UNIT 7

ENERGY RESOURCES

Structure

7.1 INTRODUCTION

Modem industrial societies are characterised by the intensive use of energy. Can you think of a day in your life without electricity or other sources of energy such as fuels for cooking and transport? Think, all the things that you use are driven by energy! Energy is required to produce food and goods and reach them to you. You will agree that energy has been a crucial factor in the current model of development. There is a close relationship between energy consumption and economic growth as measured in terms of the growth of Gross Domestic Product(GDP)in any country. It is now argued that the cost and availability of energy are two major factors in promoting economic growth of society or country as a whole.

However, as the energy intensive industrial economies have expanded, their adverse impact on the environment has grown. This aspect has come under closer scrutiny in the past few decades and an understanding of the role of energy in economic development will help us develop models of eco-friendly energy usage. Therefore, we begin our discussion of the energy as resource with an understanding of the multi-faceted role of energy in economic development. We will examine the energy resource base at our disposal and the various energy options available to us. Finally, we will analyse the carrying capacity of the Earth in relation to our energy demand with a view of switching over to renewable energy sources.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ discuss the role of energy as resource in economic growth;
- ❖ analyse the energy demand due to growing population andindustrialisation;
- ❖ describe the energy resource base of the Earth; and
- ❖ explain the management of energy with switching over to renewable sources.

7.2 ENERGY AS RESOURCE

The demand for energy doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes roughly 3% of the total energy produced in the world, in comparison of USA which has 6.25% of the world's population and utilizes 30% of the energy produced.Despite continuous increase in energy use, per capita consumption in India is still very low compared with other countries. Even today, about 80% of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable sources of energy such as fossil fuels, coal and petroleum, are not going to last for long. Forests are also being depleted at the alarming rate due to indiscriminate felling of trees. It has become, therefore, necessary to think of alternative, non-conventional sources of energy.

Energy needs in India are met by harnessing two categories of energy sources as shown below.

Energy

Non-conventional ↓

- Biomass energy
- Solar energy
- Fuel cells energy
- Geothermal energy
- Co-generation energy
- Wind energy

Conventional ↓

- Oil (Fossil Fuel)
- Natural Gas
- Coal
- Hydropower
- Atomic Energy

7.2.1 Non-Conventional Sources

There are various non-conventional sources of energy which we will deliberate here.

Biomass energy

This is a renewable energy source derived from plant resources, animal waste and the waste of various human activities. It is also derived from the by-products of the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biomass does not add net carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels.

Biomass fuels used in India account for about one third of the total fuel used in the country. Over 90% of the rural households and about 15% of the urban households use biomass fuels (e.g. wood, cowdung cakes, crop residues and sawdust). The inefficient burning of such fuels in traditional chulhas is causing a serious problem of indoor air pollution and consequent health hazards. Moreover, the unsustainable level of consumption of fuel wood leads to deforestation and desertification, which degrades the environment. Thus proper management of biomass as a resource is very essential.

In this context, technological solutions, institutional arrangements, financial support and training schemes for ensuring adequate and affordable clean energy systems and services using biomass assume great significance. An initiative in this direction has come from the Ministry of Non-conventional Energy Sources (MNES). It has been promoting indigenously developed technologies for efficient utilization of biomass fuels with a focus on extraction of more energy, reduction of household consumption of firewood, generation of employment and improvement in the living standards of rural population.

Biomass gasifier is another technology in use for energy generation (Fig. 7.1). A biomass gasifier converts solid biomass, both woody and powdery, materials such as wood, agricultural and agro-industrial wastes into gas through thermochemical gasification process.Gasifier converts solid fuel into a more convenient-to-use gaseous form of fuel.

As much as 1890 Kcal of heat can be produced from half a kilo of dry plant tissue. This is equivalent to the heat available from 250 g coal.

It has been found to be more practical to compress biomass into briquettes (small hard blocks of different shapes used as fuel) and thereby improve its utility and convenience of use. In the dense briquetted form, biomass can either be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasifier.

Fig. 7.1: Biomass gasifier.

Solar Energy

Solar energy is the most readily available abundant source of energy. It is free as it does not belong to anybody. It is also non-polluting (Fig. 7.2).

Solar run refrigerators have been developed for rural areas. These keep vegetables and fruits fresh for a longer period.

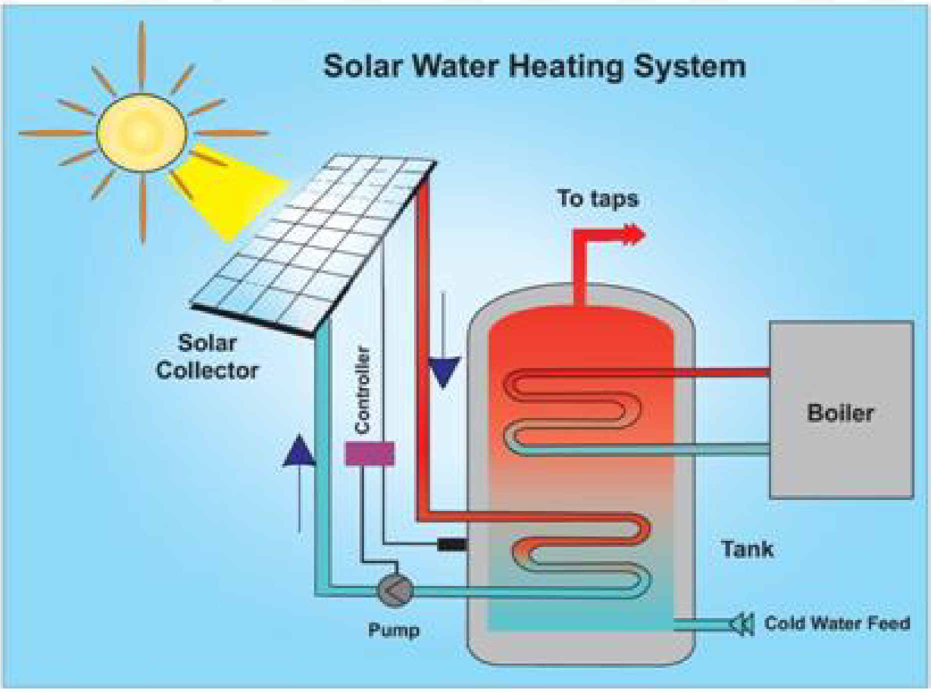

Fig.7.2: Solar energy being used for heating water.

The energy we get today from the fossil fuels like coal is in reality sun's energy, trapped in plants millions of years ago. Plants make their food and grow by using solar energy for photosynthesis. Millions of years ago, huge forests got buried in the earth's crust and they got transformed into coal and oil under great pressure and temperature therefore coal and oil are called fossil fuels.

Fig. 7.3: Solar run refrigerator.

Nowadays, we have learnt to harness solar energy for various purposes. Solar energy can be used directly to give us hot water during winter, or run a refrigerator (Fig. 7.3).It can be used, for room heating in colder regions (Fig. 7.4).Solar cookers are being used in many homes to cook food (Fig. 7.5). Solar energy can be used with the help of "photo voltaic cells" for producing electricity for driving vehicles and for illumination. Since this is an unfailing source of energy, it would be a great advantage to develop cheap and efficient photocells or photovoltaic devices to harness solar energy.

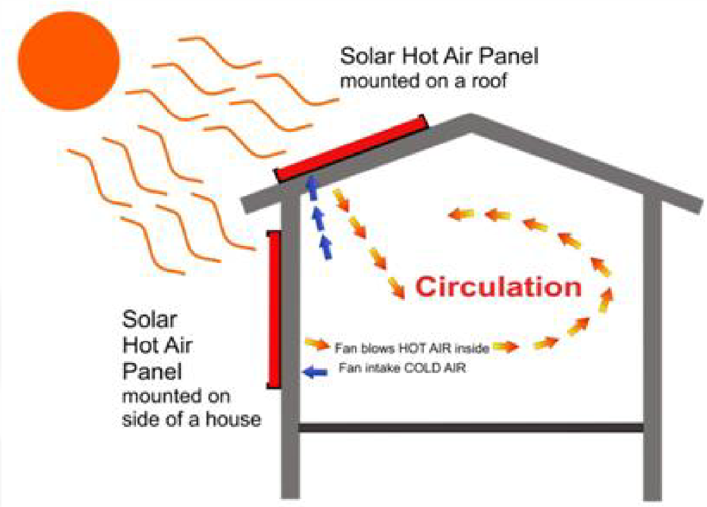

Fig. 7.4: Solar heated room.

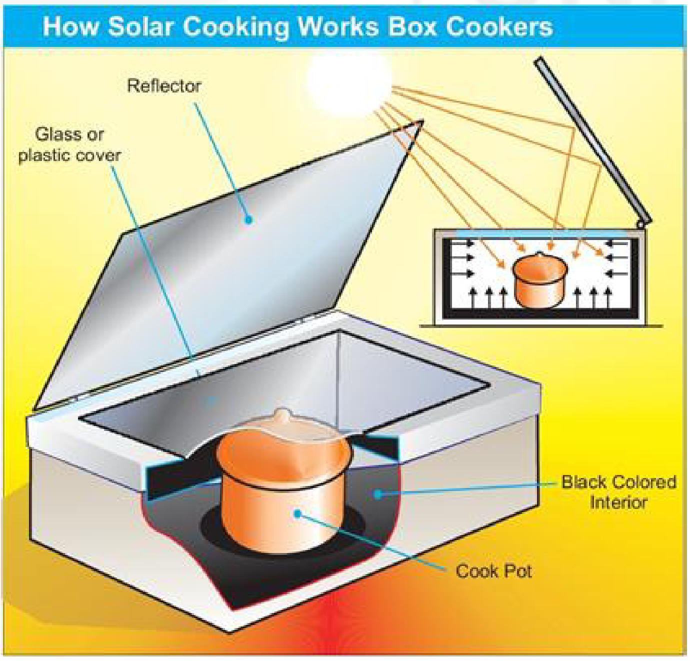

Fig. 7.5: Solar Cooker.

Solar radiation gets converted into electricity directly in Solar Photovoltaic (SPV) panels installed on buildings or in open spaces. This electricity can either be used as it is or can be stored in the battery to be used for domestic lighting, street lighting, village electrification, water pumping, desalination of salty water, powering of remote telecommunication repeater stations and railway signals. Solar passive buildings use solar energy in building designs and cut down on energy consumption for heating and cooling. This technology is fast gaining acceptance in urban architecture.

Fuel Cells

Fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity and heat, thus doing away with combustion (Fig. 7.6). A fuel cell consists of an electrolyte sandwiched between two electrodes. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water and heat.

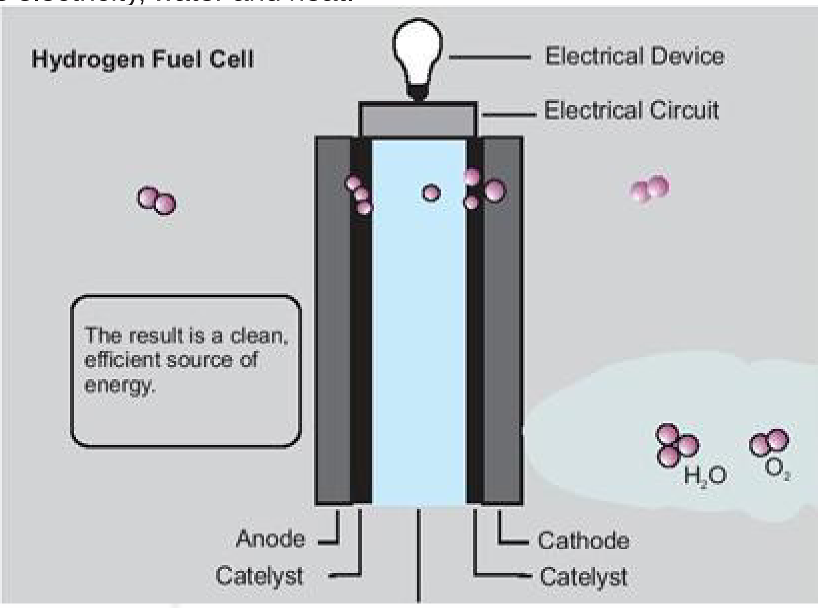

Fig. 7.6: Fuel Cells.

Fuel cells are being used in space flights and can be used in electric vehicles to dramatically reduce urban air pollution. Fuel-cell powered vehicles have very high energy conversion efficiency (almost double that of currently used engines). The emissions are significantly lower (CO_2 and water vapour being the only emissions). Fuel-cell-powered electric vehicles score over the battery operated ones in terms of increased efficiency and easier and faster refuelling. Fuel cell systems are excellent candidates for small-scale decentralized power generation for commercial buildings, hospitals and airports in remote locations.

On an average, the 60 million sq. km of tropical seas absorb solar radiation equivalent to the heat content of 245 billion barrels of oil.

Wave and Tidal Energy

Energy can also be obtained from **waves** and **tides**.These waves and tides are another source of energy which is perpetual and can be harnessed for generating electricity (Fig. 7.7), particularly where sea water can move into

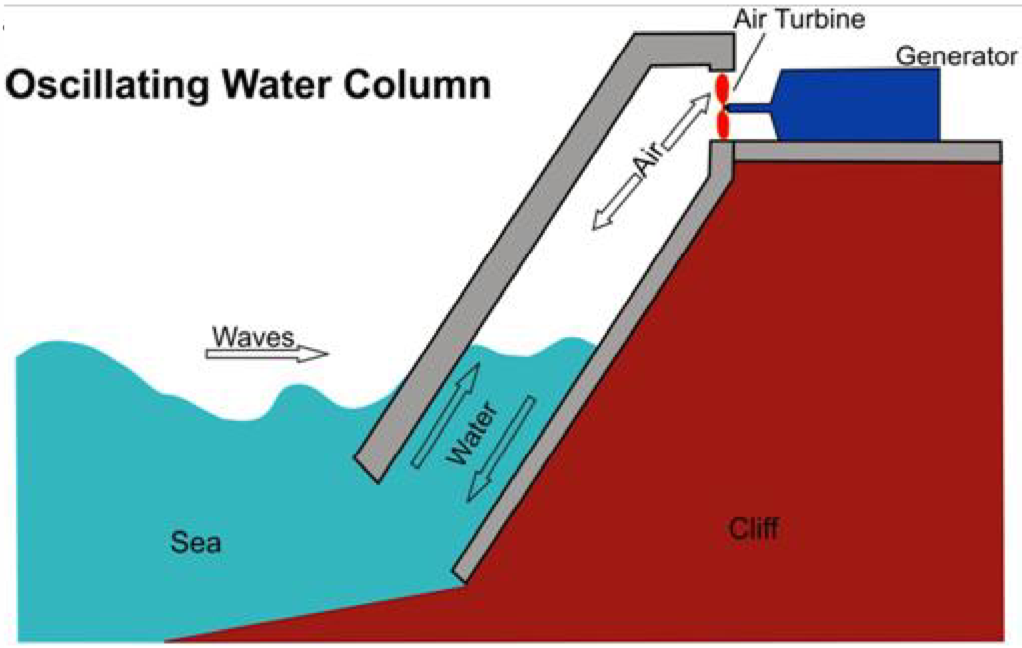

Fig.7.7: Tidal power station. Both incoming and outgoing tides are held back by a dam. The difference in water levels generates electricity in both directions as water runs through reversible turbogenerators.

Energy carried by water has also been widely used in India's hilly regions, since a wheel with pedals can be made to turn when it is put in a fast flowing stream. Flour mills of small size built on this principle were used in Kashmir fora long time. In fact, large "hydroelectric" power stations work on the same principle. A natural or artificial water fall is made to turn a modern kind of pedal wheel, called a turbine, which upon rotation generate electricity.

In India, the first wave energy project with a capacity of 150 MW, has been set up at Vizhinjam near Thiruvanathapurm. A major tidal wave power project costing Rs. 5000 crores, is proposed to be set up in the Hanthal Creek in the Gulf of Kachchh in Gujarat.

Geothermal Energy

Volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas are sources of **geothermal** energy. **Geothermal** means heat from the earth. In some countries, such as in the USA, water is pumped from underground hot water deposits and used to heat people's houses.

Hot water and superheated steam of hot springs can be used to generate electricity (Fig. 7.8). In our country there are about 46 hydrothermal areas where the temperature of the spring water exceeds 150°C. The thermal energy of hot springs can be used for generating electricity, heating buildings and homes glass-houses in colder areas for growing vegetables.

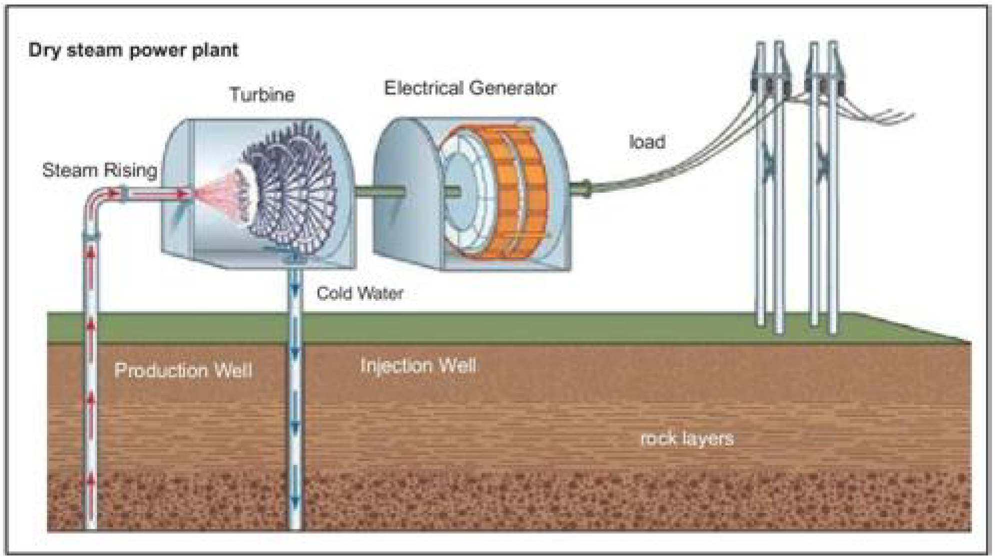

Fig.7.8: The geyser is the geothermal power operation and produces the energy directly from steam.

In India, the North-western Himalayas and the western coast are considered geothermal areas. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. An experimental 1 KW generation project in the Puga valley in the Ladakh region is being used for poultry farming, mushroom cultivation and pashmina-wool processing, all of which need higher temperature.

Co-generation

This is the concept of producing two forms of energy from the fuel, one form being heat and the other being electrical or mechanical energy. In a conventional thermal power plant, high-pressure steam is generated by burning fuels. It is used to drive a turbine, which in turn drives an alternator to produce electric power. The exhaust steam is generally condensed to water which goes back to the boiler. (Fig. 7.9)

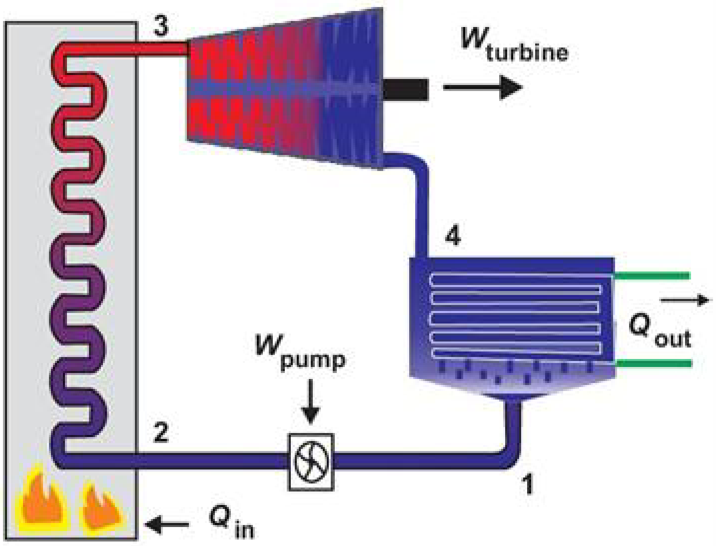

Fig. 7.9: Bagasse-based co-generation.

The efficiency of conventional power plants is only around 35% as a large amount of heat is lost in the process of condensing. In a co-generation plant, the low-pressure exhaust steam coming out of the turbine is not condensed, but used for heating purposes in factories or houses. Thus very high efficiency levels, in the range of 75-90% can be reached.The potential of power generation from co-generation in India is more than 20,000 MW even at conservative estimates.

Wind Energy

Wind Energy has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert the kinetic energy associated with the movement of air to more useful forms of power. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding,lifting water or to generate electricity. Wind turbines can be used singly or in clusters called 'wind farms'. Windmills have been used since long in many countries, but in India they have only been recently introduced (Fig. 7.10).

Fig. 7.10: Use of renewable energy as wind pump.

Biogas

You may have heard of the use of cattle dung for production of biogas which is a source of energy used for cooking (Fig. 7.11). Through a simple process cattle dung is used to produce a gas that contains 55-70% inflammable methane gas, and is clear and efficient fuel for use in rural areas. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are found to be useful supplement to cattle dung. Biogas can also be used to raise steam, which in turn may be used for running engines or machines in factories or for running turbines to generate electricity. It has been found that large biogas plants can supply the needs of a number of families or even small villages. The residual dung or the digested slurry left after generating, biogas can be used as manure for agricultural purposes. This is an economical way of obtaining energy from organic wastes. In China and India, great efforts are being made to install tens of thousands of biogas plants in rural areas.

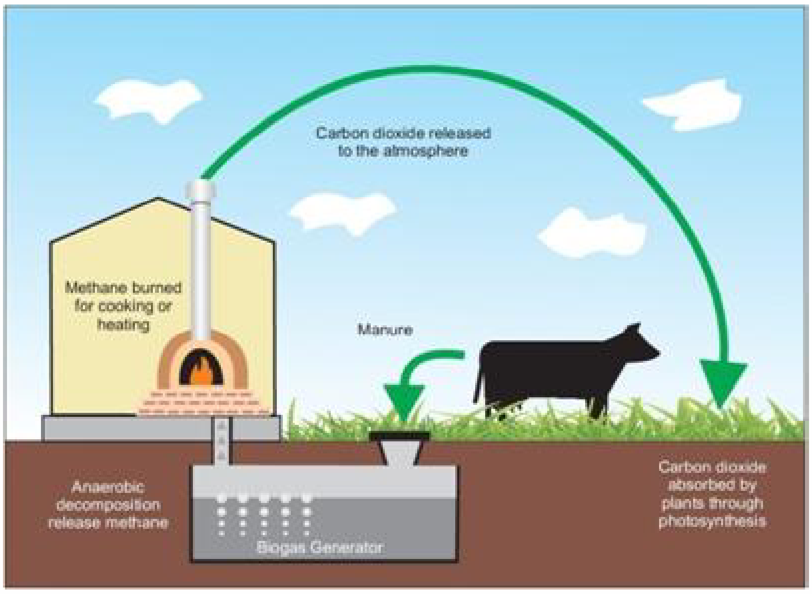

Fig. 7.11: Biogas Plant.

India has tremendous potential in non-conventional sources of energy. Our diverse geographical settings help in promotion of non-conventional energy sources of energy namely solar, wind and tidal. Looking at the future potential in generating solar energy, the International Solar Alliance was established in the year 2015. Major initiatives were taken by India for the establishment of this alliance. This would help us in developing clean and green energy that would address the problems emerging due to the use of conventional sources of energy like coal, petroleum and radio-active minerals. Therefore we can say these above mentioned non-conventional sources are the energy of future.

But, today our major energy sources are coal, fossil fuel, natural gas, hydro-power and atomic energy. These sources of energy are known as conventional sources of energy. Let us discuss these sources in detail in the following section.

7.2.2 Conventional Sources

The power production through conventional sources like oil, gas, coal and hydel lags far behind the current demand driven by growth in agriculture industry and the population. India's electricity sector currently faces problems of capacity, distribution losses, poor reliability, and frequent blackouts. Indian industry cites power supply as one of the biggest limitations on progress. One government estimate projects 8-10% annual growth in energy demand over the next 15 years if the economy grows as expected in the 7-8% per year range. The shortfall implies greater dependence on international markets.

Oil (Fossil Fuel)

Oil supplies nearly 30% of India's energy. Oil consumption in the country was approximately 1.93 million barrels per day (bpd) in 1999 and was about 4.7 million bpd in 2017. In 2017, India imported about 198 million tonnes of cruide oil and its products.

India draws most of its imports of oil from the Bombay High, Upper Assam, Cambay, Krishna-Godavari, and Cauvery basins. Oil reserves are estimated at 4.7 billion barrels. The Bombay High Field, India's largest producing field, generated 250,000 b/d in 1998 and 210,000 b/d in 1999.

Consumption of petroleum products rose from 57 million tonnes in 1991-1992 to 196 million tonnes in 2016. The India Hydrocarbon Vision 2025 report estimates future refinery demand at 368 million tons by 2025. Thus, India is becoming a major global market for petroleum products.

Natural Gas

About 7% of India's energy needs are met by **natural gas** especially in power generation, fertilizers, and petrochemicals production. Natural gas can serve to reduce dependence on foreign oil. Absence of sulphur dioxide and reduced levels of carbon dioxide and nitrogen oxide are major environmental benefits of using natural gas. Currently, India's natural gas consumption is 50 billion cubic metres (bcm) and is mostly met by domestic production. In 2017, India imported 27,570 million cubic metres of natural gas.

Coal (Fossil Fuel)

India depends on coal for more than half of its total energy needs. Nearly three quarters of the country's electricity and 63% of commercial energy comes from coal. India has huge coal reserves accounting for 8% of the world's total. It is the third leading coal producer in the world after China and the United States. Most of its coal demand is satisfied through domestic production with the only exception being coking coal that is in short supply. Despite India's wealth in coal reserves, only about 3% is coking coal so India's steel industry must import coking coal to meet about 25% of its annual needs.

Hydro Power

Hydro power is the cheapest, and cleanest and, hence, regarded the best source of energy (Fig. 7.12). However, obtaining electricity from mega dams has given rise to many controversies in recent times and small hydro power plants are emerging as viable alternatives. These plants serve the energy needs of remote and rural areas where the grid supply is not available.

Fig. 7.12: Hydro Power.

Atomic Energy

The energy released by splitting of atom in a controlled manner can be utilized for generation of electricity. The device used for this purpose is called an atomic reactor (Fig. 7.13). Nuclear reactors produce heat, which is used to generate steam, for rotating turbines for generating electricity. It is estimated that 1 kg of natural uranium, written as 235 U, generates energy equal to that produced by 35,000 kg of coal. Energy production from nuclear fuels like uranium is relatively clean, efficient, and can serve as a substitute for coal and petroleum. However, nuclear reactors need to be situated at places far away from human habitation. They have to be operated under strict safety control, to prevent any accidental leakages of radioactive material. The radioactive wastes have to be carefully disposed off. Currently, Nuclear Power Corporation of India Ltd.(NPCIL) is opening 21 nuclear power reactors with an installed capacity of 5780 MW at seven different sites.

Fig. 7.13: A view of atomic power station.

SAQ 1

Tick mark (   ) the correct options.

i. Solar energy is a

a) renewable non-conventional energy

b) non-renewable conventional energy

c) non-renewable energy

ii. Plant manufacture their food by using

a) Fossil fuel energy

b) solar energy

c) organic nutrient energy

iii. Use of non-conventional source of energy is

a) Cheap

b) Pollution free

c) Both cheap and pollution free

iv. Reactor generates

a) Biogas

b) Geothermal energy

c) Atomic energy

v. Energy we get from fossil fuels like coal is in reality

a) Geothermal energy

b) Sun's energy

c) non-conventional energy

7.3 THE CARRYING CAPACITY OF THE EARTH'S ENERGY BASE

The long-term sustainable carrying capacity for the human species on the earth varies with resource availability as well as culture and level of economic development. Thus, two measures of human carrying capacity arise:

- the biophysical carrying capacity; and
- the social carrying capacity.

The **biophysical carrying capacity** is the maximum population that can be supported by the resources of the planet at a given level of technology.

The **social carrying capacity** is the sustainable bio-physical carrying capacity within a given social organisation, including patterns of consumption and trade.

The social carrying capacity therefore must be less than the biophysical carrying capacity as it will account for the quality of life. Besides, it can give us an estimate of the number of humans that can be supported in a sustainable manner at a **given standard of living.**

In order to estimate the human population that can be sustained by the Earth, a standard of living or level of consumption must be selected or assumed. At this point, the introduction of social issues becomes important. For instance, very high global population could be supported at a very low level of food consumption, perhaps even on the brink of starvation. The result, however, could be a socially unstable situation. **A socially sustainable carrying capacity must be based on a level of consumption that meets basic human needs of food, water and space as well as provides opportunity to enjoy socio-political rights, health, education and well-being.**

Another important aspect of social sustainability is equitable distribution of resources. Inequitable distribution of wealth can lead to social instability and disruption.

SAQ 2

Fill in the blanks with appropriate words given is parentheses.

a. The carrying capacity of an ecosystem is defined as the …….. (minimum/ maximum) population size of a species that an area can support.

b. The amount of ……………. (heat/energy) consumed per person per year is a useful measure of standard of living.

c. North America's per capita energy use is …………….. (less/more) than twice that of Europeans.

d. A socially …………….. (non-sustainable/sustainable) carrying capacity must be based on level of consumption which meets basic human needs to food, water, and space as well as provides opportunity to enjoy socio-political right, health, education and well being.

7.4 ENERGY DEMAND DUE TO POPULATION GROWTH AND INDUSTRIALISATION

The human population of the developing world is predicted to increase from its current value of four billion to over eight billion by 2050, and by this time it will comprise almost ninety percent of the world population. Population growth' is one of the factors which drive the world-wide energy demand, especially the demand for electricity.

7.4.1 Energy Demand vis-à-vis Population Growth

The two main factors that lead to greatly increased world-wide demand for energy (especially electricity) during the next half-century are:

- population growth, and
- per capita economic growth in the less-developed countries.

Let us explain this further. Currently, the average person in the less-developed countries consumes only one sixth of the energy consumed by an average person in Western Europe or Japan (see Fig. 7.14).

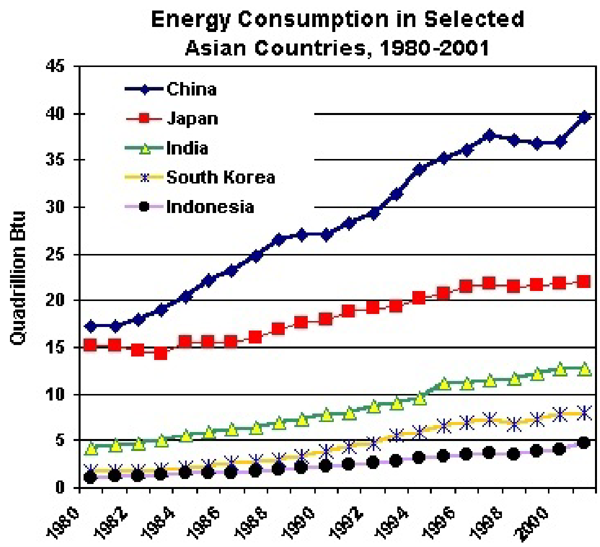

Fig.7.14: Energy consumption in selected Asian countries 1980-2001.

Doubling of per capita energy consumption in the less developed countries over the next 50 years would correspond to only a very modest degree of economic development. Yet, combined with the predicted population increase, it would lead to a two to three-fold increase in world energy consumption.

The actual increase in demand may be expected to be even greater. For example, there will be an increased demand from economic growth in the developed as well as developing countries. Improvements will undoubtedly occur in the efficiency of energy utilisation, but in the face of the expected increases in demand, these could only have relatively minor impact (Fig. 7.15).

Global energy and population

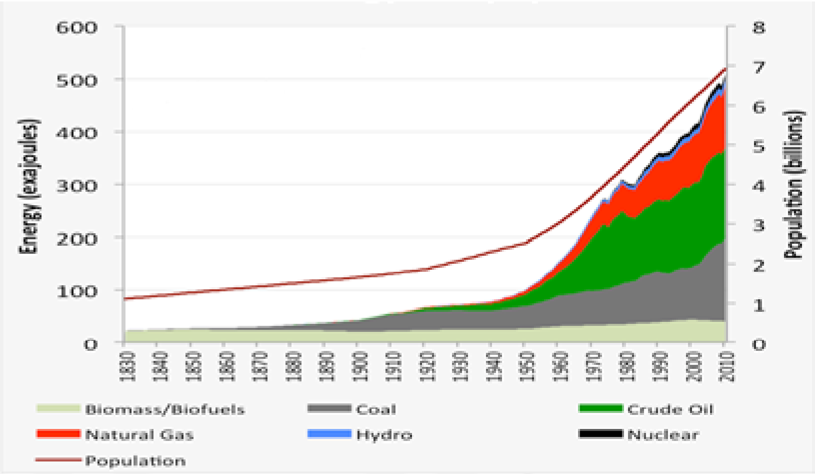

Fig.7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year.

GDP: It represents total dollar value of all goods and services produced over a specific time period.

It is one of the primary indictors used to gauge the health of country's economy.

7.4.2 Energy Demand in Industrialisation

During the initial stages of economic growth, the share of agriculture in total output falls and the share of industry rises. This is the industrialisation phase of development.In the later stages of development, the demand for services begins to increase rapidly,increasing its share of GDP (Gross Domestic Product). This latter stage is often referred to as the 'post-industrialised' society.

The growth of heavy industry (infrastructure development) during the industrialisation phase leads to enormous increases in energy consumption. Accordingly, the **energy intensity** of GDP **(defined as energy input per dollar of GDP)** increases as the share of industry in GDP increases. As development continues, however, the demand for financial services, communications, transportation, and consumer goods (light manufacturing) grows rapidly. As a result, the share of services and consumer goods increases, eventually accounting for over one-half of total output. Light industry (involved in the production of consumer goods) and services require less energy input per unit output than heavy industry. This leads to a reduction in overall energyintensity, i.e., the energy input per unit output (see Fig. 7.16).

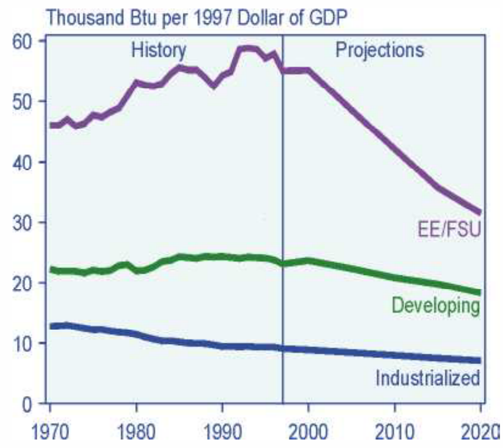

Fig.7.16: World energy intensity by region 1970-2020.

Although economic development leads to declining growth rates of per capita energy demand in the industrial sector, there is substantial growth in energy demand in the transportation, residential and commercial sectors.

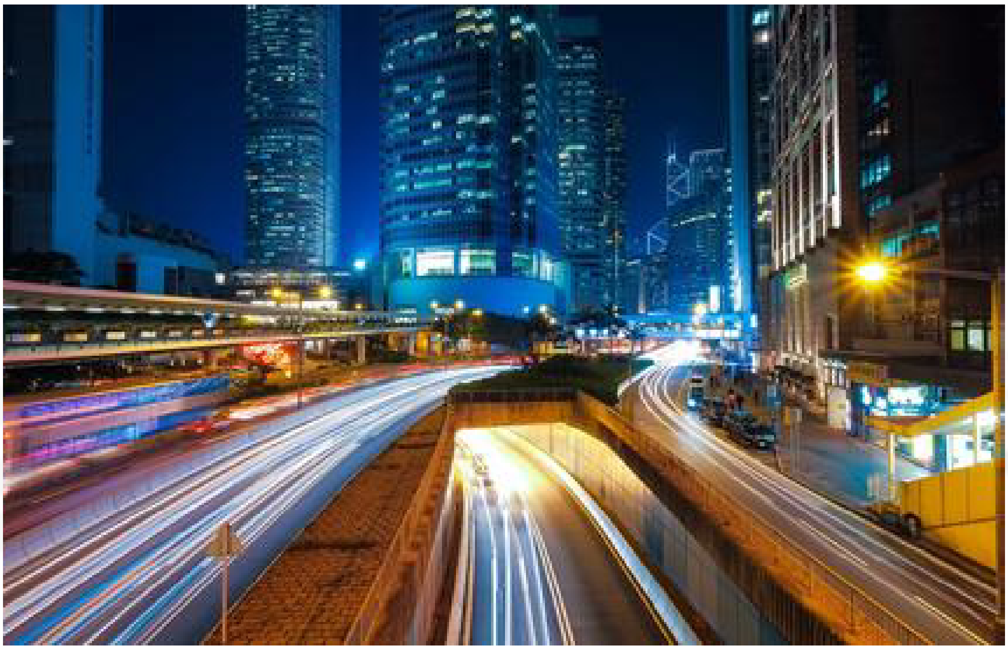

Fig.7.17: An illustration of energy consumption in the developed world.

In a recent study of the effect of economic development on end-use energy demand (Fig. 7.17), it was found that **energy demand grows at different rates in different, broadlydefined,end-use sectors (industrial, transport, residential** and **commercial).**Specifically, it was found that per capita industrial energy demand rises very rapidly at the onset of development, accounting for the maximum energy use. The growth of energy demand in industry, however, quickly declines, and energy use in the other sectors eventually takes a majority share of total end-use energy consumption. In fact,energy demand in the transportation sector continues to grow well into the post-industrial phase of development, accounting for more than half of all energy use. A simulation of energy demand by sector for an average country based on these results is depicted in Fig. 7.18.

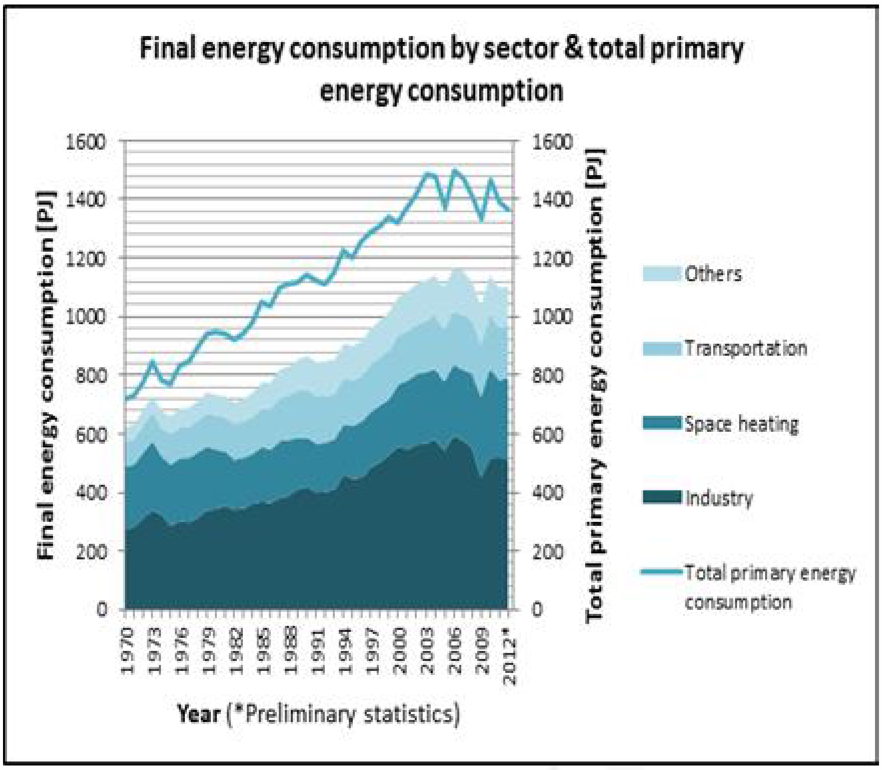

Fig.7.18: Simulated per capita end-use energy demand.

7.4.3 Energy Demand in Asian Developing Economies

Developing countries are playing an increasingly important role in the world energy markets, and their consumption of commercial energy has increased substantially over the past two decades. The increase has been particularly pronounced among the developing countries of East Asia and South East Asia and is expected to continue into the next century. However, the quantum of future energy demand by these lower-middle-income countries will depend on a host of factors, such as:

- the expected income levels;
- real energy prices;
- the continuing trend away from traditional non-commercial energy sources to commercial fuels; and
- the speed of shift toward energy-intensive activities due to urbanisation and industrialisation, increased motorisation, and household use of electrical appliances.

The growing concerns about the environment and the global nature of environmental problems have focused attention on the pattern and trend of energy demand in the developing economies. More than half of the total carbon dioxide emissions originate in the energy sector, and a large and increasing share of the flow of emissions in future will be from lower-middle-income countries. A detailed analysis of energydemand and the possibilities of inter-fuel substitution in the major coal-producingcountries, such as China and India, is very important. This is needed for a better understanding of global environmental problems and the energy needs of these economies.

SAQ 3

Discuss the trends in energy consumption from the 1950s onwards. How did the growth in population influence these trends?

7.5 FUTURE ENERGY NEEDS AND CONSERVATION

Energy is an essential input for industrial development. Energy is produced from commercial sources like coal, petroleum, hydroelectric schemes as well as from non-commercial sources like cow dung, fuel wood and agricultural wastes. Per capita consumption of commercial energy is sometimes used as an index of the economic advancement that a country has attained. India's per capita consumption of commercial energy, however, is very low. It is only one eighth of the world average.

Commercial energy accounts for a little over half of the total energy used in the country, the rest coming from non-commercial sources. Share of agriculture in commercial energy consumption has risen rapidly over the past two-and-a-half decades. Industry consumed about 78 per cent of the coal and 62 per cent of the electrical energy in the country in 1985-86. The transport sector accounted for 56 per cent of the total oil consumption during the year 1989. The energy consumption of these sectors as well as the household sector are increasing rapidly. The energy strategy, therefore, has to plan not only for an increase in indigenous availability but also aim at its efficient utilisation.

7.5.1 Conservation and Energy

Energy generation and environmental conservation are the twin issues arising from exploitative interaction of humans with natural resources.Excessive utilisation of coal and oil for generation of electricity leads to the multiple problems of acid rain, and rising carbon dioxide levels in the atmosphere. Huge dams can make substantial contributions to economic development in electricity in developing countries like India, but as in any large-scale electricity generating option, there are trade-offs. Reservoirs inundate forests, farmland and wildlife habitats and uproot entire communities of indigenous people.

The answer to the country's energy needs can only lie in adopting non-conventional sources of energy. A beginning is being made by Government of India to give the same type of resources and support to developing alternative sources of energy as have so far been extended to the development of conventional energy sources.

In the following sections we will study some of the important means of energy conservation through the incorporation of innovative and imaginative alternatives within conventional rural agricultural technologies.

7.5.2 Development of Non-Polluting Energy Systems in India

I) Improved Chullahas: In developing countries like India, the energy needs of rural poor are mostly met with by burning firewood. Traditional methods of cooking are very unhealthy for the cook, as they emit a lot of smoke. Also the heat released in burning is not efficiently utilised. Indian energy scientists have come up with smokeless stoves **(chulhas)** (Fig. 7.19) specially designed for Indian conditions. These 'Chulhas' are smokeless, permit shorter cooking time and there is also saving of fuel. In India, the overall renewable energy capacity targets have been raised from 35,776 MW in 2015 to 1,75,000 MW by 2022 (MOEF & CC, 2015). This comprises of 1,00,000 MW solar, 60,000 MW wind, 10,000 MW Biomass and 50,000 MW.

Fig. 7.19: smokeless stove (chulhas) .

The improved 'chulha' has invoked tremendous response and positive action from all concerned. Nearly 3,000 villages have been rendered 'smokeless' in the sense that in each house of these villages, either an improved 'chulha' or a biogas plant is used for cooking food. A trained work force of more than 50,000 persons, mainly women, was created to work as master craftsmen for constructing the improved chulhas.

II) Energy from City Sewage: The city sewage treatment plants use anaerobic digestion units for extracting methane from human night soil which is in the form of a sludge. The gas generated from the sludge is called sludge gas, which like biogas consists largely of methane. The Department of Non-Conventional Energy Sources has supported setting up sewage based biogas plants in Uttar Pradesh, MadhyaPradesh and Delhi.

One large size urban waste recycling plant is already operating at Okhla, Delhi. The plant comprises 15 digesters connected to 15 gas collectors. The total gas generation from the plant is about 0.6 million cubic feet per day having a heat value of 700-800"BTU" per cubic foot (equivalent to 500-570 cal per m3). The gas is being supplied to about 800 households over an area of four kilometers. The gas is about 50 per cent cheaper than the LPG gas. Another such project has been commissioned, recently at Pandraune in UP. Plants are under construction at Ayodhya in UP, Eshaopur in Delhi, and at Bhopal in MP. In Jabalpur, Municipal Corporation is setting up agarbage-based power plant to generate 7 MW electricity daily.

Many bio-organic wastes are released as by-products by distilleries in India. A new technology for waste recycling and disposal has been introduced for the first time in the country by a distillery in Gujarat. The technology, simultaneous with the treatment of 45,000 litres of waste, will generate energy equivalent to that given by10 tonnes of coal every day. The fuel is generated from the waste after fermenting the ash with yeast in a suitable culture medium. The 10 million litre capacity distillery can get 50 per cent of its fuel requirement from recycling its own waste. If all the 150 distilleries in the country adopt the technology there could be a saving of Rs 30 crores or **5,00,000** tonnes of coal annually. This will also result in an environmentally safe disposal of wastes.

III) **Solar Energy:** Biogas is a cheap and efficient fuel and its feedstock is renewable.More recently, other renewable sources for energy generation are being explored.Systematic efforts are being made to tap solar energy for meeting the demands of our rural poor. It is a decentralised energy system, which can be used to meet versatile needs of the Indian masses. Solar cooking, water heating, water desalination, space heating, crop drying, etc. are some of the modes of thermal conversion. Efforts are on to economically develop solar collectors for high temperature applications. More than 380 solar water heating systems are operating in the country. More than 1,000 large capacity water heating systems are under installation.

Solar energy can also be converted into electrical energy. Solar panels concentrate large amounts of light energy on photovoltaic cells which charge the batteries that serve as a source of electricity. This electricity can be used to run pumps, streetlighting system or even refrigerators. More than 160 solar photovoltaic pumps have been installed in the rural areas providing water for drinking and irrigation. Solar photovoltaic street lighting systems have been provided by Government of India in more than 150 villages on experimental basis. Installed in the remote villages, alsoknown as **Urjagrams**, far from power lines, solar energy makes electricity availableto people who would otherwise not be able to dream of thermal or hydel electrical energy.

IV) **Wind Energy:** Another renewable alternative source of energy is wind energy.Wind energy holds promise for systematic utilisation. The maximum exploitable potential has been estimated at about 3.2 xlo8 J/ year. It can be converted intomechanical and electrical energies and would be particularly useful in remote areas.Wind energy can be made to run turbine to generate electricity. According to Indian Meteorological Department average annual wind density of 3 kwh/m^2/day (read as kilo watt hours per square meter per day) is prevalent at a number of places in Peninsular and Central India. In some areas, the densities are higher than 10kwh/m^2/day during winter when energy requirements are very acute and 4kwh/m^2/day for 5-7 months in a year. At present this energy is being used to upwell ground water at four locations of Ajmer in Rajasthan. DNES has installed 924 wind pumps throughout the country. Wind electricity generators at appropriate locations(like Ladakh) are envisaged with aggregate capacity of 2 MW, for lighting and pumping water in addition to devising charging of batteries. In the 8th Plan, some 85 new wind-powered mills are proposed to be installed at various locations in India, where the aerodynamics of the area provides conditions suitable for this venture.

Today, there are more than 100 manufacturers in the country engaged in the production and development of different renewable energy systems and devices. It is estimated that by the end of this century, 20 per cent of the total energy demand will be met from the following non-conventional energy sources.

Try the following SAQ to see what you have understood of the various

non-conventional sources of energy. Compare your answers with those given ‘ at the end of this unit.

SAQ 4

a. What is the difference between commercial and non-commercial sources of energy?

b. State whether the following statements are correct or incorrect. Indicate youranswer by putting a (   ) or (x) in the boxes provided.

   i) City sewage cannot be used for generation of biogas.

   ii) Smokeless ‘Chulhas’ permit shorter cooking time along with saving of fuel.

   iii) Gobar gas or biogas can be used for cooking, lighting and power generation for running refrigerators or tube well pump sets.

   iv) Urjagrams are earmarked villages in which non-conventional alternate energy generating systems have been installed by Government on experimental basis.

c. Compare and contrast conventional versus alternate systems of energy generation.

7.6 SUMMARY

Let us summarise what we have learnt so far:

- Today’s modern industrial societies are characterised by the intensive use of energy. You cannot think of life without electricity or other source of energy.
- India consumes roughly 3% of world’s total energy.
- Mainly there are two sources of energy viz i) Non-conventional sources such as biomass, solar, fuel cell, geothermal, Co-generation and wind energy, ii) Conventional sources of energy like natural oil energy, gas, coal and hydro power energy.

- The amount of energy consumed per person each year is a useful measure of standard of living.
- Energy demand of developing countries is increasing due to population growth and industrialisation.
- Renewable energy sources are virtually inexhaustible. They generate with minimal pollution, causing no oil spill, nuclear meltdown, nuclear water, smog or acid rain. Renewable energy sources have no fuel costs and are freely available.
- Switching to clean, renewable energy will bring us cleaner air and water while improving human health and increasing energy security.
- Conservation of energy sources is urgently required as its excessive consumption is not only costly but also leads to multiple problems. Moreover, dependence of modern human on innovative and non-conventional sources of energy has become the only alternative.

7.7 TERMINAL QUESTIONS

1. What are the differences between conventional and non-conventional sources of energy?
2. How is biogas helpful in meeting the energy crisis of people living in rural areas?
3. Discuss any two non-conventional means of generating energy.

7.8 ANSWERS

Self-Assessment Questions

1. (i) a (ii) b (iii) c (iv) c (v) b
2. (a) maximum, b) energy, c) more, d) sustainable
3. Refer to section 7.4.
4. a) The sources of energy which are produced on a large-scale for the purpose of sale are called **commercial,** such as coal, petroleum, electricity. Those sources which serve only local needs and are not produced on a large-scale are called **non-commercial** sources such as firewood, cowdung and agricultural wastes.

   b) i) × ii) ✓ c) ✓ iv) ✓

   c) Conventional systems of energy generation are less efficient, more polluting and non-renewable whereas alternate sources of energy are innovations providing clean and efficient means of energy generation using renewable resources.

Terminal Questions

1. The conventional sources of energy such as coal, petroleum are non-renewable; they make use of old technologies for energy generation and cause environmental damage. Non-conventional sources of energy such as solar energy, energy from biomass, are based on renewable resources; they make use of comparatively recent technologies and cause minimum damage to the environment. Non-conventional sources of energy are decentralised means of making energy available to rural poor located in remote areas.

2. Refer to section 7.2.

3. The two non-conventional methods of energy generation are: a) generation of electricity through solar cells, and b) generation of electricity through wind power. In the first case, solar panels collect solar radiation and reflect it on photovoltaic cells, which become charged and can be used as battery of cells. The second makes use of force of wind to rotate a motor which generates electricity.

7.9 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.

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Acknowledgement for Figures

1. Fig. 7.1: Biomass gasifier.

   (Source: https://i.ytimg.com/vi/837XxbF4_ss/hqdefault.jpg)

2. Fig. 7.10: Use of renewable energy as wind pump.

   https://en.wikipedia.org/wiki/File:Turbines-thar-india.jpg

3. Fig. 7.12: Hydro Power. (Source: http://www2.emersonprocess.com/SiteCollectionImages /News%20Images/Agua%20Verm080.jpg)

4. Fig. 7.13: A view of atomic power station. (Source: http://www.power-eng. com/content/dam/Pennenergy/online-articles/2013/February /Sequoyah-Nuclear-Plant.jpg)(Source: http://seco.cpa.state.tx.us/images/manure-biogas.gif)

5. Fig. 7.14: Energy consumption in selected Asian countries 1980-2001.
   (Source: http://cdn0.wn.com/o25/ar/i/aa/d36e6ebee51ddd.jpg)

6. Fig. 7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year. (Source: http://www.euanmearns.com/wp-content/uploads /2014/07/world_energy_population.png)

7. Fig. 7.16: World energy intensity by region 1970-2020.(Source: http://web.fc2 .com/jump/?url=http://oilpeak.web.fc2.com/myenvironmentalism/technology /ieo2000/figure-11.jpg)

8. Fig. 7.17 An illustration of energy consumption in the developed world Source:https://pixabay.com/photos/hong-kong-city-urban-skyscrapers-1990268/