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## SOURCES OF ENERGY

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### GOOD SOURCES OF ENERGY

**A good source of energy would be one:**

1. Which would do a large amount of work per unit volume or mass?
2. Be easily accessible
3. Be easy to store and transport.
4. The source of energy has to be economical.

### CLASSIFICATION OF SOURCES OR ENERGY

We can classify energy sources in different ways. One classification is based on the reserves (supply) of an energy source. Another is based on how long we have been using it.

Renewable and nonrenewable sources of energy

**Renewable sources of energy are those which can be generated by us or which are constantly being generated by natural processes or whose supply is unlimited.**

**Nonrenewable sources of energy are those which were produced in the past by natural processes, whose supply is limited and which we cannot generate ourselves.**

Coal, natural gas and petroleum are nonrenewable sources of energy. Wood is a renewable source of energy although its supply is limited. But if we replant and use trees in a planned manner, we can be assured of a continuous supply of firewood. The sun, wind and flowing water are also renewable source because of their unlimited availability. Unlike fuels like coal, nuclear such as uranium are required in very small quantities to generate electricity. So, their reserves will last for a long, long time. They are therefore classified as renewable sources of energy.

#### Conventional and non-conventional sources of energy

Sources of energy that have been in use for centuries are called conventional sources of energy. Conventional sources include wood, coal, petroleum and flowing water. Conventional sources like coal and petroleum are nonrenewable, while sources like flowing water are renewable.

Sources of energy that we have started using in new ways or only in recent times are called nonconventional or alternate sources of energy. These include energy from the sun, the heat inside the earth (geothermal energy), tides, ocean waves, etc. Nuclear energy is also a nonconventional source. Note that non-conventional energy sources are renewable.

We have been using wind and biomass (like cow dung) for energy for ages. In that sense they are conventional sources. However, they were not used conventionally to do tasks like electricity generation, which has now been made possible with improvement in technology. In that they can also be called nonconventional sources of energy.

### FOSSIL FUELS

Fuels that were formed from the remains of dead plants and animals are called fossil fuels. These were produced by complex processes with the help of a series of natural events over millions of years. The most widely used fossil fuels are coal, petroleum and natural gas. Plants trap solar energy in the form of food, and animals get it from the sun.

We get a number of different fuels from coal and petroleum. For example, we get petrol, diesel, kerosene and LPG from petroleum, and coke and natural gas from coal. When burnt in air, fossil fuels give off heat, which is used for various purposes—from cooking to generating electricity. However, these fuels are nonrenewable, and their reserves are running out. Unfortunately, we cannot repeat the events that led to their formation.

Fossil fuels have played an important role in the technological advances made in the last three hundred years or so. Even today, most of the energy requirements of homes, industries and transport are met by fossil fuels.

It is estimated that about 25% of our total energy consumption comes from coal. More than 90% of this coal is used for electricity generation in thermal power plants.

In most thermal power plants, coal is burnt to heat water for producing steam. The steam falls on the blades of a special kind of wheel called a turbine. A turbine is a device that rotates when steam, water or wind falls on its blades. The turbine turns the shaft of an electric generator to which it is connected. In this way electricity is produced.

Thermal power plants generated 65.6% of the total electricity produced in India in 2006. the rest was generated by hydroelectric (26.6%), nuclear (3%) and renewable-energy (4.8%) power plants.

In some thermal power plants, natural gas or oil is used as fuel. Natural gas is mainly methane ( $\text{CH}_4$ ). It is the cleanest fossil fuel, producing lesser pollutants than other fossil fuels. That is why vehicles using compressed natural gas (CNG) cause less pollution.

### **POLLUTION CAUSED BY BURNING FOSSIL FUELS**

The burning of most fossil fuels causes air pollution. The pollutants produced include carbon dioxide, carbon monoxide, oxides of nitrogen, sulphur dioxide and unburnt particles.

- (a) Burning of fossil fuels like coal and petrol produces carbon dioxide. Excess carbon dioxide in the atmosphere is increasing the greenhouse effect, leading to unnatural global warming.
- (b) When coal and petrol do not burn completely, carbon monoxide is produced. Excessive inhalation of this poisonous gas can cause death.
- (c) During the combustion of coal, sulphur present in it forms sulphur dioxide. Oxides of nitrogen are formed when atmospheric nitrogen and oxygen combine at the high temperatures inside a running automobile engine. In the air, sulphur dioxide combine with oxygen and water to form sulphuric acid. Oxides of nitrogen form nitric acid. These fall on the earth with rain, which we call acid rain. Acid rain damages soil, water bodies, crops, living tissues and structures like the Taj Mahal.
- (d) The unburnt particles produced during the combustion of fossil fuels are carried by smoke.

They affect our lungs, and blacken clothes and buildings. The pollution caused by burning coal can be greatly reduced by installing a tall chimney or by installing a precipitator, which is a device that reduces the amount of suspended matter in the smoke.



## ENERGY FROM FLOWING WATER: HYDRO ENERGY

When we talk on flowing water, we think of water flowing in rivers, streams, waterfalls, and so on. The flowing water has kinetic energy the ultimate source of this energy is the sun. This is because the energy of the sun evaporates water, which forms clouds that cause rainfall or snowfall. The rain and melting snow feed rivers, etc., whose flow we use.

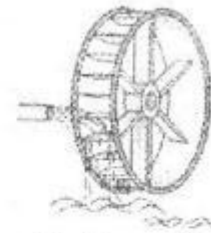


Fig. Water Wheel

The energy of flowing water has used for centuries to carry logs down rivers, to turn waterwheels to grind grain, run mills, and so on. Water striking the blades of the waterwheel makes it rotate. This design was modified to make water turbines, which are used to generate electricity from flowing water.

## HYDROELECTRICITY

**Electricity generated by using the kinetic energy of flowing water is called hydroelectricity. The electric power thus generated is called hydroelectric power.**

Electricity is generated from flowing water at a hydroelectric power plant. For large hydroelectric plants, water from a river is diverted to a large reservoir, which is an artificial lake to store water. A high dam is constructed on one side of the reservoir to hold back the water. The building housing the generator is at the base of the dam, on its other side. Water flows down through pipes from near the top of the dam to the generator house below. It strikes the blades of water turbine with tremendous speed, making it rotate. The turbine rotates the shaft of a generator to which it is connected. This makes the generator produce electricity. In this way, the kinetic energy of flowing water is used to rotate the turbine, and the rotational kinetic energy is converted into electrical energy.

It is not necessary to set up large dams for hydroelectric plants. Small hydroelectric plants can be set up to generate electricity from a few hundred kilowatts to tens of megawatts. Such plants can use water diverted from a waterfall or dam built for irrigation.

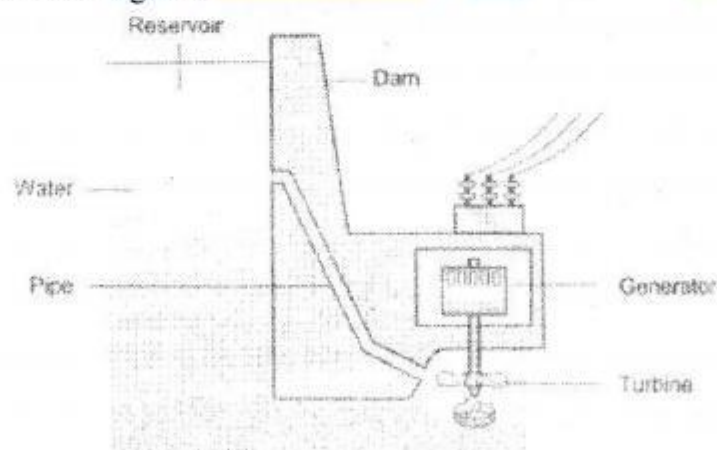


Fig. Diagram of a hydroelectric power plant

### **Advantages of hydroelectricity**

- (a) The source of energy (water) is free and renewable.
- (b) Harnessing the energy of flowing water is a pollution-free process, with no smoke, chemicals, etc., being produced.
- (c) The cost of electricity generation is low as compared to electricity generated other types of power plants.
- (d) Flowing water is a more reliable source of energy than wind.
- (e) Hydroelectricity can be generated on a large scale from a single plant.
- (f) Dams built for hydroelectric plants also help in flood control and irrigation.
- (g) Small hydroelectric stations are one of the best options for generating electricity from renewable sources, as they do not affect the environment much.

### **Disadvantages of hydroelectricity**

- (a) Dams built for large hydroelectric plants submerge a large area of land under water. This affects the plants and animals of the region. People of the area lose their lands. Apart from this, blocking or the course of a river affects fish and other organisms of the river.
- (b) Large hydroelectric power plants are expensive to build.
- (c) Not all rivers and not all areas are suitable for hydroelectric power generation.

### **Scope of hydroelectricity**

Hydroelectricity has huge potential worldwide. In India, it is estimated that 145,000 MW of hydroelectricity can be generated. Out of this, by 2006, India had an installed capacity of about 34,000 MW.

## **WIND ENERGY**

A moving mass of air is called wind. Let us see, with the help of an example, what causes wind. During the day, the land heats the sea faster than the water of the sea. Therefore, the air over the land heats up faster than that over the sea. The warm air over the land rises, and to take its place the colder air from the sea moves towards the land. This moving air is called wind. Similarly, winds arise whenever two adjoining areas on the surface of the earth are unequally heated by the sun. Like any moving object, wind has kinetic energy. Clearly, the ultimate source of this energy is the sun.

The invention of the windmill made it possible to do things like grind grain at mills and lift water with the help of wind energy. **A windmill is a device in which the energy of the wind is used to rotate a set of blades, and the rotational energy of the blades is used to do some work.** The blades of modern windmill make it look like a fan mounted on and a tall column. The blades are kept high above the ground to catch the wind.

### **GENERATING ELECTRICITY FROM WIND**

A windmill can be designed to rotate the shaft of a generator. Such a windmill is usually called a wind turbine. A specially designed wind turbine is connected to the shaft of small generator. The electricity produced by such an arrangement is not sufficient even for a small town. To be commercially useful, a number of wind-electric generators are set up in a large area, called a wind farm. The combined electrical outputs of all the generators are then used to supply power.



### Advantages of wind energy

- (a) The source of energy (wind) is free.
- (b) Harnessing wind energy is pollution-free process, with no smoke, chemicals, etc., being produced.
- (c) A small wind-electric plant can be set up near a factory to provide pollution-free power for its use.

### Limitations of wind energy

- (a) Wind energy cannot be harnessed at places where wind does not blow regularly. A wind-electric generator works only on winds of at least 15 km/h.
- (b) Wind is not a dependable source of energy because sometimes the air is absolutely still and at other times there are storms.
- (c) It is expensive to set up a wind farm for generation of electricity because wind farms need a large area.

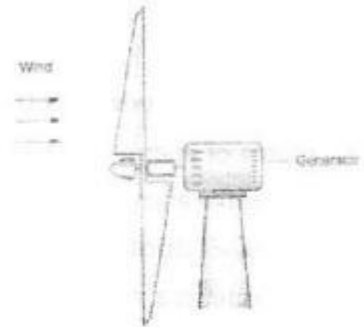


Fig. Wind turbine

### Scope of wind energy

It is estimated that India can produce more than 45,000 MW of electricity from wind energy. But in 2005, India had an installed wind-electric capacity of about 2500 MW. This made India among the top five producers of electricity from wind along with Germany, USA, Denmark and Spain. The state leading in wind-electric generation was Tamil Nadu.

## ENERGY FROM BIOMASS

What is biomass? Biomass is any organic matter from which we can get energy on a renewable basis. It includes agricultural residues, wood, animal excreta, wastes from food processing and municipal wastes. Agricultural residues include straw, hay and husk. Waste from food processing includes bagasse, which is the residue left after extracting the juice from sugar cane. Cow dung (gobar) has been a traditional biomass fuel in our country. Since plants trap solar energy in the form of food, and animals eat plants, the ultimate source of biomass energy is the sun.

### WOOD

Wood has been a major source of energy since man discovered fire. It is still used widely as a fuel for cooking and heating. In many Indian homes, food is cooked on stoves that use biomass fuels such as wood. Such a stove is called a chulha.

A traditional chulha operates at a very low efficiency. Hardly 10% of the energy contained in the wood is utilized. Also, it does not burn the wood completely, which causes a lot of smoke. Indian scientists have designed several 'smokeless' chulhas. These produce much less smoke, and the fuel is more efficiently utilized.

Wood can be more efficiently utilized by converting it into charcoal. Charcoal is produced by burning wood in an insufficient supply of oxygen. The process of burning wood in an insufficient supply of oxygen is called destructive distillation of wood. Wood is a mixture of carbon compounds like cellulose (a carbohydrate), which decompose on heating. Most of the products formed escape, and what is left behind is mainly carbon, which is a better fuel than wood. We can prepare charcoal by heating wood shavings in a closed container that has a hole for gases to escape.

### **CHARCOAL IS A BETTER FUEL THAN WOOD**

- (a) When the same mass of charcoal and wood are burnt, charcoal produces almost twice the heat produced by wood. So its energy-conversion efficiency is better than that of wood.
- (b) Charcoal produces much less smoke than wood.
- (c) Charcoal is compact fuel that is more convenient to handle than wood.

### **CATTLE DUNG**

Cattle dung has been traditionally used as a fuel in India. The dung is shaped into flat cakes, dried and used as fuel for cooking. Burning cattle-dung cake produces some heat and a lot of smoke. Scientists have now found a better way of using cattle dung-to produce biogas, which is an excellent fuel. This gas is popularly called gobar gas.

### **BIOGAS**

Certain types of bacteria decompose wet biomass in an oxygen-free (anaerobic) environment to produce a combustible mixture of gases, called biogas. The process is called anaerobic digestion. Biogas can contain up to 75% methane, 23% carbon dioxide and 2% other gases, including hydrogen and hydrogen sulphide. Methane is an excellent fuel.

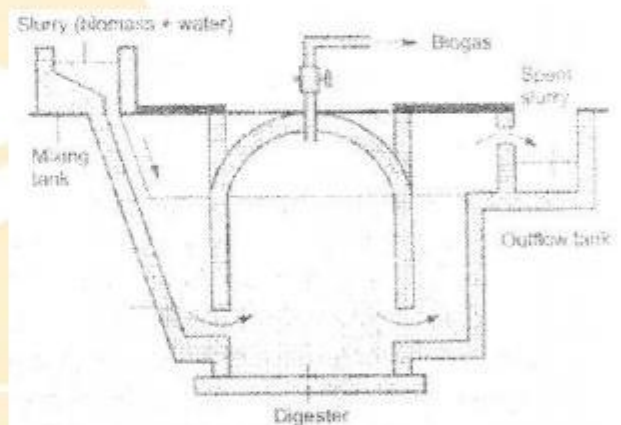
Biogas can be produced in a biogas plant by using cattle dung, sewage, agricultural residues, and so on. It can be used for electricity generation and for cooking. A few lakh biogas plants have been built in our country.

### **BIOGAS PLANT**

A biogas plant has a digester in which the biomass is decomposed, a mixing tank for mixing the biomass with water, an outflow tank and a means of collecting gas. The biomass, e.g., cattle dung, is mixed with water in the mixing tank to form slurry. The slurry from this tank flows into the digester, which is a sealed chamber. The biomass decomposes here and expands, and the gas produced presses down the slurry. This causes the spent slurry to overflow into the outflow tank. The spent slurry is used as manure. The upper part of the digester has an outlet for gas. To prevent excessive pressure build up, the gas is removed from time to time.

### **ADVANTAGES OF BIOGAS**

- (a) A biogas plant is quite simple and can be easily built in rural areas.
- (b) Biogas is an excellent, clean fuel that burns without producing ash and smoke.
- (c) The spent slurry is good manure.
- (d) Biogas plants are a safe and useful way of waste disposal.
- (e) Use of biogas in rural areas leads to saving of firewood, and reduces deforestation.



**Fig. Wind turbine**



## SOLAR ENERGY

The earth receives a huge amount of energy from the sun. Each square metre of the earth's upper atmosphere receives about 1.36 kilojoules (kJ) of solar energy per second. In other words, solar energy is incident at the rate of  $1.36 \text{ Kw/m}^2$ .

The entire energy incident on the upper atmosphere of the earth does not reach its surface. About 40% of this energy is reflected by the atmosphere into space. Then some of it is absorbed by the gases and particles present in the atmosphere. Finally, only about 47% of the incident energy reaches the earth's surface. Solar energy sustains life processes on the earth. Plants use it to make food. Traditionally we have been using solar energy for drying clothes and grains, making salt from sea water, etc. Newer uses include solar heating devices and solar cells. Solar heating devices such as solar cookers and solar water heaters use the heat energy that comes with sunlight. Solar cells convert solar energy into electricity.

### Advantages of solar energy

- (a) It is available everywhere.
- (b) It is available in plenty (renewable), and it is free.
- (c) It does not cause pollution.

### Limitations of solar energy

- (a) It cannot be used at night.
- (b) Devices based on solar energy do not work well on cloudy days.

## SOLAR HEATING DEVICES

A solar heating device uses solar energy to heat things like water and food. To make a solar heating device effective, we have to ensure that device absorbs a lot of heat from sunlight and does not lose too much of the collected heat. To achieve these, the following measures are taken.

**Increasing the absorption of heat** Everything on which sunlight falls absorbs heat from it. However, black and dark-coloured surfaces absorb heat better than do light-coloured and white surfaces. That is why we feel hotter than usual when we wear dark clothes in summer.

In certain types of solar heating devices, the surfaces meant for collecting sunlight are painted black to increase the absorption of heat.

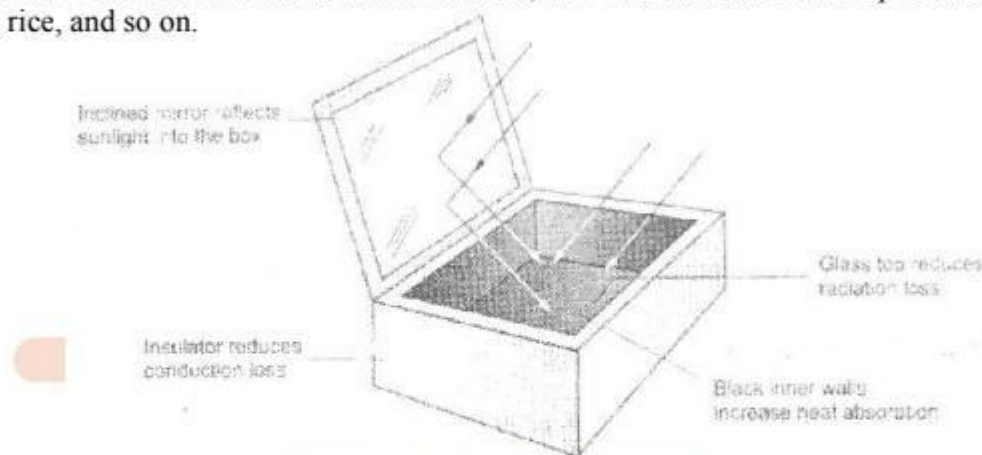
**Reducing the loss of heat** A hot object loses heat to its surroundings by conduction, convection and radiation. Different methods are used to reduce the loss of heat in heating devices. In a box-type device, to reduce heat loss by conduction, the walls are made of an insulator, i.e., a material that is a poor conductor of heat. The box is made airtight so that the air inside cannot take the heat out of the box. Thus, convection loss is also reduced. Radiation loss is reduced by covering the top of the box with glass. Sunlight passes through the glass and heats the materials inside the box. The heated materials radiate heat, but these get reflected back into the box by the glass. This traps the heat (in the same way it is trapped in a greenhouse).

**Increasing the amount of sunlight collected** A reflector such as a plane mirror is used to reflect sunlight into the heating device so that more sunlight centers it.

## BOX-TYPE SOLAR COOKER

A solar cooker is a device that uses solar energy for cooking. In its simplest form it consists of a special box in which the food to be cooked is placed. The box is made of an insulating material such as plastic or wood. The box may be double-walled, with an insulating material (even air) between the outer and inner walls. This reduces heat loss due to conduction more effectively. The inner walls are painted black to increase heat absorption. The box is covered with a glass sheet. This reduces heat loss by radiation and traps heat, which increases the temperature inside the box. The covered box is made airtight to reduce heat loss by convection. To increase the amount of sunlight going into the box, a plane mirror is hinged at an angle at the top of the box.

The food to be cooked is taken in a vessel and placed inside the cooker. The temperature inside the cooker reaches  $100-140^{\circ}\text{C}$  in about 2-3 hours in summer. So, we can cook food that requires slow heating like dal, vegetables, rice, and so on.



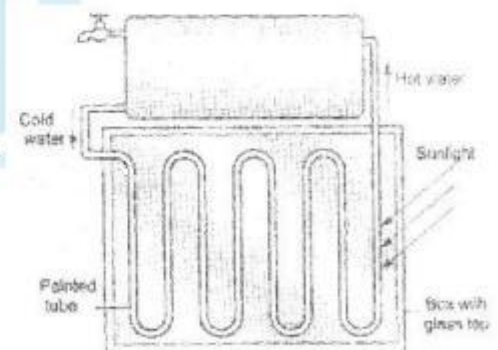
**Fig. Box-type solar cooker**

**Advantages** Solar cookers are inexpensive to own and operate. We can put food in several vessels inside the cooker so that they get cooked simultaneously. These cookers reduce firewood and LPG consumption. And they do not produce any smoke.

**Disadvantages** A solar cooker can be used only during daytime. They can be used effectively only in regions with warm climate. They take a long time to cook food in winters and on cloudy days. We cannot use box-type cookers to fry food or make roti.

## SOLAR WATER HEATER

Solar energy can be used to heat water. In a solar water heater, sunlight is allowed to fall on a box made of a poor conductor of heat. The glass top of the box lets in sunlight and traps heat. Water enters a tube that is painted black to increase the absorption of heat. It is bent several times to increase its length inside the box. This allows the water flowing through it sufficient time to absorb heat. Hot water collects in the tank of the heater for use.



**Fig. Solar water heater**



## **SOLAR CELLS**

A device which converts solar energy directly into electricity is called a solar cell or a photovoltaic (PV) cell. Some substances like silicon are semiconductors. Their ability to conduct electricity is much less than of conductors. However, when certain substances are added to semiconductors, they are able to conduct electricity much better. Solar cells are made from such altered semiconductors.

When sunlight falls on a solar cell, a potential difference of about 0.5-1 V develops across it. The power of a solar cell depends on its surface area. The greater the surface area of the solar cell, the greater is the solar energy collected by it, and hence, the greater is the power generated. Small solar cells are, therefore suitable for use in only those electronic devices that require very little power. Such devices include calculators and watches. A typical solar cell delivers much less power than a common dry cell.

## **SOLAR PANEL**

Although a solar cell provides very power, a large number of connected solar cells, spread over a large area, can provide sufficient power for many applications. Such an arrangement of solar cells is called a solar panel. The solar cells in a solar panel are connected in such a way that the total potential difference and the total capacity to provide electric current become large.

Uses of solar panels the advantage of solar panels is more in areas where the usual energy sources are not available. That is why they are used as the source of electric power in satellites. Solar panels have also been used in unmanned aircraft that fly at high altitudes for long periods, conduction scientific experiments. Experimental solar-powered cars have also been made. In many parts of India, solar panels are being used to charge rechargeable batteries during the day. At night, these batteries provide electric power for lighting, etc. They are also being used for operating traffic lights, water pumps, telephones, TV sets and radio receivers.

## **ADVANTAGES OF SOLAR CELLS**

- (a) Solar cells are suitable for use in remote areas where electrical power lines have not reached.
- (b) Solar cells require little maintenance and last for a long time.
- (c) After installation, n further cost is involved in generating electricity directly from solar cells.
- (d) Solar cells are environment friendly, as they do not cause any pollution.

## **LIMITATIONS OF GENERATING ELECTRICITY FROM SOLAR CELLS**

- (a) Solar panels are expensive. Although silicon is the second-most abundant element on earth, the cost of purifying silicon for making semiconductors used in solar cells is very high. This increases the cost of solar cells.
- (b) The solar cells in a solar panel are connected using silver, to keep the resistance as low as possible. This also increases the cost.
- (c) Solar cells provide direct current (D.C.), while most household appliances work on A.C. Special devices (inverters) are needed to convert the D.C. to A.C.
- (d) Since the power output of solar cells is low, a large number of solar panels, spread over a larger area, are required, even to meet the normal electrical power requirement of a household.
- (e) Like all solar devices, solar cells work only during the day, and their effectiveness is reduced in winters and on cloudy days. For the power requirement at night, storage batteries are charged by solar cells during the day. The batteries further add to the cost.

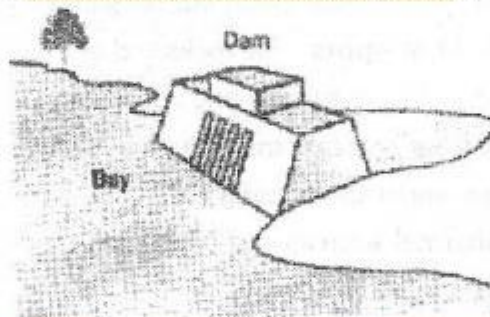
## ELECTRICITY FROM THE OCEAN

- Electricity can be generated from the ocean by utilizing the following facts.
- Tides cause the level of sea water to rise and fall periodically. This is mainly due to the gravitational pull exerted by the moon, and to some extent by the sun. The water level is maximum at high tide and minimum at low tide. The difference in water levels can be utilized to generate electricity.
- Waves in the ocean involve a lot of kinetic energy, which can be converted to electricity.
- The water at the surface of the ocean is warmer than the water deep below. Their temperature difference can be utilized to generate electricity.

### GENERATING ELECTRICITY FROM TIDES

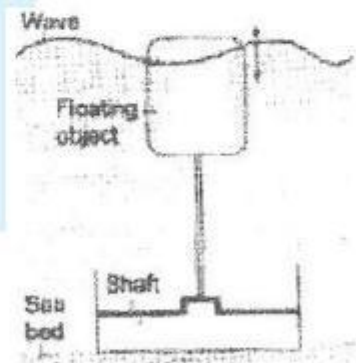
A tidal power plant can be located at the mouth of a narrow bay, where tides cause regular and appreciable rise in the level of water. A dam with gates is constructed at the mouth of the bay. At high tide, the level of the water in the bay rises, and it is allowed to flow in and collect behind the dam. When the tide ebbs, the water level in the sea starts falling. The dam gates are then closed. As a result, the level of water behind the dam remains higher than that in the bay. When the difference in the levels is sufficient, the gates of the dam are opened, and water is allowed to fall into the bay. This falling water is used to drive turbines connected to electric generators. (In some power plants, the water flowing in at high tide is also used to generate a part of the power.)

For a tidal power plant, the difference between the water levels at high tide and low tide should be about 5 meters. Not many places have this. For this reason, tidal energy cannot be a major source of electrical power.



### GENERATING ELECTRICITY FROM OCEAN WAVES

We can convert the energy of ocean waves into electricity at places where there are strong waves. Figure shows schematically one setup for generating electricity from waves. A large air-filled object, called a **surface follower**, floats in the sea and moves up and down with the waves. It is linked to a shaft at the bottom of the sea in such a way that its up-down motion is converted into the rotational motion of the shaft. The rotation of the shaft is used to turn the shaft of an electric generator.

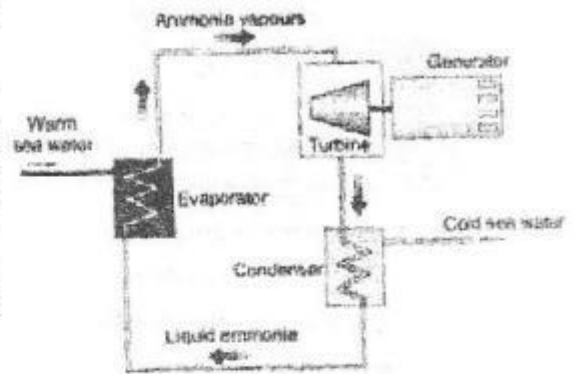


Ocean waves are caused by winds. Since winds arise due to the heating of the earth's surface by the sun, the ultimate source of energy of ocean waves is the sun.



## OCEAN THERMAL ENERGY CONVERSION (OTEC)

Solar energy falling on the surface of the ocean warms it. The water at the surface of the ocean is warmer than the water deep below. Generally, the difference in temperature is about  $20^{\circ}\text{C}$  between the surface water and the water at a depth of 2 km. This temperature difference can be used to operate an ocean thermal energy conversion (OTEC) plant. Clearly, the ultimate source of stored thermal energy of the ocean is the sun.

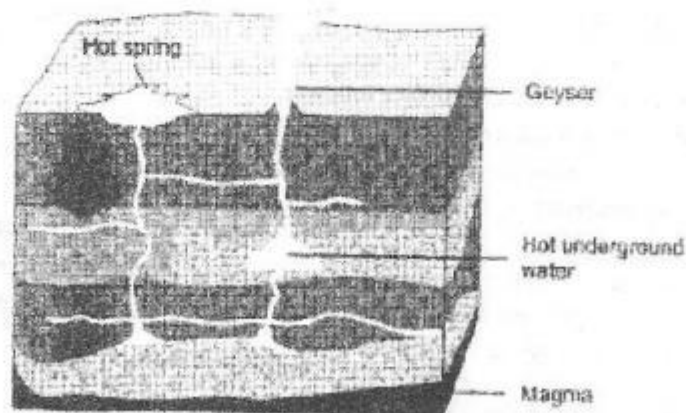


In one system for OTEC, a fluid with low boiling point such as ammonia or chlorofluorocarbon (CFC) is used as the 'working fluid'. Warm sea water is used to vaporize liquid ammonia in an evaporator. The expanding vapors of ammonia turn a turbine connected to a generator. Then the vapors go to a condenser. There, cold sea water, pumped up from the deep, is used to liquefy the ammonia. This ammonia is reused, and the cycle goes on.

## GEO THERMAL ENERGY

Geothermal energy means energy stored as heat in the earth. You know that below the earth's crust lies a layer called the mantle. The temperature near the upper part of the mantle is around  $1500^{\circ}\text{C}$ . The material here is in a partially molten state and is called magma.

In some areas, hot magma swells up into the crust, but remains trapped below the surface of the earth. Such areas in the earth's crust are called **hot spots**. The rocks and groundwater above these hot spots get heated. At some places, the hot water comes to the surface and collects in pools called hot springs. In some cases, the water gets converted to steam. Steam or steam mixed with hot water pushes out of the surface of the earth with great force. The fountain of steam and water coming out from the surface of the earth is called a **geyser**. Steam as well as hot water from geothermal sources can be utilized by us. Some common uses include heating of buildings and generation of electricity.



## GENERATING ELECTRICITY FROM GEOTHERMAL ENERGY

At places where dry steam comes out of the surface of the earth, it can be used directly to turn turbines connected to generators. The world's largest geothermal electric power plant, at Geysers Steam Field, California, uses this method to generate electricity. At places where steam does not come out on its own, arrangements are made to convert the hot underground water into steam. The steam is then used to turn turbines.

### Advantages of geothermal energy

- (a) Geothermal plants can operate round the clock, unlike those based on solar and tidal energy.
- (b) Geothermal energy is almost pollution free.
- (c) It is cheaper to run a geothermal plant than a coal-based plant.
- (d) The source of energy is free and renewable.

## NUCLEAR ENERGY

### NUCLEAR FISSION

The word 'fission' means to split or break up into parts. Nuclear fission is a reaction in which a heavy nucleus splits into two middleweight nuclei, releasing a lot of energy.

**The process of a heavy nucleus splitting into two middleweight nuclei is called nuclear fission.**

One of the isotopes of uranium is U-235 (235 is its mass number, i.e., the sum of the number of neutrons and protons). The nucleus of U-235 can be used to start a nuclear fission reaction by bombarding it with slow-moving neutrons. In this process, U-235 itself does not undergo fission. It converts to U-236, which is highly unstable. As soon as it forms, U-236 splits in two parts, i.e., fissions. Some neutrons, generally 2 or 3, are emitted in this process.

The nuclei of the elements formed by fission are unstable. They disintegrate further to form stable nuclei. Gamma ray (electromagnetic radiation) and particles such as neutrons and electrons are emitted by the nuclei at different stages between the fission and the creation of stable nuclei.

In the fission of uranium, the combined mass of the fission products is less than the combined mass of the neutron and the U-235 nucleus, with which the reaction started. This loss in mass gets converted into energy. Energy released in fission reactions Einstein's famous equation,  $E = mc^2$ . In this equation, E, m and c stand for energy, mass and the speed of light in vacuum respectively. From this equation we can get the amount of energy released when matter of a certain mass is destroyed taking  $c = 3 \times 10^8$  m / s in vacuum, 1 kg of disappearing mass will give rise to  $9 \times 10^{16}$  J of energy.

When dealing with atoms and nuclei, scientists prefer to measure mass in a unit called atomic mass unit (u), which is defined as 1/12 of the mass of one atom of carbon-12. And they often use the unit electron volt (eV) to measure energy.

$$1u \approx 1.67 \times 10^{-27} \text{ kg}$$

$$1\text{eV} \approx 1.6 \times 10^{-19} \text{ J}$$

It turns out that 1 u of mass, when converted into energy, releases about 931 MeV of energy.

How much energy do we get from fission of one uranium nucleus? From the fission of one U-236 nucleus, we get about  $200 \times 10^6$  eV (200 MeV) of energy. To get an idea of the amount of energy liberated by fission, let us do a comparison with energy released by burning coal. When 1 g of coal burnt completely, 30 kJ of energy is produced. A fission reaction that consumes 1 g of U-235 produces  $8.3 \times 10^7$  kJ of energy !

The energy released in nuclear fission can be used to generate electricity as well as to make atom bombs.



## **CHAIN REACTIONS**

Suppose a slow neutron is absorbed by a nucleus of U-235 in a block of uranium. The resulting U-236 nucleus fissions, and in the process 2 or 3 neutrons are emitted. These neutrons can be absorbed by other U-235 nuclei, starting other fission reactions, from which neutrons are emitted. In this way, the fission reaction continues by itself, without requiring any further external neutrons. One fission triggers another fission, in a self-sustaining sequence of fission reactions.

A reaction that continues on its own as one occurrence of the reaction triggers the next occurrence is called a chain reaction.

A chain reaction in 1 kg of U-235 will cause the fission of all its nuclei in less than one minute.

This will release a tremendous amount of energy in a very short time, leading to an explosion. Fortunately, the rate of a chain reaction can be controlled with materials that absorb neutrons. This is done when fission is used in nuclear power plants.

## **GENERATING ELECTRICITY AT NUCLEAR POWER PLANTS**

To generate electricity, nuclear fission is carried out in a setup called a nuclear reactor. The energy released is used to generate steam, which drives turbines connected to generators. The whole system, including the nuclear reactor, the turbine, etc., is called a nuclear power plant.

## **ADVANTAGES AND DISADVANTAGES OF NUCLEAR POWER ADVANTAGES**

### **ADVANTAGES**

- (a) Nuclear power plants consume very little fuel.
- (b) If operated properly, nuclear power plants produce less atmospheric pollution than thermal power plants.
- (c) A sizeable amount of fuel can be reclaimed by processing the spent fuel material. In contrast, fuels like coal cannot be reclaimed once they have been used.
- (d) Some radioactive isotopes are produced as by-products in the process, and these are used in medicine and industry.
- (e) Nuclear power is a viable option where fossil fuels like coal are not available, or where it is not possible to generate electricity from wind, water, etc,

### **DISADVANTAGES**

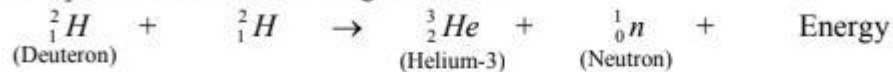
- (a) A lot of radioactive and toxic waste are produced in the different stages of energy production from nuclear fission. They cannot be simply thrown away. So they are stored in long-term underground storage facilities, which are expensive to build.
- (b) In case of accidental leakage of nuclear radiation. Nuclear radiation may affect those near the site. Radioactive materials that may leak out can contaminate vast areas of land, crops, water bodies, etc.
- (c) Nuclear power plants cannot be located near populated areas.
- (d) Nuclear power plants are expensive to build.
- (e) Nuclear power plants also pose security problems, as the fuel and by-products can be used to build nuclear weapons.

## NUCLEAR FUSION

You have seen that when a heavy nucleus breaks into two middleweight nuclei, a lot of energy is liberated. Energy is also liberated when two light nuclei combine to form a single nucleus. This process is called nuclear fusion.

**The process of two or more light nuclei combining to form a heavier nucleus is called nuclear fusion.**

An example of nuclear fusion is given below.

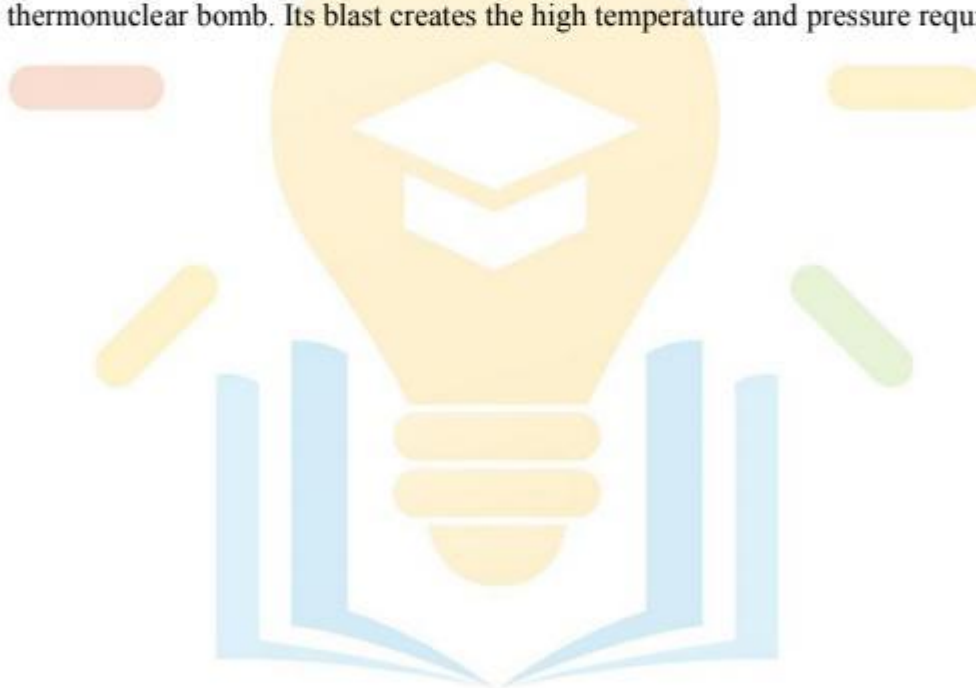


Deuteron is the nucleus of deuterium, an isotope of hydrogen. Two deuterons combine to form the nucleus of helium-3, an isotope of helium. In this reaction, the mass of the product nucleus is less than the combined mass of the starting nuclei. The difference of mass is converted to energy, given by  $E = mc^2$ . (Einstein equation) The energy of the sun comes from nuclear fusion in which, in a series of reactions, hydrogen gets converted into helium. This is accompanied by the release of a huge amount of energy.

We have plenty of hydrogen on the earth. Is it possible to use it to get energy from fusion?

Scientists are working hard to produce usable energy from fusion reactions. However, the high temperature (about 10<sup>7</sup> K) required for fusion causes problems. All materials vaporize at the temperature. So, we cannot even have a solid container to hold the particles for fusion.

Fusion has been used to make nuclear bombs that are more powerful than those based on fission. These are called hydrogen bombs or thermonuclear bombs. To start fusion, a small fission bomb is used as the first-stage of the thermonuclear bomb. Its blast creates the high temperature and pressure required for fusion.





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## USING ENERGY JUDICIOUSLY

The total coal reserves in your in our country are estimated to be about 80 billion tones, but we are consuming it at a rate of 250 million tons per year. At this rate resource that nature produced over millions of years will be consumed in just a few hundred years! The situation is more alarming is ht case of oil (petroleum) reserves. The known oil reserves of our country are about 500 million tones only, of which we are consuming 30 million tones per year. So, the oil reserves will last for a few decades only.

The demand for energy is increasing every day. The increasing demand cannot be met for a long time unless new resources are harnessed. Since conventional, nonrenewable energy sources are depletion very fast. This situation is called energy crisis. Increased use of fossil is also causing environmental problems such as air pollution which leads to health problems, acid rain and global warming.

To overcome the energy crisis and to save the environment, we have to use energy judiciously. This means using less of nonrenewable and more of renewable energy sources, not wasting energy and saving energy wherever possible.

We can stop the wastage of energy for example, by switching off lights, fans, coolers, etc., when they are not in use. In large cities, sharing a car with other people going to work in the same area or using public transport can save a lot fuel. Many such commonsense things can be done to save energy. Think about this: making sure that taps do not leak saves the energy used in pumping extra water.

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## OBJECTIVE TYPE QUESTIONS

## Choose The Correct Option in Each of The Following

- Which of the following is a renewable source of energy?  
(A) Coal (B) Natural gas (C) Wood (D) Petroleum
- The purpose of the glass cover on top of a box-type solar cooker is to  
(A) allow one to see the food being cooked (B) allow more sunlight into the box  
(C) prevent dust from entering the box (D) reduce heat loss by radiation
- A solar panel is made by combining a large number of  
(A) solar cookers (B) solar cells (C) solar water heaters (D) solar concentrators
- To work properly, wind-electric generators need wind speeds of at least about  
(A) 1.5 km/h (B) 15 km/h (C) 150 km/h (D) 1500 km/h
- The site of a hydroelectric plant should be chosen carefully because it  
(A) produces a large amount of carbon monoxide and carbon dioxide  
(B) produces a large amount of electricity  
(C) affects the organisms of the region  
(D) is expensive
- Electricity from the ocean can be generated based on utilizing  
(A) kinetic energy of the waves but not stored thermal energy  
(B) stored thermal energy but not kinetic energy of the waves  
(C) kinetic energy of the waves as well as stored thermal energy  
(D) neither kinetic energy of the waves nor stored thermal energy
- Which energy is not derived from the sun?  
(A) Nuclear energy (B) Wind energy (C) Biomass energy (D) Ocean-wave energy
- Which of the following is not biomass?  
(A) Sun (B) Rice husk (C) Wood (D) Cattle dung
- The condition for producing biogas is  
(A) air but not water (B) water but not air (C) air and water (D) neither air nor water
- Geothermal energy is feasible in regions that  
(A) are near the sea (B) have thermal plants  
(C) have coal mines (D) are over hot spots in the crust
- A solar water heater cannot be used to get hot water on  
(A) a sunny day. (B) a cloudy day. (C) a hot day. (D) a windy day.



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12. Which of the following is not an example of a bio-mass energy source?  
(A) wood                      (B) gobar-gas                      (C) nuclear energy                      (D) coal
13. Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the Sun's energy?  
(A) geothermal energy                      (B) wind energy  
(C) nuclear energy                      (D) bio-mass.

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OBJECTIVE	ANSWER KEY						EXERCISE - 1						
<b>Que.</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>
<b>Ans.</b>	<b>C</b>	<b>D</b>	<b>B</b>	<b>B</b>	<b>C</b>	<b>C</b>	<b>A</b>	<b>A</b>	<b>B</b>	<b>D</b>	<b>B</b>	<b>C</b>	<b>C</b>



## SUBJECTIVE TYPE QUESTIONS

## VERY SHORT ANSWER TYPE QUESTIONS

1. Name two renewable and two nonrenewable sources of energy.
2. Name two conventional and two nonconventional sources of energy.
3. What is the ultimate source of the energy of fossil fuels?
4. Name four fuels that we get from fossil fuels.
5. Among fossil fuels, which is the least polluting?
6. What happens when coal burns incompletely?
7. What is a turbine?
8. What is hydroelectricity?
9. Mention two ways by which water can be used to produce hydroelectricity.
10. What kind of energy does wind possess?
11. In the context to energy production, what is biomass?
12. What is the main constituent of biogas?
13. Which will cause the least amount of smoke when burnt-wood, cattle-dung cakes or biogas?
14. Why is solar energy considered renewable.
15. If 100 joules of solar energy is received by the upper atmosphere, how much of it reaches the earth's surface?
16. What is a solar heating device?
17. In a box-type solar cooker what is the range of temperature that can be achieved in two three hours?
18. Why is the inside surface of a box-type solar cooker blackened?
19. A solar cell transforms energy of one form into another form. What are these two forms of energy?
20. What is a solar panel?
21. Can a solar panel be used directly to power the TV set in your home?
22. What is geothermal energy?
23. What is nuclear fission?
24. What is a chain reaction?
25. What is nuclear fusion?
26. What is nuclear reactor?
27. Name the process by which the sun produces its energy.
28. Which process is carried out at a higher temperature: nuclear fusion or nuclear fission?
29. Give an example of how you can stop the wastage of energy.

## SHORT ANSWER TYPE QUESTIONS

1. Why are fossil fuels considered nonrenewable?
2. Can the excessive use of coal have a deterioration effect on structures like the Taj Mahal? If yes, in what way?
3. How is charcoal produced?
4. Why is charcoal a better fuel than wood?
5. (a) Name the four gases commonly present in biogas. (b) List two advantages of using biogas over fossil fuels.
6. When we harness wind energy, we harness solar energy indirectly. Explain.
7. How is electricity produced from wind energy? What are wind farms?
8. What are the advantages and limitations of wind energy?
9. Give two reasons why hydroelectricity is preferable to electricity from a coal-based plant.
10. Where are tidal power plants usually located? What are the limitations of tidal power?
11. Draw a diagram to show the basic design of a box-type solar cooker.
12. Explain the role of the glass top in a box type solar cooker.
13. What are the limitations of solar heating devices?
14. What are the advantages of solar energy?
15. Describe three uses of a solar panel.
16. What is the difficulty in the large-scale use of solar cells in electricity production?
17. How can electricity be generated from waves?
18. How are the wastes produced in nuclear power plants different from those produced at other power plants? What happens to the waste?
19. Compare and contrast fossil fuels and the Sun as direct sources of energy.
20. Compare and contrast bio-mass and hydro electricity as source of energy.
21. What are the limitations of extracting energy from –  
(a) the wind?            (b) waves?            (c) tides?
22. On what basis would you classify energy sources as  
(a) renewable and non-renewable?  
(b) exhaustible and inexhaustible?  
Are the options given in (a) and (b) the same?
23. What are the qualities of an ideal source of energy?
24. What are the advantages and disadvantages of using a solar cooker? Are there places where solar cookers would have limited utility?
25. What are the environmental consequences of the increasing demand for energy? What steps would you suggest to reduce energy consumption?
26. What is a good source of energy?
27. What is a good fuel?
28. If you could use any source of energy for heating your food, which one would you use and why?
29. What are the disadvantages of fossil fuels?



30. Why are we looking at alternate sources of energy?
31. How has the traditional use of wind and water energy been modified for our convenience?
32. What kind of mirror-concave, convex or plain – would be best suited for use in a solar cooker? Why?
33. What are the limitations of the energy that can be obtained from the oceans?
34. What is geothermal energy?
35. What are the advantages of nuclear energy?
36. Can any source of energy be pollution-free? Why or why not?
37. Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?
38. Name two renewable or non-conventional source of energy.
39. Name two non-renewable or non-conventional sources of energy.
40. How is charcoal obtained from wood?
41. Name the component of sunlight carrying maximum heat.
42. Name the device which directly converts solar energy into electric energy.
43. What is the range of temperature attained inside a box type solar cooker when placed in the sun for two to three hours?
44. What is the main basic cause for winds to blow?
45. What is a wind form? What is the minimum wind velocity required to obtained useful energy with a wind mill?
46. Name the factor which enables the ocean to act as a store house of energy.
47. Name two main combustibile components of biogas.
48. What is a fossil fuel? Give two examples of fossil fuels.
49. What is a nuclear fission and Nuclear fussion?
50. The mass number of three elements A, B and C are 2, 180 and 235. Which one of them is suitable to make a hydrogen bomb?
51. Wind mill in used to produce electricity. Write the sequence of energy conversion in a wind mill.
52. Define “electron-volt”.
53. What is biogas? How can biogas be obtained? Why is the use of biogas obtained from cow-dung advised in preference to burning of cow-dung cokes?
54. Why is the use of wood as a fuel not advised although forests can be replenished?
55. “Why is there a need to harness non-conventional source of energy?”
56. Charcoal is a better fuel than wood. Explain why?
57. What is the role of a plane mirror and a glass sheet in a solar cooker?
58. Why is energy of water flowing in a river considered to be an indirect form of solar energy?
59. Why are fossil fuels known as a non-renewable sources of energy?
60. Why are many thermal power plants set up near coal or oil fields?

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### LONG ANSWER TYPE QUESTION

1. What is the difference between renewable and nonrenewable sources of energy?
2. What are characteristics of a good energy source?
3. What are the problems caused by burning fossil fuels?
4. Describe the construction and working of a biogas plant.
5. Why is hydro energy considered an indirect source of solar energy? Explain how hydro energy can be converted into electrical. State two advantages of hydro energy.
6. What causes wind to blow? Name a part of India where wind energy is commercially harnessed. Compare wind power and the power of flowing water for generating electricity. What are the hindrances in developing them?
7. Discuss the advantages and disadvantages of generating electricity from the wind.
8. Describe a box-type solar cooker, mentioning how the loss of heat is reduced in it.
9. Briefly discuss three principles based on which electricity can be generated from the ocean.
10. Describe how the difference in temperatures at different depths of the ocean can be utilized for generating electricity.
11. What are the problems created by the increased demand of energy? How can we solve them?