

Energy: - Whenever a body is capable of doing work, the body is said to possess energy. Thus energy is defined as the ability of a body to do work and the amount of energy possessed by a body is equal to the amount of work it can do when its energy is released.

Units of energy: -

On S.I. system, energy is measured in the units of joules or in calories, and on C.G.S. system in ergs. However, the commercial unit of energy is kilowatt-hour. The energy is said to be one kilowatt-hour, when a body consumes one kilowatt of energy in one hour.

Sources of energy : a source of energy is that which is capable of providing enough useful energy at a steady rate over a long period of time.

A good source of energy should be :

- i) Safe and convenient to use, e.g., nuclear energy can be used only by highly trained engineers with the help of nuclear power plants. It cannot be used for our household purposed.
- ii) Easy to transport, e.g., coal, petrol, diesel, LPG etc. Have to be transported from the places of their production to the consumers.
- iii) Easy to store, e.g., huge storage tanks are required to store petrol, diesel, LPG etc.

Characteristics of an ideal or a good fuel:

1. It should have a high calorific or a heat value, so that it can produce maximum energy by low fuel consumption.
2. It should have a proper ignition temperature, so that it can burn easily.]
3. It should not produce harmful gases during combustion.
4. It should be cheap in cost and easily available in plenty for everyone.
5. It should be easily and convenient to handle, store and transport from one place to another.
6. It should not be valuable to any other purpose than as a fuel.
7. It should burn smoothly and should not leave much residue after its combustion.

Classification of sources energy :

The sources of energy can be classified as follows :

- (i) **Renewable** (ii) **Non-Renewable.**

1. **Renewable sources of energy :-** Renewable sources of energy are those which are inexhaustible, i.e., which can be replaced as we use them and can be used to produce energy again and again.

These are available in an unlimited amount in nature and develop within a relatively short period of time.

Examples of Renewable Sources of Energy.

(i) *Solar energy*, (ii) *Wind Energy*, (iii) *water energy (hydro-energy)*, (iv) *geothermal energy*, (v) *ocean energy*, (vi) *biomass energy (firewood, animal dung and biodegradable waste from cities and crop residues constitute biomass).*

Advantages of Renewable Sources of Energy :

- (i) These sources will last as long as the Earth receives light from the sun.
- (ii) These sources are freely available in nature.
- (iii) These sources do not cause any pollution.

2. Non-Renewable Sources of Energy :

Non-renewable sources of energy are those which are exhaustible and cannot be replaced once they have been used.

These sources have been accumulated in nature over a very long period of million of years.

Examples of Non-renewable sources of Energy :

- (i) *Coal* (ii) *Oil and* (iii) *Natural gas.*

All these fuels are called fossil fuels.

Disadvantages of Non-renewable sources of Energy :

- (i) Due to their extensive use, these sources are fast depleting.
- (ii) It is difficult to discover and exploit new deposits of these sources.
- (iii) These sources are a major cause of environmental pollution.

Conventional and Non-conventional Sources of Energy :

Sources of energy are also classified as : (i) Conventional sources of energy (ii) Non-conventional sources of energy.

Conventional sources of energy : Are those which are used extensively and a meet a marked portion of our energy requirement and these are :

- (a) Fossil fuels (coal, oil and natural gas) and
- (b) Hydro energy (energy of water flowing in rivers).

Biomass energy and wind energy also fall in this category as these are being used since ancient times.

Non-conventional sources of energy : Are those which are not used as extensively as the conventional ones and meet our energy requirement only on a limited scale. Solar energy, ocean energy (tidal energy, wave energy, ocean thermal energy, OTE), Geothermal energy and nuclear energy belong to this category. These sources of energy which have been tapped with the aid of advances in technology to meet our growing energy needs are also called alternative sources of energy.

Wind Energy: -When large masses of air move from one place to another it is referred to as wind. During this process kinetic energy gets associated with it which is referred to as wind energy.

Principle of utilisation of wind energy: -

Wind energy is efficiently converted into electrical energy with the aid of a windmill. A windmill is a large fan having big blades, which rotate by the force exerted by moving wind on them. These blades remain continuously rotating as long as wind is blowing and can be used to drive a large number of machines like water pumps, flour mills etc. But these days a windmill is used to generate electric current which is used for various purposes and therefore wind power stations are established all over the world which convert wind energy directly into electrical energy.

Uses of wind energy: -

The important uses of wind energy are;

- 1. It is used to drive windmills, water lifting pumps and flour mills etc.
- 2. It is used to propel sail boats.
- 3. It is used to fly engine less aeroplanes or gliders in the air.
- 4. It is used to generate electricity used for various purposes like lightening, heating etc.

Advantages of generating wind energy: -

The chief advantages of using wind energy are;

1. It is readily and abundantly available at every place of the earth free of cost.
2. It is eco-friendly and does not produce any kind of environmental pollution.
3. It is a renewable source as air itself is a renewable and inexhaustible resource.
4. It is a cheap source of energy, as it does not involve any costly investment.

Fossil Fuels :

Fossil fuels are the remains of prehistoric plants and animals which got buried deep inside the earth millions of years ago due to some natural processes.

The energy of fossil fuels is in fact, that solar energy which was trapped by natural processes a very long time ago. Coal, petroleum and natural gas are fossil fuels.

Formation of Fossil Fuels: During its formation, an entire organism or its parts often get buried in sand or mud. These, then decay and disintegrate leaving no signs of their existence. Infact, the harder parts of organisms after their death, settle down and are covered by sediments and subjected to extreme pressure and temperature of the earth converts them into fossil fuels, the process being referred to as fossilization.

Disadvantages of Fossil Fuels:

1. The fossil fuels are non-renewable sources of energy and once used cannot be renewed.
2. Burning of fossil fuels causes air pollution.
3. The fossil fuels reserves in the earth are limited and may get exhausted soon.

Solar Energy:- The energy produced by the sun in the form of heat and light energy is called as solar energy.

Principles of utilisation of Solar Energy: - Solar energy is utilised by the involvement of two main principles:

- (i). ***In the appliances requiring a moderate temperature***, the incident sun rays are reflected by a plain mirror on a black container which absorbs the solar energy and gets heated .
- (ii). ***In the appliances requiring a high temperature***, the incident sun rays are reflected and concentrated by using a large concave reflector which focuses all the sun rays at a single point called focus and any object kept at the focus gets strongly heated.

Harnessing or utilisation of Solar energy:- The sun is the ultimate source of energy having a remarkable capacity to produce energy in the form of heat and light. The energy produced by the sun in one day is about 50,000 times more than the energy consumed in the whole world in one year. But solar energy has certain limitations, which does not facilitate its large-scale utilisation. However, solar energy can be put to use in two differ ways Viz.

1. **Direct utilization:** - Directly the solar energy can be used either by collecting it as heat energy or by converting it into electricity.
- 2) **Indirect utilization:** - Indirectly the solar energy can be utilized by converting it into chemical energy like biomass or by utilising the energy obtained from wind, sea waves, tides etc.

Solar Heating Devices: - A device that gets heated by absorbing solar energy radiated by the sun in the form of heat and light energy is called a solar heating device. For eg. Solar cooker, solar water heater, solar furnace and solar cells are solar heating devices.

Solar cooker: - A solar cooker is a device which utilises solar energy for cooking food material. It consists of an insulated wooden box (B) painted with black from inner side. The lid of the box is provided with a plane mirror reflector (R) and a glass sheet (G). The food to be cooked is placed in a metal container (C) painted with black from outer side and kept in the box. The container is covered with the glass sheet. The box is then kept in direct sunlight and its reflector is adjusted in such away that a strong beam of sun light falls over it.

Working: - When the solar cooker is kept in direct sunlight, the reflector (R) reflects both visible and infrared rays of the sunlight on to the top of the box in the form of a strong beam of light. The black surface of the box and the vessel absorbs it. When the inner black surface becomes quite hot, it also starts radiating heat energy in the form of infrared rays, but the upper glass sheet (G) does not allow these rays to pass through it and go outside the box. As a result, these infrared rays get absorbed in the box, which increases its internal temperature up to about 1000C. This high temperature cooks the food material kept in the metallic container inside the box.

Limitations of solar Cooker:-

1. It can not be used during night.
2. On a cloudy day, it can not be used.
3. The direction of the reflector has to be adjusted according to the position of the sun.
4. It can not be used for making 'chappatis'.
5. It can not be used for frying.

Solar cell: - A solar cell is a device which converts solar energy (light energy) directly into electricity. It is made of semi-conducting material like silicon, germanium, selenium or gallium. A modern solar cell is made from wafers of semi conducting materials containing impurities in such away that a potential difference gets generated when light falls on them. A 4 cm 2 solar cells produces a potential difference of about 0.4--0.5volts and generate about 60 milli-amperes of current. To generate a large amount of current a number of solar cells are arranged together in a definite pattern in a solar panel. The energy (electric current) generated in a solar panel is stored in a battery connected to it and can be used for various purposes.

Uses of a solar cell: - The solar cells are used effectively in various fields, but some of its important uses are:

Solar cells are used for production of electricity for lighting, houses, streets etc. Solar cells are used for production of electricity to run electronic appliances like televisions, radios, watches, calculators, toys, toy games etc. Solar cells are used to develop electricity for offshore oil drilling platforms etc. Solar cells are used to generate electricity in artificial satellites, rockets, and space vehicles etc.

Hydro electricity: - When the water flowing in a river is stored in a high rise dam and allowed to fall from the top of the dam. The water rushes down with a great force, which can be utilised to drive large water turbine. These turbines are connected with electric generators, which generate electric current. The electricity generated in this process is termed as hydro electricity or hydel power. Infact the process involves transference of potential energy of the water into kinetic energy and then into electric energy.

Advantages of generating hydro electricity :- The main advantages of using water energy for the generation of hydro electricity are listed as under :

1. It is readily and abundantly available everywhere free of cost.
2. It is eco-friendly and does not produce any kind of environmental pollution.
3. It is a renewable source as water itself is a renewable and inexhaustible resource.
4. It is a cheap source of energy, as it does not involve any costly investment.

Energy from Oceans : - The oceans acquire almost 71% of the surface of the earth and the enormous amount of water present in them not only act as a big collector of solar heat energy, but also store large amount of it due to its high specific heat. Thus ocean water can be used as a renewable resource of energy. The main forms of ocean energy are described as under;

i) Ocean Thermal energy :- The energy available due to the temperature difference between the deeper levels and surface of an ocean is called as ocean thermal energy.

ii) Ocean Tidal energy :- The rise of ocean water due to attraction of the moon is referred to as high tide and its fall as low tide. The enormous movement of water due to high and low tide provide a large amount of energy known as ocean tidal energy. This tidal energy can be utilised by constructing a tidal barrage or dam.

iii) Sea wave energy:- The energy obtained from the high speed sea waves is referred to as sea wave energy. Infact these high speed sea waves have a lot of kinetic energy associated with them, which can used to drive dynamos which convert kinetic energy into electrical energy.

iv) Energy from Nuclear deuterium of oceans:- The ocean water contains unlimited amount of heavy hydrogen isotope called deuterium which is isotope hydrogen having one proton and one neutron in its nucleus. Scientists are working hard to produce energy by carrying by out controlled nuclear fission of deuterium isotope. The process is still in its experimental stage.

v) Energy from Salinity gradient in seas:- The difference in the concentration of salts in the water of the two or more seas is called as salinity gradient. This salinity gradient is now a day used to obtain energy with the involvement of suitable techniques.

vi) Energy from sea vegetation or biomass:- Sea vegetation or biomass is another direct source of energy because the enormous amount of sea weeds present in the sea water provides an endless supply of methane fuel.

Limitations of Energy from Oceans :-

The limitations of energy that can be obtained from the oceans are:

- i) Tidal Energy for which very few suitable sites are available for construction of dams and the power generation is intermittent and not very large.
- ii) Wave Energy where power output is variable and the presently available technologies are very expensive.
- iii) Ocean Thermal Energy where the conversion efficiency is low (3% - 4%) and a lot of capital investment is required.

Bio-Mass:- Biomass is defined as living matter or its residue and is a renewable sources of energy.

The biomass includes (i) all the new plant growth (ii) agricultural and forest residues (like biogases, bark, saw dust, wood shavings, roots, animal droppings etc.) (iii) Carbonaceous wastes (like sewage, garbage, night-soil, etc.) (iv) Biodegradable organic effluent from industries.

Biogas:- Biogas is a mixture of gases produced by anaerobic degradation of biomass in the presence of water but in the absence of oxygen.

It is a renewable source of energy on account of its production from vastly and continuously available organic wastes.

Advantages of Biogas:-

- i) A biogas plant, being quite simple, can easily be built in rural areas. A small plant using dung from 3 to 4 heads of cattle is capable of supplying biogas for 6 hours daily for cooking purposes.
- ii) Biogas is a clean fuel that burns without smoke and leaves no ash.
- iii) The main constituent of biogas, i.e., ethane has a higher calorific value (55kJ/g) than of petrol (50kJ/g).
- iv) The spent slurry, being rich in nitrogen and phosphorus, is good manure.
- v) By using biogas, firewood is saved and deforestation is reduced.

Composition of Biogas:- Biogas is mainly composed methane (up to 75%), CO₂ (25%) and traces of other gases such as nitrogen and hydrogen. Whereas methane is a high value calorific fuel, carbon dioxide is an inert gas.

Biogas is prepared in biogas plants which are of two types: (i) Fixed Dome Type (ii) Floating Gas Holder Type.

Fixed Dome Type Biogas Plant:-

The main parts of fixed of dome type of biogas plants are:

1. Digester. It is well shaped underground tank made of bricks. Its roof is some-shaped which acts as a storage tank for biogas.
2. Mixing tank. It is constructed on the ground level where cattle dung and water are mixed.
3. Inlet tank. It is constructed underground below the mixing tank.
4. Overflow tank. It is constructed slightly below the level of mixing tank.
5. Outlet tank. It is constructed below the overflow tank.

Working of Biogas Plant:-

Cattle dung and water are mixed in equal proportion in the mixing tank to form slurry. This slurry is fed into the digester tank through inlet tank when the digester tank is filled about $\frac{2}{3}$ rd of its capacity, the dome is left free for collection of biogas. The slurry undergoes anaerobic fermentation and biogas is produced after 50 to 60 days. As biogas is collected in the dome it exerts pressure due to which spent slurry goes to the overflow tank through outlet tank and fresh slurry is fed into the digester and continuous supply of biogas is obtained. Spent slurry is used as manure.

Geothermal energy :- Geothermal energy is the heat of the earth and is the naturally occurring thermal energy found within rock formations and the fluids held within those formations.

Geothermal energy is one of those few sources of energy that do not come directly or indirectly from the solar energy.

The underground hot water in contact with hot spots changes into steam. As the steam is trapped between the rocks, it gets compressed to high pressure. At some places, hot water and steam gush out from the Earth's surface after making their way through large cracks between the rocks and form natural geysers. Geothermal energy carried by natural geysers is utilized for generating electricity.

Merits of geothermal Energy:-

1. Geothermal energy is the most versatile and least polluting renewable source of energy.
2. It can be harnessed for 24 hours throughout the year.
3. Geothermal energy is relatively inexpensive.
4. As compared to solar energy and wind energy, the power generation level of geothermal energy is higher.
5. Geothermal energy can be used for power generation as well as direct heating. In USA, water is pumped from underground hot water deposits and is used to heat houses.

Limitations of Geothermal Energy:

1. Geothermal hot spots are scattered and usually some distance away from the areas that need energy.
2. The overall power production has a lower efficiency (about 15%) as compared to that of fossil fuels (35% to 40%).
3. Though as a whole, geothermal energy is inexhaustible, a single site has a limited life span of about 10 years.
4. Noise pollution is caused by drilling operations at geothermal sites.

Nuclear Energy:-

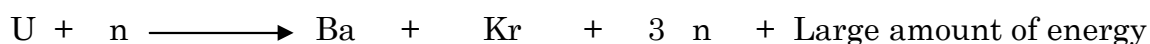
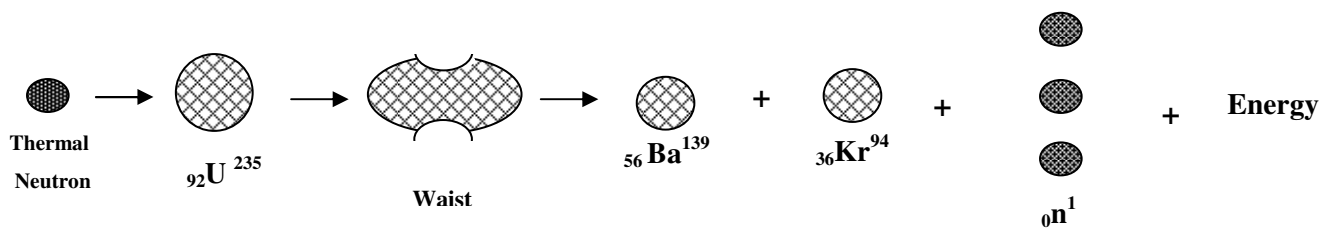
A reaction in which the nucleus of an atom undergoes a change to form a new atom and releases an enormous amount of energy is called as nuclear energy. There are two distinct ways of obtaining nuclear energy. a) Nuclear fission b) Nuclear fusion.

Nuclear Fission reaction:

This type of nuclear reaction was first of all reported by Otto Hahn in 1938. He stated that when an unstable heavy nucleus is bombarded with slow speed thermal neutrons, it splits into two small stable nuclei, liberates an enormous amount of heat and light energy.

When uranium 235 atoms are bombarded with slow moving thermal neutrons, it breaks up into two small stable nuclei of Barium and Krypton. The process also produces three

neutrons and an enormous amount of heat energy and light energy. The reaction involved is shown as under:



In all nuclear fission reactions, a small quantity of matter is lost i.e., the total mass of all the fission products is less than the total mass of the reactants. This lost matter gets converted into energy, which is released in any nuclear fission reaction. The energy (E) obtained due to loss of matter of mass m is given by the famous Einstein's equation.

$$E = mc^2$$

Nuclear Fusion reaction:

This type of nuclear reaction was first of all reported by Hans Bethe in 1939. The word 'fusion' means 'to combine together'. So, nuclear fusion means combining together of two or more nuclei to form a single nucleus. Thus, a process in which two lighter nuclei fuse (combine) together to form a stable heavier nucleus with a simultaneous release of a very large amount of energy is called nuclear fusion. The energy produced in a fusion reaction is much higher than that produced in a nuclear fission reaction.

Nuclear fusion takes place only at very high temperature, about 4 – 15 million degrees ($4 \times 10^6 \text{ }^\circ\text{C}$ – $15 \times 10^6 \text{ }^\circ\text{C}$). That is why nuclear fusion is also called thermonuclear reaction.

Advantages of Nuclear Energy:-

The advantages of nuclear energy are that:

- It produces a large amount of useful energy from a very small amount of a nuclear fuel (like uranium-235).
- Once the nuclear fuel (like uranium-235) is loaded into the reactor, the nuclear power plant can go on producing electricity for two to three years at a stretch. There is no need for putting in nuclear fuel again and again.
- It does not produce gases like carbon dioxide which contributes to greenhouse effect or sulphur dioxide which causes acid rain.

Disadvantages of Nuclear Energy :-

- The major hazard of nuclear power generation is the storage and disposal of spent or used fuels – the uranium still decaying into harmful subatomic particles (radiations).
- Improper nuclear-waste storage and disposal result in environmental contamination.
- There is a risk of accidental leakage of nuclear radiation.

iv) The high cost of installation of a nuclear power plant, high risk of environmental

contamination and limited availability of uranium makes large-scale use of nuclear energy prohibitive.

Environmental consequences of the increasing demand for energy:-

1. The combustion for fossil fuels is producing acid rain and damaging plants (crops), soil and aquatic life.
2. The burning of fossil fuels is increasing the amount of greenhouse gas carbon dioxide in the atmosphere.
3. The cutting down of trees from the forest (deforestation) for obtaining fire-wood is causing soil erosion and destroying wild life.
4. The construction of hydro-power plants is disturbing ecological balance.
5. Nuclear power plants are increasing radioactivity in the environment.

Difference between Nuclear fission and fusion:

Nuclear Fission	Nuclear Fusion
1) It involves breaking of a heavy nucleus into lighter nuclei into a heavy two light nuclei. 2) It is carried out by the bombardment of thermal two lighter nuclei up to neutrons over a heavy nucleus 3) It is a chain reaction. 4) It is a controlled process. 5) It produces an enormous amount of energy. 6) Fission products are hazardous.	1) It involves binding of two nucleuses. 2) It is carried out by heating an extreme temperature. 3) It is not a chain reaction. 4) It is an uncontrolled process. 5) It produces more energy than nuclear fission. 6) It does not cause pollution.