves of OPEC countries are given in Table 3.7.

Table 3.7 : Oil reserves of OPEC 1980–2005

Declared reserves of major Opec Producers (billion of barrels)								
Year	Iran	Iraq	Kuwait	Saudi Arabia	UAE	Venezuela	Libya	Nigeria
1980	58.3	30.0	67.9	168.0	30.4	19.5	20.3	16.7
1981	57.0	32.0	67.7	167.9	32.2	19.9	22.6	16.5
1982	56.1	*59.0*	67.2	165.5	32.4	24.9	22.2	16.8
1983	55.3	65.0	67.0	168.8	32.3	25.9	21.8	16.6
1984	58.9	65.0	*92.7*	171.7	32.5	28.0	21.4	16.7
1985	59.0	65.0	92.5	171.5	33.0	*54.5*	21.3	16.6
1986	*92.9*	72.0	94.5	169.7	*97.2*	55.5	22.8	16.1
1987	92.9	*100.0*	94.5	169.6	98.1	58.1	22.8	16.0
1988	92.9	100.0	94.5	*255.0*	98.1	58.5	22.8	16.0
1989	92.9	100.0	97.1	260.1	98.1	59.0	22.8	16.0
1990	92.9	100.0	97.0	260.3	98.1	60.1	22.8	17.1
1991	92.9	100.0	96.5	260.9	98.1	62.6	22.8	20.0
1992	92.9	100.0	96.5	261.2	98.1	63.3	22.8	21.0
1993	92.9	100.0	96.5	261.4	98.1	64.4	22.8	21.0
1994	94.3	100.0	96.5	261.4	98.1	64.9	22.8	21.0
1995	93.7	100.0	96.5	261.5	98.1	66.3	29.5	20.8
1996	92.6	112.0	96.5	261.4	97.8	72.7	29.5	20.8
1997	92.6	112.5	96.5	261.5	97.8	74.9	29.5	20.8
1998	93.7	112.5	96.5	261.5	97.8	76.1	29.5	22.5
1999	93.1	112.5	96.5	262.8	97.8	76.8	29.5	29.0
2000	99.5	112.5	96.5	262.8	97.8	76.8	36.0	29.0
2001	99.1	115.0	96.5	262.7	97.8	77.7	36.0	31.5
2002	*130.7*	115.0	96.5	262.8	97.8	77.3	36.0	34.3
2003	133.3	115.0	99.0	262.7	97.8	77.2	39.1	35.3
2004	132.7	115.0	101.5	264.3	97.8	79.7	39.1	35.9
2005	137.5	115.0	101.5	264.2	97.8	80.0	41.5	36.2
2006	138.4	115.0	101.5	264.3	97.8	87.3	41.5	36.2
2007	138.2	115.0	101.5	264.2	97.8	99.4	43.7	36.2
2008	137.6	115.0	101.5	264.1	97.8	99.4	43.7	36.2

Using estimated reserves: 800 billions of barrels, world consumption: 76 millions per day), it looks like planet Earth has have oil for about 10,000 days, i.e. about 27 years. If consumption increases an average 5% a year, then we have oil for about 15 years. But the US Geological Survey estimates the amount of oil that is still to be found at about 3 trillions, three times the oil reserves known today. The real issue is when will production be insufficient to cover demand? That largely depends on demand, not on reserves (http://www.scaruffi.com/politics/oil.html). The greatest oil reserves of top 20 countries are given in Table 3.8.

Table 3.8 : Greatest Oil Reserves by Country, 2006

Rank	Country	Proved reserves (billion barrels)
1.	Saudi Arabia	264.3
2.	Canada	178.8
3.	Iran	132.5
4.	Iraq	115.0
5.	Kuwait	101.5
6.	United Arab Emirates	97.8
7.	Venezuela	79.7
8.	Russia	60.0
9.	Libya	39.1
10.	Nigeria	35.9
11.	United States	21.4
12.	China	18.3
13.	Qatar	15.2
14.	Mexico	12.9
15.	Algeria	11.4
16.	Brazil	11.2
17.	Kazakhstan	9.0
18.	Norway	7.7
19.	Azerbaijan	7.0
20.	India	5.8
Top 20 countries		1224.5 (95%)
Rest of world		68.1 (5%)
World total		**1,292.6**

http : //www.infoplease.com/ipa/A0872964.html

3.3.3 Natural Gas

Proved reserves of natural gas in cubic meters (cu m) are those quantities of natural gas, which, by analysis of geological and engineering data, can be estimated with a high degree of confidence to be commercially recoverable from a given date forward, from known reservoirs and under current economic conditions. Natural gas - proved reserves as on January 2008 are 1.075 trillion cu m (CIA World Book).

The countrywide reserves of natural gas is given in Table 3.9.

Table 3.9 : Countrywide Reserves of Natural Gas

Country Name	Value in 10^6 m^3(cubic meter)	Country Name	Value in 10^6 m^3(cubic meter)
Russia	47,570,000	Philippines	107,500
Iran	26,370,000	Cameroon	105,900
Qatar	25,790,000	Romania	96,410
Saudi Arabia	6,568,000	Chile	93,970
United Arab Emirates	5,823,000	Bahrain	88,260
United States	5,551,000	Congo, Republic of the	86,900
Nigeria	5,015,000	Sudan	86,000
Algeria	4,359,000	Denmark	75,660
Venezuela	4,112,000	Tunisia	74,680
Iraq	3,170,000	Cuba	67,890
Turkmenistan	2,860,000	Namibia	59,750
Indonesia	2,630,000	Rwanda	54,320
China	2,450,000	Afghanistan	47,530
Norway	2,288,000	Serbia	46,170
Malaysia	2,037,000	Angola	44,000
Uzbekistan	1,798,000	Japan	38,020
Kazakhstan	1,765,000	Israel	37,340
Netherlands	1,684,000	Equatorial Guinea	35,310
Egypt	1,589,000	Hungary	32,860,
Canada	1,537,000	Gabon	32,590
Kuwait	1,521,000	New Zealand	29,670
Libya	1,430,000	Croatia	27,160
Ukraine	1,075,000	Cote d'Ivoire	27,160
India	1,056,000	Ethiopia	23,900

Azerbaijan	849,500	Ghana	22,810
Oman	795,200	Tanzania	21,730
Pakistan	764,600	Slovakia	14,390
Australia	750,600	Austria	14,390
Trinidad and Tobago	702,800	Taiwan	13,550
Bolivia	651,800	Ireland	9,505
Argentina	512,400	Ecuador	9,369
United Kingdom	509,200	Georgia	8,147
Yemen	459,000	Turkey	8,147
Mexico	434,100	Jordan	5,975
Thailand	400,700	Bulgaria	5,703
Brunei	374,800	Kyrgyzstan	5,432
France	341,000	Tajikistan	5,432
Papua New Guinea	331,300	Somalia	5,432
Brazil	312,700	Czech Republic	3,802
Burma	271,600	Guatemala	2,960
Germany	246,500	Belarus	2,716
Syria	240,000	Spain	2,444
Peru	236,900	Morocco	1,629
Italy	217,300	Benin	1,086
East Timor	200,000	Congo, Democratic Republic of the	950.5
Vietnam	184,700	Greece	950.5
Poland	158,100	Albania	814.7
Bangladesh	135,800	Barbados	135.8
Mozambique	122,200	South Africa	27.16
Colombia	109,700		

3.4 NUCLEAR POWER

In 2005 nuclear power accounted for 6.3% of world's total primary energy supply. The nuclear power production in 2006 accounted 2,658 TWh (23.3 EJ), which was 16% of world's total electricity production. In November 2007, there were 439 operational nuclear reactors worldwide, with total capacity of 372,002 MWe. A further 33 reactors were under construction, 94 reactors were planned and 222 reactors were proposed.

Fusion power is the process driving our sun and other stars. It generates large quantities of heat by fusing the nuclei of hydrogen or helium isotopes, which may be derived from seawater. The heat can theoretically be harnessed to generate electricity. The temperatures and pressures needed to sustain fusion make it a very difficult process to control. The tantalizing potential of fusion is its theoretical ability to supply vast quantities of energy, with relatively little pollution.

SAQ 1

(a) Describe in brief the fossil fuels.

(b) What are the advantages and disadvantages of fossil fuels.

(c) How much CO_2 do you get from combustion of fossil fuels? How can the mass of the CO_2 be greater than the mass of the fuel burned?

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3.5 LET US SUM UP

Renewable resources are available each year, unlike non-renewable resources which are eventually depleted. A simple comparison is a coal mine and a forest. While the forest could be depleted, if it is managed properly it represents a continuous supply of energy, vs the coal mine which once it has been exhausted is gone. Most of earth's available energy resources are renewable resources.

The fossil fuels are not going to last forever. We have to find out an optimal mix of all available energy resources for the sustainable development.

3.6 KEY WORDS

Coal

A piece of glowing carbon or charred wood; brownish black solid combustible substance formed by the partial decomposition of vegetable matter without free access of air and under the influence of moisture and often increased pressure and temperature that is widely used as a natural fuel

Natural gas

Gas issuing from the earth's crust through natural openings or bored wells; a combustible mixture of methane and higher hydrocarbons used chiefly as a fuel and raw material

Non-Renewable Sources of energy

Those sources of energy which have accumulated in nature over a long time and cannot be quickly replaced when exhausted are called non-renewable sources of energy.

Oil

Oil is a thick, black, gooey liquid also called **petroleum**. It's found way down in the ground, usually between layers of rock. To get oil out, a well is dug.

Petroleum

Petroleum is a dark colored, viscous, and foul smelling crude oil.

Renewable Sources of energy

Those sources of energy which are being produced continuously in nature and are inexhaustible, are called renewable sources of energy.

3.7 ANSWERS TO SAQs

SAQ 1

(a) Fossil fuels, coal, oil and natural gas, are a non-renewable source of energy. Formed from plants and animals that lived up to 300 million years ago. Fossil fuels are found in deposits beneath the earth. The fuels are burned to release the chemical energy that is stored within this resource. Over 85% of our energy demands are met by the combustion of fossil fuels.

(b) Fossil fuels are excellent sources of energy for our transportation needs. They are also the primary source of electrical energy in the world today. Coal power plants account for about 52% of the world's demand. We, as a world, burn approximately 1.9 billion tons of coal a year to generate electricity. Fossil fuels take millions of years to make. We are using up the fuels that were made more than 300 million years ago before the time of the dinosaurs. Once they are gone they are gone. So, it's most important to work for stopping wasting fossil fuels. They are not renewable; they can't really be made again. We can save fossil fuels by conserving energy.

(c) Let us illustrate with the combustion of natural gas (methane).

C = carbon, atomic weight approximately 12

H = hydrogen, atomic weight approximately 1

O = oxygen, atomic weight approximately 16

CH_4 = methane, molecular weight approximately 16

O_2 = molecular oxygen, molecular weight approximately 32

CO_2 = carbon dioxide, molecular weight approximately 44

H_2O = water, molecular weight approximately 18

For combustion of methane

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

So, combustion of 16 mass units (grams, pounds, whatever) of methane produces 44 mass units of carbon dioxide and 36 mass units of water while consuming 64 mass units of oxygen.