ICSE
Living Science
Physics

Class 9

Chapter 8 Energy

As per the guidelines of NEP 2020

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Revised and Updated

Living Science Physics

Based on the latest ICSE syllabus

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LEARNING OBJECTIVES

Energy Flow and its Importance

- Energy flow
- Law of conservation of energy

Sources of Energy

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

Fossil Fuels

- Formation of fossil fuels
- Disadvantages of fossil fuels

Hydropower Plants

- Advantages of hydroelectricity generation
- Disadvantages of hydroelectric plants

Wind Energy

- Wind energy farm
- Advantages of wind energy

Alternative or Non-conventional Sources of Energy

- Solar energy
- Solar cells
- Biogas
- Tidal energy

Nuclear Energy

- Nuclear fission
- Electricity from nuclear energy
- Nuclear fusion
- Conservation of energy

Greenhouse Effect

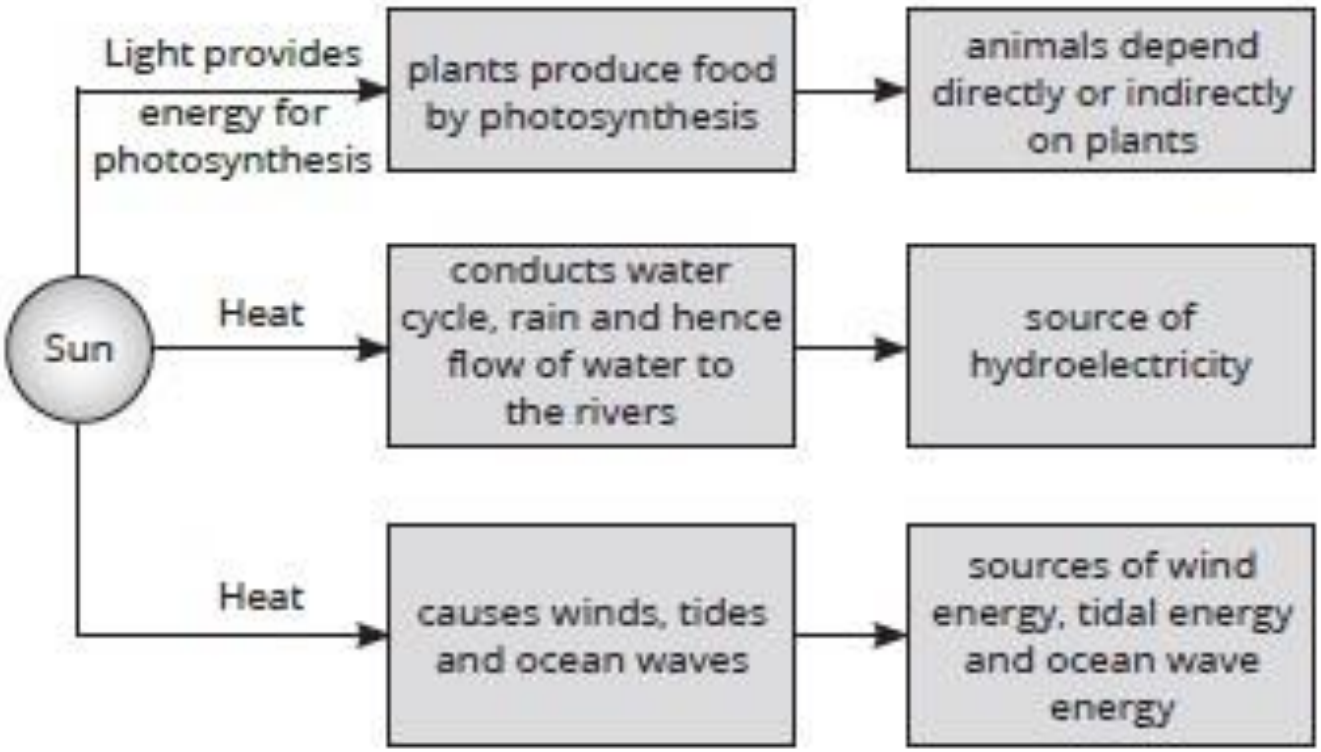
Global Warming

Energy Degradation

Energy Flow

Transformation of energy is referred to as **flow of energy**. This flow of energy is linear. **The flow of energy is not reversible**. The study of these energy flows forms the subject matter of thermodynamics.

Thermodynamics is thebranch of science that deals with the concept of heat and temperature and the inter-conversion of heat and other forms of energy. It mainly deals with the transformation of heat into mechanical work and vice versa.



Law of conservation of energy

It states that “energy can neither be created nor destroyed. However, it can be transformed from one form to another**.** This means

1. If certain amount of energy of one kind disappears (used up), an exact equivalent amount of some other kind of energy is produced.

2. The total energy of the universe remains constant.

Sources of Energy

A source of energy is that which can provide adequate usable (useful) energy at a steady rate over a long period of time. 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. Cheap and easily available
6. Pollution free

Classification of sources of energy

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

1. Renewable sources of energy: Those sources of energy which are inexhaustible, i.e. which can be renewed in short intervals of time are called renewable sources of energy. Renewable sources of energy are available in continuous supply. For example, wood, water, wind and solar energy are 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. These will be exhausted in future. For example, coal, petroleum and natural gas are nonrenewable sources of energy.

Conventional and non-conventional sources of energy

The sources of energy which are used extensively 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), wind energy. Most of the conventional sources of energy are going to be exhausted in future.

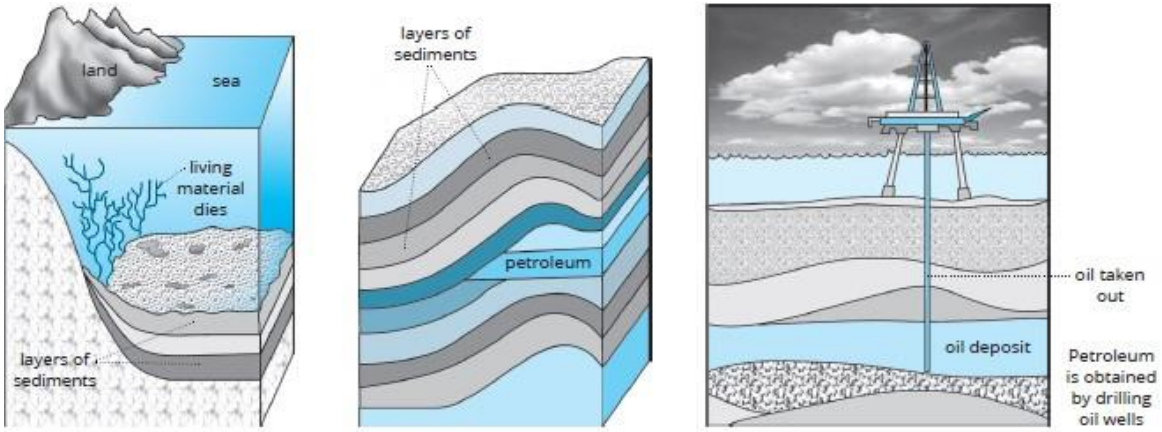
The sources of energy which are not used extensively and meet our energy requirement on a limited scale are called **non-conventional of energy**. For example, solar energy, ocean energy (tidal energy), ocean thermal energy, geothermal energy, nuclear energy, etc. Most of the non-conventional sources of energy are available in continuous supply on the earth.

Fossil Fuels

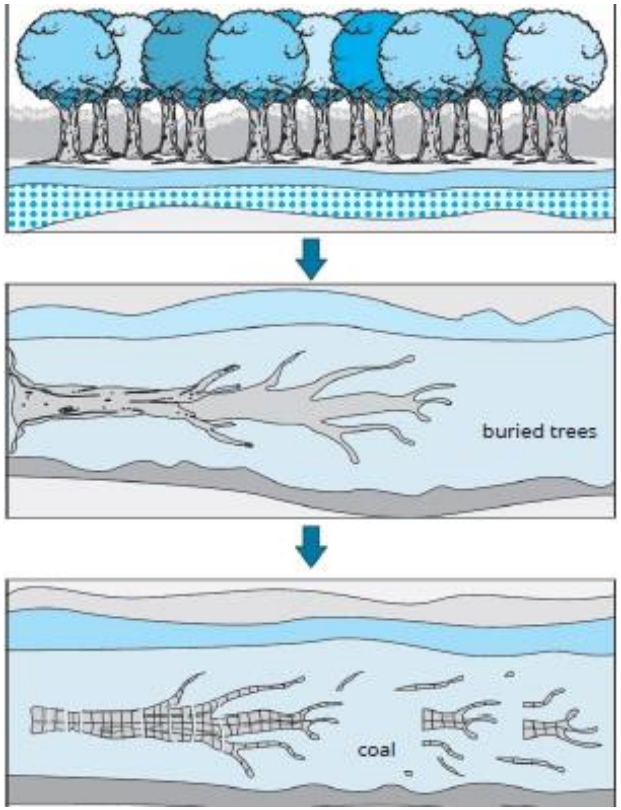
The fuels formed from the prehistoric remains of dead plants and animals buried deep under the earth's crust under special conditions are called fossil fuels.

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 volcanic eruptions, the forests were buried under the surface of the earth and got covered with sediments like mud and soil, away from the reach of oxygen 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 buried in a similar manner under similar conditions got converted into **petroleum** and **natural gas.**



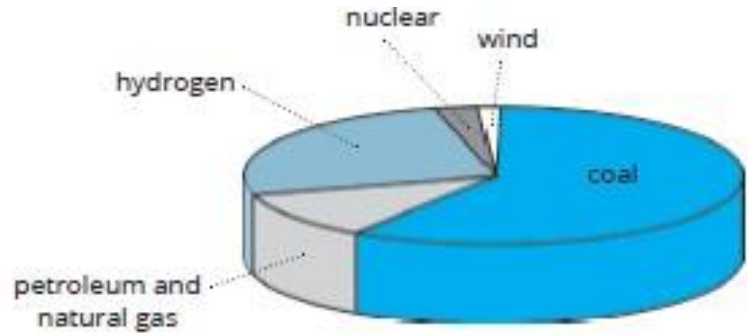
Formation of petroleum



Formation of Coal

Disadvantages of fossil fuels

Non-renewable sources of energy: Fossil fuels are non-renewable sources of energy. They are exhaustible. If we were to continue consuming these sources at the present alarming rate, we would soon run out of them.

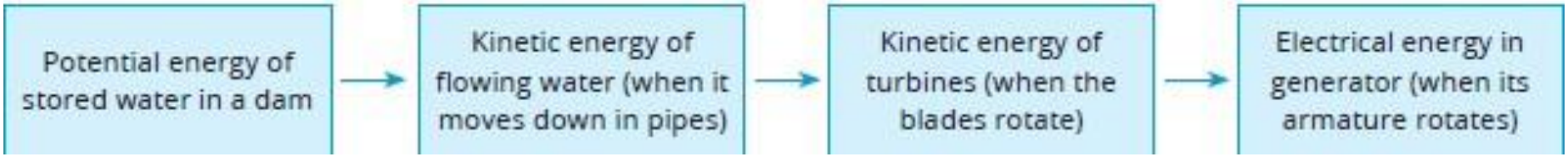


2. Environmental pollution: We have learnt in our previous class that burning of fossil fuels causes air pollution. The burning of carbon-containing-fuels releases ash and fine particles of unburnt carbon in the air. These fine particles, called **suspended particulate matter (SPM)** are very harmful. The exhausts of vehicles release lead compounds. They are poisonous. The use of unleaded petrol is expected to reduce lead pollution.

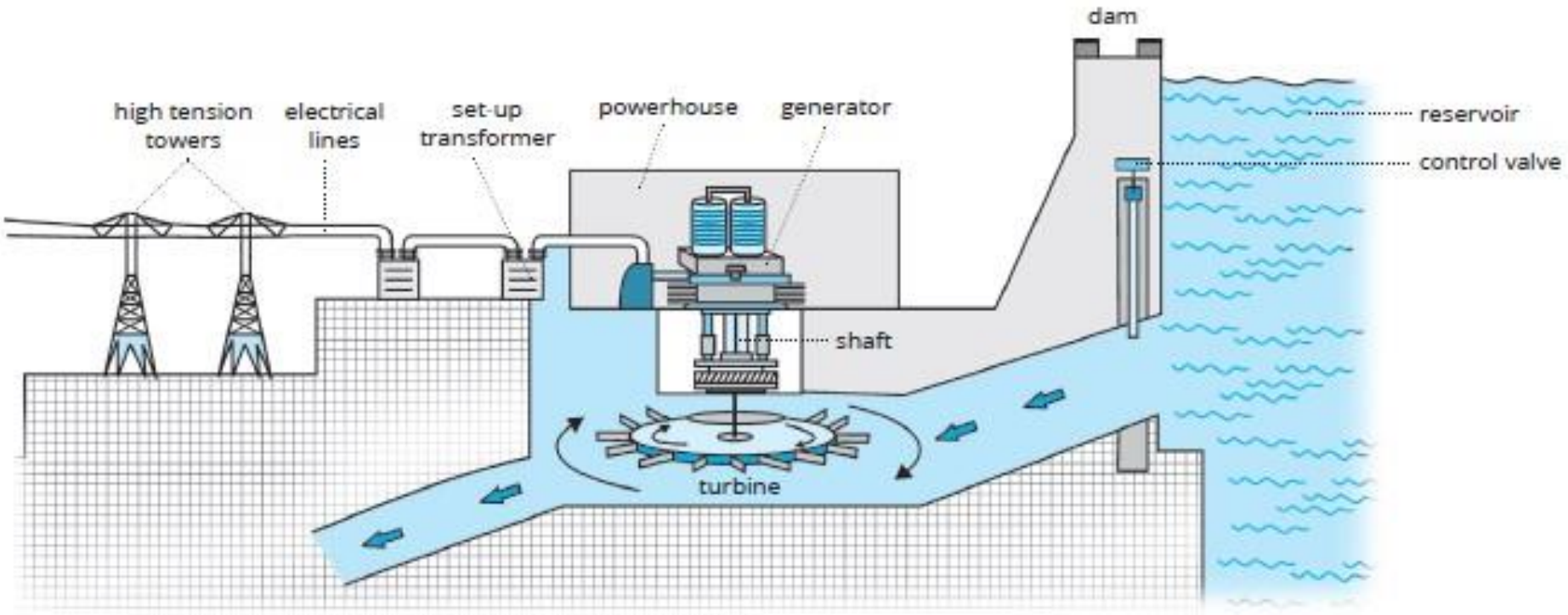
Hydropower Plants

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

Basic principle of producing hydroelectricity



Hydroelectric generator



Advantages of hydroelectricity generation

1.It 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.

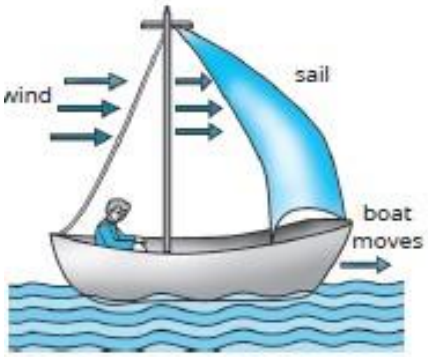
4. Hydropower plants constructed to generate hydroelectricity are multipurpose projects. They help in controlling floods, enable us to use water for irrigation, develop recreational sites, etc.

Disadvantages of hydroelectricity generation

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. Humans and animals have to migrate from this place.
3. Large ecosystems are destroyed when submerged under water in the dams.

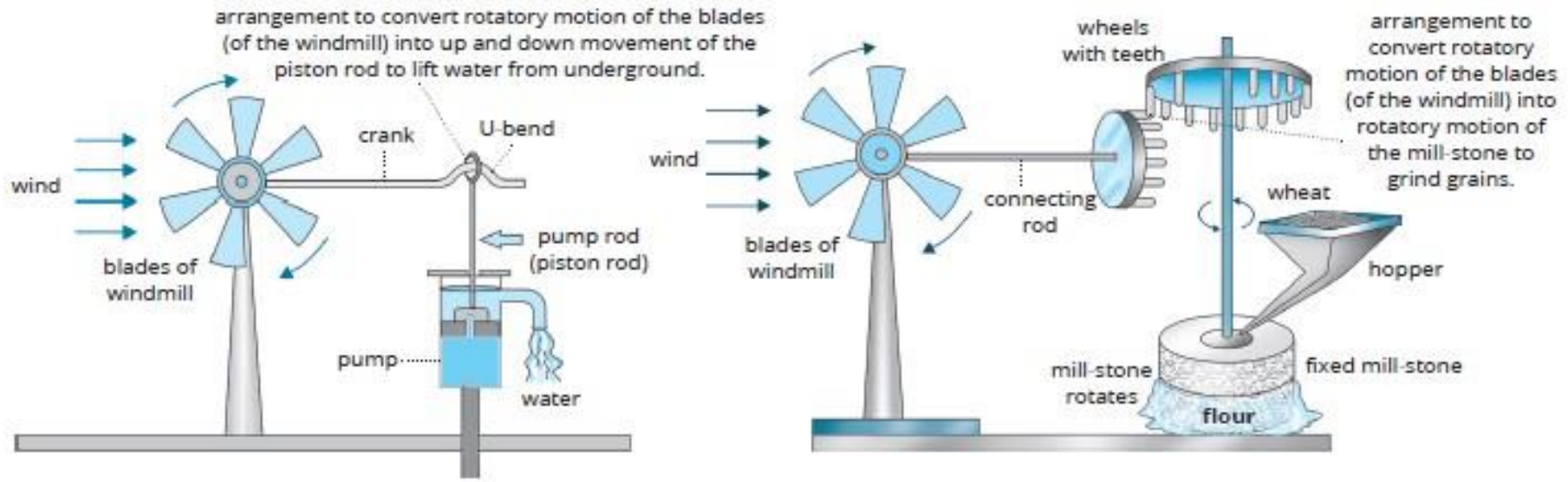
Wind Energy

When an object is in motion, it has kinetic energy. So, wind possesses kinetic energy. This kinetic energy of the wind can be used to do mechanical work. The energy of wind is used to propel the sailboats to transport man and materials from one place to another.



Basic principle of producing hydroelectricity

Technological innovation was made in the form of efficient **wind turbine generator** (modified windmills) which use wind energy to generate electricity. It consists of a rotator to which large-sized blades are fixed. The arrangement of the rotator and its blades is called **wind turbine**. The wind turbine is fixed over the top of a tall tower in such a way that the rotator and its blades are free to rotate. The shaft of the wind turbine is connected to the armature of an electric generator.



a. Windmill connected to water-lifting pump

b. Windmill connected to a flour mill

Wind energy farm

The electricity produced by a single windmill is quite less and cannot be used for commercial purposes. **A cluster of wind turbine generators installed over a large area is called a wind energy farm**. The electricity produced by each wind turbine generator is coupled together to produce electricity on a large scale which is used for commercial purposes.

Alternative or Nonconventional Sources of Energy

We should do the following to meet our increasing energy demands:

1. Develop the technology to use the conventional sources of energy.

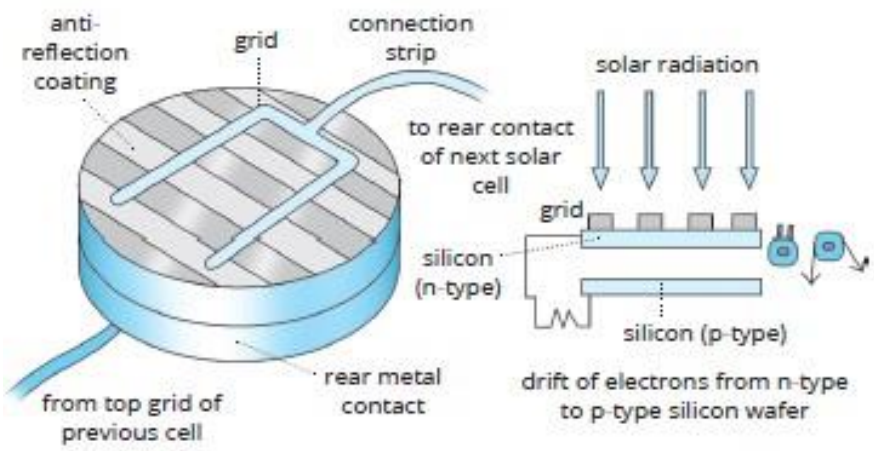
2. Shift our preference to renewable sources of energy.

3. Develop the technology to use non-conventional sources of energy like solar energy, energy from the sea, geothermal energy and nuclear energy.

Solar Energy

The sun is the ultimate source of all energy. The energy obtained from the sun is called solar energy.

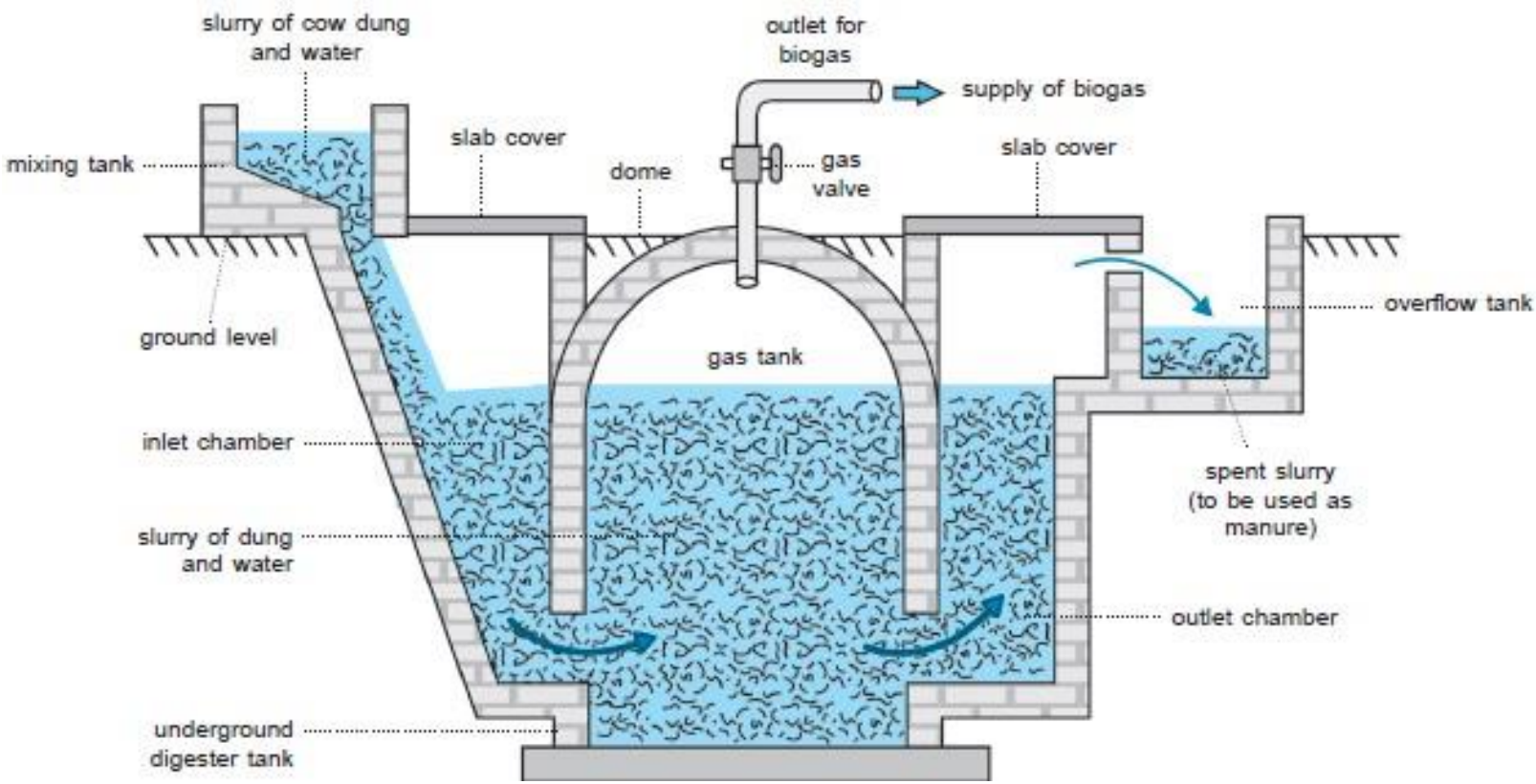
Solar Cell: A solar cell is a device which directly converts solar energy into electrical energy. In a solar cell, it is the light energy present in solar energy which gets converted into electrical energy. So, a solar cell is also called a **solar photo voltaic (SPV) cell**.



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

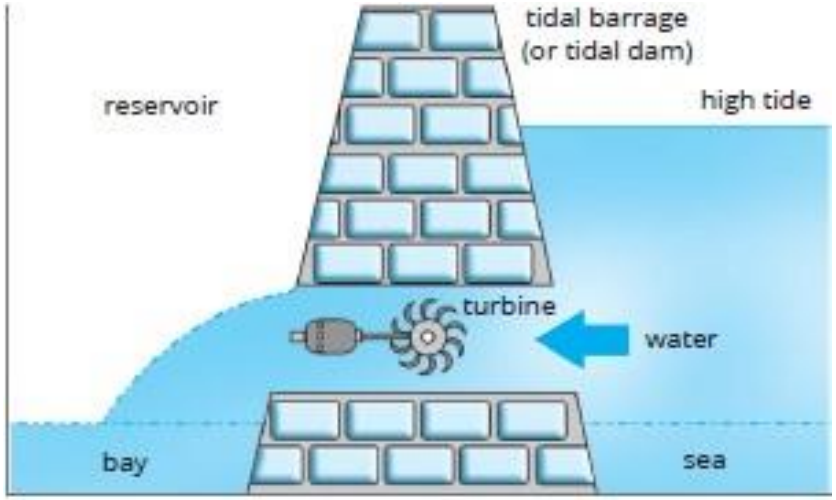
Biogas

Biogas is obtained by anaerobic fermentation of animal 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. The chief constituent of biogas is methane (present up to 75% by volume). Methane is an extremely good fuel.

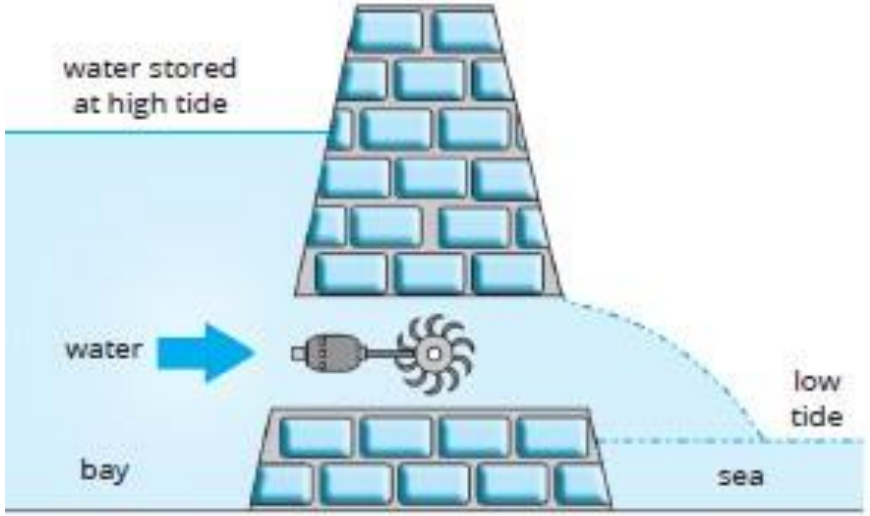


Tidal Energy

The alternate rise and fall in the water level of oceans and seas is known as tides. **These tides are caused due to the gravitational pull of mainly the moon (and to some extent the sun) on the water and the earth itself**. The rise of the ocean water is called high tide while the fall of the ocean water is called low tide. The tides can keep very huge amount of water in movement and therefore provide a source of large amount of energy. At places where water rises 5–6 metres during high tide, we can construct a tidal power plant to harness energy from tides. **The energy obtained from tidal waves is known as tidal energy**.



a. At high tide, water flows from sea into reservoir and turns the turbine



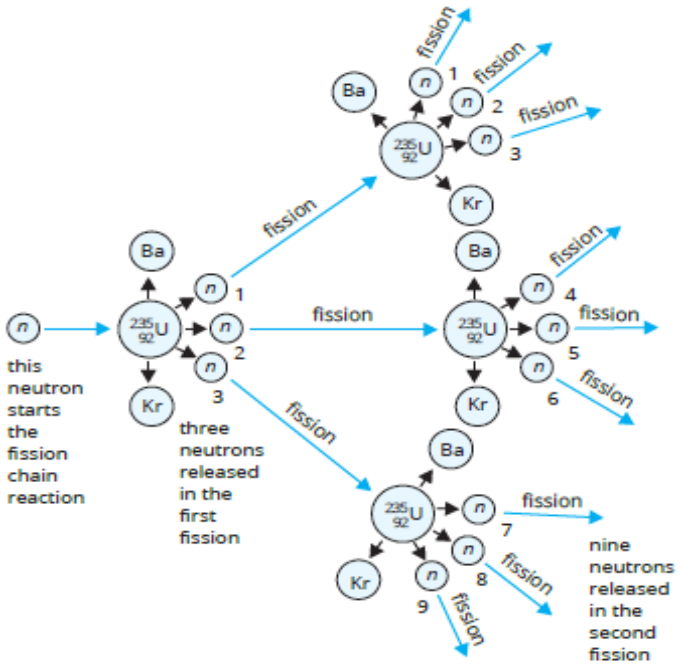
b. At low tide, stored water flows out from reservoir into sea and turns the turbine

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. The nuclear energy can be obtained by two ways: **a.** Nuclear fission **b.** Nuclear fusion.

Nuclear Fission

The process of splitting of the nucleus of a heavy atom such as $^{235}_{92}U$ (by bombarding with slow neutrons) into two or more lighter nuclei with the liberation of enormous amount of energy is called nuclear fission. For example, when uranium-235 atoms are bombarded with slow moving neutrons, the heavy uranium breaks up to produce two medium weight atoms, barium-139 and krypton-94 with the emission of 3 neutrons. A large amount of energy is produced during the reaction.



Uncontrolled chain reaction during the fission of U-235

Conservation of Energy

According to the law of conservation of mass, in a nuclear fission reaction, the mass of the original nucleus must be equal to the sum of the masses of the individual products formed. But from **mass spectrography, 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 the masses of the individual product nucleons is called **mass defect** or **loss in mass**.

According to Einstein's mass-energy equivalence, in a nuclear reaction, the loss in mass (mass defect) is converted into energy. The energy so obtained is called nuclear energy.

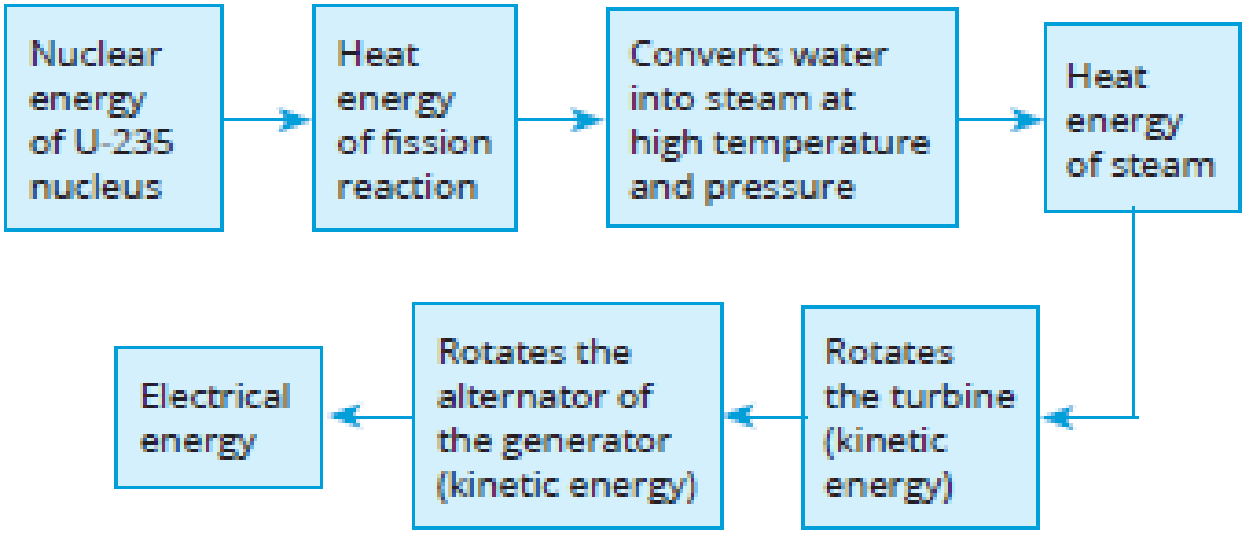
If Δm is the loss in mass, the nuclear energy released (E) according to Einstein's equation is

$$E = \Delta m c^2$$

where Δm = mass defect or loss in mass, c = speed of light in vacuum. The energy released in nuclear reactions is expressed in units of electron volt (eV) or million electron volt (MeV).

Electricity from Nuclear Energy

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. In a nuclear power plant, the energy transforms in the following sequence:



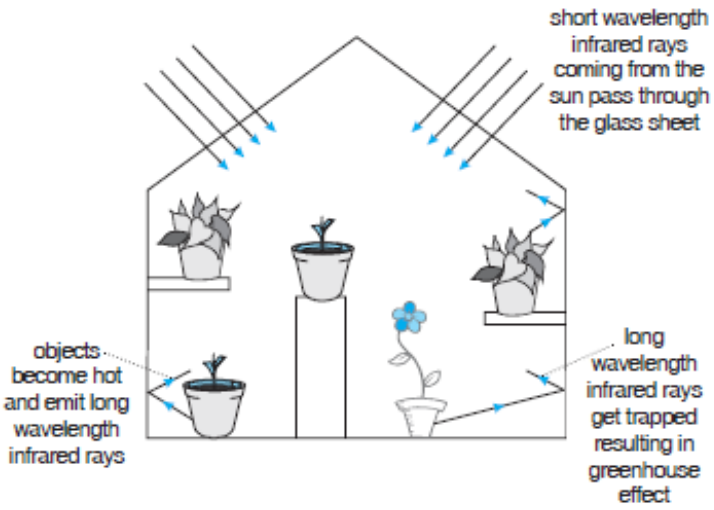
Nuclear Fusion

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. For example, two deuterium atoms (heavy hydrogen atoms with mass number 2) combine to form a heavy nucleus of helium and a neutron is emitted. A large amount of energy is also produced during the reaction.

Note: Refer to **Table 8.3 for** Comparison between nuclear fission and nuclear fusion

Greenhouse Effect

When fossil fuels like coal, petrol and diesel are burnt in vehicles, by factories, in power stations and homes, a lot of carbon dioxide, methane, water vapour, etc. (also known as greenhouse gases) enter the atmosphere of the Earth. Since plants take in carbon dioxide during photosynthesis and give out oxygen, large scale deforestation also contributes to the increase in the percentage of carbon dioxide, methane, etc. in air.



A layer of these gases acts as a wall of a greenhouse allowing sunlight to pass through it but preventing re-radiation of too much heat from the earth's surface into the space. However, excess concentration of these gases in air trap more heat from sunlight and results in the rise in temperature of the earth's atmosphere. This is known as greenhouse effect.

Global Warming

Global warming is the increase in the average temperature of the Earth near its surface, air and oceans. The increase in atmospheric greenhouse gases like carbon dioxide, methane, etc. due to human activity has caused most of the global warming observed. Increase in carbon dioxide content in the atmosphere enhances greenhouse effect. The excessive heat will then melt all the glaciers (snow mountains) and lead to the flooding of low lying areas of the earth.

Energy Degradation

Any energy which is used to do work is called usable energy. So, when any work has to be done, some usable energy is converted into unusable energy. Unusable energy does not perform any work and ultimately gets lost to the surroundings (and hence is not useful for any productive work). So, we conclude that when usable energy is used to do some work, it is consumed and cannot be used again.

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 due to their easy availability and also meet a major portion of energy requirement. 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 and meet energy requirement on a limited scale. For example, solar energy, ocean energy and geothermal energy.

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

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

9. Disadvantages of hydroelectric power plants: a. Leads to ecological imbalance **b.** large varieties of plants and trees are submerged **c.** creates problems of satisfactory rehabilitation **d.** decaying submerged vegetation produces greenhouse gases.

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

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

12. Advantages of wind energy: a. Environment-friendly and efficient source of energy **b.** renewable source of energy **c.** available free of cost.

13. 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.

14. Solar energy: The energy obtained from the sun.
15. Solar cell: A device which directly converts solar energy into electrical energy.
16. 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.
17. Advantages of nuclear energy: a. Tremendous amount of energy **b.** no air pollution **c.** economical cost of production of electricity in long run.
18. Disadvantages of nuclear energy: **a.** Huge installation cost **b.** high risk of environmental contamination **c.** limited supply of uranium.
19. Environmental consequences: Use of a source of energy disturbs the environment.
♦ Hydroelectric power plant—plants and trees get submerged, man and animals have to migrate.
♦ Windmills—affects the routes of the migratory birds.
♦ Nuclear power plant—emission of radiations results in contamination of environment.
20. Greenhouse effect: The heating of the earth's surface and its lower atmosphere by the trapping of infrared radiations (by the atmospheric gases) is called greenhouse effect.