



CHAPTER

12

SOURCES OF ENERGY

We have learnt in the previous class that the total energy during a physical or a chemical process is conserved. Why, then, do we talk so much about the energy crisis ? The question can be answered if we recall what else we learnt about energy. We have also learnt that energy exists in different forms and one form of it can be converted to another. Let us consider some examples. If we drop a metallic plate from a height, the loss in potential energy is converted mostly into sound energy, when it hits the ground. If we light a candle, the chemical energy of the wax is converted to heat and light energies on burning. Besides, some other products are also obtained on burning. Since, the total energy during a chemical or physical change remains the same – can we put together the heat and light generated along with the products of the reaction during the burning of candle to get back the chemical energy in the form of wax ?

In another example, suppose 400ml of water at 75°C is kept in a room whose temperature is 25°C (say). The temperature of water will come to 25°C by losing its heat content. Is there any way of collecting the heat lost to the surrounding and making the water hot once it was cooled down ?

In the above examples we will see that energy in the usable form is dissipated to the surroundings in less usable form. That is why, we are not able to perform endless activities without thinking about the energy resources, for any process.

Hence, to do work, we use source of energy. The energy so consumed cannot be used again.

12.1 What are the various Sources of Energy ?

In our day-to-day life we use energy from various sources for doing different works. We use petrol to run cars, scooter and motor cycles etc. We also use diesel to run buses, trucks, water pump, electric generators etc. We

use electricity for lighting our houses and streets. We also use energy in our muscles to perform physical works such as household works, running, cycling etc. Try to recognise the different forms of energy with which we are using in day-to-day life, as an activity.

Activity 12.1

1. List four forms of energy that you use from morning, when you wake up, till you reach school.
2. From where do we get these forms of energy ?
3. Can we call them as sources of energy ?

The muscular energy required for carrying out physical work, the electrical energy needed for using electric appliances and the chemical energy required for cooking food, for running different vehicles are obtained from different sources. Sometimes, we need to know how to select the suitable source for obtaining the required energy in its suitable form. To understand the above facts, let us try to perform the following activity.

Activity 12.2

1. Examine the various options that we should have when we choose a fuel for cooking our food.
2. What are the criteria for categorising a good fuel.
3. Would your choice be different if you live
(A) in a forest ? (B) in a remote village on a mountain or island ? (C) in town or city? (D) five hundred years ago ?
4. How are the factors different in each of the cases ?

After studying the above two activities, one can see that the particular fuel or source of energy we select for performing some work depends on a number of factors. For example, while selecting a fuel for any purpose we should ask ourselves the following relevant questions. The questions are –

- (i) How much heat does the fuel release on burning ?
- (ii) Does it produce a lot of smoke on burning ?
- (iii) Does it produce poisonous material on burning ?
- (iv) Is it readily and abundantly available ?

12.2 Selection of Fuel

The selection of fuel depends on the need of the consumers. Local conditions and personnel liking also influence the consumer in the selection of the fuel. Besides, selection of fuel depends on the work to be done. Would we choose one fuel for cooking and another for heating the room in winter or cold season ?

Thus a good source of energy would be one

- (i) Which would do a large amount of work by burning unit volume or unit mass of it,
- (ii) be easily accessible or available in plenty,
- (iii) be easy to transport and handle,
- (iv) be easy to store i.e. it should need less space for storage, and
- (v) be economical

Try to answer

1. What is a good source of energy ?
2. What are the characteristics of a good fuel ?

12.3 Conventional Sources of Energy

The simplest, earliest and the most common use of energy by man has been in the form of the energy stored in muscles of his body. The next use of energy by man was in the form of fire. In ancient times wood was the most common source of heat energy. Man next learnt to harness the energy of moving water and wind (i.e. the moving air). The energy so obtained was used for limited activities. Try to find out some of these uses. Next, the exploitation of coal as a source of heat and other forms of energy made the industrial revolution possible. Increasing industrialization has resulted to a better quality of human life all over the world. As a result, the global demand for energy is at a tremendous rate. The growing demand for energy was met on a larger scale by the fossil fuels – coal and petroleum. For India coal is the backbone of national economy and is a source of energy in key industries like railways, steel and thermal power plants. Our technologies were also developed for using coal and petroleum.

But the fossil fuels (coal and petroleum) were formed over millions of years ago on the earth and there are only limited resources because of the

finite size of the earth. Fossil fuels are preserved in the earth's crust as remains of animals and plants. The main fossil fuels are (i) coal (ii) petroleum and (iii) natural gas. Thus, the fossil fuels are non-renewable sources of energy. So we need to conserve them. Experts are of the opinion that if we were to continue consuming these sources of energy at the present alarming rates, we would soon run out of these sources of energy. In order to avoid this, alternate sources of energy were explored by scientists. However, we still continue to be largely dependent on fossil fuels for most of our energy requirements. The situation can be understood from the pie-chart given in figure 12.1.

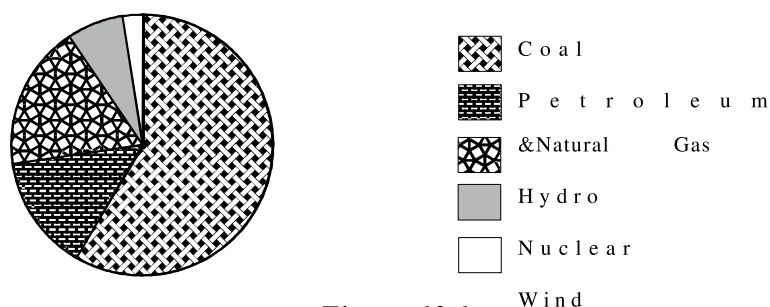


Figure 12.1

The burning of fossil fuels has many disadvantages since the end products of combustion enter into the air. We learnt in class IX, about the air pollution caused by burning of coal or petroleum products. These are mainly oxides of carbon, hydrogen, nitrogen and sulphur, which are acidic oxides. These oxides introduced in the atmosphere are the cause of acid rain which affects our water and soil resources. The unburnt particles of carbon and hydro carbons also enter into the atmosphere. These substances deteriorate the quality of air and the air is said to be polluted. Breathing in such air is harmful. In addition to the problem of air pollution, recall the green house effect, caused by excessive release of carbon dioxide.

Now-a-days, the pollution caused by burning of fossil fuels can be somewhat reduced by increasing the efficiency of the combustion process. This is done by using various techniques to reduce the escape of harmful gases and ashes into the surroundings. Fossil fuels are used directly in gas stoves and vehicles. Moreover, the major fuels used for generating electricity are fossil fuels, inspite of pollutions caused by burning them.

Let us think over for a while – how would our lives change if we could no longer get electricity ? The amount of electricity consumed by each individual in a country is one of the parameters to measure the growth of the country.

Potential energy of a water body stored at a height is another traditional source of energy. Hydel power plants convert the potential energy into electricity. The natural water reservoir or water falls which could be used for this plant is very few. So, hydro-power plants are associated with dams. High rise dams are constructed on the river to collect water in larger reservoirs. The water from the higher level is allowed to run down through a pipe. The potential energy in the stored water is changed into kinetic energy. This kinetic energy is used to move the turbine of the generator. Thus electricity is produced.

The reservoir would be refilled when there is rain. It is a natural process of water cycle. Thus hydro-power plant is a renewable source of energy.

Construction of big dams have certain problems. Large areas of agricultural land and human habitation are to be sacrificed as they get submerged. Large eco-systems are destroyed when submerged under the water. When the vegetation are submerged they rot under anaerobic condition and give rise to large amount of methane which is also a green house gas.

12.4 Improvements in the Technology for using Conventional Sources of Energy

About 80% of the energy consumed by the rural mass in India is based on biomass. The material contained in the bodies of plants and animals is called biomass. When plants die, their biomass can be used as fuel for domestic purposes. In our homes, we burn wood in the traditional Chulhas which have poor efficiency of about 8 percent only. At the same time it leads to health hazards from the smoke coming out due to incomplete combustion. The above problems are overcome in smokeless Chulhas which allow better combustion and have better efficiency. The smoke, at the same time is removed through chimney attached to it. Charcoal is also used as fuel for domestic and industrial purposes. Charcoal is made by burning wood in a pit where the supply of air is insufficient. In doing so, volatile matters in the wood are drawn off leaving behind a residue black in colour. This black residue is charcoal. Charcoal is mainly carbon.

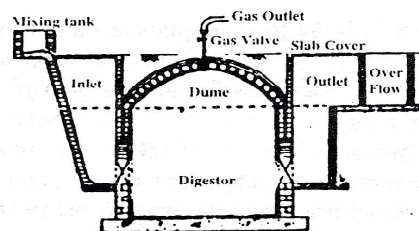
Dried animal dung cakes are also used as domestic fuels in rural areas. When they burn with insufficient supply of air a lot of smoke is produced. This leads to air pollution. At the same time animal dung contains a lot of nutrients vital to soil. It is, therefore, unwise to burn animal dung cakes directly. In order to save the vital nutrients from the animal dung for use in agriculture and to reduce the air pollution to some extent, bio-gas plants have now been designed and are used in rural and some sub-urban house-holds. The wastes

from animals and plants, what we called as biomass can be degraded easily by anaerobic organisms in absence of air but with water. In this process, organic manure which is better than the dry cattle dung and mixture of gases such as methane, carbon dioxide, hydrogen, hydrogen sulphide are produced. The gas mixture is called the biogas. Biogas mainly contains methane about 65 to 75 percent. It is an excellent fuel. It burns without smoke, leaving no residue like ash in wood, charcoal and coal burning. Its heating capacity is high. Bio-gas is also used for lighting. By converting biomass into biogas heating efficiency is increased by about 20 percent.

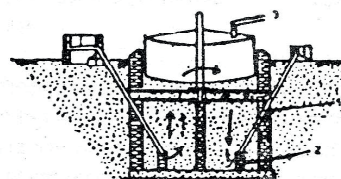
The slurry left in the plant after the gas is withdrawn is rich in phosphorous and nitrogen compounds and is a good quality manure.

Taking due considerations of the above advantages, Khadi and village industries Corporation and other government agencies actively promote the construction of biogas plants. In a country like India having largest cattle population, there is tremendous scope for community size biogas plants which can meet a large percentage of domestic energy needs in the rural areas. This would reduce pressure on chemical fertilizers, stress on forest and other fossil fuels.

There are two types of biogas plants. They are fixed dome type and floating gas holder type.



Fixed dome



Floating gas holder

Figure 12.2

In both the types, thin semiliquid mixture of animal dung and water is put into the plant. Human excreta can also be added in the mixture. The biogas so produced is drawn off through pipes for use at specific points. For continuous supply of it, the plant needs regular supply of biomass. In big cities where underground sewage facilities exist, sewage gas – a mixture of methane and carbon dioxide may be collected. Out of this mixture methane gas may be separated out for using as fuel.

12.5 Alternative or Non-Conventional Sources of Energy

Our life -style is changing. We are using machines to do more and more work for us. Our demand for energy increases day by day. Our basic requirements are also increased. So, we need to look for more and more sources of energy. To develop the technology for using the available or known source of energy more efficiently and to look to new sources of energy are two main areas to pay our attention. Any new source of energy we seek to exploit would need specific devices developed with that source in mind. We shall now look at some source of energy that we seek to tap and the technology designed to capture and store energy from that source.

Solar Energy

We are receiving the energy from the sun in the form of light energy and heat energy. The quantity of solar energy reaching the earth's upper atmosphere has been estimated at about $1.39 \text{ kJ/m}^2/\text{s}$. The total solar energy of all wavelengths received per unit time by a surface of unit area oriented normally to the Sun's rays at the top of the earth's atmosphere is called **Solar constant**. Thus, the solar constant is $1.39 \text{ kJ/m}^2/\text{s}$. It has been calculated that energy received over the total surface of the earth amounts to $3.57 \times 10^{14} \text{ kJ/s}$, roughly 20,000 times larger than the current global energy consumption. The energy is absorbed by numerous atmospheric particles. The total incoming radiation may be divided into direct radiation and diffused or indirect radiation resulting from scattering in the atmosphere and earth's surface. The maximum influx on the average is about 4 to 7 kWh/m². The heat that we feel in sunlight is mainly due to the presence of infra-red wavelength in sunlight and it heats up the land and water on the surface of earth. How can you tap this huge amount of energy ? To understand it a little more let us perform the following activity.

Activity 12.3

1. Take two bottles of the same capacity.
2. Paint one white and the other black (or wrap one with white paper and the other with black paper)
3. Fill both the bottles with the same quantity of water.
4. Place the bottles in direct sunlight for an hour.
5. Touch the bottles. Which one is hotter ?

Can you think of ways in which this finding could be used in your daily life .

A black surface absorbs more heat as compared to a white surface. Solar cookers and solar water heaters are designed using this principle. A solar cooker may have solar heat collector. Solar collectors may be divided into two types – (i) Concentrating or focussing type and (ii) flat or non-focussing type.

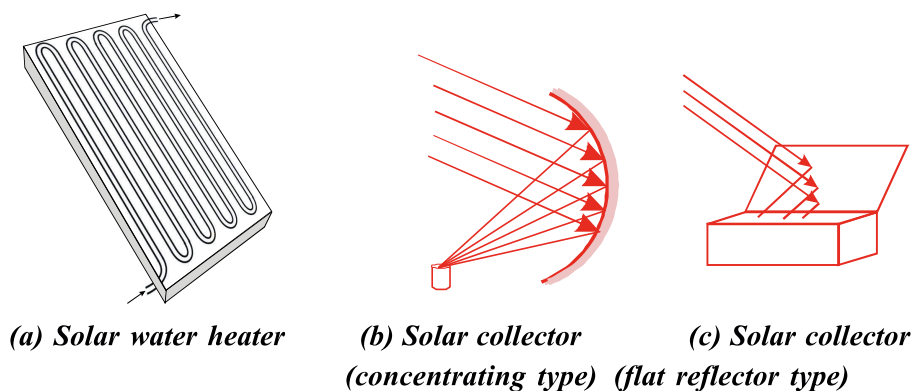


Figure 12.3

The reflector is made of foils of aluminium or aluminised plastics or strips of mirror and the pot used for cooking may be of aluminium or stainless steel. The outer surface of the cooker is coated with lamp black or nickel black. Solar cookers are covered with glass plate to trap the heat more by green house effect also.

These devices are useful only at certain times during the day, when there is sunshine.

Solar energy can be used to generate electricity

Heat produced by the sun's rays can be used to generate electricity indirectly. In this process, solar energy is used to heat a liquid of low boiling point. The resulting vapour is made to turn turbines which are connected to generators. One such example is Abhimanyu solar pump developed in the National Physical Laboratory, New Delhi, which can generate 1 kW of electricity. At present the use of these engines is rather limited.

In another way, sunlight can be used to generate electricity with the help of light sensitive cells known as solar cells or solar batteries. Such devices are also called photo voltaic devices. These cells are used most

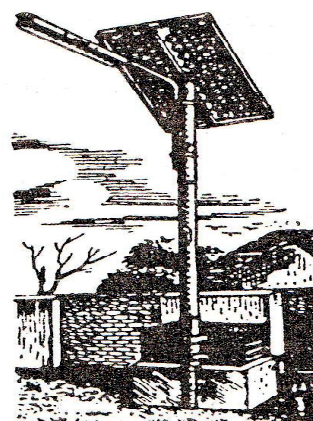


Figure 12.4 Solar panel

often in space vehicles and artificial satellites to power their electrical devices and electronic instruments. Solar batteries were developed for the first time by the scientists of the Bell Telephone Laboratories, America. Now-a-days, Central Electronics Limited (CEL), India has developed solar batteries. It is made up of a number of cells. Each cell consists of a wafer of pure silicon, to which certain impurities have been doped. In other words, they are solid state semiconductor devices which convert solar energy directly into D C (direct current) electrical energy. Because of limitations on the maximum voltage and current of a single solar cell a number of solar cells are connected in series and then arranged in parallel resulting to a mixed grouping of cells. Such a combination is known as panel. The panel is finally covered with glass in order to protect the cells from the atmosphere and dust. To use the electricity during the night time and on cloudy days when there is no direct sunshine, the electrical energy is stored in accumulators or secondary batteries. The stored electrical energy is used again in the night or in cloudy periods. This system is very much useful in remote unelectrified villages.

Wind Energy

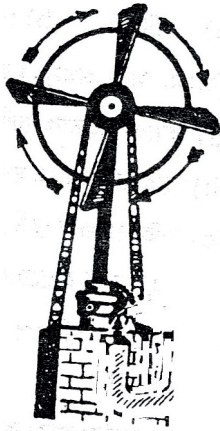


Figure 12.5 Windmill

Wind is nothing but the air in motion. The movement of air is also due to the convection current set up in the atmosphere on account of non-uniform heating of the earth's surface by the sun. There are both horizontal and vertical motions of air. What we call wind is mainly the horizontal movement of the air near the earth's surface. We are primarily interested in it.

Earlier wind power was used for propulsion of ships or directly converted into mechanical energy to lift water, to grind corn and for agricultural uses. For the use of wind power to generate electricity, the kinetic energy of the wind is to be converted into some convenient form of mechanical motion which in turn will drive the shaft of an electric generator. For the purpose there is a wind turbine mounted upon a tower Figure 12.5. The kinetic energy of the wind is used to provide rotatory motion of the wind turbine which can be used to do work. The other equipments like gear boxes, speed control devices, safety devices and electrical generators may be mounted on the tower. The diameter of the turbine and height of the tower are designed to suit the wind velocity in the region of installation and the power requirement. It is known that at higher points above the earth's surface, the wind is steady and has greater velocity.

The power available from the wind depends on :

(i) the area of the blade circle, (ii) density of the air, and (iii) cube of the wind velocity.

The output of a single wind mill is quite small and cannot be used for commercial purpose. Therefore, a number of wind mills are erected over a large area, which is known as wind energy farm. The energy output is coupled together to get electricity on a commercial scale.

The merits of using wind energy are :

- (i) It is an environment friendly effort.
- (ii) No recurring expenses for energy production required.

The limitations in harnessing wind energy are :

- (i) Wind energy farms can be established only at selected places where wind blows for the greater parts of a year with a speed higher than 15km/h to maintain the required speed of the turbine.
- (ii) Establishment of wind energy farm requires large area of land.
- (iii) There should be enough back up facilities like storage cells.
- (iv) Initial cost of establishment of the farm is quite high.
- (v) Since the equipments are exposed outside, they need proper maintenance.

It is estimated that nearly 45,000 MW of electrical power can be generated if India's wind potential is fully exploited. The largest wind energy farm in India is located at Kanyakumari in Tamil Nadu. It generates 380 MW of electricity. In the case of Denmark wind energy, from a vast network of wind mills, claims more than 25% of the total electricity used in the country.

Energy from the Sea

Tide is a natural phenomenon occurring periodically on the sea. It creates the difference of water level on the sea. Thus Tidal energy is developed. Can you think how to tap the energy there ? Sea water is never at rest. Sea water has a huge amount of kinetic energy. Would it be possible to tap the energy associated with sea wave?

The water at the surface of sea or ocean is heated by the sun while water in the deeper section is relatively cold. This difference in temperature is exploited to obtain energy in ocean thermal energy conversion plants. The difference of temperature is about 20°C at the depth of 2km. The heat in the surface water is used to boil a volatile liquid like ammonia. The vapour of the

liquid are then used to run the turbine of generator. Cold water from the depth is used to condense the vapour again to liquid.

The potential energy of the sea is quite large, but efficient commercial exploitation is yet to be worked out.

Geothermal Energy

Have you heard about hot springs ? Sometimes the molten rocks in the deeper regions of earth's crust are pushed up and trapped in certain regions as hot spots. When underground water comes in contact with the hot spot steam is generated. Some of the hot water and steam may find outlets at the surface. They are found in the form of hot spring. Still a large amount of steam remains trapped in the rocks. When the steam is rooted through a pipe to a turbine of a generator, electricity can be produced. The site where such energy can be exploited on the commercially viable project is very limited. There are a number of power plants based on geothermal energy operational in New Zealand and United States of America.

Nuclear Energy

What is nuclear energy ? The energy released during nuclear reaction is called nuclear energy. There are two types of nuclear reactions. They are (i) nuclear fission and (ii) nuclear fusion. In nuclear fission the nucleus of a heavy atom (such as uranium, plutonium or thorium) is splitted into two lighter nuclei with the help of slow moving neutron. In this process a huge amount of energy is released. The sum of the masses of the product nuclei is less than the mass of the original nucleus. The mass lost is converted into energy. In nuclear reactors the amount of energy released is controlled and used to run the turbine of electric generator.

In nuclear fusion two energetic light nuclei fuse together to make a heavy nucleus with the release of huge amount of energy. In this process also the lost of mass of the interacting nuclei is responsible for the production of the huge amount of energy. Nuclear fusion is responsible for the energy in the sun and the star. To control the fusion reaction for the production of electricity for our use is yet to achieve. Still, nuclear energy cannot be used in large scale on the following grounds (problems). Storage and disposal of spent or used fuel is a major problem. Harmful radiation from the nuclear waste cause damage to the human body and environment. Improper nuclear-waste storage and disposal result in environmental contamination. Further, there is a risk of accidental leakage of nuclear radiation. The high cost of installation is also an additional problem.

We have studied various sources of energy either conventional or non-conventional. Exploiting any source of energy disturbs the environment in some way or the other. We always choose the source depending upon the following factors –

- (a) the ease of extracting energy from the source.
- (b) the economics of extracting energy from the source.
- (c) efficiency of the technology available.
- (d) the environmental damage that would be caused by using the source.

POINTS TO REMEMBER

- i. Muscular energy, electrical energy, chemical energy etc. are obtained from different sources.
- ii. Energy from wood, fossil fuel, hydel power plants are conventional sources of energy.
- iii. Improvement in the technology of using conventional sources of energy is highly needed.
- iv. Use of solar energy, wind energy, tidal energy, geothermal energy etc. are non-conventional sources of energy.
- v. While selecting a fuel we have to consider the easiness of extracting energy from the source, cost of extraction, efficiency of technology available and impact on environment.

EXERCISE

- 1. What is a good source of energy ?
- 2. What is a good fuel ?
- 3. If you could use any source of energy for heating your food, which one would you use and why ?
- 4. What kind of mirror – concave, convex or plane would be best suited for use in a solar cooker? Why ?
- 5. What is geothermal energy ?
- 6. Can any source of energy be pollution free ? Give reason in support of your answer.

7. Name two energy source that you would consider to be renewable. Give reasons for your choice.
8. Give the name of two energy sources that you would consider to be exhaustible. Give reasons for your choice.
9. What are the qualities of an ideal source of energy ?
10. What are the advantages of using a solar cooker ? Are there places where solar cookers would have limited utility ?

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