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# SOURCES OF ENERGY

All of us take food for survival and growth of our body. Vehicles like motorcycles, tractors, buses, trucks, ships and aeroplanes require fuel for their running. Even for cooking food we require fuel. Do you know What is important which we get from the food or from the fuel? Yes, you are right. It is the energy. From the time you wake up to the time you go to sleep at night, energy plays an important role in your life. Energy is important in everyone's life, whether you notice it or not. Without sufficient energy people face difficulties doing their day to day work. All forms of energy including solar energy, light energy, mechanical energy, nuclear energy, and the energy of our body are important to us. The energy of your body enables you to talk, to move and to walk. Is it possible to do any task without energy?

The basic question is: from where do we get all the energy we need? In this lesson we will learn about different sources of energy, their importance and limitations. We will also learn about the energy crisis and how and why it came about? The ways and means of saving and conserving energy in our daily life will also be discussed in this lesson.

## OBJECTIVES

After studying this lesson, you will be able to:

- *define energy and list various forms of energy;*
- *identify conventional and non-conventional sources of energy used in India;*
- *distinguish between renewable and non-renewable sources of energy;*
- *describe various types of sources of energy e.g. fossil fuels, water, wind, biomass, sea, geothermal, nuclear energy;*
- *recognise that the sun is the ultimate source of energy;*
- *explain the advantages and disadvantages of different sources of energy;*

- *explain what is energy crisis and how did it develop;*
- *recognise the need of conservation of energy sources and*
- *explain the methods of mitigation of energy crisis – energy efficiency and conservation in your daily life.*

## 12.1 ENERGY – AN INTRODUCTION

Energy is a very common word frequently used in our day-to-day life. Energy is defined as the ability to do work. We require energy for all types of activities including the activities within our body, with our body or with other bodies. When we say a body has energy, it means that it is capable of doing work. Look around you will find countless examples where energy is used to do work. An engine uses energy of its fuel to move a car along. A battery stores the energy needed to switch on the radio or tape recorder. The heavy flow of water can break the banks of rivers as it also has energy in it. Similarly the wind also carries enough energy to shake trees.

### 12.1.1 Importance of Energy in our Life

Energy plays a very important role in our lives, providing comfort, increasing productivity and allowing us to live the way we want to. Since the beginning of mankind, we have made use of wood, water, and fossil fuels as a means of heating and making machines work. Almost for all types of activities, we rely on one or another form of energy.

Amount of energy used by a society is an indicator of its economic growth and development. Without energy even our body would be unable to perform basic functions like respiratory, circulatory, or digestive functions to name a few. Plants would also be unable to complete the process of converting Carbon dioxide, water and minerals into food without the light from the Sun. Almost all the machines used for the production and manufacture of different types of items would be unable to operate without the use of a source of electrical energy. Almost everything we see around us, the clothes we wear, the food we eat, the houses we live in, the paper we write on, the vehicles we drive, all need energy to be created or transformed from some natural resource to the final product. Nowadays, the electrical energy has become so important that almost in all walks of life electricity is required. For example all electrical appliances in our homes and at our workplace require electricity. All the industries and factories run on electricity.

### 12.1.2 Various forms of Energy

In our daily life we use different forms of energy such as heat energy, light energy, mechanical energy, electrical energy, chemical energy, and sound energy. The most



common forms of energy are heat, light and electricity. We use all these forms of energies for different types of work.

As per requirement, one form of energy can be converted into another form of energy by using specific types of devices or processes. We get energy for our daily use from different sources. We will learn about details of different forms of energy in other lessons.

### 12.1.3 Different Sources of Energy

In simple terms we can say that anything out of which usable energy can be extracted is a source of energy. There is a variety of sources that provide us energy for different purposes. You must be familiar with coal, petrol, diesel kerosene and natural gas. Similarly you must have also heard about hydroelectric power, wind mills, solar panels, biomass etc.

It can be easily seen that some of the energy sources can be replenished in a short period of time. Such energy sources are referred to as "renewable" energy sources, whereas the energy sources that we are using up and cannot be generated in a short period of time are called non-renewable energy sources. Thus, all the sources of energy can be divided into two categories: renewable sources and non-renewable sources of energy.

### INTEXT QUESTIONS 12.1

1. List out any five activities from your daily life in which different forms of energy are involved.
2. What are the three most common forms of energy that we use frequently?
3. Differentiate between renewable and non-renewable sources of energy.

## 12.2 NON-RENEWABLE ENERGY SOURCES

You know that petrol and diesel extracted from crude oil are commonly used to run different kinds of vehicles, such as cars, buses, tractors, trucks, train, aeroplanes etc. Similarly, kerosene and natural gas are used as fuels in lamps and stoves. You should also know that crude oil coal and natural gas occur in limited and exhaustible quantities. They cannot be regenerated in a short period of time or used again and again. Hence, they are called non-renewable sources of energy.

It is a fact that at present we get most of our energy from non-renewable energy sources which include fossil fuels such as coal, crude oil and natural gas. Looking at the present and future energy requirements, it is expected that our oil and natural

gas reserves may last for another 30-35 years (assuming no major new fields are discovered). Similarly the coal reserves may last no longer than another 100 years. So we must use these non-renewable energy sources judicially and avoid all wastages.

Radioactive elements like natural uranium are also non-renewable. When the atoms of uranium are split into two or more parts, a very large amount of energy is released which can be used to generate electrical energy.

Let us now, look into details of the fossil fuels as sources of energy.

### 12.2.1 Fossil Fuels – Conventional Source of Energy

Fossil fuels, such as coal, oil and natural gas, are important non-renewable sources of energy. Since the beginning of mankind, we have been using fossil fuels to generate heat, light and electricity for various purposes. These are the primary sources for generating electrical energy in the world today. Over 85% of our energy demands are met by the combustion of fossil fuels. Carbon is the main constituent of these fossil fuels. Fossil fuels are excellent sources of energy for our transportation needs. You may be surprised to know that approximately 1.9 billion tons of coal is burnt in a year to generate electricity in the world. A large amount of chemical energy is stored in the fossil fuels. This stored chemical energy is converted into various other forms of energy such as heat, light and mechanical energy.

You may be interested in knowing how the fossil fuels are formed? Millions of years ago the remains of dead plants and animals were buried under the ground. Over the years by the action of heat from the Earth's core and pressure from rock and soil, these buried and decomposed organic materials have been converted into fossil fuels.

#### (a) Coal

Coal is formed in a way similar to the other fossil fuels, though it goes through a different process called "coalification". Coal is made of decomposed plant matter in conditions of high temperature and pressure, though it takes a relatively shorter amount of time to form. Coal is not a uniform substance either; its composition varies from deposit to deposit. Factors that cause this deviation are the types of original plant matter, and the extent to which the plant matter decomposed.

There are different types of coal such as peat, lignite, sub-bituminous and bituminous. The first kind of coal is **peat** which is merely a mass of dead and decomposing plant matter. Peat has been used as fuel in the past, as an alternative to wood. Next, the peat becomes **lignite**, a brownish rock that contains recognizable plant matter and has a relatively low calorific value. Lignite is basically the halfway point from peat



to coal. The next phase is **sub-bituminous** which is a shade of dull black with very little visible plant matter. This type of coal has a less than ideal calorific value. **Bituminous** coal is the best quality of coal. It. is jet black, very dense and brittle. This type of coal has high calorific value.

### Generation of Electrical Energy from Coal

You may be curious to know that how do we get electrical energy from coal? It is basically by means of *coal power plants*. These power plants first burn the coal in large furnaces creating tremendous amounts of heat. This heat is used to boil water in boilers so as to convert it into steam. The steam expands, causing pressure to increase in the boiler. A steam turbine is placed at the exit of the boiler so that the moving steam rotates the turbine. In this process the energy from the moving steam gets converted into mechanical energy. The rotating turbine is used to spin a magnet inside a power generator. This generator is a large electromagnet that encases the spinning magnet. In this way the electricity is generated and so generated electricity is then sent to the national power grid from where it is distributed in different areas.

### (b) Natural Gas

Natural gas is another major source of the energy in our country. Oil and gas fields have been found everywhere on the planet except on the continent of Antarctica. These fields always contain some gas, but this natural gas (methane) does not take nearly as long to form. Natural gas is also found in independent deposits within the ground as well as from others sources too. Methane is a common gas found in swamps and is also the byproduct of animals' digestive system.

Although Natural Gas is a fossil fuel, it is cleaner burning than gasoline, but does produce Carbon Dioxide, the main greenhouse gas. Like petrol and diesel, natural gas is also a finite source, though available in larger quantities than the former.

## 12.2.2 Advantages and Disadvantages of Energy from Fossil Fuels

Use of fossil fuels as sources of energy has both advantages and disadvantages. Let us first take advantages:

- Generation of energy from the fossil fuels technology-wise is easy and relatively cost effective,
- Fossil fuels have a very high calorific value
- Fossil fuels can generate huge amounts of electricity in just a single location.
- Transportation of fossil fuels like oil and gas to the power stations can be made through the use of pipe-lines, making it an easy task.
- Power plants that utilize gas are very efficient.

- Construction of power plants that work on fossil fuels is relatively easy technology-wise and they can be constructed in almost any location.

If we look into the disadvantages of using fossil fuels, we find that:

- Pollution is a major disadvantage of using fossil fuels as source of energy. During the process of combustion of fossil fuels a lot of toxic gases (and fly-ash in case of coal) are generated which cause pollution of the atmosphere. These gases include carbon dioxide, which traps the Sun's heat and may be causing global warming. Besides carbon dioxide, coal also gives off sulphur dioxide which may cause acid rain.
- The supply of fossil fuels is limited and cannot be replenished. The rate at which they are being consumed, their reservoirs are sure to run out soon.
- Extraction of fossil fuels including coal has resulted in the destruction of wide areas of land and has endangered the environmental balance in some areas
- Mining of fossil fuels including coal is difficult and rated as one of the most dangerous jobs. Many a times, it endangers the lives of miners
- Use of natural gas can cause unpleasant smell in the area.

**Do you know**

The particles formed on burning of fossil fuels are very dangerous. These small particles can exist in the air for indefinite periods of time, up to several weeks and can travel for miles. The particles, sometimes smaller than 10 microns in diameter, can reach deep within the lungs. Particles that are smaller than this can enter the blood stream, irritating the lungs and carry with them toxic substances such as heavy metals and pollutants. Those affected by these particulates could become afflicted with fatal asthma attacks and other serious pulmonary diseases.

Industrial societies need huge amounts of energy to run their homes, vehicles and factories. More than 80% of this energy comes from burning coal, oil and natural gas. These are called fossil fuels, because they formed from the remains of plants and tiny sea creatures that lived on Earth many millions of years ago. They include fuels made from oil, such as petrol, diesel and fuel for jet planes.

### 12.2.3 Energy from the Atom – Nuclear Energy

The atoms of a few elements such as radium and uranium act as natural source of energy. In fact atoms of these elements spontaneously undergo changes in which the nucleus of the atom disintegrates.

Let us see how we get energy from the atom. You should know that a large amount of energy is stored in the nucleus of every atom. The energy stored in the nuclei of atoms can be released by breaking a heavy nucleus such as uranium into two lighter

nuclei. The splitting of the nucleus of an atom into fragments that are roughly equal in mass with the release of energy is called **nuclear fission**. (A small amount of each fission mass vanishes, in releasing huge amounts of energy as per $E = mc^2$, where m is the missing mass and $c$ is the velocity of light). When a free neutron strikes a Uranium (235) nucleus at a correct speed, it gets absorbed. A Uranium (235) nucleus on absorbing a neutron becomes highly unstable and splits into nuclei of smaller atoms releasing huge amount of energy in the process. During this process, a few neutrons are also released. These neutrons split other nuclei of the Uranium (235). The reaction continues rapidly and is known as the **chain reaction**. In this process a large amount of energy is released. This energy is used for boiling water till it becomes steam. Steam so generated is used to drive a turbine which helps in generating electrical energy.

### Nuclear Fusion

Energy is also produced when two light nuclei such as deuterium (heavy hydrogen) combine together to form a heavy nucleus. A process in which the nuclei of light atoms are combined to form a nucleus of a heavier atom with the release of energy is called **nuclear fusion.**

Nuclear fusion requires very high temperature, say of the order of 4 million degree Celsius (4000000 °C). This is the mechanism through which energy is produced in stars, including our sun. This reaction has been used to make hydrogen bombs.

The fission reaction is carried out in a controlled and regulated manner in nuclear reactors. (Else, they would explode like bombs with an uncontrolled chain reaction.) In order to control the fission reaction, some of the neutrons released by the reaction are absorbed by the control rods made of boron / cadmium. In our country nuclear reactors are functioning at Tarapur, Kalpakkam, Kota and Narora for generating electricity.

**Do you know**

If the nuclear chain reaction is uncontrolled, all the nuclei in the piece of uranium split in a fraction of a second and this may cause a devastating explosion – such as those of the atom bombs dropped on Hiroshima and Nagasaki in Japan by America.

## (a) Uses of Nuclear Energy

Nuclear energy is non-renewable as the uranium fuels used are consumed in the fission reaction and hence are non replenishable. Nevertheless, nuclear energy has many uses:

(i) Energy produced in a nuclear reactor can be harnessed to produce electricity.

(ii) Nuclear energy is also being used to power submarines and ship. Vessels driven by nuclear energy can sail for long periods without having to refuel.

(iii) Radioisotopes obtained as by-products in nuclear reactions are used in medicine, agriculture and research.

### (b) Hazards of Nuclear Energy

On one side nuclear energy seems to be an alternative to fossil fuels, on the other, it can also be hazardous. Nuclear radiations and the radioactive wastes are two major hazards that accompany production of nuclear energy. Let us know little more about them.

1. In the process of producing nuclear energy, harmful nuclear radiations may get accidentally leaked/released which can penetrate human bodies and cause irreparable damage to cells. For preventing this from happening, nuclear reactors are covered with a thick shell of radiation absorbent material such as lead. However, accidental releases of these extremely harmful radiations into the environment pose a constant threat to those inhabiting the surrounding areas. Perhaps you may be aware of the two major accidents in nuclear power plants – one at the Three Mile Island (U.S.A.) and the other at Chernobyl (the then Soviet Union). The immediate devastation caused in these two accidents through the release of harmful nuclear radiations was huge and its full extent is yet to be assessed.
2. Another hazard relate to the problems involving disposal of harmful radiant wastes mainly spent fuels produced in the fission process. During nuclear reactions, a number of harmful substances capable of emitting nuclear radiations are generated. These substances are called nuclear wastes. Presently, most of the nuclear waste generated in nuclear power plants is simply being stored underground in strong lead containers. We have not yet been able to discover safer and more satisfactory methods of disposing the nuclear wastes.

There are major advantages of using nuclear energy over fossil fuels.

- Unlike fossil fuels, the nuclear fuel used in nuclear power stations, do not burn. Hence no waste gases are produced.
- Small amounts fuel materials, yield huge amount of energy.

## INTEXT QUESTIONS 12.2

1. Name any four non-renewable sources of energy and give at least one advantage of each.
2. Nuclear energy is considered to be a very powerful alternative of fossil fuels. Even then why is it not being used on a much larger scale?
3. What are the limitations of using natural gas for meeting our energy requirements?

## 12.3 RENEWABLE ENERGY SOURCES

You have learnt in the previous section that the fossil fuels such as coal, oil and natural gas meet most of the energy needs of the world today. But what will happen when the reserves of these non-renewable sources of energy get completely exhausted?, We also need to pay attention to the damaging effects of fossil fuels on the environment.

The solution, surely, must lie in switching to alternative sources of energy and environment-friendly natural fuels. There are several alternative and renewable sources of energy which are not only environment friendly but can also be available in abundance. Water, wind, sunlight, geothermal, sea waves, hydrogen and biomass are some such possible sources of energy. In addition to the renewability, there are other reasons why we should look to switching over to such sources. Such as:

- To reduce pollutants, greenhouse gases and toxins that are by-products of non-renewable sources of energy;
- The use of alternative energy sources can help preserve the delicate ecological balance of the earth, and help conserve the non-renewable energy sources like fossil fuels; and
- Renewable sources are inexhaustible.

Fortunately there are many means of harnessing renewable sources of energy which have less damaging effects on our environment. Here are some possible alternatives in the next sub sections.

### 12.3.1 Sun - The Ultimate Source of Energy

The sun has been providing us heat and light for billions of years and it is expected that it will continue to do so for billions of years to come. All plants get their energy from the sun and all animals get their energy mainly from the plants. Therefore, it may be concluded that sun is a source of energy for animals. Even the energy stored in butter, milk and eggs comes form the sun. Why do we say so? The sun in fact is the ultimate source of energy for all living beings. Apart from nuclear energy, all other forms of energy result from solar energy. It is said that the fossil fuels, bio-fuels and natural gas are in effect "bottled" solar energy. The wind and rivers which provide renewable energy are also the result of solar energy. Can you think how?

Fig. 12.1

Sun is one of the most powerful renewable sources of energy for the future. As long as the sun exists, we will continue to get its energy. About 30% of the incoming solar radiation is absorbed by the upper atmospheres, the rest is absorbed by the land, sea and clouds.

**Fig. 12.2** *Photovoltaic Water Pumping*

Solar energy is used commonly for heating, cooking, production of electricity, and even in the desalination of seawater. With the help of solar cells, solar energy is converted into electricity. One of the most common uses of the sun's energy has been for water heating systems. It is also used to provide power to the vehicles, generate electricity, lighting streets, cooking etc. On a small scale, solar energy is being used to heat up water for daily use in our homes and also the swimming pools. On a larger scale, solar energy could be used to run cars, power plants, and space ships etc.

**Fig. 12.3** *Solar flat plate collector*

**Fig. 12.4** *Box type solar cookers*

## (a) Advantages of Using Solar Energy

We have been using the light and heat of the sun's rays since ancient times for different purposes. Some of the advantages of using solar energy are:

- Use of solar energy causes no environmental pollution, because no chemical waste or toxic gases get released while using solar energy,

- Solar energy can be used for practical purposes such as heating and lighting,
- The sun is an ever lasting source of energy which is freely available, and
- Can be converted into electrical energy and put to many uses.

### (b) Limitations of Using Solar Energy

No doubt, the sun is the source of all the energies in one way or another, but using the sun as a source of energy also has certain limitations. Firstly, solar power plants can not produce energy if the sun is not shining. For example during night time and cloudy days it is not possible to produce energy from the sun. Secondly, establishment of solar power stations can be very expensive. Thirdly the solar panels need to be regularly maintained and cleaned to continue generating electricity.

## 12.3.2 Wind Energy

Wind power is another alternative energy source that could be used without producing by-products that are harmful to nature. Like solar power, harnessing the wind is highly dependent on weather and location. However, it is one of the oldest and cleanest forms of energy and the most developed of the renewable energy sources. There is the potential for a large amount of energy to be produced from windmill.

**Fig. 12.5** *Windmill*

You must have seen a **phirki**. It is also called a wind-vane. What happens when you blow air on the blades of **phirki**? It starts rotating. Using **phirki**, you can easily experience that wind provides energy.

**Fig. 12.6** *Phirki*

### (a) Advantages of Wind Energy

- Wind energy is free of cost and reliable,
- Wind power is clean and produces no environmental pollution,
- In wind power generation no harmful by-products are left over as in case of burning of fossil fuels,
- Since wind is a renewable source of energy, we never run out of it,
- Farming and grazing can still take place on land occupied by wind turbines which can help in the production of bio fuels. When used inland, the land beneath the windmill can still be used for farming purposes.
- Wind farms can be built off-shore.
- In some cases wind farms can even be tourist attractions.

### (b) Limitations of Wind Energy

- Wind power is not available all the time, at all the places and has to be used while being produced, as it cannot be stored.
- Persistent wind and consistent wind speeds are needed for continuous power generation. If wind speed decreases, the turbine lingers and less electricity is generated.
- The wind farms, whether onshore or off shores are unsightly, noisy and generate a lot of opposition.
- Large wind farms can have a negative effect on the scenery.
- They are hazards for wildlife, especially birds who commonly fly into their blades.

Different parts of our country, which are windy most of the time, have windmills to pump water and generate electricity. These wind mills are big wind-wanes in which wind energy is used. Let us look into the working of a windmill.

### (c) Working of Windmill

A windmill is basically a mechanical arrangement to convert wind energy into another form of energy. It has blades. The blades of the windmill rotate in a vertical plane which is kept perpendicular to the wind. As wind flow crosses the blades of the windmill, the blades start rotating. The rotation of blades makes the turbine rotate. The turbine is attached with an electrical generator which converts mechanical energy of the turbine into electrical energy. The blades are angled into the wind, so as to rotate in a way which maximize the generation of electricity.

In older windmills, wind energy was used to run machinery to do physical work, like crushing grain or pumping water. Wind towers are usually built together on wind farms. Now, electrical currents are harnessed via large scale wind farms that are used by national electrical grids, as well as small individual turbines used for providing electricity to isolated locations or individual homes.

The wind speed is vital in the production of electricity, and the optimum speed is approximately 25 km/h and this causes the blades to rotate.

## 12.3.3 Hydroelectric Energy

Like wind energy, the flowing water and water stored in huge dams is also a very important source of energy which is known as hydroelectric energy. But, over-development and unrestricted harnessing of water power can have a devastating effect on the local environment and habitation areas.

### (a) Generation of Hydroelectricity

Hydroelectric is produced by the natural flow or fall of water. By channelling water that is flowing downhill, the force of the water can be used to turn turbines and via a generator, produce electricity.

Hydroelectricity comes from the damming of rivers and utilizing the potential energy stored in water. As shown in the Fig. 12.7, when the water stored behind a dam is released its potential/kinetic energy is transferred onto turbine blades and used to generate electricity. Though the initial cost of setting up of hydroelectric power system is high, it has relatively low maintenance costs and provides relatively inexpensive power.

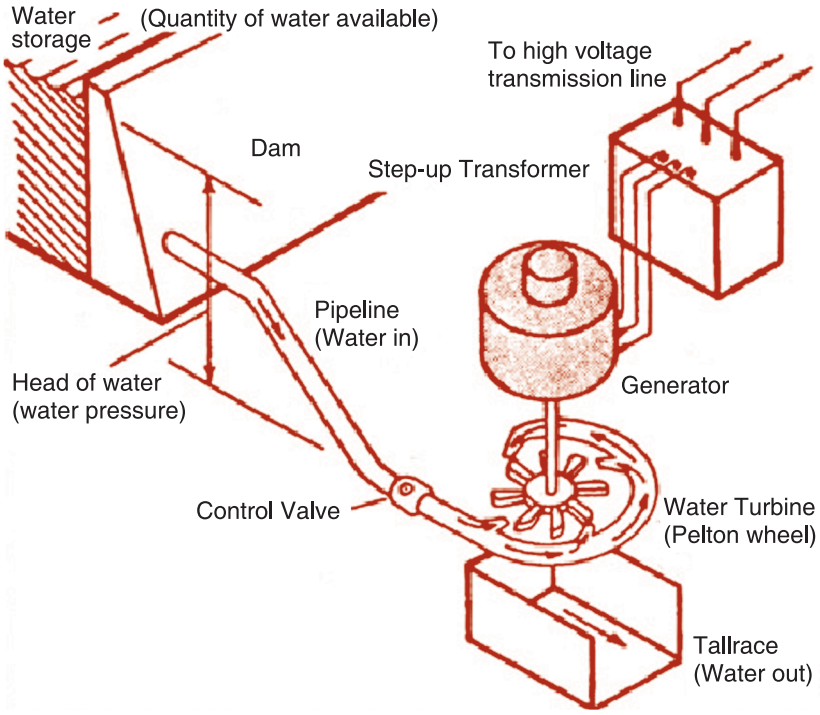


**Fig. 12.7** *Generation of Hydroelectricity*

The power output of the hydroelectric source is determined by the difference in height between the source and the outflow. This height difference is known as the head and the greater the head, the larger the output. For this purpose, very big dams are made on the rivers and other water flows.

### (b) Advantages of Hydroelectric Power

- It is a source of renewable energy in the form of hydroelectric power.
- It is cost effective and is competitively productive against non renewable sources.
- Electricity can be generated constantly, because there are no external factors, which affect the availability of water.
- Hydroelectric power produces no waste or pollution since no chemicals are involved.
- Water used for hydro power can be reused for other purposes/like irrigation etc.

### (c) Limitations in Using Hydroelectric Power

Though water is an excellent source of generating electricity, it also has certain limitations:

- The hydroelectric power plants cannot be sited at a place of our choice. There must be a strong current or considerable height to make the production worthwhile, as the capital cost of setting up production is relatively quite high.
- Dams can be very expensive to build.
- There needs to be a sufficient, and continuously strong water current, or water head, to produce energy.

## 12.3.4 Geothermal Energy

Geothermal energy is another alternative source of energy. Geothermal energy is obtained from the internal heat of the earth. In fact it is one of the oldest types of natural sources of heat. It dates back to Roman times, when the heat from the earth was used instead of fire, to heat rooms and/or warm water for baths. Presently it is being used as a source for producing electricity, mainly in regions of tectonic plate movement.

Now the basic question is how do we get geothermal energy? You must have heard about the volcanoes found around the world. These volcanic features are called geothermal hotspots. Basically a hotspot is an area of reduced thickness in the mantle which expects excess internal heat from the interior of the earth to the outer crust. These hotspots are well known for their unique effects seen on the earth's surface, such as the volcanic islands, the mineral deposits and geysers (or hot springs). The heat from these geothermal hotspots is altered in the form of steam which is used to run a steam turbine that can generate electricity.

### (a) Advantages of Geothermal Energy

Geothermal energy is used for heating homes and for generating electricity without producing any harmful emissions. Some of the advantages of using geothermal energy are:

- Unlike most power stations, a geothermal power plant does not create any pollution. Harnessed correctly, it leads to no harmful by-products.
- Geothermal Power plants have very low running costs. Because they require energy to run a water pump (which is provided by the power plant itself). Moreover, there are no costs for purchasing, transporting, or cleaning up of fuels.
- Geothermal power plants are an excellent source of clean, and inexpensive renewable energy.

- Geothermal energy can be used to produce electricity 24 hours a day.
- Geothermal power plants are generally small and have little effect on the natural landscape, or the near environment.

### (b) Limitations of Using Geothermal Energy

Though geothermal energy has several advantages, it also has limitations:

- If harnessed incorrectly, geothermal energy can produce pollutants.
- Improper drilling into the earth can release hazardous minerals and gases.
- Geothermal power plant sites are prone to running out of steam in the long run.

**Do you know**

The Earth can be divided into three large sections: the mantle, the inner core, and the outer core. The inner core is at the center of the earth. The pressure and temperature increase as one move closer to the center of the earth. As one moves outwards from the inner core, one encounters the outer core and then mantle followed by the crust. The mantle is a layer that is below the crust of the earth. This is said to go down 2,900 kms; its temperature is about 870 degrees Celsius. The outer core has a very high temperature which ranges from about 4,400 degrees Celsius to about 6,100 degrees Celsius. The outer core begins where the mantle ends and it extends further down to the center 2,250 kms. The inner core is about 6,400 km below the earth's surface. The temperature at the inner core of the earth is at the high of about 7,000 degrees Celsius. The high temperature of the earth's core is the basic reason behind geothermal energy.

## 12.3.5 Ocean – A Source of Energy

You may be surprised to know that the ocean is also a powerful source of renewable energy. The energy of the ocean can be harnessed in three basic ways: using wave power, using tidal power, and using ocean water temperature variations. Let us study each of these, one by one.

### (a) Using Ocean Wave Power to Generate Energy

You may know that different types of waves are continuously generated in the ocean. The back-and-forth or up-and-down movement of waves can be captured to harness the wave power by using it to force air in and out of a chamber to drive a piston or spin a turbine that can power a generator. In fact, kinetic energy exists in the moving waves of the ocean. That energy can be used to power a turbine as shown in Fig.12.8. In this figure you can see that when the wave rises into a chamber, it forces the air

out of the chamber. The moving air spins a turbine which can turn a generator. When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed.

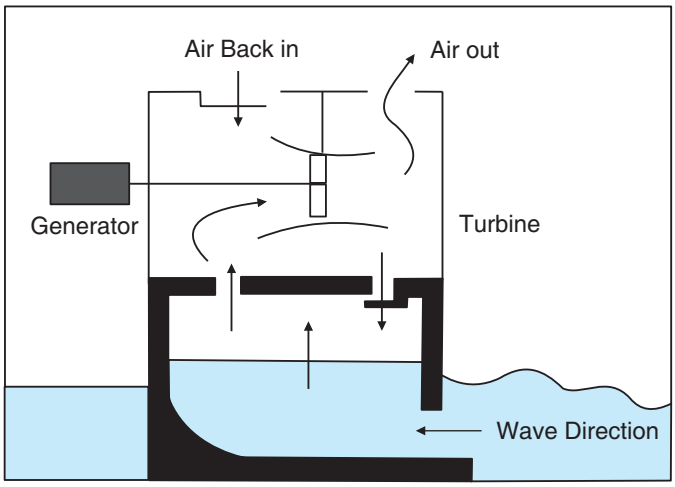


**Fig. 12.8** *Generation of Ocean Energy*

This is only one type of wave-energy system. Others actually use the up and down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator. Presently in some cases the wave power is being used in small lighthouses and warning buoys.

### (b) Using Tidal Power of Ocean to Generate Energy

The tidal energy of ocean can also be harnessed by trapping water at high tide and then capturing its energy as it rushes out and drops to low tide. When tides come into the shore, they can be trapped in reservoirs behind dams. And when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant. Presently, the power of the tides is being harnessed to produce electricity in Canada and France.

### (c) Using Ocean Water Temperature Variations to Generate Energy

If you go swimming in the ocean and dive deep below the surface, you will notice that the water gets colder the deeper you go. It is warmer on the surface because sunlight warms the water. But below the surface, the ocean gets very cold. That is why scuba divers wear wet suits when they dive down deep. Their wet suits trap their body heat to keep them warm.

This temperature difference between deep and surface waters in the ocean is also used to extract energy from the flow of heat between the two. The process is called "ocean thermal energy conversion" (OTEC). Power plants can be built that use this difference in temperature to generate energy. Presently, it is being used in Japan and in Hawaii in demonstration projects.

### (d) Advantages and Disadvantages of Using Ocean Energy

The energy potential of an ocean, particularly tidal basins, is large. The ocean energy is preferable to that of wind because tides are constant and predictable and that water's natural density requires fewer turbines than are needed to produce the same amount of wind power. However, tidal energy systems can have environmental impacts on tidal basins because of reduced tidal flow and silt build up.

## 12.3.6 Energy from Biomass

You may know that the biomass is organic material made from plants and animals. It includes garbage, industrial waste, crop residue, manure, wood, sewage and dead parts of living objects. Like all other sources of energy, it also contains stored energy from the sun. Therefore, biomass is also a very good source of energy.

Do you know how biomass contains sun's energy? You know that the plants absorb sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people who eat them. On burning the biomass, the chemical energy stored in it is converted into heat energy. The thermal energy released from biomass can be used to provide heat to industries and homes, and also to produce steam for generating electricity. But you have learnt by now that on burning any type of fuel, harmful emissions are released. So how biomass can be a good source of energy? Can we get energy from biomass without burning?

Yes. Burning biomass is not the only way to release its energy. Biomass can be converted to other useable forms of energy, such as biogas or methane, ethanol and biodiesel. You have learnt earlier that methane is the main ingredient of natural gas as well. The smelly stuff like rotting garbage, and agricultural and human wastes release methane gas - also called "landfill gas" or "biogas". Like liquid petroleum gas (LPG), the biogas is also used for cooking and lighting.

Biofuel including biogas and bio-diesel is another important fuel produced from left-over food products like vegetable oils and animal fats. Biofuel is made mainly in two ways. The first is when large amounts of crops high in sugar or starch content are grown, and then fermented with yeast to produce ethyl alcohol or ethanol. Plants like corn, soybeans, rapeseed, wheat, sugar cane and sugar beet are used to produce ethanol. Ethanol can be used as an alternative fuel in petrol engines, but it is very corrosive and so can be harmful to engine parts and components. The other option is that it can be mixed with petrol to produce a more bio-friendly fuel which can be used in engines. In the second method, plants high in vegetable oils are grown and then the vegetable oil is processed to produce bio-diesel.

Thus we can say that biomass can be used as a source of energy in the following three ways:

- by burning dry biomass directly to produce heat, or generate steam.
- by decomposition of biomass in the absence of oxygen to produce methane gas.
- by producing bio-diesel from the plants high in vegetable oils.

### (a) Advantages of Using Biomass as Source of Energy

Biomass is an inexhaustible energy source because we can always grow more trees and crops, and waste will always exist. Using biomass as a source of energy has following advantages:

- When direct combustion of biomass is not used to generate energy, there is hardly any environmental impact.
- Biodiesel and other fuels produced by biomass are viable and a clean source of energy.
- Biomass is easily available throughout the world.
- The residue from biomass plants can be used as manure.

### (b) Limitations of Using Biomass as Source of Energy

Though biomass is a clean and renewable source of energy, it has certain limitations. Some of them are:

- The bio-fuel or ethanol produced from biomass is not as energy efficient as petrol.
- If the biomass is directly burnt, it may contribute to global warming and increase emissions causing environmental pollution.
- The main ingredient of biofuel i.e. methane is harmful to the environment.
- Biomass is a relatively expensive source for generating energy, both in terms of producing the biomass and converting it to ethanol.

## 12.3.7 Hydrogen – A Future Source of Energy

Hydrogen could be a very environmentally friendly source of energy in the future. In the long-term, hydrogen is likely to reduce dependence on conventional sources of energy such as petrol, diesel and coal etc. In addition to it, the use of hydrogen as source of energy will help in reducing the emission of greenhouse gases and other pollutants.

When hydrogen is burned, the only emission it makes is water vapour, so a key advantage of hydrogen is that when burned, carbon dioxide ($CO_2$) is not produced. Thus, we can say that hydrogen does not pollute the air. Hydrogen has the potential to run a fuel-cell engine with greater efficiency over an internal combustion engine. The same amount of hydrogen will take a fuel-cell car at least twice as far as a car running on gasoline.



Though, the hydrogen fuel cell has proved to be a viable source of energy for vehicles, but there are serious questions on its production, storage and distribution. There are also questions on its efficiency, in so far as it takes more energy to manufacture it than what it produces. Besides, it costs a considerable amount of money to run a hydrogen vehicle because it takes a large amount of energy to liquefy the fuel.

**Do you know**

Hydrogen is one of the most abundant elements in the universe. It is the lightest element, and it is a gas at normal temperature and pressure. Hydrogen as a gas is not found naturally on Earth, because hydrogen gas is lighter than air and rises into the atmosphere. Natural hydrogen is always associated with other elements in compound form such as water, coal and petroleum.

## INTEXT QUESTIONS 12.3

1. Name any one alternative source of energy which you would like to use in your home. Justify your answer.
2. Biofuel is considered to be a good fuel. Why is it not being used on a mass scale to replace the fossil fuels in our country?
3. List any five traditional uses of solar energy.

## 12.4 TRANSFORMATION OF ENERGY

As you have learnt earlier, energy can exist in many different forms. It is also true that energy can be changed from one form to another. But it cannot be created or destroyed. Normally, we talk about 'using energy', but do you know, it never gets 'used up'. It just gets transformed into another form. Eventually, most of it ends up as heat, but it is so spread out that it cannot be detected or used.

Let us see how transformation of energy takes place in our day-to-day life. Some examples are:

- The food has chemical energy stored in it. When our body uses this stored energy to do some work, it gets converted in to kinetic energy. Similarly, when you kick a ball, your muscles change chemical energy from your food into kinetic energy. As the ball moves through the air and across the ground, friction slows it down and its kinetic energy is changed into thermal energy (heat).
- A car uses stored chemical energy in petrol or diesel to move. The engine changes the chemical energy into heat and kinetic energy to power the car. Things that are moving, such as vehicles, flowing water, and winds etc. have kinetic energy.

- In a thermal power station, the chemical energy of coal is transformed into heat energy of the hot steam, and then into mechanical energy of turbine. This mechanical energy is transformed by a generator into electrical energy, which passes through the power lines to various places – cities, towns, houses, factories etc., where it is transformed back to heat, light, sound or mechanical energy.
- Spring or other stretched or compressed materials have potential energy.
- The water stored in dams and reservoirs also has potential energy which gets converted in other forms of energy.
- When hot materials cool down, they give off heat, or thermal energy. The fuels and batteries have chemical energy stored in them. When they are used their energy is released by chemical reactions.
- When you talk on the phone, your voice i.e. sound energy is transformed into electrical energy, which is transmitted through wire or the air. The phone on the other end changes the electrical energy into sound energy through the speaker. Similarly, a television changes electrical energy into light and sound energy.

As per the "Law of Conservation of Energy", energy can neither be created nor destroyed, it can only be transformed from one form of energy into another. Details about the transformation of energy will be discussed in another lesson.

## 12.5 ENERGY CRISIS AND ITS MITIGATION

All activities, small or big, need one or another form of energy. We can say that the energy is the lifeline for our survival and development. Because of paucity of electrical energy, some Indian households, particularly in rural areas, go without electricity for days. Even in urban areas the situation is not very good. There are frequent electricity cuts for several hours during a day. This becomes a severe problem during the summer. Energy demand in the future will continue to increase as India's population and its needs continues to grow.

The situation in which a country suffers from frequent disruptions in energy supplies because of large and increasing gaps between availability and demand of electricity accompanied by rapidly increasing energy prices that threaten economic and social development of the nation may be termed as the **energy crisis.** Energy crisis is being faced by all developing nations including India. What are the reasons behind such as energy crisis?

### 12.5.1 Reasons behind Energy Crisis

It is a fact that presently around 85 percent of the world's energy supply is met from oil, coal and natural gas. Clearly, we live in the age of coal and oil, but the availability, of both of these resources of energy are very limited and will not last beyond a few decades. If we think about the Indian situation only, coal accounts for over 70%



of India's energy production. However, it is a limited resource and also creates environmental problems. Even if more coal is mined, the increasing gap between the demand and supply of energy in India can not be easily bridged. Indian villagers are forced to spend from two to six hours per day gathering fuel for their household cooking needs. Moreover, India's reliance on firewood has led to deforestation and pollution. Thus, the basic reasons behind over energy crisis seem to be the following:

- Our over-dependence on limited and exhaustible sources of energy such as our coal and oil deposits.
- Increasing gap in the demand and supply of the energy.
- Ever increasing prices of the energy and fuel from other countries.
- Reluctance in using alternative and renewable sources of energy, such as solar, wind, bio-energy, etc..
- Overuse and misuse of the available sources of energy.

### 12.5.2 Methods of Mitigating Energy Crisis

In order to mitigate the problem of energy crisis, the Government as well as the people of the country should take collective and serious steps.

(a) It is believed that one possible solution to India's energy problems is Nuclear Power. Accordingly, we signed a Nuclear Deal to import fuel and technology. The model of nuclear powered energy has been successful in countries like France where they meet more than 75% of their electricity requirements from nuclear energy.

(b) The use of renewable sources of energy like solar power, wind power, hydroelectric power, biogas and biofuel etc should be promoted. As automobiles are major consumers of petroleum fuels/oils, an effort should be made to increase the mileage standards of the automobiles. Even the generation of energy from renewable sources is not very simple and cost effective. Therefore, all of us should make a sincere effort to save and conserve the energy.

(c) Being an agricultural nation we could have come up with a more ingenious solution to produce ethanol and biofuel from sugarcane and vegetable oils.

In addition to the above initiatives to solve the problem of energy crisis, we should follow an 'energy conservation approach' in our daily life. Some useful tips, on how we can save energy in our daily life, are given in the following section.

### 12.5.3 Conservation of Energy

The key for resolving the country's energy crisis lies with us citizens. Among things we can do is the conservation of our non-renewable sources of energy. It is said

that energy saved is as good as energy generated. Therefore, we should not only judiciously use energy sources but save energy as much as we can. You can start conservation of energy in your home. Some of the important tips for saving energy are:

- Switch off lights, fans and other appliances when not in use. Water taps should not be left open.
- While cooking rice, dal etc. the vessel should remain covered and, for cooking, only the required quantity of water should be used. If you soak pulses in water for some time before cooking, it will save energy in cooking.
- Another way of saving energy is by use of more efficient appliances. For example, a LED or CF light is much more efficient that a tube light or bulb; and a tube-light gives much more light than a bulb of same power rating. In fact, bulbs are being totally phased out in some countries. Better stoves burn fuel efficiently and give more heat per unit of fuel burned. The fuel efficient vehicles should be used and their engines should be maintained properly. Similarly, more energy efficient electrical appliances having energy saving stars should be used,

These are only some of the habits which can save a lot of energy. We should find ways for not wasting energy where it can be saved. For example, if you are required to go to a nearby place you may walk or go by a bicycle and avoid the use of an automobile. You may use public transport in place of your own vehicle to save fuel. Share automobiles rides to office, instead of driving alone to office.

## INTEXT QUESTIONS 12.4

1. What are the steps that you can and should take for saving energy at home or in the office?
2. List at least three reasons behind the energy crisis in our country.
3. What do you mean by the statement that 'energy can neither be created nor destroyed?

## WHAT YOU HAVE LEARNT

- All processes taking place on the earth require energy. Energy is the ability to do work.
- The sun is considered to be ultimate source of energy for life on earth. We all directly or indirectly use sun's energy which is also called solar energy.
- Coal and petroleum are fossil fuels. Presently, they are the main source of energy in our country.

- Energy sources are either renewable or non-renewable. Non-renewable sources are getting depleted.
- We should try to utilize renewable sources of energy in order to conserve fossil fuels and also to protect our environment.
- Energy exists in various forms. Energy can be transformed from one form to another. Energy can neither be created nor destroyed. In any energy transformation, the sum total of energy remains contant.
- Fission is a process of splitting up of the nucleus of a heavy atom into fragments of roughly of equal masses. Huge amount of energy is released in the process of nuclear fission, where the missing mass gets converted into energy (vide $E = mc^2$).
- In order to conserve energy we should not only judiciously use energy sources, we should also save energy as much and as far as we can.

## TERMINAL EXERCISE

1. What are different forms of energy?
2. Distinguish between conventional and non-conventional sources of energy.
3. What are conventional sources of energy? Give two examples.
4. Why non-conventional sources of energy are preferred over the conventional sources?
5. "Sun is the ultimate source of energy". Justify this statement.
6. List some uses of nuclear energy.
7. What are the hazards of producing nuclear energy?
8. What do you mean by the energy crisis? List out the possible reasons.
9. What measures should be taken to mitigate the problem of energy crisis in our country?
10. Why should we save energy?

## ANSWERS TO INTEXT QUESTIONS

### 12.1

1. (i) Cooking of food – heat energy and chemical energy of fuel
   (ii) Lightning of bulbs – electrical energy and light energy
   (iii) Talking to each other – sound energy

(iv) Cycling – mechanical energy

(v) Torch – chemical energy of cells

2. (i) Heat, (ii) Light and (iii) Electricity

3. The energy sources that can be replenished in a short period of time are called renewable energy sources, whereas the energy sources that we are using up and cannot be generated in a short period of time are called non-renewable energy sources.

## 12.2

1. (i) Coal, Advantage: It is cheaper and easily accessible.

(ii) Oil, Advantage: It is excellent sources of energy for our transportation.

(iii) Natural Gas, Advantage: It is cleaner burning than gasoline, but does produce Carbon Dioxide, the main greenhouse gas and it has high calorific value.

(iv) Nuclear Fuel, Advantage: Nuclear fuel used in nuclear power stations does not burn and hence no waste gases are produced.

2. Because of the following reasons:

It is difficult to set up nuclear power plants and also a lot of money has to be spent on safety of the nuclear power plants. Moreover the nuclear waste produced from plants can be hazardous.

3. Limitations of using natural gas for meeting our energy requirements:

Stock of natural gas is limited and it cannot be replenished.

Use of natural gas can cause unpleasant smell in the area.

## 12.3

1. Solar energy. Because it is free and easily available in the area in which we live. It can be used for cooking, water heating and also for keeping our home warm in winter.

2. (i) The bio-fuel is not as energy efficient as petrol.

(ii) The main ingredient of bio-fuel i.e. methane is harmful to the environment.

(iii) Bio-fuel is a relatively expensive source for generating energy, both in terms of producing the biomass and converting it to ethanol.

3. Traditional uses of solar energy.

(i) drying of clothes (ii) heating of water (iii) drying crops,

(iv) breeding and raising chicks and (v) drying manure

Notes

## 12.4

1. Steps for saving energy
   - Switch off lights, fans and other appliances when not in use.
   - Water taps should not be left open.
   - While cooking vegetables the vessel should remain covered.
   - For cooking, only the required quantity of water should be used.
   - Soak pulses in water for some time before cooking,
   - use of more efficient appliances.
   - use public transport in place of your own vehicle to save fuel.
   - Share automobiles rides to office, instead of driving alone to office.
2. Reasons behind the energy crisis in our country.
   - Our over-dependence on limited and exhaustible sources of energy such as our coal and oil deposits.
   - Increasing gap in the demand and supply of the energy.
   - Ever increasing prices of the energy and fuel from other countries.
   - Reluctance in using alternative and renewable sources of energy, such as solar, wind, bio-energy, etc..
   - Overuse and misuse of the available sources of energy.
3. The statement 'energy can neither be created nor be destroyed' means that energy the total energy remains constant. It can only be transformed from one form of energy into another.