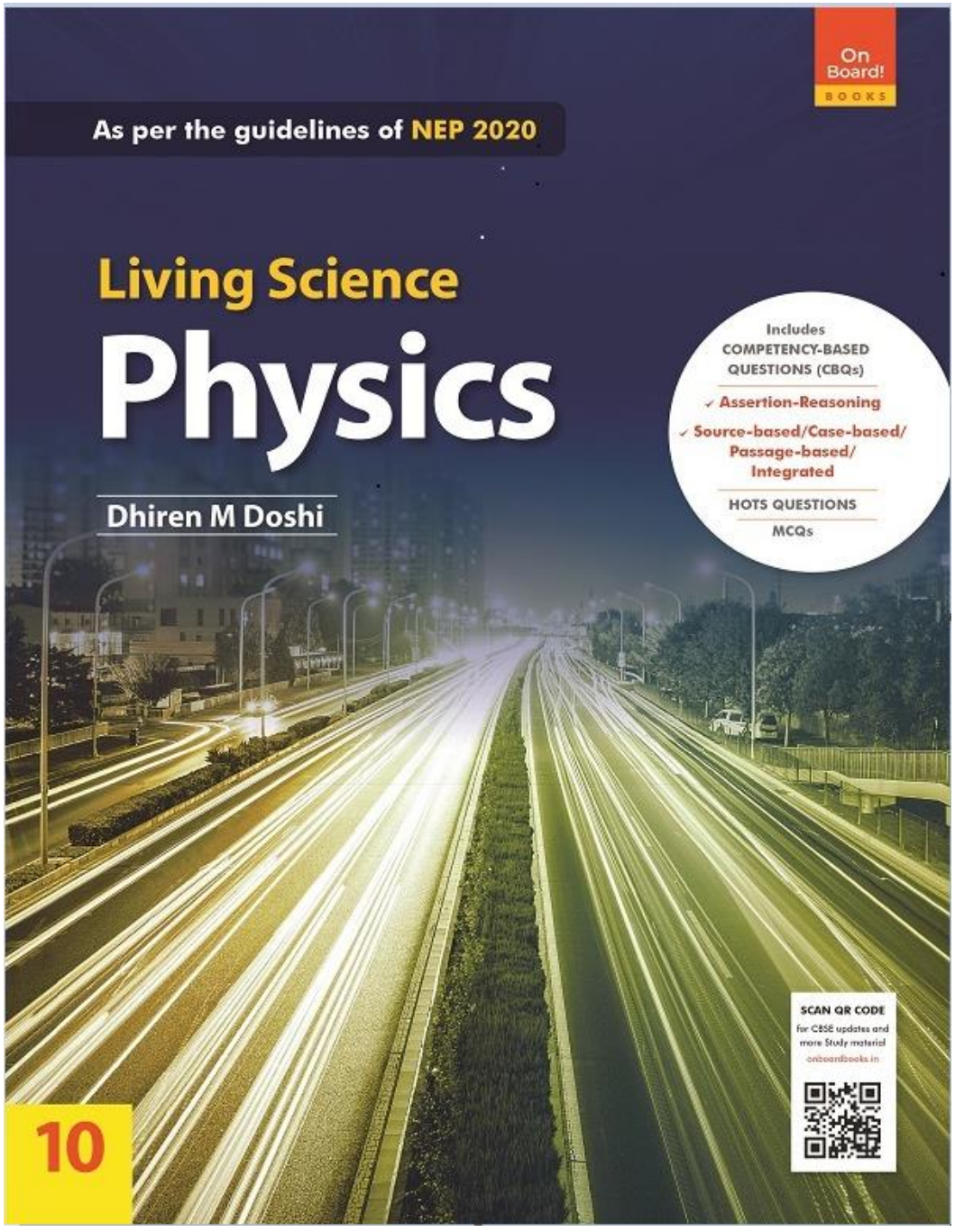


CBSE Living Science Physics

Class 10

Chapter 3: Sources of Energy

LEARNING OBJECTIVES

Sources of Energy

- ❖ Characteristics of a good source of energy
- ❖ Classification of sources of energy

Fuels

- ❖ Characteristics of an ideal fuel
- ❖ Fossil fuels
- ❖ Formation of fossil fuels

Production of Electricity – Power Plants

- ❖ Thermal power plant
- ❖ Hydro power plants

Biomass

- ❖ Uses of biogas

Wind Energy

- ❖ Advantages of wind energy

Alternative Sources of Energy

❖ Solar energy, ❖ Tidal energy ❖ Wave energy ❖ Geothermal energy ❖ Nuclear energy : Atom Bomb, Hydrogen Bomb

Conservation of Energy

Principle of Conservation of Energy

According to the principle of conservation of energy, energy can neither be created nor be destroyed. This means the sum total of energies of all kinds in an isolated system remains constant.

Sources of Energy

A source of energy is that which can provide adequate amount of usable (useful) energy at a steady rate over a long period of time.

Characteristics of a good source of energy

A good source of energy possesses the following characteristics.

1. Large amount of work done per unit volume or mass
2. Safe and convenient to use
3. Easy to transport
4. Easy to store
5. Economical and easily available
6. Environmental pollution

Classification of sources of energy

All sources of energy can be classified into two main categories on the basis of their recycling period.

Renewable sources of energy

Those sources of energy which are inexhaustible, i.e. which can be renewed after short intervals of time are called renewable sources of energy.

Non-renewable sources of energy

The sources of energy which are exhaustible, i.e. which cannot be renewed or replaced in short intervals of time are called non-renewable sources of energy.

Conventional and non-conventional sources of energy

The sources of energy can be classified into two categories on the basis of their usability:

Conventional sources of energy

The traditional sources of energy which are extensively used due to their easy availability and also meet a major portion of our energy requirement are called **conventional sources of energy**. For example, fossil fuels (coal, petroleum, natural gas), hydro energy (energy of flowing water in rivers), energy from biomass (firewood, animal dung, biodegradable waste) and wind energy.

Non-conventional sources of energy

The non-traditional sources of energy which are not used extensively and meet our energy requirement on a limited scale are called **non-conventional sources of energy**. For example, solar energy, ocean energy (tidal energy), ocean thermal energy, geothermal energy and nuclear energy.

Refer to Table 3.1 for Differences between renewable and non-renewable sources of energy and Table 3.2 for Differences between conventional and non-conventional sources of energy

Fuels

A combustible substance which on burning in air produces a large amount of heat energy is called a fuel. Some commonly used fuels are cooking gas (LPG), wood, coal, petrol, diesel and kerosene.

We have different kinds of fuels. For example:

- **Solid fuels:** coal, coke, wood, charcoal, cow-dung cakes, etc.
- **Liquid fuels:** petrol, kerosene, diesel, alcohol, etc.
- **Gaseous fuels:** natural gas, LPG, gobar gas, coal gas, etc.

Characteristics of an ideal fuel

Following are the characteristics of a good fuel.

1. It should be economical and easily available.

2. It should burn at a moderate and steady rate, i.e. it should not burn either too fast or too slow.

3. It should not produce any poisonous and irritating fumes or smoke during burning.

4. It should not leave much ash after burning.

5. It should produce large amount of heat per unit mass, i.e. it should have high calorific value.

6. It should be easy to handle, safe to transport and convenient to store.
7. It should have a proper ignition temperature (just above room temperature) so that it can be burnt easily.
8. It should not be valuable for some other purpose than a fuel. For example, charcoal is a fuel but it is more valuable as a reducing agent in a metallurgical process while extracting a metal from its ore.

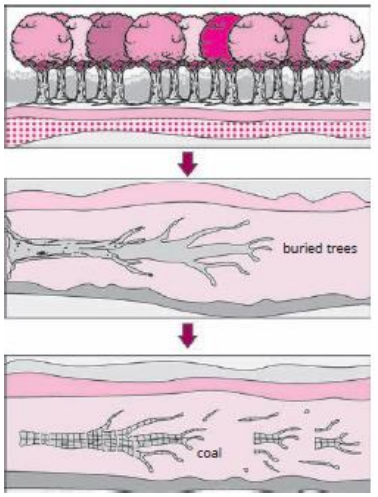
Conventional Sources of Energy

Fossil fuels

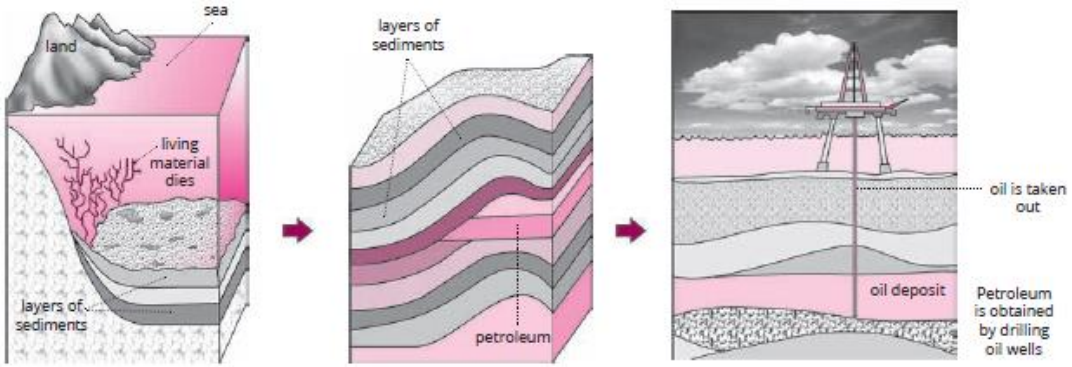
The fuels formed from the prehistoric remains of dead plants and animals buried deep under the earth's crust under special conditions are called fossil fuels.

Formation of fossil fuels

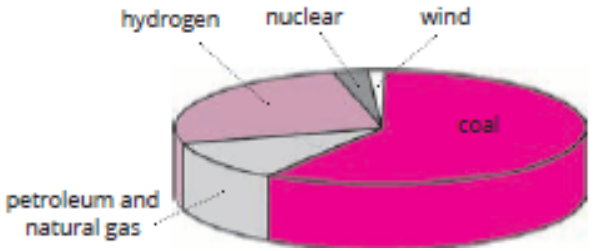
Millions of years ago, the earth was covered with thick forests growing in swamps. Due to natural calamities like earthquakes and volcanoes, the forests were buried under the surface of the earth and got covered with sediments like mud and soil, away from the reach of air. Due to high temperature and pressure inside the earth, the bacterial decomposition of large plants (trees of the buried forests) in the absence of oxygen converted them into coal .



Small plants and animals living in sea which got buried in a similar manner under similar conditions are converted into **petroleum** and **natural gas**



Formation of petroleum



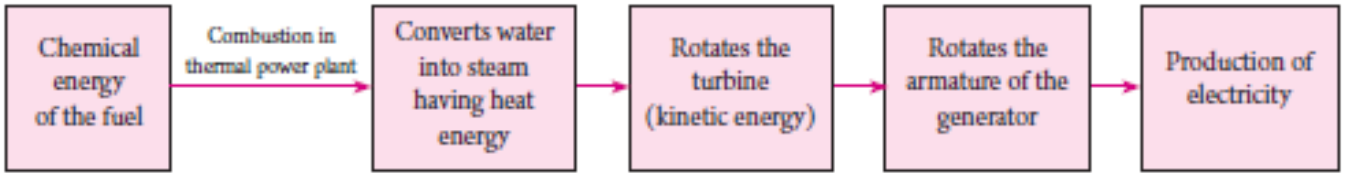
Pie-chart showing the major sources of energy in India

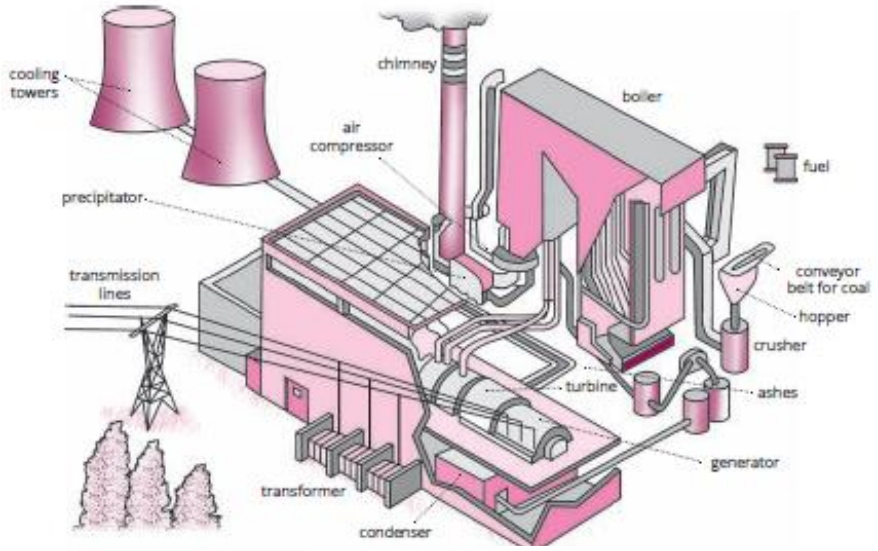
Fossil fuels are classified as non-renewable sources of energy because if exhausted, they cannot be regenerated (replenished) in a short time as they take millions of years to form again.

Production of Electricity – Power Plants

1. Thermal power plant

A power plant in which a fossil fuel (coal or petroleum) is burnt to produce heat energy which is converted into electrical energy is called a thermal power plant.

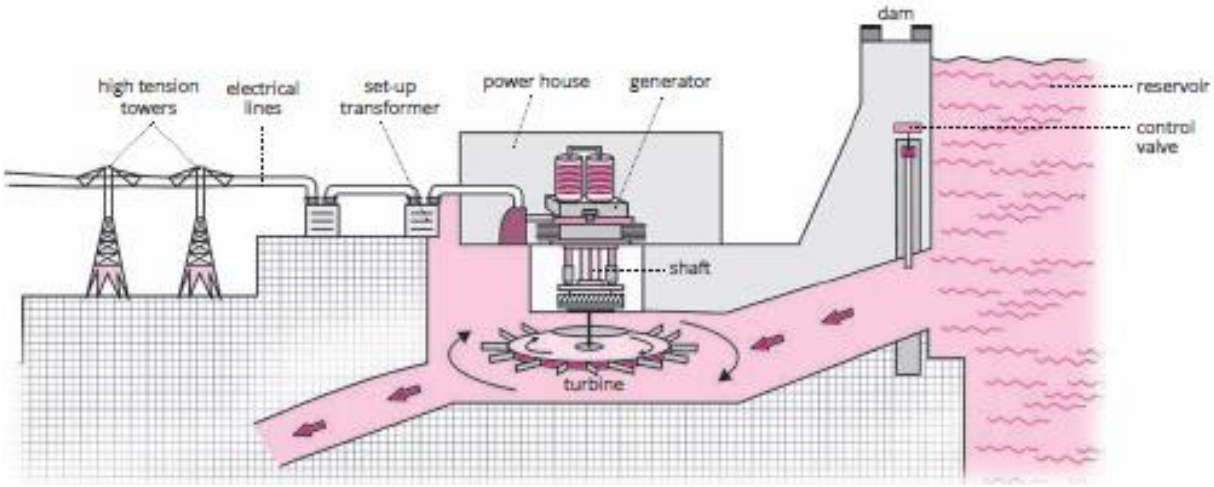




A thermal power plant

2. Hydro power plants

The power station where electricity is produced by using the energy of flowing water to drive generators is called hydro power plant (or hydroelectric power station).



Hydroelectric generator

Potential energy of stored water in a dam → Kinetic energy of flowing water (when it moves down in pipes) → Kinetic energy of turbines (when the blades rotate) → Electrical energy in generator (when its armature rotates)

Advantages of hydroelectricity generation

The advantages of generating hydroelectricity are discussed below:

1. The generation of hydroelectricity in a hydroelectric power plant does not cause any environmental pollution.

2. The energy of flowing water is a renewable source of energy.

3. Hydroelectricity is one of the cheapest sources of energy. The hydro power plant constructed to produce it also has a low maintenance cost.

4. Hydro power plants constructed to generate hydroelectricity are multipurpose projects. They help in controlling floods, enable us to use water for irrigation, serve as recreational sites, etc.

Disadvantages of hydroelectric plants

The construction of high-rise dams on rivers for generating hydroelectricity causes the following social and ecological problems.

1. When we construct a dam, we lose a large area of agricultural land and human habitation (towns and villages) as they get submerged.

2. Many plants and trees are destroyed due to submerging in water of the reservoir (man-made lake) formed for the dam. Humans and animals have to migrate from this place as they are rendered homeless.

3. The people displaced from the dam site need to be given satisfactory rehabilitation which becomes a big problem and challenge before the government.
4. Large ecosystems are destroyed when submerged under the water in dams.
5. The vegetation (plants and trees) submerged under water rots under anaerobic conditions and produces a large amount of methane which is also a greenhouse gas.
6. Hydroelectric plants are one of the cheapest sources of electricity but these plants can be constructed only in a limited number of places, preferably in hilly terrains (areas) where high altitude river flows.
7. Due to construction of the dam, there are no annual floods in the river. The soil in the downstream becomes poor in quality (less fertile) because there are no annual floods to deposit nutrient-rich silt on the banks of the river. The crop yield also decreases in these areas.

Biomas

Biomass is defined as the total mass of all living organisms in an ecosystem. When we speak of energy from biomass, we mean energy derived from the remains of living organisms and from the excreta of animals.

Wood as a fuel

Wood is still used as a fuel to cook food in small open furnaces called *chulhas* and also in industrial boilers. Wood when used as a fuel is called **firewood**.

Disadvantages of burning wood directly as a fuel

1. The calorific value of wood is low, being only 17 kJ/g. Thus, to produce sufficient amount of heat, we need to burn a large quantity of wood.
2. Using wood as fuel leads to cutting down of trees in forests (deforestation).
3. The burning of wood produces a lot of smoke and harmful gases which pollute the air (air pollution).
4. Wood occupies a large area and its transportation is difficult. So, it's not a compact and convenient fuel to use.
5. Wood does not burn completely, it produces a lot of residue.

Cow-dung as a fuel

In our villages, cow-dung cakes are burnt in *chulhas* for cooking food.

Disadvantages of burning cow-dung directly as a fuel

1. Burning of cow-dung as a fuel destroys the useful nutrients which otherwise have been used in agriculture.
2. Cow-dung cakes have low calorific value. So, we need a large amount of cow-dung cakes to obtain the required heat.

3. Cow-dung cakes do not burn completely, they produce a lot of ash as residue.

4. Dung cakes produce a lot of smoke and harmful gases on burning which cause air pollution.

Technology used for converting wood into charcoal

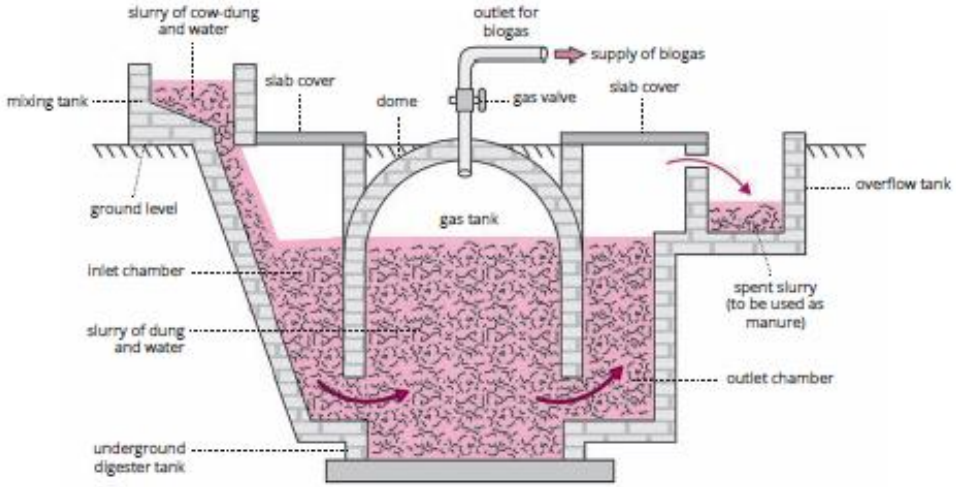
Charcoal is prepared by the strong heating of wood in closed vessels in a limited supply of air (oxygen). When wood is heated strongly in a closed vessel in a limited supply of oxygen, then water and volatile material present in it get removed and a black residue called charcoal is left behind. This process is called destructive distillation of wood. Thus, wood minus volatile materials is charcoal.

Technology used for converting cow-dung into biogas

Technological advancement has enabled us to convert cow-dung into more efficient fuel called **biogas**. Biogas is obtained by anaerobic decomposition of cow-dung in the presence of water. Biogas is produced in a plant called **biogas plant** (also called *gobar* gas plant in villages).

Biogas is a mixture of methane, carbon dioxide, hydrogen and traces of hydrogen sulphide

Refer to Table 3.3 for Differences between charcoal and wood



A biogas plant

Working of a biogas plant

1. Cow-dung and water are mixed in equal proportions in a mixing tank to prepare a semi-fluid mixture called **slurry**.

2. The slurry so prepared is passed on the underground digester tank through an inlet chamber. The digester tank is a sealed chamber in which there is no oxygen. It is in the digester tank where the slurry is decomposed in about 50–60 days by anaerobic bacteria to produce biogas.This biogas produced gets collected in the gas tank.

3. As biogas keeps collecting in the dome, it exerts pressure on the spent slurry in the digester tank. This pressure forces the spent slurry to flow into the overflow tank through the outlet chamber.

Refer to Table 3.5 for Comparison and contrast between biomass and hydroelectricity

4. The spent slurry is gradually removed from the overflow tank. It is rich in nitrogen and phosphorus compounds, so it is taken in fields and used as manure.
5. The biogas which gets collected in the gas tank is taken out through the biogas outlet pipe and used as required.
6. To get a continuous supply of biogas, fresh slurry is added to the digester tank periodically to replace the spent slurry.
The biogas so obtained is a better fuel than the dry cow-dung cakes.

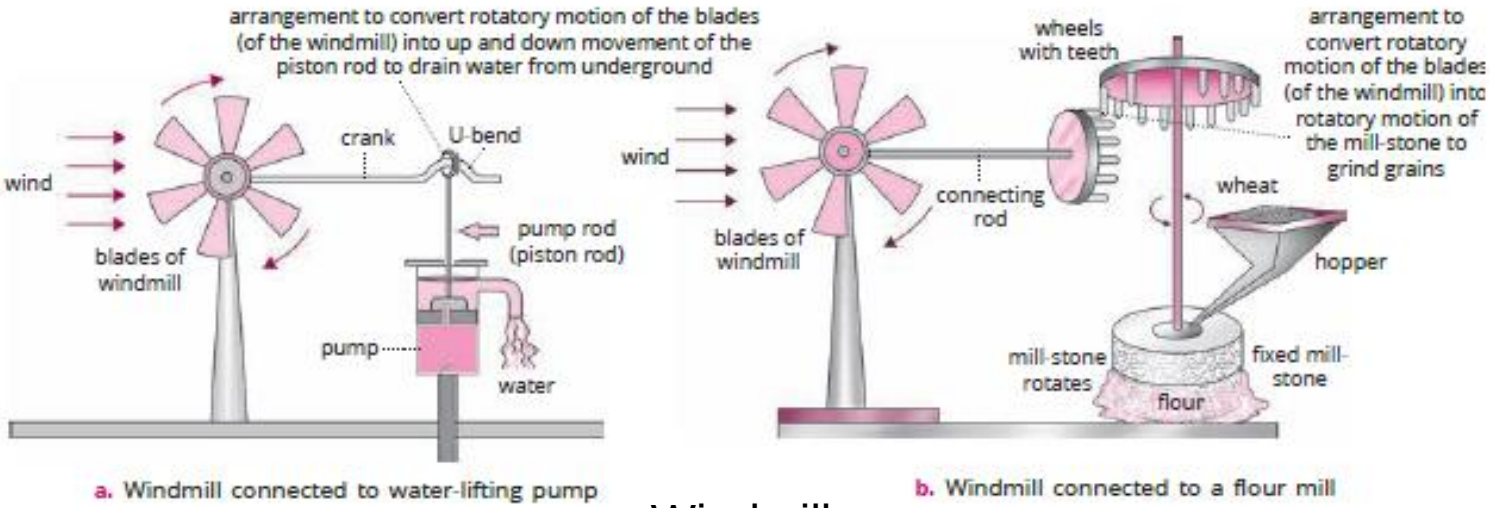
Uses of biogas

1. Biogas is used as a fuel for cooking food.
2. It is used for illumination purposes.
3. It can be used for driving engines of water pumping sets used for irrigation.

Wind energy

Moving air is called wind. Kinetic energy possessed by wind is called wind energy. This kinetic energy of the wind can be used to do mechanical work.
Wind energy is used in the following manner:
1. The energy of wind is used to propel the sailboats to transport human beings and materials from one place to another.
2. Wind energy was harnessed by windmills to do mechanical work.

In a water-lifting pump, the rotatory motion of windmill's blades was utilized to lift water from a well. In a flour-mill, the rotatory motion of blades of the windmill was utilized to rotate the mill-stone to grind the grains like wheat and corn into flour.



Windmills

Wind turbine generator – technological innovation

Technological innovation was made in the form of efficient **wind turbine generator** (modified windmills), which use wind energy to generate electricity.

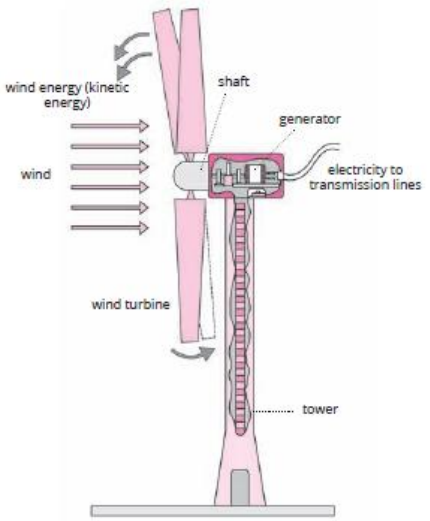
Working of a wind turbine generator

1.When a fast moving wind (having a speed of more than 20 km/h) strikes the blades of the wind turbine, it exerts a force on its blades. The blades of the wind turbine start rotating continuously. The shaft of the wind turbine also starts rotating.

2. The rotating shaft of the wind turbine rotates the armature of the generator and electricity is produced.
3. The electricity so produced is fed to step-up transformer and then supplied to homes and industries through transmission lines.

Wind energy farm

A cluster of wind turbine generators installed over a large area is called a wind energy farm.



Wind turbine generator

Advantages of wind energy

1. Wind energy is an environment-friendly and efficient source of energy. It does not cause any environmental pollution.
2. Wind energy is a renewable source of energy. It is inexhaustible as long as the sun keeps shining.
3. Wind energy is available free of cost. It requires no recurring expenses for the production of electricity through wind energy. So, it is one of the cheapest sources of energy.

A wind energy farm

Alternative or Non-conventional Sources of Energy

Solar Energy

The energy obtained from the sun is called solar energy.

Solar Constant

Solar constant is the amount of solar energy received per second by one square metre area at outer edge of the earth's atmosphere exposed perpendicularly to the rays of the sun at the average distance between the sun and the earth. The approximate value of solar constant is 1.4 kJ per second per square metre or 1.4 kW/m^2.

Solar constant enables us to:

1. estimate the solar energy received by an area in a given time, i.e. Solar energy received = solar constant $\times$ area $\times$ time

2. calculate the temperature of the sun.

Traditional uses of solar energy

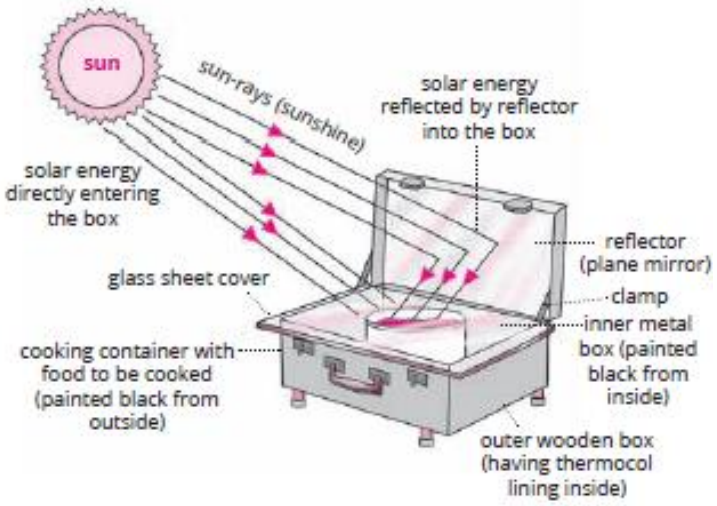
1. Solar energy has been used for drying clothes.

2. Solar energy has been used for the preservation of fruits, vegetables and fish by the process of sun-drying.

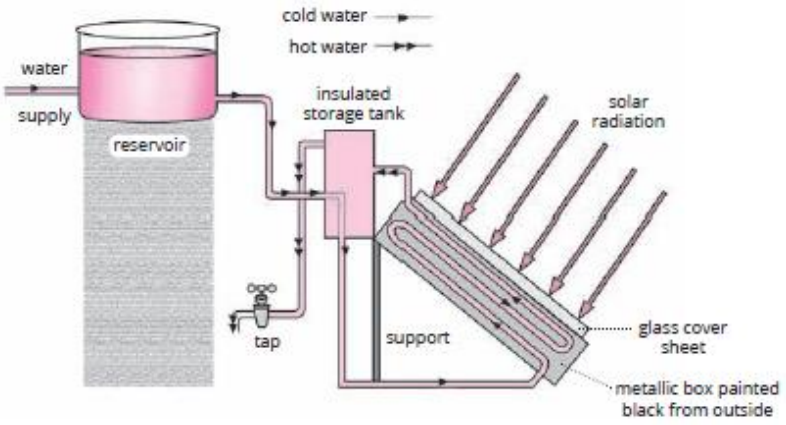
3. Solar energy has been used for obtaining salt from sea water.

Improvement in the technology for using solar energy

Scientists have developed special devices which are being used to convert solar energy into usable forms. Some of them are solar cookers, solar heaters, solar furnaces, etc.



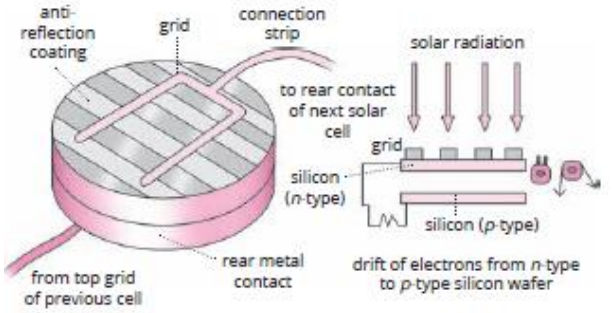
Solar cooker



Solar water heater

Solar cell: A solar cell is a device which directly converts solar energy into electrical energy.

solar cell panel : A group of solar cells connected in a specific pattern to produce desired potential difference and magnitude of current (electric power) is called solar cell panel



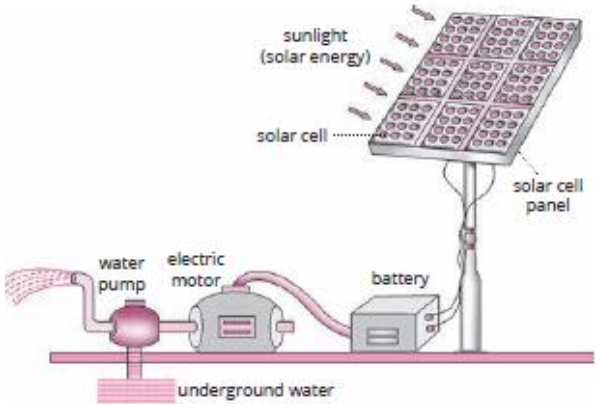
Solar cell

Advantages of solar cells/solar cell panels

1. Solar cells have no moving parts, are easy to construct and require little maintenance.

2. Solar cell panels can be installed in remote and very less populated areas

3. Solar cells and solar cell panel both derive their energy from solar radiation, which is a renewable source of energy and also inexhaustible.



Solar panel

4. Solar cells and solar cell panels do not cause any environmental pollution.

5. Use of solar cells enables us to save usage of fossil fuels as solar cells require no fuel.

Uses of solar cell panels

1. Artificial satellites and space probes, like Mars orbiters, use solar cell panels as the main source of energy.

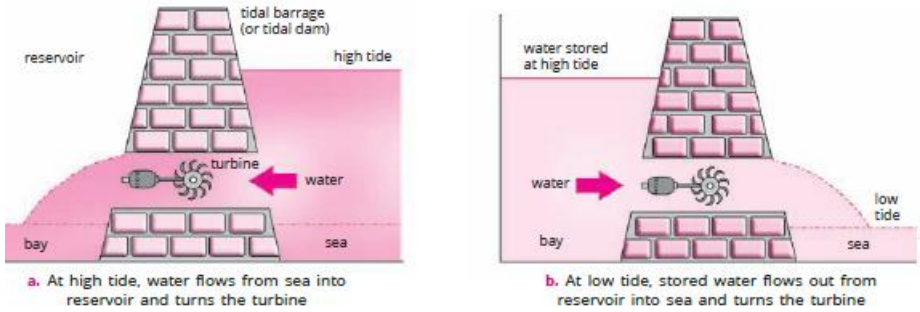
2. Radio broadcasting or TV relay stations in remote areas use solar cell panels for transmission.

3. Traffic signals, electric watches, calculators and many toys are fitted with solar cells.

4. Solar cell panels are being used to produce electricity for street lighting, operating water pumps for domestic and agricultural works in remote/rural areas.

Tidal energy

The energy obtained from tidal waves is known as tidal energy.



Tidal energy

Advantages of tidal energy

1. It is an inexhaustible and renewable source of energy.

2. It does not cause any environmental pollution.

3. It is not affected by the uncertainty in rainfall.

4. It does not produce any harmful waste.

5. It saves our valuable fossil fuels as it does not require any fuel for its production.

6. Once the tidal power plant is established, it has low maintenance cost.

Limitations of tidal energy

1. Limited scope: Tidal dams cannot be established everywhere. There are very few sites around the world which are suitable for building tidal dams to harness tidal energy.

2. Small scale power generation: The rise and fall of sea water during tides is not enough to generate electricity on a large scale.

3. High maintenance cost: The sluice gates and blades of turbines are exposed to salty sea-water, so they need a high level of maintenance. Hence, the cost incurred in its maintenance is high.

4. Variable output: There is variation in tides during daytime, so power generation is also affected.

Wave energy

The energy associated with sea waves is called wave energy. A wide variety of devices have been developed to trap wave energy to rotate the blades of the turbine. The shaft of rotating turbine rotates the armature of the generator and electricity is produced.

Advantages of wave energy

It is an inexhaustible and renewable source of energy. It does not cause any environmental pollution and does not produce any harmful waste products. It also saves valuable fossil fuels.

Limitations of wave energy

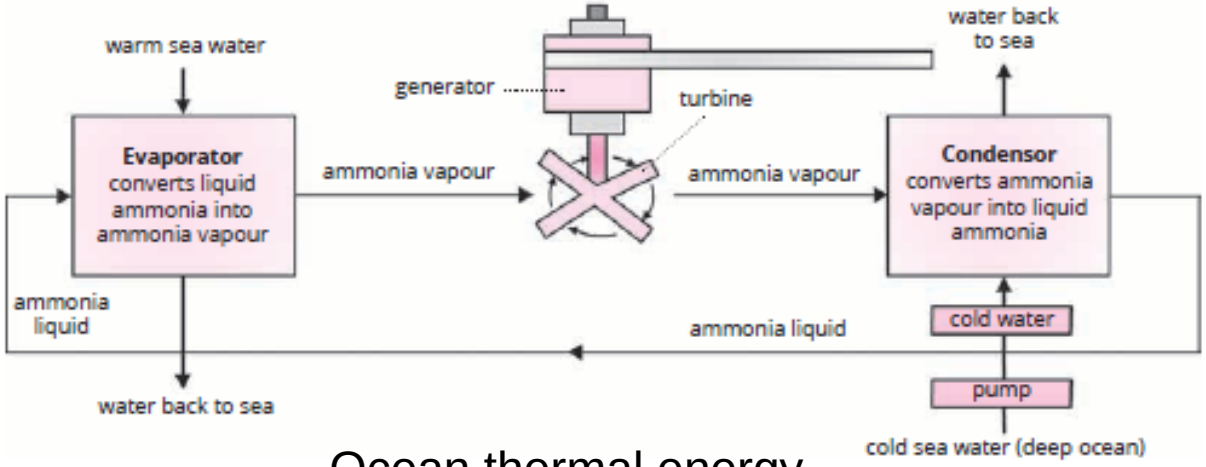
It is same as in the case of tidal energy, i.e. it produces electricity on small scale, its maintenance cost is high, cost of production of electricity is high, and output varies.

Ocean thermal energy

The energy available due to the difference in temperature between water at the surface and water at depths is called ocean thermal energy (OTE).

Advantages of OTEC

It is same as tidal energy and wave energy, i.e. it is an inexhaustible and renewable source of energy, does not cause any environmental pollution, does not produce any harmful waste products, saves valuable fossil fuels and has low maintenance cost.



Ocean thermal energy

Geothermal energy

The heat inside the earth that can be utilized as a source of energy under favourable conditions is called geothermal energy.

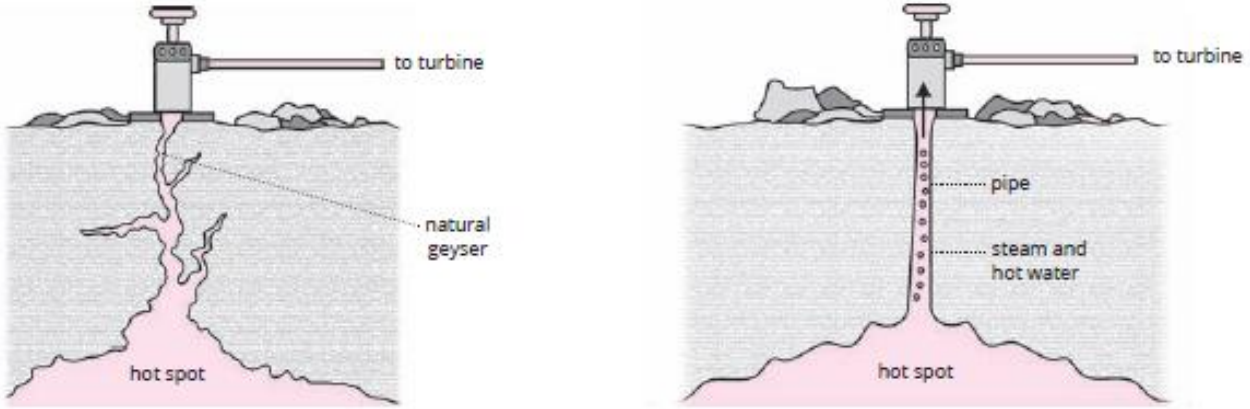
Advantages of geothermal energy

1. Geothermal energy is a renewable source of energy. Since the interior of the earth is going to remain hot for millions of years, geothermal energy is an inexhaustible source of energy.

2. It is a clean source of energy as it does not cause any environmental pollution.

3. The cost of production of electricity is not much, i.e. the electricity produced is inexpensive and economical.

4. It enables us to save our fossil fuels as it requires no fuels for its production.



Geothermal energy

Nuclear energy

The energy released by either splitting up of a heavy unstable nucleus or by fusion of two or more light nuclei is called nuclear energy.

Nuclear Fission

The process of splitting of the nucleus of a heavy atom such as 235 92U (by bombarding with slow neutrons) into two or more lighter nuclei with the release of tremendous amount of energy is called nuclear fission.

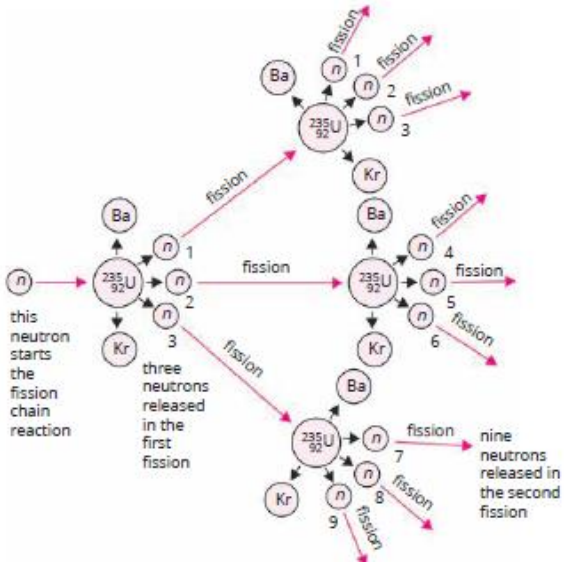
Chain reaction: A kind of reaction where the particle which initiates (starts) the reaction is also produced during the reaction and carries on the reaction further to make it self-propagating and continuous is called a **chain reaction**.

Chain reactions are of two kinds:

1. Controlled chain reaction **2.** Uncontrolled chain reac

Conservation of Energy

As a rule in case of nuclear fission reaction, the mass of the original nucleus must be equal to the sum of the masses of the products formed. But from mass spectrometry, it is found that the mass of the original nucleus is just a little more than the sum of the masses of the individual products. The difference between the actual mass of the original nucleus and the sum of masses of the products formed is called mass defect or loss in mass. It is represented by Δm.



Uncontrolled chain reaction during the fission of U-235

∴ Mass defect $\Delta m = M - A$ where, M is the mass of the original nucleus, and A is the sum of masses of the products formed.

If Δm is the loss in mass, the nuclear energy released (E) according to Einstein's equation is

$E = \Delta mc^2$ where Δm = mass defect or loss in mass,

c = speed of light in vacuum (i.e. 3×10^8 m s^{-1})

The energy released in nuclear reactions is expressed in units of electron volt (eV) or million electron volt (MeV).

Electricity from Nuclear Energy

The most important use of nuclear energy is the generation of electricity. This is done by using a set-up called **nuclear power plant**.

Nuclear power plant

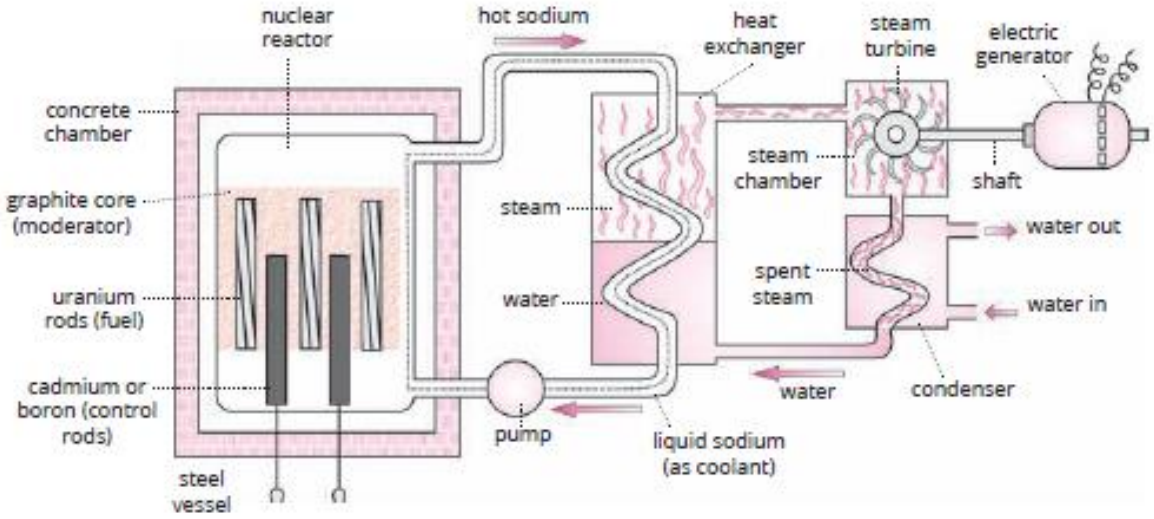
The set-up used for generating electricity from the heat energy released in a controlled nuclear fission chain reaction is called a nuclear power plant.

Advantages of nuclear energy

1. Tremendous amount of energy produced: Tremendous amount of energy can be produced from a very small amount of nuclear fuel (uranium, plutonium, thorium, etc.).

2. Energy supply: The nuclear power plant can go on producing electricity for a long span of time once its reactor is loaded with nuclear fuel like uranium.

3. Polluting gases: Unlike fossil fuels, it does not produce carbon dioxide, so it does not contribute to the greenhouse effect. It does not produce sulphur dioxide, so it does not cause acid rain.



Nuclear power plant
(Atomic power plant)

Disadvantages of nuclear energy

1. Expensive installation: The cost of installation of a nuclear power plant is very high.
2. High risk of environmental contamination
3. Risk of accidental leakage
4. Limited supply of uranium:

Atom bomb (or nuclear bomb)

An atom bomb (nuclear bomb) is a highly destructive device in which the nuclear fuel (like U-235 and Pu-239) is assembled in such a compact manner that when put to use, its fission is deliberately allowed to go out of control. It produces tremendous amount of energy in a very short time resulting in an explosion.

Nuclear fusion

The process in which two lighter nuclei fuse to form a stable heavier nucleus with the liberation of enormous amount of energy is called nuclear fusion.

Hydrogen bomb

Nuclear fusion reaction has resulted in the production of hydrogen bomb. A hydrogen bomb is the most powerful weapon of destruction. It is based on thermonuclear fusion reaction (i.e. nuclear reaction taking place at extremely high temperatures of the order of 10^7 K).

A hydrogen bomb consists of heavy isotopes of hydrogen such as deuterium and tritium along with lithium . A nuclear bomb based on the fission of uranium or plutonium is placed at the core of the hydrogen bomb.

Refer to Table 3.8 for Comparison between nuclear fission and nuclear fusion

SUMMARY

1. Source of energy: Any system which can provide adequate usable (useful) energy at a steady rate over a long period of time.

2. Characteristics of a good source of energy: a. large amount of work done per unit volume or mass **b.** safe and convenient to use **c.** easy to transport **d.** easy to store **e.** cheap and easily available **f.** does not cause any environmental pollution.

3. Renewable sources of energy: Those sources of energy which are inexhaustible, i.e. which can be renewed in short intervals of time. For example, wood, water, wind and solar energy.

4. Non-renewable sources of energy: Those sources of energy which are exhaustible, i.e. which cannot be renewed or replaced in short intervals of time. For example, fossil fuels.

5. Conventional sources of energy: Those sources of energy which are extensively used by man due to their easy availability and also meet a major portion of man's energy requirements. For example, fossil fuels, hydro energy, energy from biomass and wind energy.

6. Non-conventional sources of energy: Those sources of energy which are not extensively used by man and meet man's energy requirements on a limited scale.

7. Fuel: A combustible substance which on burning in air produces a large amount of heat energy.

8. Characteristics of a good fuel: a. should be cheap (economical) **b.** easily available **c.** leave no residue **d.** should not produce any poisonous fumes or smoke **e.** easy to handle, transport and store **f.** have a proper ignition temperature **g.** should not be valuable for some other purposes other than a fuel.

9. Disadvantages of fossil fuels: a. non-renewable sources of energy **b.** cause air pollution **c.** cause acid rain.

10. Thermal power plant: A power plant in which a fossil fuel is burnt to produce heat energy which is converted into electrical energy.

11. Hydroelectric power plant: A power plant where electricity is produced by using the energy of flowing water to drive generators.

12. Advantages of hydroelectricity: a. does not cause any environmental pollution **b.** renewable source of energy **c.** cheapest source of energy.

13. Disadvantages of hydroelectric power plants: a. lead to ecological imbalance **b.** large varieties of plants and trees are submerged **c.** create problems of satisfactory rehabilitation **d.** rotten submerged vegetation produces greenhouse gases.

14. Energy from biomass: Energy derived from the remains of living organisms and from the excreta of animals.

15. Advantages of charcoal over wood: a. high calorific value **b.** causes no air pollution **c.** no residue produced **d.** compact fuel.

16. Biogas: It is a mixture of methane, carbon dioxide, hydrogen and traces of hydrogen sulphide.

17. Advantages of biogas plant: a. supply of biogas **b.** supply of manure **c.** safe and efficient method of disposing organic waste.

18. Wind energy: Energy possessed by wind by virtue of its kinetic energy is called wind energy.

19. Wind farm: A cluster of wind turbine generators installed over a large area is called a wind energy farm.

20. Advantages of wind energy: a. environment-friendly and efficient source of energy **b.** renewable source of energy **c.** no recurring expenses for the generation of electricity.

21. Limitations of harnessing wind energy: a. Wind farm cannot be established everywhere **b.** needs back-up facilities **c.** needs very large area **d.** high cost of maintenance **e.** high installation cost.

22. Solar energy: The energy obtained from sun.

23. Solar cell: A device which directly converts solar energy into electrical energy.

24. Tidal energy: The energy obtained from tidal waves is called tidal energy.

25. Wave energy: The energy associated with sea waves is called wave energy.

26. Ocean thermal energy: The energy available due to the difference in the temperature between water at the surface and water at depth is called ocean thermal energy.

27. Advantages of energy from sea: a. inexhaustible and renewable source of energy **b.** does not cause any environmental pollution **c.** does not produce any harmful waste **d.** saves fossil fuels **e.** low maintenance cost.

28. Limitations of energy from sea: a. limited scope **b.** small-scale power generation **c.** variable output **d.** huge investments.

29. Geothermal energy: The heat inside the earth under favourable conditions can be utilized as a source of energy and this energy is called geothermal energy.

30. Nuclear power plant: A power plant for generating electricity from the heat energy released in a controlled nuclear fission chain reaction is called a nuclear power plant.

31. Conservation of energy: Wise and economical use of energy resources is called conservation of energy.