UNIT-III
Energy Resources, Electricity Bill & Safety Measures

Energy sources are classified into two major sets, Conventional Energy Sources
Non-conventional Energy Sources

1.Non-Renewable sources (or) Conventional energy sources : The sources of energy which once used cannot be replaced are called as non-renewable source of energy such as coal, petroleum etc.

2.Renewable sources (or) Non-Conventional energy sources: The source of energy which will never runout are called renewable source of energy such as sun, water, wind, tides and biomass etc.

1. Conventional Energy Sources:

Conventional energy sources are fully established and are mainly non-renewable. Conventional energy mainly comes from fossil fuels such as oil, natural gases and coal. They occur naturally under the earth's surface in the form of crude oil, which is extracted, purified and distilled to separate it into various petroleum products.

Advantages of Conventional Energy Sources:

- Required low cost Equipment
- These Sources readily available
- Gas stations are easily accessible in developed countries.

Disadvantages of Conventional Energy Sources:

- Depletion of fossil fuels
- Environmental Hazards
- Health Hazards
- Life cycle costs versus running costs

2. Non-Conventional Energy Sources:

- Non-conventional sources of energy on the other hand
- include mostly renewable sources
- Ex: solar energy, wind Energy, Biomass, ocean Energy,
- Intensive Agricultural & Hydro electric plants, Wave, Tidal & Hybrid etc.

Advantages of Non-Conventional Energy Sources:

- Non-Conventional Energy sources are environmentally friendly.
- Pollution free.
- These sources of energy are also renewable, meaning that utilizing them does not lead to any depletion.

Disadvantages of Non-Conventional Energy Sources:

- Most sources or renewable energy are periodic and never constant, rendering them quite unreliable.

Ex: wind energy that is undependable because the wind is not always blowing or sometimes not strong enough to drive the generators.

Difference between Conventional & Non – Conventional Energy Sources: Conventional Sources:

Conventional sources:

1. The conventional sources are nothing but commercial sources, which are obtained in a limited quantity.

Ex: Coal, Oil, Uranium etc.

2. These may be exhausted at one time and then won't be available. Thus named as non-renewable sources.

3. The per unit cost of this energy is higher , because of fuel cost.

4. The sources are lead to the cause at pollution.

5. It requires regular maintenance

6. Its energy yield ratio is very high.

7. It Produces energy in a short period of time.

8. Energy production can be done at any time.

Non-Conventional Sources:

1. The Non- conventional sources are not commercial sources, which are available naturally in large amounts.
Ex: Solar, wind, ocean etc.

2. If these sources are exhausted and again came into existence depends upon their seasons. Thus named as renewable sources.

3. The per unit cost of this energy is lower. Because of no fuel cost.

4. The sources are pollution less energy sources.

5. It does not requires regular maintenance.

6. Its energy yield ratio is very low.

7. It requires much time to produce an amount of energy.

8. Energy production can be done at some particular time.
9.Installation Cost is High.

Hydro-electric Power Station

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a hydro-electric power station. Hydro electric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. In a hydro-electric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (i.e., product of head and flow of water) into mechanical energy at the turbine shaft. The turbine drives the alternator which converts mechanical energy into electrical energy. Hydro-electric power stations are becoming very popular because the reserves of fuels (i.e., coal and oil) are depleting day by day. They have the added importance for flood control, storage of water for irrigation and water for drinking purposes.

Advantages:

(i) It requires no fuel as water is used for the generation of electrical energy.

(ii) It is quite neat and clean as no smoke or ash is produced.

(iii) It requires very small running charges because water is the source of energy which is available free of cost.

(iv) It is comparatively simple in construction and requires less maintenance.

(v) It does not require a long starting time like a steam power station. In fact, such plants can be put into service instantly.

(vi) It is robust and has a longer life.

(vii) Such plants serve many purposes. In addition to the generation of electrical energy, they also help in irrigation and controlling floods.

(viii) Although such plants require the attention of highly skilled persons at the time of construction, yet for operation, a few experienced persons may do the job well.

Disadvantages

(i) It involves high capital cost due to construction of dam.

(ii) There is uncertainty about the availability of huge amount of water due to dependence on weather conditions.

(iii) Skilled and experienced hands are required to build the plant.

(iv) It requires high cost of transmission lines as the plant is located in hilly areas which are quite away from the consumers.

Choice of Site for Hydro-electric Power Stations:

The following points should be taken into account while selecting the site for a hydro-electric power station :

(i) Availability of water. Since the primary requirement of a hydro-electric power station is the availability of huge quantity of water, such plants should be built at a place (e.g., river, canal) where adequate water is available at a good head.

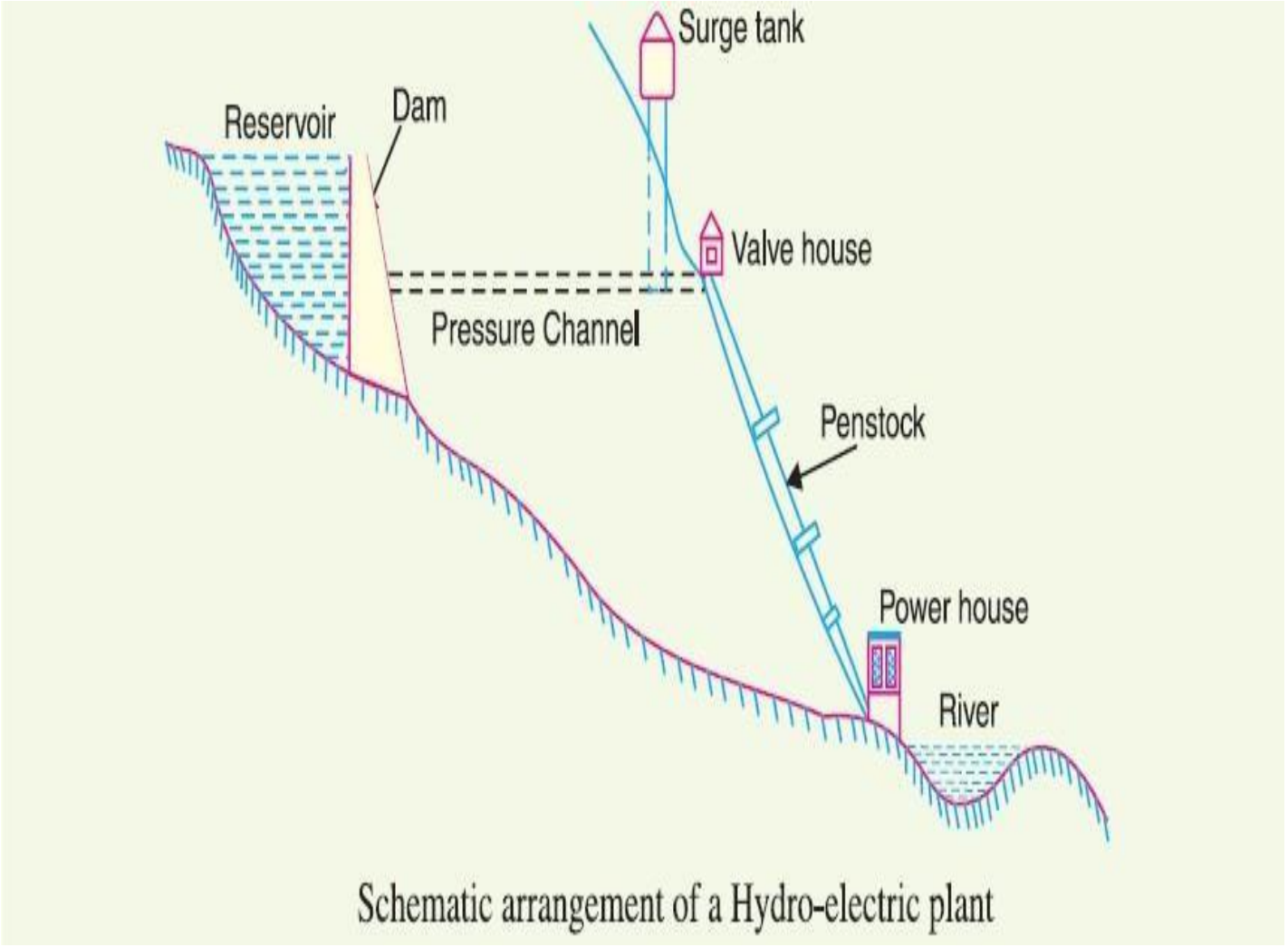
(ii) Storage of water. There are wide variations in water supply from a river or canal during the year. This makes it necessary to store water by constructing a dam in order to ensure the generation of power throughout the year. The storage helps in equalizing the flow of water so that any excess quantity of water at a certain period of the year can be made available during times of very low flow in the river.

(iii) Cost and type of land. The land for the construction of the plant should be available at a reasonable price. Further, the bearing capacity of the ground should be adequate to withstand the weight of heavy equipment to be installed.

(iv) Transportation facilities. The site selected for a hydro-electric plant should be accessible by rail and road so that necessary equipment and machinery could be easily transported.

Schematic Arrangement of Hydro-electric Power Station:

Hydro-electric power station simply involves the conversion of hydraulic energy into electrical energy. The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock. The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy. A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close* due to electrical load being thrown off. When the gates close, there is a sudden stopping of water at the lower end of the penstock and consequently the penstock can burst like a paper log. The surge tank absorbs this pressure swing by increase in its level of water.



Schematic arrangement of a Hydro-electric plant

Constituents of Hydro-electric Plant

The constituents of a hydro-electric plant are

(1) hydraulic structures

(2) water turbines and

(3) electrical equipment

1. Hydraulic structures. Hydraulic structures in a hydro-electric power station include dam, spillways, head works, surge tank, penstock and accessory works.

(i) Dam. A dam is a barrier which stores water and creates water head. Dams are built of concrete or stone masonry, earth or rock fill. The type and arrangement depends upon the topography of the site. A masonry dam may be built in a narrow canyon. An earth dam may be best suited for a wide valley. The type of dam also depends upon the foundation conditions, local materials and transportation available, occurrence of earthquakes and other hazards.

(ii) Spillways. There are times when the river flow exceeds the storage capacity of the reservoir. Such a situation arises during heavy rainfall in the catchment area. In order to discharge the surplus water from the storage reservoir into the river on the downstream side of the dam, spillways are used. Spillways are constructed of concrete piers on the top of the dam. Gates are provided between these piers and surplus water is discharged over the crest of the dam by opening these gates.

(iii) Surge tank. A surge tank is a small reservoir or tank (open at the top) in which water level rises or falls to reduce the pressure swings in the conduit. A surge tank is located near the beginning of the conduit. The excess water at the lower end of the conduit rushes back to the surge tank and increases its water level. Thus the conduit is prevented from bursting.

(v) Penstocks. Penstocks are open or closed conduits which carry water to the turbines. They are generally made of reinforced concrete or steel. Concrete penstocks are suitable for low heads (< 30 m) as greater pressure causes rapid deterioration of concrete. The steel penstocks can be designed for any head, the thickness of the penstock increases with the head or working pressure.

2. Water turbines. Water turbines are used to convert the energy of falling water into mechanical energy.

3. Electrical equipment. The electrical equipment of a hydro-electric power station includes alternators, transformers, circuit breakers and other switching and protective devices.

NUCLEAR POWER GENERATING SYSTEMS

Nuclear Power Station :A generating station in which nuclear energy is converted into electrical energy is known as a nuclear power station. In nuclear power station, heavy elements such as Uranium (U235) or Thorium (Th232) are subjected to nuclear fission in a special apparatus known as a reactor. The heat energy thus released is utilized in raising steam at high temperature and pressure. The steam runs the steam turbine which converts steam energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy. The most important feature of a nuclear power station is that huge amount of electrical energy can be produced from a relatively small amount of nuclear fuel as compared to other conventional types of power stations. It has been found that complete fission of 1 kg of Uranium (U235) can produce as much energy as can be produced by the burning of 4,500 tons of high-grade coal. Although the recovery of principal nuclear fuels (i.e., Uranium and Thorium) is difficult and expensive, yet the total energy content of the estimated world reserves of these fuels are considerably higher than those of conventional fuels such as coal, oil and gas. At present, energy crisis is gripping us and, therefore, nuclear energy can be successfully employed for producing low cost electrical energy on a large scale to meet the growing commercial and industrial demands.

Advantages:

(i) The amount of fuel required is quite small. Therefore, there is a considerable saving in the cost of fuel transportation.

(ii) A nuclear power plant requires less space as compared to any other type of the same size.

(iii) It has low running charges as a small amount of fuel is used for producing bulk electrical energy.

(iv) This type of plant is very economical for producing bulk electric power.

(v) It can be located near the load centres because it does not require large quantities of water and need not be near coal mines. Therefore, the cost of primary distribution is reduced.

(vi) There are large deposits of nuclear fuels available all over the world. Therefore, such plants can ensure continued supply of electrical energy for thousands of years.

(vii) It ensures reliability of operation.

Disadvantages:

(i) The fuel used is expensive and is difficult to recover.

(ii) The capital cost on a nuclear plant is very high as compared to other types of plants.

(iii) The erection and commissioning of the plant requires greater technical know-how.

(iv) The fission by-products are generally radioactive and may cause a dangerous amount of radioactive pollution.

(v) Maintenance charges are high due to lack of standardization. Moreover, high salaries of specially trained personnel employed to handle the plant further raise the cost.

(vi) Nuclear power plants are not well suited for varying loads as the reactor does not respond to the load fluctuations efficiently.

(vii) The disposal of the by-products, which are radioactive, is a big problem. They have either to be disposed off in a deep trench or in a sea away from sea-shore.

Arrangement of Nuclear Power Station:

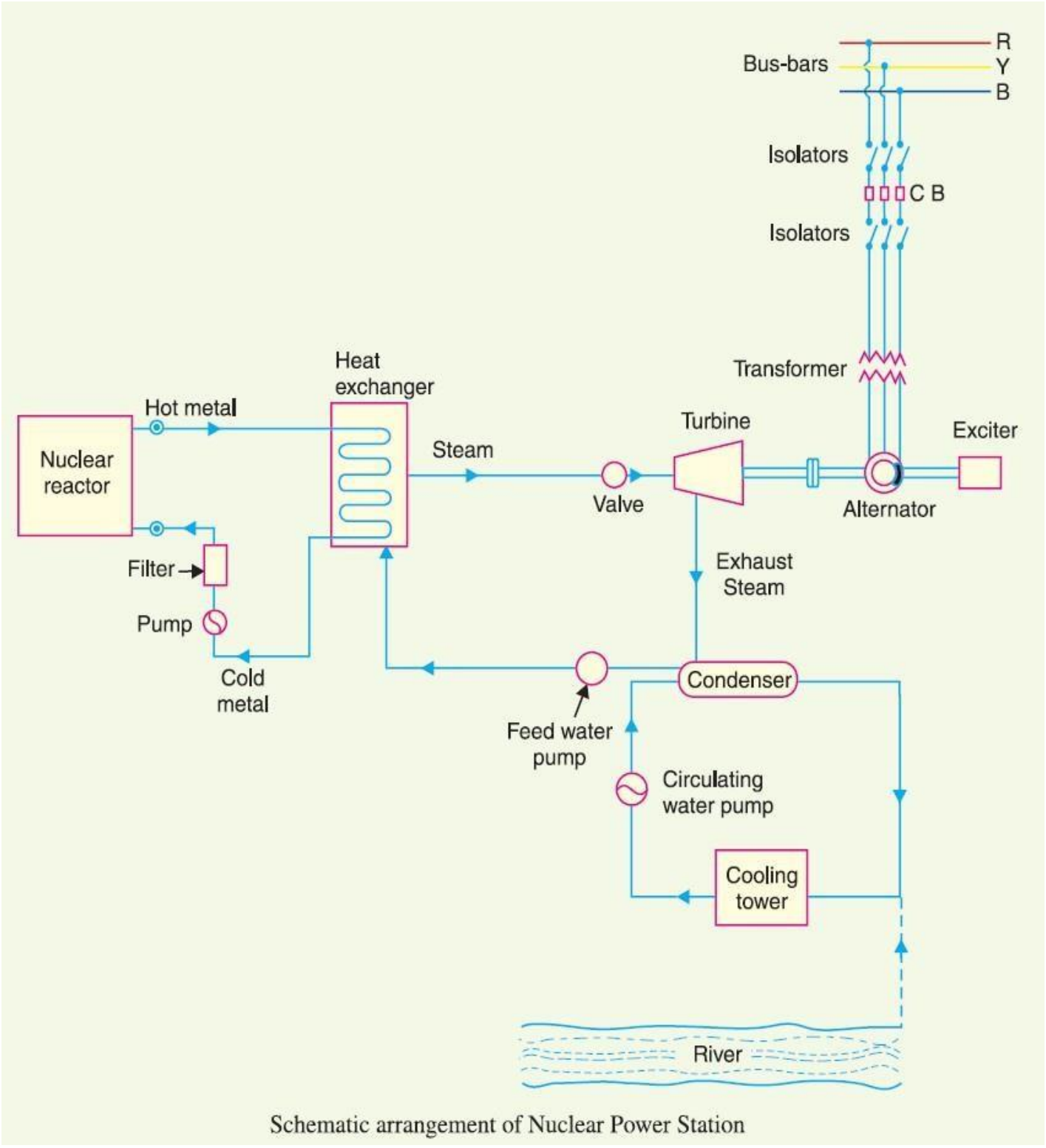
The whole arrangement can be divided into the following main stages :

(i) Nuclear reactor

(ii) Heat exchanger

(iii) Steam turbine

(iv) Alternator.

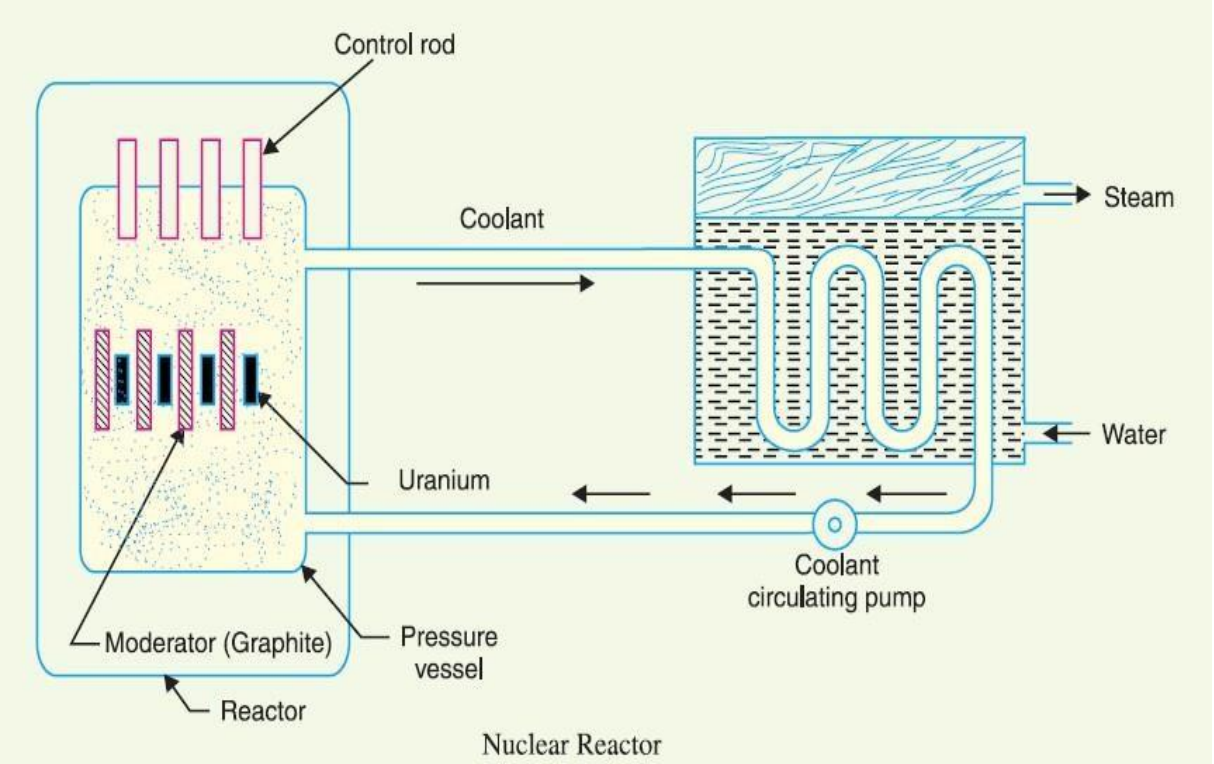


Schematic arrangement of Nuclear Power Station

(i) Nuclear reactor. It is an apparatus in which nuclear fuel (U235) is subjected to nuclear fission. It controls the chain reaction that starts once the fission is done. If the chain reaction is not controlled, the result will be an explosion due to the fast increase in the energy released.

A nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of Uranium, moderator and control rods. The fuel rods constitute the fission material and release huge amount of energy when bombarded with slow moving neutrons. The moderator consists of graphite rods which enclose the fuel rods. The moderator slows down the

neutrons before they bombard the fuel rods. The control rods are of cadmium and are inserted into the reactor. Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission. When the control rods are pushed in deep enough, they absorb most of fission neutrons and hence few are available for chain reaction which, therefore, stops. However, as they are being withdrawn, more and more of these fission neutrons cause fission and hence the intensity of chain reaction (or heat produced) is increased. Therefore, by pulling out the control rods, power of the nuclear reactor is increased, whereas by pushing them in, it is reduced. In actual practice, the lowering or raising of control rods is accomplished automatically according to the requirement of load. The heat produced in the reactor is removed by the coolant, generally a sodium metal. The coolant carries the heat to the heat exchanger.



Nuclear Reactor

(ii) Heat exchanger. The coolant gives up heat to the heat exchanger which is utilized in raising the steam. After giving up heat, the coolant is again fed to the reactor.

(iii) Steam turbine. The steam produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchanger through feed water pump.

(iv) Alternator. The steam turbine drives the alternator which converts mechanical energy into electrical energy. The output from the alternator is delivered to the bus-bars through transformer, circuit breakers and isolators.

Selection of Site for Nuclear Power Station:

(i) Availability of water. As sufficient water is required for cooling purposes, therefore, the plant site should be located where ample quantity of water is available, e.g., across a river or by sea-side.

(ii) Disposal of waste. The waste produced by fission in a nuclear power station is generally radioactive which must be disposed off properly to avoid health hazards. The waste should either be buried in a deep trench or disposed off in sea quite away from the sea shore. Therefore, the site selected for such a plant should have adequate arrangement for the disposal of radioactive waste.

(iii) Distance from populated areas. The site selected for a nuclear power station should be quite away from the populated areas as there is a danger of presence of radioactivity in the atmosphere near the plant. However, as a precautionary measure, a dome is used in the plant which does not allow the radioactivity to spread by wind or underground waterways.

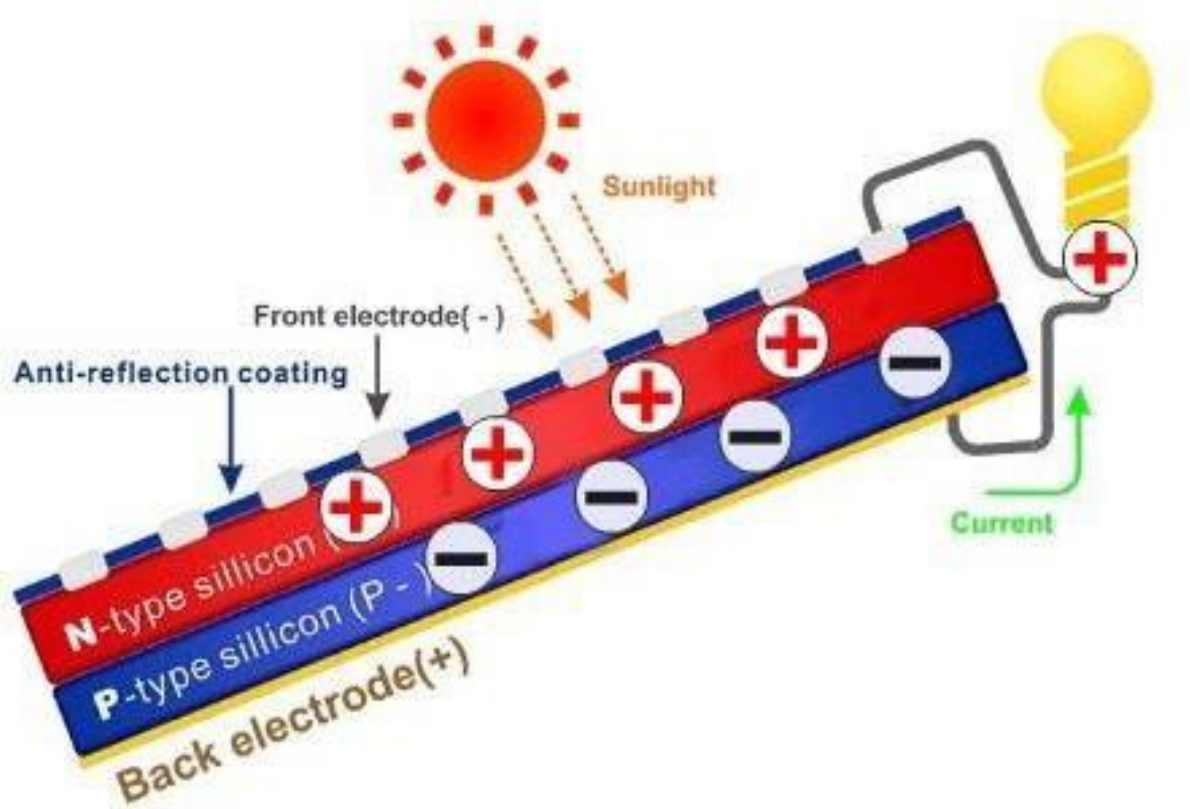
(iv) Transportation facilities. The site selected for a nuclear power station should have adequate facilities in order to transport the heavy equipment during erection and to facilitate the movement of the workers employed in the plant.

From the above factors for a nuclear power station would be near sea or river and away from thickly populated areas.

Solar Cell

A solar cell is made up of two layers of silicon that are treated to let electricity flow through them when exposed to sunlight. One layer is positively charged, the other negatively charged. As photons enter the layers, they give up their energy to the atoms in the silicon in the form of electrons.

Working Principle of Solar Cell

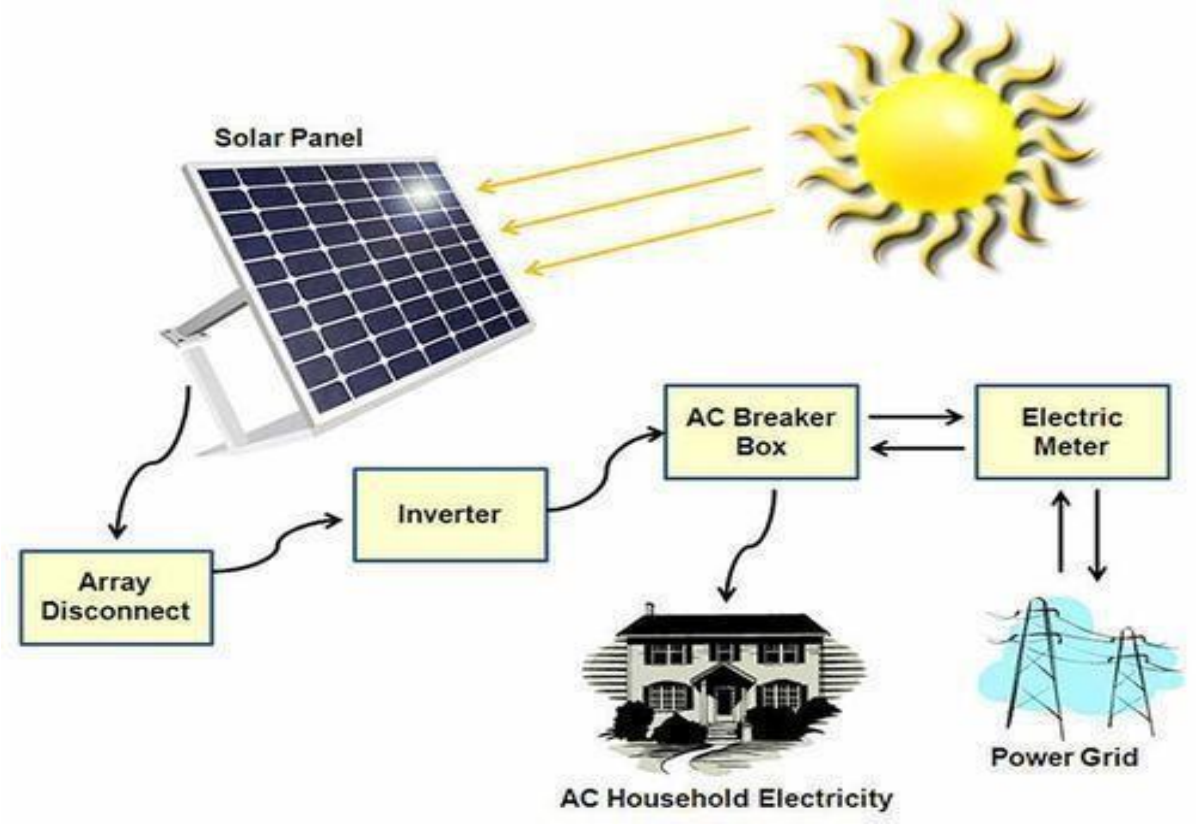


When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction.

Battery charge controller

A battery charge controller (BCC) regulates the flow of electricity from the PV generator to the battery. Its function is to regulate the voltage and current from the PV array in order to prevent overcharging and also over discharging of the battery.

Inverter: Function of an inverter is to convert the direct current (DC) power that solar panels create to alternating current (AC) power that is usable in homes and businesses or fed directly into the grid in front-of-the-meter projects (utility-scale solar arrays).



Materials Used in Solar Cell

Commonly used material is Silicon.

Advantages of Solar Cell

1. No pollution associated with it.
2. It must last for a long time.
3. No maintenance cost.

Disadvantages of Solar Cell

1. It has high cost of installation.
2. It has low efficiency.
3. During cloudy day, the energy cannot be produced and also at night we will not get solar energy.

Applications of PV cell:

Water Pumping: PV powered pumping systems are excellent, simple, reliable – life 20 yrs.

Commercial Lighting: PV powered lighting systems are reliable and low-cost alternative. Security, billboard sign, area, and outdoor lighting are all viable applications for PV.

Consumer electronics: Solar powered watches, calculators, and cameras are all everyday applications for PV technologies.

Telecommunications

Residential Power: A residence located more than a mile from the electric grid can install a PV system more inexpensively than extending the electric grid.

Wind Energy

Introduction

- Wind is simply air in motion.
- Wind is caused by the energy radiated to the Earth by the Sun

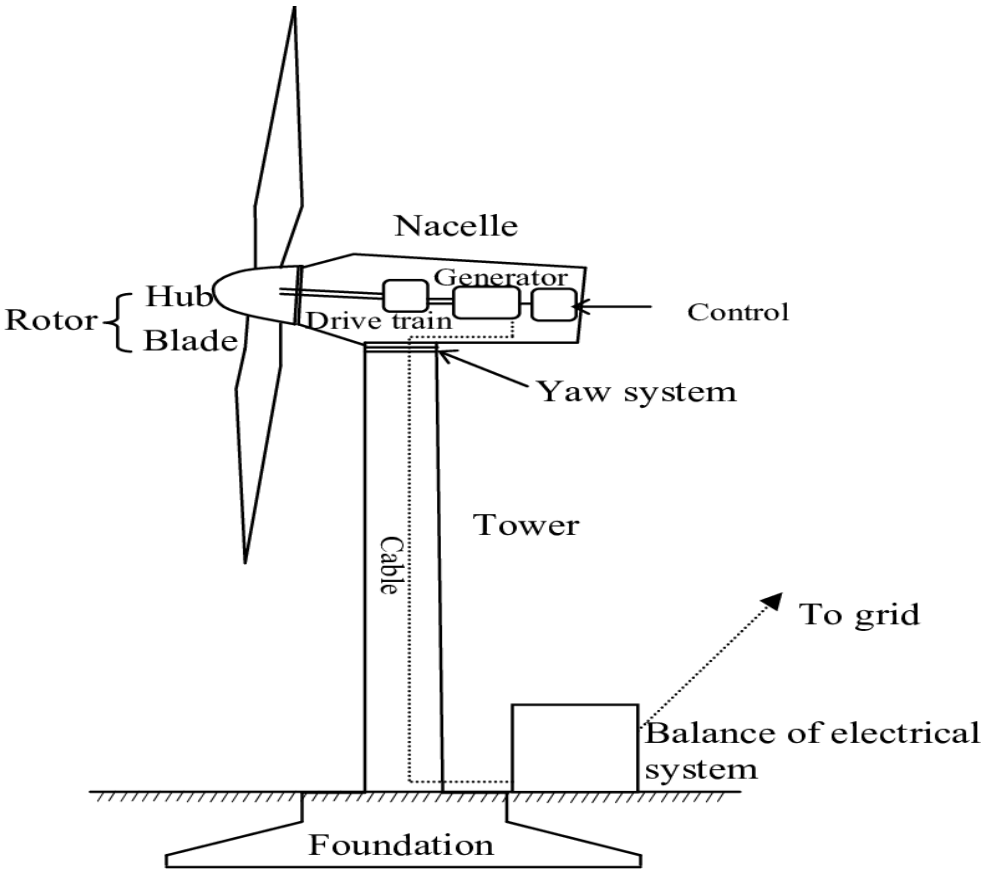
ADVANTAGES OF WIND ENERGY

* Wind power system is a renewable source of energy .
* Wind power systems are non-polluting .
* Wind energy systems avoid fuel provision .

DISADVANTAGES OF WIND ENERGY

*The available of wind energy is fluctuating in nature so wind energy needs storage capacity because of its irregularities .
*Wind energy systems are noisy in operating .
*Wind power systems have a relatively high overall weight .

Basic components of a WECS (Wind Energy Conversion System):



Horizontal Axis Machines: The axis of rotation is horizontal and aero turbine plane is vertical facing wind.

- Horizontal axis wind mills may be propeller type or multibladed type as shown in fig.
- Orientation of the axis of the rotors are kept along the horizontal axis .

- Most commonly used wind mills are propeller type with 2 or three blades.
- 2 blade designs are most effective but it faces the difficulty of vibrations during orientation to wind direction called YAW control.
- 3 blades are preferable , since its rotor is naturally balanced used for power generation.
- Wind mills are mounted on the top of the tower.
- Rotational speed of propeller type are in the range of 300-400rpm, while the speed of multiblade type wind mills are 60-80rpm.
- Material used for blades is glass fiber reinforced plastic.
- Diameter of rotors varies from 2m to 5m.

Advantages of horizontal axis wind mills:

- Tall towers allows access to stronger area in sites with wind shear.
- Tall towers allows placement on uneven load.
- Can be sited in forests above the tree line.
- Most are self-starting.
- Can be cheaper per unit of output because of higher production, and higher efficiency.
- Electric power generation
- Pumping water

Disadvantages of horizontal axis wind mills:

- Difficulty in operating the near ground, turbulent winds.
- Tall towers and long blades are difficult to transport on the sea and on the land.
- Height can create local opposition.

UNIT-III

Energy Resources, Electricity Bill & Safety Measures

Electricity bill

Power rating of household appliances

The Rating of an electrical appliance indicates the voltage at which the appliance is designed to work and the current consumption at that voltage. The Power rating of the appliance is related the power it consumes. Every electrical appliance has a power rating which indicates the amount of electricity required to do work. This is usually given in **watts (W) or kilowatts (kW).**

The Energy consumption of a device is calculated by multiplying the wattage of a device and operational hours

Energy consumption = Wattage X operational hours.

UNIT:

The unit of electrical energy consumed is kWh. One kilowatt-hour is the electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour.

Therefore 1kwh =1 unit.

Calculation of Power consumption of electrical home appliances.

Consider different home appliances to calculate approximate total energy consumption of house per month.

S.No	Appliances	Watts	NO	Total no of watts	Total no kilowatt (KW)	No of operational hours per day	Energy consumed in kwh(units) per day= energy consumed / 1000
1	Tube light	60 W	10	600	0.6	5	3
2	Fan	75 W	4	300	0.3	8	2.4
3	Refrigerator	200W	1	200	0.2	24	4.8
4	AC	1000W	1	1000	1	5	5
5	Laptop	50W	1	50	0.05	2	0.1
6	Television	50W	1	50	0.05	3	0.15
7	Grinders	1000W	1	1000	1	½	0.5
8	Printers	50W	1	50	0.05	½	0.025
9	Washing Machine	2000W	1	2000	2	1	2
10	Micro wave	1000W	1	1000	1	1	1
						Total	**18.9=19units**

Therefore per day 19 units of energy is consumed

For 1 month = 19 x 30 = **570 units per month**

Tariff

The electrical energy generated in generating station is delivered to a large number of consumers at reasonable rates.

Definition of tariff:

The rate at which the electrical energy is supplied to a consumer is known as **tariff.**

The tariff should include:

1. Recovery of cost of generating electrical energy in power stations
2. Recovery of cost of capital investment in transmission and distribution.
3. Recovery of operation and maintenance of supply of electrical energy.
4. A suitable profit on capital investment.

The consumers who have appreciable maximum demand for them two-part tariff method is employed.

Two Part Tariff

When the rate of electricity energy is charged on the maximum demand of the consumer and the units consumed is called two-part tariff.

In this tariff scheme, the total costs charged to the consumers consist of two components: fixed charges and variable charges. It can be expressed as:

Total Cost = [A (kW) + B (kWh)] Rs

Where, Fixed charges - A = charge per kW of max demand

Variable charges - B = charge per kWh of energy consumed.

The fixed charges will depend upon maximum demand of the consumer and the variable charge will depend upon the energy (units) consumed. The fixed charges are due to generation, transmission and maintenance.

Advantages

If a consumer does not consume any energy in a particular month, the supplier will get the return equal to the fixed charges.

Disadvantages

If a consumer does not use any electricity, he has to pay the fixed charges regularly.

The maximum demand of the consumer is not determined. Hence, there is error of assessment of max demand.

Electricity Bill

Calculation of electricity bill for low tension domestic consumer is as follows.

The electricity bill consists of two components: fixed charges and variable charges (running charges).

It can be expressed as:

Total Electricity Bill = [A kW + B kWh] + Tax

Where, Fixed charges - A = charge per kW of max demand

A=Total kW X charge per kW

Example: if the sanctioned load is 3KW then A= [1x85 + 2x95] = 275Rs

(Note: For 1kw it is 85 Rs and above 1kw it is 95 Rs per kw)

Where Variable charges - B = charge per kwh of energy consumed.

B = No of units consumed x rate per unit

Example: If the no of units consumed is 120 units then

B = [50 x 4.1 + 50 x 5.55 + 20 x 7.1] = 624 Rs

(Note: For 0 - 50 units – 4.1Rs per unit, 50 -100 units – 5.55 Rs per unit, 100 - 200 units – 7.1Rs per unit).
Therefore, Total Electricity bill for given example is = 275 +624+ Tax.

Equipment Safety measures

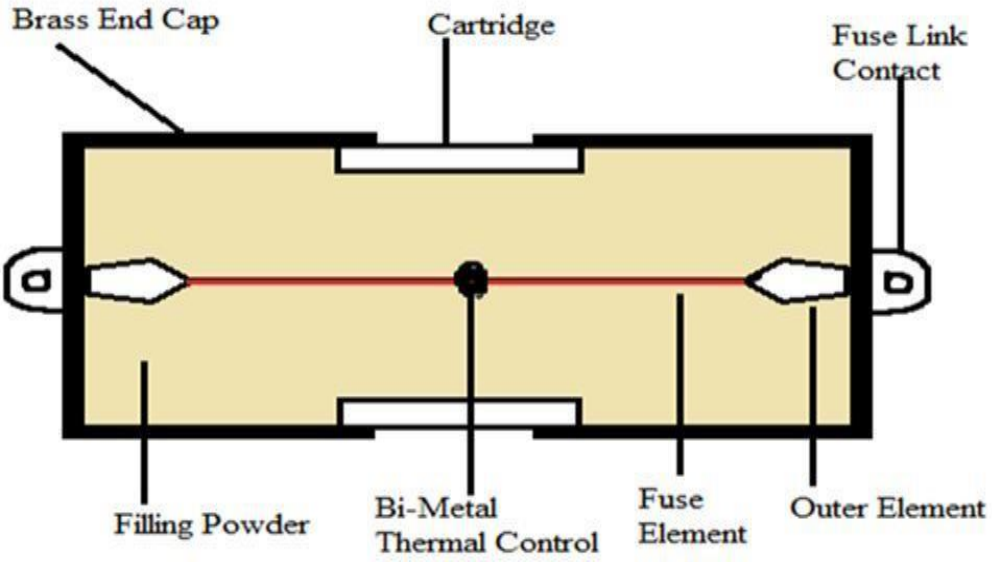
Protective Devices

Protection for electrical installation must be provided in the event of faults such as short circuit, overload and earth faults. The protective device must be fast acting and isolate the faulty part of the circuit immediately. It also helps in isolating only required part of the circuit without affecting the remaining circuit during maintenance. The following devices are usually used to provide the necessary protection:

- Fuses
- Relays
- Miniature circuit breakers (MCB)
- Earth leakage circuit breakers (ELCB)

Fuse:

An Electric Fuse is a protective device which interrupts the flow of excessive current in an Electric circuit. This works on the principle of heating effect of the Electric Current



A Fuse consists of conducting wire, which has high resistivity and low melting point. The thickness of the Fuse wire is determined based on the amount of current flow in the circuit. If a fault causes a flow of excess current, then a Conductor break the Circuit by melting or separating it, the thin Conductor used is known as an Electric Fuse. The wire inside the Fuse melts if there is an occurrence of high Current due to a short Circuit or an overloaded Circuit. As a result of which the Current stops flowing since the wire has broken. In order to stop the flow of Electricity. Once a Fuse melts, it can be changed or replaced witha new Fuse. A Fuse is normally made up of elements like zinc, copper, aluminum and silver.

Miniature circuit breaker (MCB):

An MCB - miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a molded insulating material.

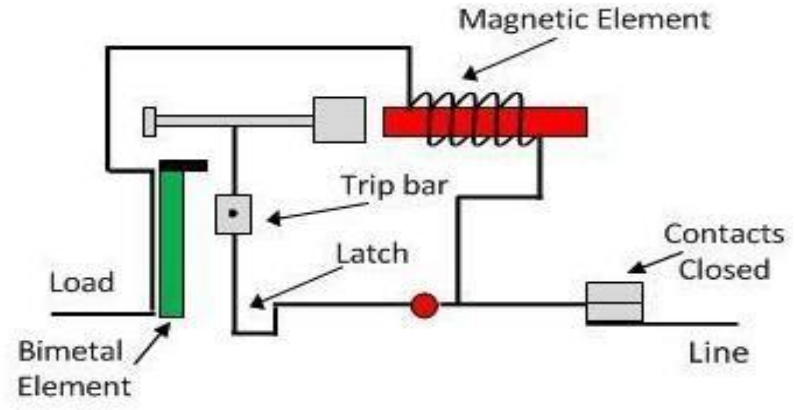
The main function of an MCB is to open the circuit automatically when the current passing through MCB exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary. An MCB is a simple, easily operable device and is maintenance-free too. It can be easily replaced.

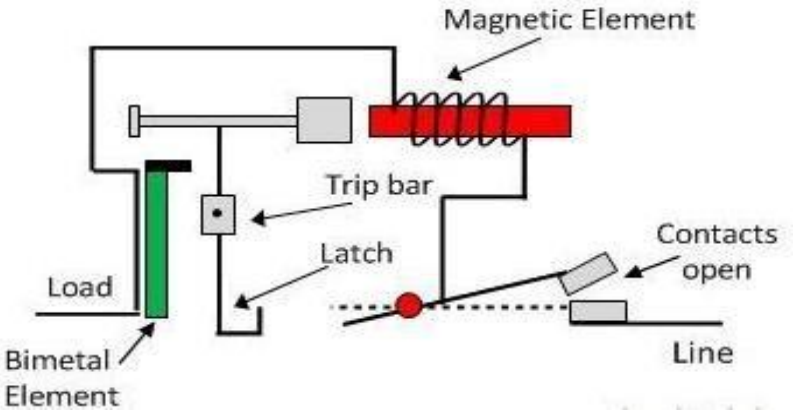
The trip unit is the key part of the MCB on which the unit operates. The bi-metal present in the MCB circuit protects against overload current and the electromagnet in the circuit protects against short-circuit current.

Working

When the overflow of current takes place through MCB, the bimetallic strip gets heated and it deflects by bending. The deflection of the bi-metallic strip or trip bar releases a latch. The latch causes the MCB to turn off by stopping the flow of the current in the circuit. This process helps to safeguard the appliances or devices from the hazards happening due to overload or overcurrent. To restart the flow of current, MCB must be turned ON manually.

In the case of short circuit conditions, the current rises suddenly in an unpredictable way, leading to the electromechanical displacement of the plunger associated with a solenoid. The plunger hits the trip lever, it causes the automatic release of the latch mechanism by opening the circuit breaker contacts.





Comparison between Electric Fuse and MCB

ELECTRIC FUSE	MINIATURE CIRCUIT BREAKER – MCB
Whenever excessive current flows through the fuse, the conducting material inside it melts down thereby interrupting the current flow.	An electromagnetic mechanism present inside the MCB helps it to instantaneously interrupt the current flow during faults.
Fuses other than rewireable fuses cannot bereused.	Miniature circuit breakers can be reused afterthe clearance of faults.
Fuses acts faster than MCB. Typicaltripping time 2ms.	Tripping time for MCB is 20ms.
Can protect against short circuit andoverloads.	Can protect against short circuit and overloads.
Cheaper than MCB.	MCB costlier than fuses.
Fuse cannot be used as an ON/OFFswitch.	The Circuit breaker is used as an ON/OFF switches.

Personal safety measures:

Electric shock and precautions:

An electric shock is the sudden discharge of electricity through a part of the body when a person comes in contact with electrical equipment.

The factors affecting the severity of shock are

1. Magnitude of the current through the body
2. Path of the current through the body
3. Time for which current is passed through the body
4. Frequency of the current
5. Physical and physiological condition of the person.

Precautions against Electric shock

- Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of the electric current.
- Never use equipment with damaged insulation. The insulation of conductors must be proper and in good condition.
- Earth connection should be maintained in proper condition
- Use of the fuses and cables of proper rating.
- Use the rubber soled shoes while working.
- Megger tests should be done to check the insulation.
- Never touch two different terminals at the same time.
- Never remove the plug by pulling wire.
- The sockets should be placed at a proper height.
- Switch off supply and remove the fuses before starting the work with any installation.
- Always use insulated screw drivers, and line testers.

Earthing:

Connection of the body of electric equipment to the general mass of the earth by wire of negligible resistance is called **Earthing**. It brings the body of the equipment to the zero potential during electric shock.

Necessity of Earthing

1. To protect the human beings from danger of shock in case they come in contact with the charged frame due to defective insulation.
2. It guarantees the safety of electrical appliances and devices from the excessive amount of electric current.
3. It protects the appliances from high voltage surges and lightning discharge.
4. It provides an alternative path for leakage of current hence protects the equipment.
5. It keeps the voltage constant in the healthy phase
6. It protects the Electric system and buildings from lightning.
7. It avoids the risk of fire in the electrical installation system.
8. To maintain the line voltage constant under unbalanced load condition.

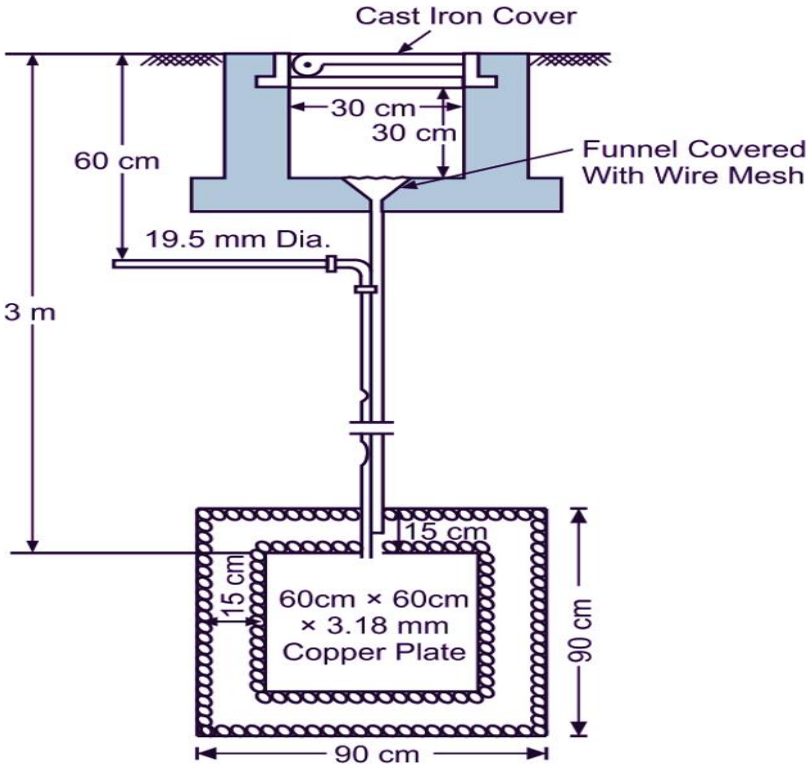
Types of Earthing

They are two types of earthing

1. Plate earthing
2. Pipe earthing

1. Plate Earthing:

In this method a copper plate or Galvanized Iron (GI) plate of 60cmX60cmX3.18cm is placed vertically down inside the ground at a depth of 3m. The plate is surrounded by the alternate layers of salt and coal with a minimum thickness of about 15cm. The earth wires drawn through the GI pipe are bolted through the earth plate. The GI pipe is fitted with the funnel on a top in order to have an effective earthing by pouring the salt water periodically. The schematic arrangement is as shown below.

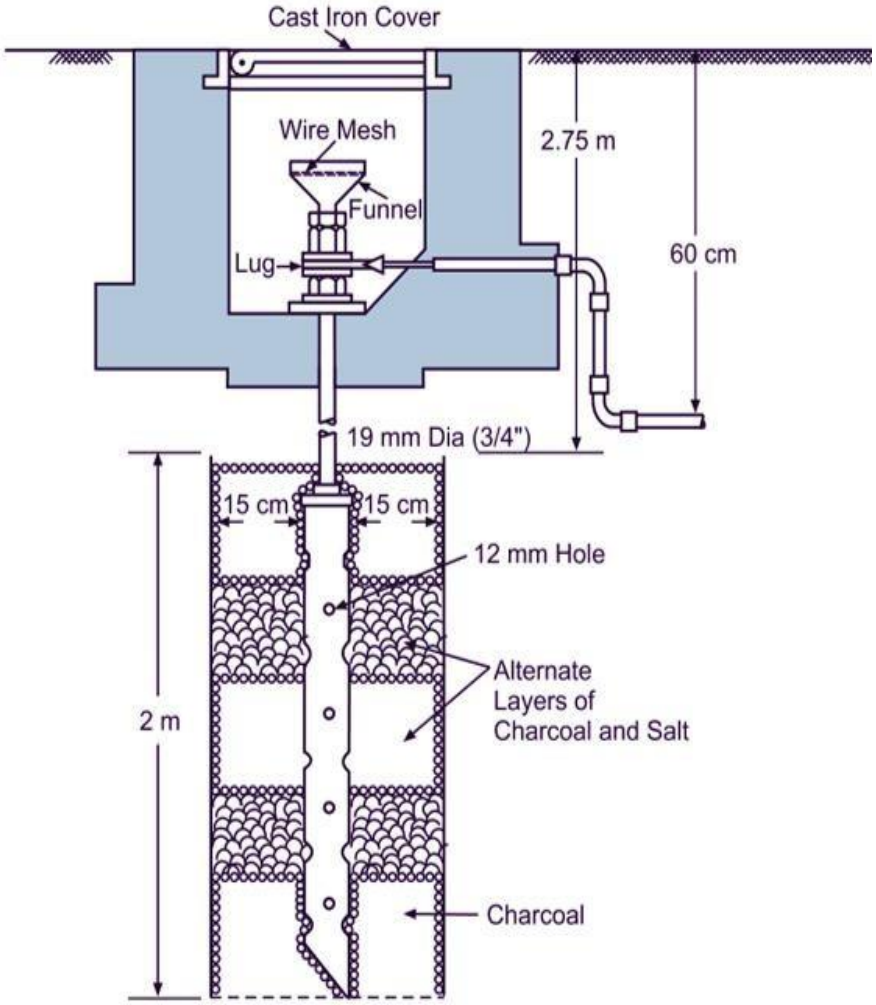


The earthing efficiency increases with the increase of the plate area and depth of the pit. The depth of the pit depends upon the resistivity of the soil.

The only disadvantage of this method is that discontinuity of earth wires from the earthing plate which is placed below the ground as it cannot be observed physically this may cause miss leading and result into heavy losses under fault condition.

2. Pipe Earthing:

In this method a Galvanized iron pipe of 38 mm diameter and length of 2 meters with 12 mm holes is placed vertically into the ground at a depth of 5m. This pipe acts as an earth electrode. The depth depends upon the condition of the soil. The schematic arrangement is as shown below.



The pit area around the pipe is filled with the alternate layers of salt and coal for improving the condition of the soil and earthing efficiency. The earth wires are connected to the top section of the pipe above the ground level with nut and bolts. The funnel is provided to pour the salt water.

The contact surface of GI pipe with the soil is more as compare to the plate. Hence it can handle large leakage current for the same electrode size. The earth wires connected to the GI pipe above the ground level can be physically inspected time to time.

The only disadvantage of pipe earthing is that, the pipe length has to be increased sufficiently in caseof soil of high specific resistivity. This increases excavation work and hence increased in cost.