PART 1

ALTERNATE ENERGY

1

INTRODUCTION TO ALTERNATE ENERGY SOURCES

1.1. ENERGY SOURCES ON EARTH

The earth's energy input is almost entirely constituted of incident solar radiation. This amounts to 173,000 TW. Tides and the heat source inside the earth (mostly radioactivity) also contribute about 3 TW and 32 TW, respectively to the energy input. Around 52,000 TW (*i.e.*, about 30% of the incoming solar radiation) is reflected back to the interplanetary space, called **albedo of the earth**. The remaining energy is degraded to heat and re-emitted as long wave infrared radiation. Figure 1.1 represents the energy balance processes on the earth [1]. The relative stability of earth's temperature indicates the balance between planetary input and output of energy.

Solar radiation 173,000 TW	Direct reflection	...	52,000 TW	Short wave radiation
	Direct conversion to heat	...	78,000 TW	Long wave radiation
	Evaporation of water	...	39,000 TW	
	Wind and waves	...	3600 TW	
	Photosynthesis	...	40 TW	
Geothermal	Tides	...	3 TW	
	Volcanoes and hot springs	...	0.3 TW	
	Rock conduction	...	32 TW	

Fig. 1.1. Earth energy balance [1].

The sources of energy available to mankind are broadly classified into two forms that are renewable and non-renewable. The energy used by mankind originates from (*i*) radiant energy emitted by the sun (solar energy and its derivatives), (*ii*) geothermal energy from the interior of earth, (*iii*) tidal energy originating from the gravitational pull of the moon, and (*iv*) nuclear energy. The energy sources (both renewable and non-renewable) on the earth are represented in Fig. 1.2.

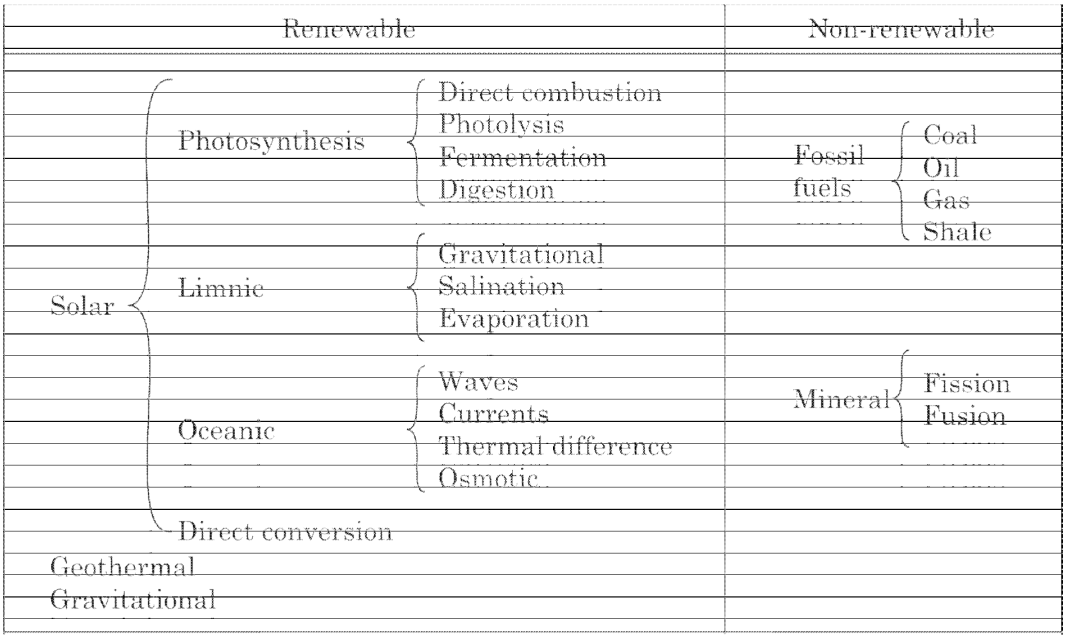

Fig. 1.2. The energy sources of earth.

The 'renewable energy sources' include hydro energy, biomass energy, solar energy, wind energy and geothermal energy. The term 'new' renewable sources further focus on modern and sustainable forms of renewable energy. These include modern biomass energy, geothermal heat and electricity, small hydropower, low temperature solar heat, wind electricity, solar thermal and photovoltaic electricity, and ocean energy (such as tidal, wave, current, thermal, osmotic, and marine biomass energy). The term 'combustible renewable and wastes' includes all vegetables and animal matter that are used directly or that are converted to solid fuels, biomass-derived gaseous and liquid fuels, and industrial and municipal wastes that are converted to modern energy carriers. The main biomass fuels in developing countries are firewood, charcoal, agricultural residues and dung, which are referred to as traditional biomass [2].

Solar energy is the largest energy source. It is inexhaustible as long as there is sunshine. Solar derived energies are solar thermal, photovoltaic, wind, hydropower, photosynthesis (biomass), ocean energy (waves, thermal, currents, osmotic) (Fig. 1.2) and fossil fuels (coal, oil and gas).

Low temperature solar heat is produced by black bodies after the absorption of sunlight. High temperature solar heat is generated by focussing sunlight. Atmosphere warming by solar heating results in turbulence that manifests as wind. Photovoltaic is the direct conversion of the ultraviolet component of sunlight into electricity in appropriate materials.

Hydropower is indirectly linked to sunlight. Sunlight evaporates the water in the oceans, which then precipitates on land masses as rain resulting in the formation of rivers. A small portion of the incident solar energy on the earth is converted by photosynthesis into biomass (organic matter). Some of these organic matters, buried inside the earth hundreds of millions of years ago by sedimentation and earthquakes, were transformed by bacterial action into fossil fuel resources such as coal, oil and gas.

Table 1.1 indicates the energy available on earth along with fossil fuel reserves. Prolonged availability is not the only criteria to choose an energy source. Other factors, like its conversion into the forms that meet human needs, effect on environment and health issues, application at the local, regional and global level, guaranteed energy security, etc. are also considered.

Table 1.1. Energy available on earth [3]

Solar	173,000 TW
Geothermal	32 TW
Tidal	3 TW
Photosynthesis	40 TW
Winds, waves, convection and currents	370 TW
Fossil fuel reserves (mainly coal)	≈ 2000 TW

Table 1.2 presents the fossil fuel reserves and Table 1.3 shows estimated reserves of fissionable materials [1]. The estimates of fissionable materials do not include old Soviet Union and China. The figures for oil and gas include proved reserves, reserve growth and undiscovered reserves. The value for coal indicates only proved reserves. Proved reserves are fuels that have been discovered but not yet produced. Reserve growth of fuels indicates the increase in the reserves of existing fields owing to further development of these fields. Uncovered reserves represent the best possible estimate of potential new findings.

Table 1.2. Fossil fuel reserves as on the year 2002 [1]

Coal	39,000 EJ
Oil	18,000 EJ
Gas	15,000 EJ
Liquid gas	2300 EJ

Table 1.3 Reserves of fissionable materials

^{235}U	2600 EJ
^{238}U	320,000 EJ
^{232}Th	11,000 EJ

1.2. ENERGY UTILIZATION

Man was non-technological and did not use even fire in ancient times. The use of fire and diet involving cooked food evolved much later. Animal energy was employed for several purposes, in particular for transportation and pumping water for irrigation in the primitive agricultural Mesopotamia, around 4000 B.C. Solar energy was used for drying cereals and bricks. The utilization of wind, water and fire to produce useful work is an ancient practice. Wind has been driving sailboats since at least 3000 B.C. The extensive use of windmills started in Persia around 300 A.D. and, only much later, spread to China and Europe. The windmills and water wheels were specifically used for pumping water and grinding cereals.

There was widespread adoption of advanced agriculture, the use of fireplaces to heat homes, the burning of ceramics and bricks, and the use of wind and water during 1200 A.D. in Europe. The energy utilization rate in Europe during this period was estimated to be around 2000 W/capita.

Table 1.4 provides the per capita rate of energy use in the United States for selected years [4]. The energy was used for food, transportation, clothing, tools, housing, etc. The energy consumption rate in the world increased from approximately 0.03×10^{14} kWh in 1850 to 0.64×10^{14} kWh in 1970 and to an estimated value of 1.03×10^{14} kWh in 1990 [5]. The world's population increased from approximately one billion to five billion during this period [6]. Thus, the average annual energy consumption per person in the world rose from 2930 kWh in 1850 to about 24,600 kWh in 1990. The estimated average energy consumption rate for the world in 1990 is significantly lower than the average energy consumption in the United States (Table 1.4).

Table 1.4. Per capita energy use in the United States [4]

Year	*kWh/y*	*Year*	*kWh/y*
1800	12,000	1950	66,200
1850	17,000	1960	72,000
1900	32,200	1970	97,000
1925	52,800	1980	96,700
1940	53,000	1990	99,600

The rapid growth in population is a serious concern today. The population growth rate in the world has been around 1.4% per year in the last few decades. A population of about 7 billion is anticipated by the year 2010 and of about 11 billion by 2050 at the present growth rate. Thus, an energy increase of 1.4% a year is required to sustain just the population growth rate.

The present day energy utilization levels in the United States, in Eastern Europe and in the world are 11, 5 and 2 kW/capita, respectively. The energy utilization rate is expected to reach 122, 65 and 26 TW per annum, respectively in the year 2050 compared to the present value of 12.7 TW per annum for the world [2] on the basis of the present per capita utilization figures.

Most of the energy used in the world at present comes from non-renewable sources. Table 1.5 shows a pattern of the utilization of these energy sources in 2001 for the whole world as well as for the United States. The renewable sources make only a minor contribution to the overall energy picture.

Table 1.5. Overall energy utilization in 2001 [1]

	World (%)	*United States (%)*
Coal	23.3	23.0
Gas	22.5	23.2
Oil	40.0	38.9
Nuclear	6.5	7.6
Hydro	7.0	3.8
Others	0.7	3.5

Renewable energy sources constituted about 17% of the utilization of the world's primary energy in 2004. This was predominately traditional biomass, used for cooking and heating, especially in rural areas of developing countries. Large hydropower projects provided about 16% of the global electricity. The 'new' renewable energy (modern biomass energy, geothermal heat and electricity, small hydropower, low temperature solar heat, wind electricity, solar thermal and photovoltaic electricity, and ocean energy) together have contributed to about 2% of the world's energy use [2]. However, 'new' renewable energy displays impressive growth rates (Table 1.6) between 2000 and 2004.

Table 1.6. Average annual growth rates of renewable energy capacity during 2000 to 2004 [2]

Solar PV, grid connected	60.0%
Wind power	28.5%
Bio-diesel	25.0%
Solar hot water/heating	16.5%
Solar PV, off-grid	16.5%
Geothermal heating	13.5%
Ethanol	11.5%
Small hydropower	6.5%
Biomass power	3.2%
Geothermal power	2.6%
Biomass heating	2.5%
Large hydropower	2.5%

The availability of renewable energy resources is very large in comparison to the global energy requirement. Table 1.7 presents annual global renewable energy resources from both a theoretical and a technical perspective. However, the level of their future utilization primarily depends on the economic performance of technologies utilizing these resources.

Table 1.7. Annual global renewable energy resources [2]

Energy Resources	*Energy Use, 2001 (EJ/y)*	*Technical Potential (EJ/y)*	*Theoretical Potential (EJ/y)*
Hydro energy	9.4	50	150
Biomass	45.0	> 250	2900
Solar	0.2	> 1600	3,900,000
Wind	0.2	600	6000
Geothermal	2.1	5000	140,000,000
Ocean	—	—	7400
Total	~ 57	> 7500	> 143,000,000

1.3. GLOBAL ENERGY PROBLEMS AND ROLE OF RENEWABLE ENERGY

There is a trend of increasing energy utilization globally at present. This is due to both a rise in per capita and the population explosion. Furthermore, fossil fuels, such as coal, oil and natural gas constitute about 85% of the world's current energy use. These fossil fuels took multimillions of years of complex reduction, conservation and progression from vegetational trapping of solar radiation by photosynthesis to deep-well storage of the energy concentrated below the earth's surface.

Most of the easily accessible sources of oil and gas have already been tapped. Extraction of these fuels from the remaining reservoirs is becoming progressively more expensive. There are technological difficulties associated with the identification of new reserves and the extraction of fuels from more remote locations. This is mainly due to ecological obstacles. Most of the fuel used by developed nations is imported. This is causing political problems. The sources of fossil fuels are finite. Oil is predicted to run out within the next 40 years while coal is predicted to last for anywhere between 75 to 200 years [7]. Fossil fuels, however, are at present the most inexpensive and most convenient of all energy resources.

The use of fossil fuels pollutes the environment. The most undesirable gas emitted is carbon dioxide. The progressively increasing concentration of carbon dioxide in the atmosphere (from 270 ppm in the late 1800 to about 365 ppm at present) has become a great concern, especially in view of the growing signs of ecological catastrophe. For example, there has been a 40% decrease in the thickness of the north polar ice in last few decades and a summertime hole appeared in the polar ice in the first year of the present millennium. The interaction of carbon in hydrocarbon fuels with the air's oxygen takes place during the process of fossil fuel combustion. The consequent release into and accumulation in the atmosphere of carbon dioxide, carbon monoxide, and other climate-changing gases has led to global warming, the so called the **Greenhouse Effect.** This has increased the evaporation of the tropical oceans. The resultant moisture that migrates towards the poles, precipitates as snow and reduces the amount of heat absorbed from the sun.

The use of fossil fuels over the years has resulted in a gradual increase in atmospheric toxicity, filthy water, and debilitating diseases. Global warming is expected to bring draughts and hurricanes, tropical diseases in the North, and widespread coastal flooding. Drying forests in Europe and acid rain everywhere has necessitated curbing sulphur, nitrogen oxides, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), particulate emissions, and other pollutants.

A recent study [8] examined the generation of ozone in four metropolitan areas in the United States (Sacramento, Chicago, St.Louis, and Los Angeles) and concluded that a future increase of global atmospheric CO_2 will result in an increase in the ozone concentrations. Higher ozone levels can promote premature mortality and respiratory diseases. Doubled CO_2 concentrations in Los Angles are expected to increase the annual average daily maximum temperature from 20.7 to 24.9°C and the annual average daily minimum temperature from 14.1 to 18.2°C.

'Zero emissions' from cars, buses, industry, ships, and home furnaces is becoming the new world standard. Both industrialized countries and emerging economics are aspiring towards varying degrees of emission intensity and dedication to this standard.

In brief, not only are fossil fuels expected to run out some time in the near future, but also have a major impact on the environment and the atmosphere. Therefore, the world is increasingly concerned about 'energy security' due to qualms about the eventual drying up of the petroleum resources. This includes the increasing vulnerability of the long supplies lines from the unstable Middle East. Also, the environmental concern became a much stronger impetus by the end of the twentieth century driving the world towards renewable, alternate forms of energy. The use of fossil fuels is expected to decline with renewable sources gradually achieving dominance and potentially accounting for about 40% of global energy consumption by 2050 and 80% by 2100 [9].

Renewable energy is expected to contribute to as high as 30% of global electricity production by 2050. Renewable energy contributions to fuels used directly could reach nearly one-fourth by 2025, with maximum contributions coming from biomass-derived fuels, such as methanol, ethanol, hydrogen, and biogas. Methanol and hydrogen may well prove to be the bio-fuels of choice because of the fact that they are the energy carriers most suitable for the fuel cells that can be used for transportation.

It is expected that in the second quarter of the current century there will be comparable interregional flows of oil, natural gas, and methanol, and that hydrogen derived from renewable energy sources will begin to play a role in energy commerce [10]. This diversified supply mix is in sharp contrast to the situation prevailing today, where oil dominates international commerce in liquid and gaseous fuels.

Global CO_2 emissions by combustion of fossil fuels in the renewable intensive global energy setting is expected to reduce by 12% by 2025 and 26% by 2050 [10]. The per capita emissions of developing countries in 2050 is expected to be only one-third of those for industrialized countries [10].

The benefits associated with renewable energy are summarized as follows:

Social and Economic Development. Production of renewable energy, particularly biomass, can generate economic development and employment opportunities, particularly in rural areas that otherwise have limited opportunities for economic growth. Renewable energy can, thus, help reduce poverty in rural areas. This can reduce pressures for urban migration. The local employment and income generation can result from manufacturing, project development and servicing activities.

Usually renewable energy devices are decentralized, are modular in size and have low operating costs. These involve short construction times, and provide much greater flexibility in energy planning and investment. The principal beneficiaries of the adoption of renewable sources of energy are the developing countries. Technologies that utilize biomass, and particularly fuel wood for cooking and heating in these countries, are rather inefficient and wasteful. Improved technologies for biomass use can help reduction in deforestation. For example, several countries like India, Kenya and other African countries use improved wood and charcoal cooking stoves. The production of ethanol, an excellent substitute for gasoline from sugar cane in Brazil, is another example.

Land Restoration. Growing biomass for energy on degraded lands can provide the incentives and financing needed to restore these lands, which are rendered nearly useless by previous agricultural or forestry practices. The lands farmed for energy can not be restored, however, to their original condition. But the recovery of these lands for biomass plantations can support rural developments, prevent erosion, and provide a better habitat for wildlife than at present.

Reduced Air Pollution. Renewable energy technologies, such as methanol or hydrogen for fuel cell operated vehicles, produce virtually no air pollution and acid deposition. Also, these do not require costly additional controls for pollutions.

Abatement of Global Warming. Renewable energy use does not produce CO_2 and other greenhouse emissions that contribute to global warming. The release of CO_2 during biomass combustion equals the amount absorbed from the atmosphere by plants grown for biomass fuel. Therefore, the increased use of renewable energy, (which is carbon free or neutral), contributes to a reduction in CO_2 concentration in the atmosphere and thus mitigates climate change. This in turn improves health conditions and provides a healthy environment for better living.

Fuel Supply Diversity and Energy Security. A substantial interregional energy trade involving a diversity of energy carriers and suppliers is expected in a renewable intensive energy future. This increases energy security. Renewable energy, in the mid- and long-term perspective, prolongs the availability of most fossil fuels for satisfying both energy needs and various other non-energy needs. Energy importers can have the ability to choose from among more producers and fuel types than available at present. This is expected to provide a situation less vulnerable to monopoly, price manipulation or unexpected disruption of supplies.

Such competition also renders wide swings in energy price less likely. This leads eventually to the stabilization of the world oil price. The growth in world energy trade can also provide new opportunities for energy suppliers. The prospects for trade in alcohol fuels such as methanol derived from biomass, natural gas (not a renewable fuel but an important complement to renewable energy), and later, hydrogen are especially promising.

Reducing the Risks and Proliferation. Competitive renewable resources can reduce incentives to build a large world infrastructure in support of nuclear energy. This in turn avoids major increases in the production, transportation, and storage of plutonium and other nuclear materials. Such a development also reduces the potential for conflict, sabotage, disruption of production and trade of fossil fuels and fissionable materials. The wide impact of deficits in electricity supply has been dramatized by recent 'blackouts' in the eastern United States, the United Kingdom and Italy, probably due to accidents, which are difficult to eliminate with highly centralized production and distribution systems.

1.4. INTRODUCTION TO ALTERNATE ENERGY SOURCES

Conventional energy sources include the principal energy sources that are currently being utilized on a large scale (refer Table 1.5). These include fossil fuels contributing to 85% (constituted of coal 23%, oil 40% and gas 22%), large hydroelectric power contributing to 7% and nuclear to 6.5%. The status and consequence of the over-dependence on the fossil fuels have already been elaborated in section 1.3 above.

Hydroelectric power is the only form of renewable energy that has been able to compete on a large scale with fossil fuels. Large hydropower stations have supplied about 16% of the global electricity [2]. It accounts for about 10% (~ 90,000 MW) of the electric power generated [9] in the United States, which is almost 98% of the renewable energy. Table 1.8 shows the regional and world contributions from hydropower in recent years. These figures represent an average over four years (1999 to 2002). Norway obtains almost all her electricity from hydro, Brazil obtains about 80%, and Canada and Sweden obtain about half. The scope for large scale expansion of hydropower is limited in the industrialized world, where it has almost reached its economic capacity. The potential still exists in the developing world. But large hydropower projects often face financial, environmental and social constraints.

However, the interest in hydropower (both large and small) projects is rising globally. Some 131,000 MW hydroelectric capacities are planned for Central and South America, and another 127,000 MW for Asia [9]. The biggest hydroelectric plant today (126,000 MW) is at Itaipu, on the Parana River in Brazil. Upon completion, the three Gorges project in the Yangtze River in China will be the largest dam project in the world. The construction of the dam began in 1994, with a scheduled completion in 2016. The dam will be 2.1 km long and 186 m high, creating a reservoir of about 650 km long. The reservoir will cover 60,700 ha of land with water. Nearly 2 million people will have to be relocated. Also, 160 towns, 16 archaeological sites and 8000 cultural sites will be under water. The three Gorges dam may eventually provide 11% of China's electricity requirement [7].

Table 1.8. National hydro contributions [10]

Country	*Output (TWh/y)*
Canada	345
Brazil	288
USA	264
China	231
Russia	167
Norway	129
Japan	91
India	76
Sweden	74
France	74
Venezuela	61
Italy	51
Australia	42
Switzerland	40
Spain	35
Rest of the world	626
World	2593

Large scale hydropower generation is regarded as a mature technology, which is unlikely to advance further. The refurbishment of plants has shown that advanced technologies can increase the energy output with essentially unchanged water flows. However, there is room for further technical developments for small hydropower projects. The costs of small projects can come down substantially with the choice of very favourable sites, the use of existing administrative structure and existing civil works for flood control purposes. The installed capacity in 2004 is about 720 GW for large hydro and 62 GW for small hydro [2].

Nuclear Energy. Atoms with large atomic number can be broken down into smaller atoms with the release of energy. This is called **nuclear fission.** The process requires an atom with atomic number larger than 26. Atoms with low atomic numbers, on the other hand, can be combined into a heavier one, releasing energy. This is called **nuclear fusion** and requires that the final product have an atomic number smaller than 26.

Nuclear fission energy is a substantial source of energy in many countries. The United States led the world with an installed capacity of 98 GW in 2001 followed by France with 60 GW and Japan with 42 GW (the last two figures are for 1996) [1]. They have exhibited excellent utilization factors of 87.6% in the United States in 2001, 69.5% in France in 1996 and 75.4% in Japan in 1996, with contribution to electricity production being 18%, 76.1% and 33.4%, respectively.

The cost of nuclear electricity is high, about twice that from fossil fuels. The nuclear power almost entirely lost its lustre as a source of primary energy for electricity production since the mid 1980s, after the Chernobyl accident. The major objection to fission type reactors is not so much the danger of the operation of the power plants, but rather the problem of disposing of large amounts of long-lived radioactive by-products. In brief, lack of safety, dangerously radioactive 'ashes' and scarcity of fuel are the problems with fission reactors, beside electricity generation being costly. Based on the experiences, Germany had decided to phase out nineteen of their nuclear power plants in the year 2000.

Fusion reactors may overcome all of the above problems. Fusion produces no radioactive fuel waste unlike nuclear fission, although the fusion reactor itself becomes radioactive over time. Also, fusion unlike fission produces no bomb-grade materials, has no chance of cascading into a 'runaway' critical reaction and has a virtually unlimited fuel supply. The primary reaction requires deuterium and tritium, the two heavy isotopes of hydrogen. Deuterium is extracted from seawater. Tritium is made in a reactor from lithium, and also found in seawater. Therefore, a fusion reactor can literally run on seawater. Fusion produces no local air emissions and no greenhouse gases. However, scientists and engineers have to devise an economic method of controlling the thermonuclear reaction for the fusion reactor to be successful. Hydrogen can be generated in a fusion reactor itself.

Alternate Energy Sources. As discussed above, the conventional sources of energy constitute fossil fuels (oil, coal, gas), large hydropower plants and nuclear fission energy. These sources more or less meet the global energy requirement at present. The alternate energy sources, on the other hand, are constituted of both renewable and non-renewable (except conventional fuels) forms, which are expected to provide a pathway toward a sustainable energy future. The alternate sources include:

Renewable Sources:

- Solar energy (thermal and photovoltaic)
- Wind energy
- Biomass energy
- Geothermal energy
- Ocean energy (tidal, thermal, wave, current, and osmotic)
- Small hydropower.

Non-renewable Sources:

- Hydrogen energy
- Fuel cells
- Nuclear fusion energy
- Magnetohydrodynamics (MHD)
- Others (Thermoelectricity, Thermionics, Alkali metal thermal electric converter).

Renewable energy sources are generally abundant throughout the world. Some of these energy sources are dilute, intermittent, and regional. They require means for storage and transportation. Some of the alternate sources are costly at present and expected to become economical through newer technologies. Also, some of them require further research and developmental activities for their sustenance in large scale utilization. All these factors are presented in detail in individual topics discussed in subsequent chapters.

Nuclear fission energy, a potential conventional energy source, has also been covered in this book with a view that it may gain renewed popularity through improvement in technology for cost reduction as well as safety of operation including taking care of long-lived radioactive wastes. In fact, there is a good reason to reconsider fission generators as an important contributor to the main energy supply system, if these problems are overcome.

REVIEW QUESTIONS

1. Discuss planetary energy balance. (1.1)
2. What is the albedo of earth? (1.1)
3. How much solar radiation is incident on earth? (1.1)
4. Define renewable and non-renewable forms of energy. (1.1)
5. What are the original sources of energy that constitute the requirement of the mankind? (1.1)
6. What are the sources of energy that constitute renewable energy? (1.1)
7. What are the solar-energy derived fuels? (1.1)
8. What constitutes fossil fuels? (1.1)
9. How are the fossil fuels formed? (1.1, 1.3)
10. How is an energy source judged? (1.1)
11. How is the evolution of energy utilization rate by mankind taken place starting from ancient times? (1.2)
12. What was the expected per capita energy utilization in Europe during 1200 A.D.? What is now? (1.2)
13. What has been the population growth rate in the world in recent decades? (1.2)
14. What are the present day energy consumption levels in the United States, Eastern Europe and world? (1.2)
15. What is the present energy utilization of the world per annum? What is expected in 2050? (1.2)
16. What has been the percent contribution of renewable energy sources in the world's primary energy use during 2004? (1.2)
17. Which is the component of renewable energy sources that has exhibited maximum growth rates during 2000 to 2004? (1.2)
18. When natural flows of renewable resources are very large in comparison with global energy use, then what stands on the way for their large scale utilization? (1.2)
19. Why is global energy utilization increasing at very high rate? (1.3)
20. What is the present time contribution of fossil fuels to the world's energy use? (1.3)
21. What are the economical, technological and political problems in the utilization of fossil fuels? (1.3)
22. How is the use of fossil fuels polluting the environment? (1.3)
23. What is the concentration of CO_2 in the atmosphere at present? (1.3)
24. What is the ecological catastrophe observed in recent past? (1.3)
25. What are the effects on global warming? Is it also greenhouse effect? (1.3)
26. Why is ozone concentration rising in the atmosphere? What is its effect on human being? (1.3)
27. Why is the world more concerned about energy security? (1.3)
28. What is the expected percentage contribution of renewable sources to the global energy consumption during 2050? (1.3)
29. What are the biomass-derived fuels? (1.3)
30. What are the socio-economic benefits received due to the use of renewable energy? (1.3)
31. How does utilization of renewable energy help reducing air pollution and global warming? (1.3)
32. How does renewable energy use help in fuel supply diversity and energy security? (1.3)
33. Renewable energy helps in reducing risks and proliferation in energy use. How? (1.3)
34. What are the constituents of conventional energy sources? (1.4)
35. What is the contribution of these constituents to the present day energy utilization of the world? (1.4)

36. Why is the scope for utilizing large hydropower project diminishing in industrialized countries? (1.4)

37. What are the drawbacks with implementing large hydropower projects? (1.4)

38. Which is the biggest hydroelectric plant today? (1.4)

39. Why is three Gorges project controversial? (1.4)

40. What are the countries using nuclear energy maximum? Which is the country depending most on nuclear energy? (1.4)

41. What are the disadvantages of using nuclear fission energy? (1.4)

42. What are the advantages of nuclear fusion energy? (1.4)

43. What are the constituents of alternate energy sources? (1.4)

44. What are the main draw backs with renewable energy sources? (1.4)

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