UNIT III
ENERGY RESOURCES, ELECTRICITY BILL & SAFETY MEASURES

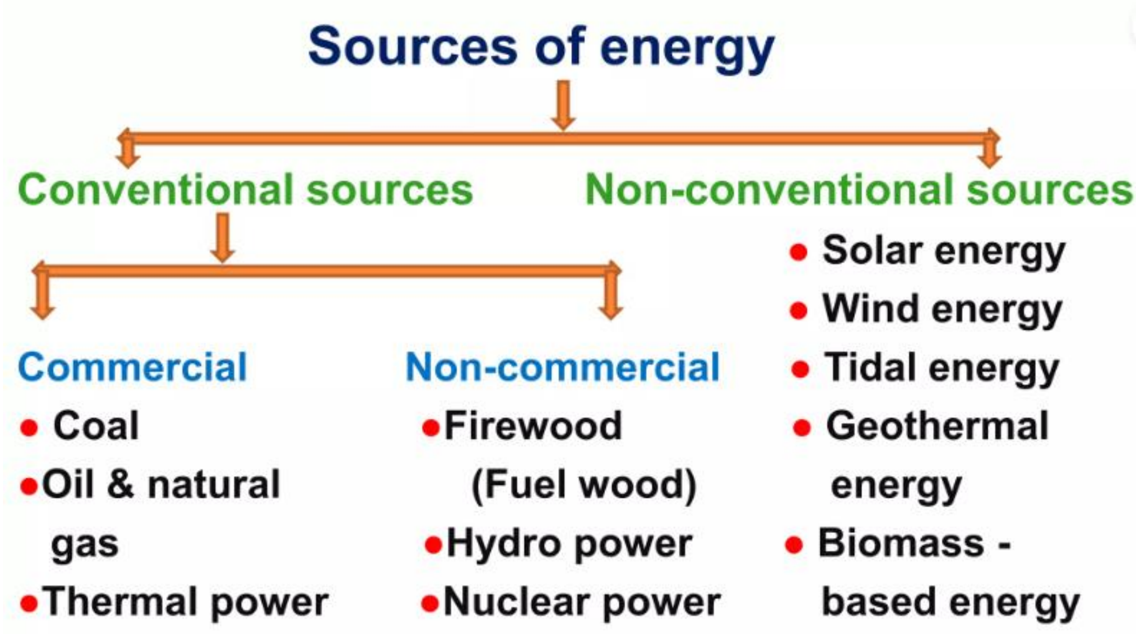
Energy Resources: Conventional and non-conventional energy resources; Layout and operation of various Power Generation systems: Hydel, Nuclear, Solar & Wind power generation.
Electricity bill: Power rating of household appliances including air conditioners, PCs, Laptops, Printers, etc. Definition of "unit" used for consumption of electrical energy, two-part electricity tariff, calculation of electricity bill for domestic consumers.
Equipment Safety Measures: Working principle of Fuse and Miniature circuit breaker (MCB), merits and demerits. Personal safety measures: Electric Shock, Earthing and its types, Safety Precautions to avoid shock.

SOURCES OF ENERGY:

The two major sources of energy is classified as:

- Conventional Sources
- Non-Conventional Sources

The classification of the sources of energy is given in the below image.



CONVENTIONAL SOURCES OF ENERGY

Conventional Sources of Energy are also known as non-renewable sources of energy and are available in limited quantity apart from hydro-electric power. Further, it is classified under commercial and non-commercial energy.

COMMERCIAL ENERGY SOURCES

Coal, electricity and petroleum are known as commercial energy since the consumer needs to pay its price to buy them.

Coal:

Coal is the most important source of energy. There are more than 148790 coal deposits in India, and between 2005-2006, the annual production went up to 343 million tons. India is the fourth-largest coal-producing country, and the deposits are primarily found in Bihar, Orissa, Madhya Pradesh, Jharkhand and Bengal.

Oil and Natural Gas:

Oil is considered liquid gold and one of the crucial energy sources in India and the world. Oil is primarily used in planes, automobiles, trains and ships. The total oil production in India was 0.3 million tons in 1950-51, which increased up to 32.4 million tons in 2000-01. It is mainly found in Assam, Gujarat and Mumbai.

Electricity:

Electricity is a common form of energy used for domestic and commercial purposes, and it is mainly utilized in electrical appliances like fridges, T.V, washing machines and air conditioning.
The major sources of power generation are:
i) Nuclear Power ii) Thermal Power iii) Hydro-electric power

Thermal Power: Thermal power is generated at various power stations utilizing oil and coal. It is a vital source of electric current, and its share in the nation's total capacity in 2004-05 was 70 percent.

Hydroelectric Power: Hydroelectric power is produced by constructing dams above flowing rivers like Damodar Valley Project and Bhakra Nangal Project. The installed capacity of hydroelectric power was 587.4 mW in 1950-51 and went up to 19600 mW in 2004-05.

Nuclear Power: The fuel used in nuclear power plants is Uranium, which costs less than coal. Nuclear power plants can be found in Kaiga (Karnataka), Kota (Rajasthan), Naroura (UP) and Kalapakam(Chennai).

NON-COMMERCIAL ENERGY SOURCES

Generally, the freely available energy sources are considered non-commercial energy sources. Examples of non-commercial energy sources include straw, dried dung, firewood.

NON-CONVENTIONAL SOURCES OF ENERGY

Non-conventional sources are also known as renewable sources of energy. Examples of non-conventional sources of energy include solar energy, bioenergy, tidal energy and wind energy.

Solar Energy:

Solar Energy is produced by sunlight. The photovoltaic cells are exposed to sunlight based on the form of electricity that needs to be produced. The energy is utilized for cooking and distillation of water.

Wind Energy:

Wind energy is generated by harnessing the power of wind and mostly used in operating water pumps for irrigation purposes. India stands as the second-largest country in the generation of wind power.

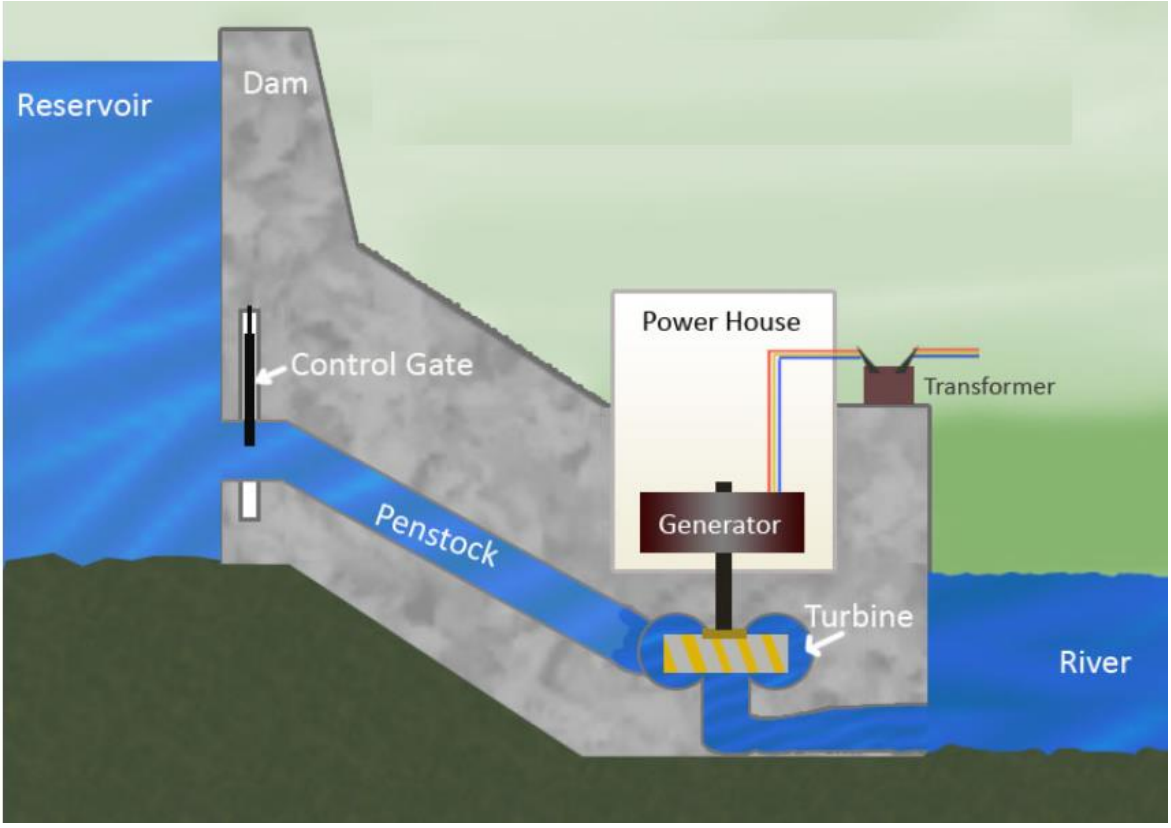
Tidal Energy:

Tidal energy is generated by exploiting the tidal waves of the sea. This source is yet to be tapped due to the lack of cost-effective technology.

Conventional	Non Conventional
Conventional sources of energy are those sources which have been use since the early times.	Non-conventional sources of energy have generally been identified in the recent past.
They are exhaustible except hydro-energy.	They are inexhaustible.
They cause pollution when used as they emit smoke and ash.	Generally these are pollution-free.
Their generation and use involve huge expenditure.	Low expenditure required.
Very expensive to maintain, store, transmit as they are carried over long distances through transmission grids.	Less expensive due to local use and easy maintenance.
Examples are – coal, natural gas, water, fire-wood.	Examples are – geothermal energy, solar energy, wind energy, tidal energy, biogas energy, nuclear energy.

LAYOUT AND OPERATION OF HYDEL POWER GENERATION SYSTEM

Generation of electricity by hydropower (potential energy in stored water) is one of the cleanest methods of producing electric power. In 2012, hydroelectric power plants contributed about 16% of total electricity generation of the world. Hydroelectricity is the most widely used form of renewable energy. It is a flexible source of electricity and also the cost of electricity generation is relatively low. The layout of hydel power generating system is shown in the fig.



Dam and Reservoir: The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (called as water head) in the reservoir determines how much of potential energy is stored in it.

Control Gate: Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water which is to be released in the penstock can be controlled by a control gate. When the control gate is fully opened, maximum amount of water is released through the penstock.

Penstock: A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

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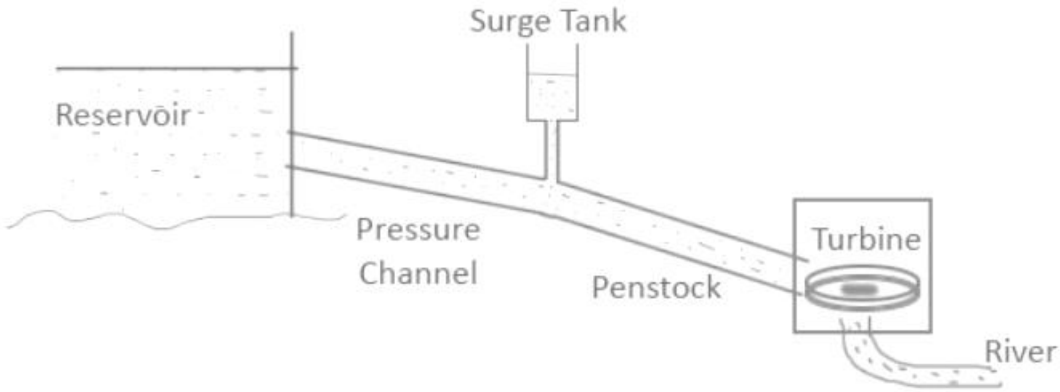
Water Turbine: Water from the penstock is taken into the water turbine. The turbine is mechanically coupled to an electric generator. Kinetic energy of the water drives the turbine and consequently the generator gets driven. There are two main types of water turbine; (i) Impulse turbine and (ii) Reaction turbine. Impulse turbines are used for large heads and reaction turbines are used for low and medium heads.

Generator: A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for the transmission purpose.

Surge Tank:

Surge tanks are usually provided in high or medium head power plants when considerably long penstock is required. A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the power house. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock. When there is sudden reduction in load on the turbine, the governor closes the gates of the turbine to reduce the water flow. This causes pressure to increase abnormally in the penstock. This is prevented by using a surge tank, in which the water level rises to reduce the pressure. On the other hand, the **surge tank** provides excess water needed when the gates are suddenly opened to meet the increased load demand.

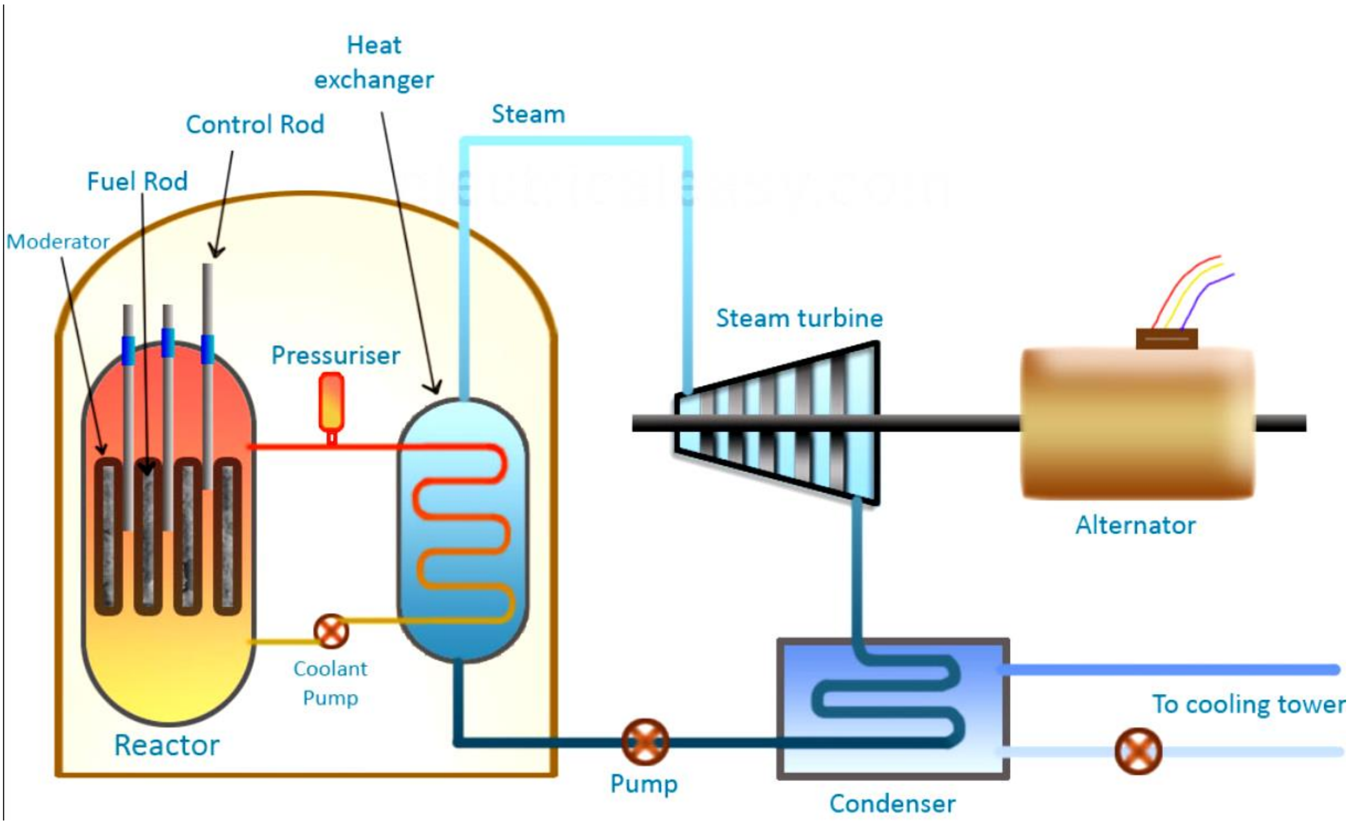


LAYOUT AND OPERATION OF NUCLEAR POWER GENERATION SYSTEM

In a nuclear power plant, heat energy is generated by a nuclear reaction called as nuclear fission. Nuclear fission of heavy elements such as Uranium or Thorium is carried out in a special apparatus called as a nuclear reactor. A large amount of heat energy is generated due to nuclear fission. Rest parts of a nuclear power plant are very similar to conventional thermal power plants. It is found that fission of only 1 Kg of Uranium produces as much heat energy as that can be produced by 4,500 tons of high grade coal. This considerably reduces the transportation cost of fuel, which is a major advantage of nuclear power plants. Also, there are large deposits of nuclear fuels available all over the world and, hence, nuclear power plants can ensure continued supply of electrical energy for thousands of years. About 10% of the total electricity of the world is generated in nuclear power plants.

Heavy elements such as Uranium (U^{235}) or Thorium (Th^{232}) are subjected to nuclear fission reaction in a nuclear reactor. Due to fission, a large amount of heat energy is produced which is transferred to the reactor coolant. The coolant may be water, gas or a liquid metal. The heated coolant is made to flow through a heat exchanger where water is converted into high-temperature steam. The generated steam is then allowed to drive a steam turbine. The steam, after doing its work, is converted back into the water and recycled to the heat exchanger. The steam turbine is coupled to an alternator which generates electricity. The generated electrical voltage is then stepped up using a transformer for the purpose of long-distance transmission.

The layout of nuclear power generating system is shown in the fig.



Nuclear Reactor

A nuclear reactor is a special apparatus used to perform nuclear fission. Since the nuclear fission is radioactive, the reactor is covered by a protective shield. Splitting up of nuclei of heavy atoms is called as nuclear fission, during which huge amount of energy is released. Nuclear fission is done by bombarding slow moving neutrons on the nuclei of heavy element. As the nuclei break up, it releases energy as well as more neutrons which further cause fission of neighbouring atoms. Hence, it is a chain reaction and it must be controlled, otherwise it may result in explosion. A nuclear reactor consists of fuel rods, control rods and moderator. A fuel rod contains small round fuel pallets (uranium pallets). Control rods are of cadmium which absorb neutrons. They are inserted into reactor and can be moved in or out to control the reaction. The moderator can be graphite rods or the coolant itself. Moderator slows down the neutrons before they bombard on the fuel rods.

Two types of nuclear reactors that are widely used -

1. **Pressurised Water Reactor (PWR) –**
   This type of reactor uses regular water as coolant. The coolant (water) is kept at very high pressure so that it does not boil. The heated water is transferred through heat exchanger where water from secondary coolant loop is converted into steam. Thus the secondary loop is

completely free from radioactive stuff. In a PWR, the coolant water itself acts as a moderator. Due to these advantages, pressurised water reactors are most commonly used.

2. **Boiling Water Reactor (BWR) –**

   In this type of reactor only one coolant loop is present. The water is allowed to boil in the reactor. The steam is generated as it heads out of the reactor and then flows through the steam turbine. One major disadvantage of a BWR is that, the coolant water comes in direct contact with fuel rods as well as the turbine. So, there is a possibility that radioactive material could be placed on the turbine.

Heat Exchanger

In the heat exchanger, the primary coolant transfers heat to the secondary coolant (water). Thus water from the secondary loop is converted into steam. The primary system and secondary system are closed loop, and they are never allowed to mix up with each other. Thus, heat exchanger helps in keeping secondary system free from radioactive stuff. Heat exchanger is absent in boiling water reactors.

Steam Turbine

Generated steam is passed through a steam turbine, which runs due to pressure of the steam. As the steam is passed through the turbine blades, the pressure of steam gradually decreases and it expands in volume. The steam turbine is coupled to an alternator through a rotating shaft.

Alternator

The steam turbine rotates the shaft of an alternator thus generating electrical energy. Electrical output of the alternator is the delivered to a step up transformer to transfer it over distances.

Condenser

The steam coming out of the turbine, after it has done its work, is then converted back into water in a condenser. The steam is cooled by passing it through a third cold water loop.

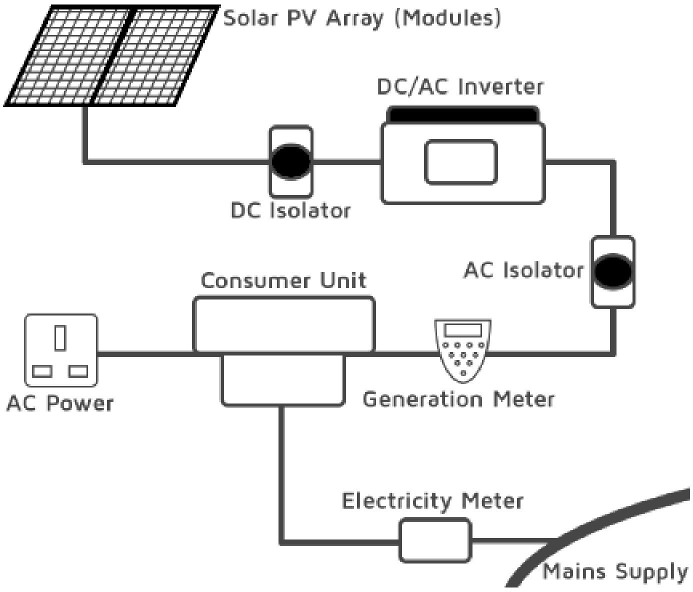
LAYOUT AND OPERATION OF SOLAR POWER GENERATION SYSTEM

Solar photovoltaic (PV) panels use cells containing a semi-conductor material to capture the sun's energy and convert solar radiation into electricity. The most commonly used semi-conductor material is silicon, which is an abundant natural resource found in sand. When light strikes the cell a certain amount of energy is absorbed within the semiconductor material, knocking electrons, the negatively charged particles that form the basis of electricity, loose.

Most PV cells have two layers of semi-conductor material, one positively charged and one negatively charged. When light shines on the semi-conductor the electric field across the junction between these two layers causes electricity to flow, generating direct current (DC). By placing metal contacts on the top and bottom of the PV cell, we can draw that current off for external use.

Solar PV electric panels do not require bright sunlight in order to operate, meaning that you can still generate electricity on cloudy days, however in general the greater the intensity of light the higher the flow of electricity. Although, due to the reflection of sunlight, days with slight cloud can result in higher energy yields than days with a completely cloudless sky.

It is important to realise that you can only use your free solar electricity when it is being generated – so unless you also invest in batteries to store power for use in the evenings and at night, you will need to pay for your energy use as normal when the panels are not producing electric.



A typical grid connected roof mounted system consists of a number of components, as shown in the diagram.

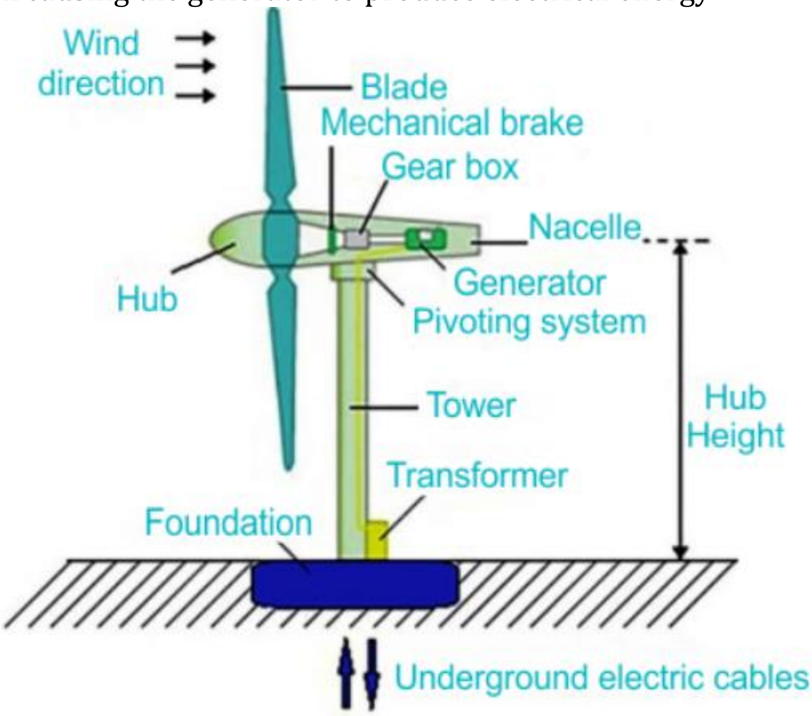
Direct Current (DC) needs to be converted into alternating current (AC) so it can be used in a domestic building; this is performed by an inverter. The AC electricity then passes via the generation meter, which measures how much electricity has been created, and on to the consumer unit where it can be fed into the property for use or exported back to the national grid via the electricity meter.

LAYOUT AND OPERATION OF WIND POWER GENERATION SYSTEM

Wind Power plants are a collection of wind turbines either horizontal or vertical type. These turbines collect the energy individually and are connected to a common plant. The wind turbine is also similar to the normal turbine, as it converts kinetic energy into mechanical energy. And they are designed in such a way that the height and length of the blades are maintained at some ratio.

The wind turbine works on the principle of conversion of kinetic energy of wind to mechanical energy used to rotate the blades of a fan connected to an electric generator. When the wind or air touches the blades (or) vanes of the windmill it the air pressure can be uneven, higher on one side of the blade and lower on the other. Hence, uneven pressure causes the blades to spin around the center of the turbine. The turbine does not operate at wind speeds above 55 mph with the use of the controller.

The rotor shaft of the turbine (ie., low speed and high speed) is interlinked with the gearbox which converts the speed from 30 to 60 rpm into 1000 to 1800 rpm. As the gearbox consists of gears, to transmit mechanical energy. These speeds are most suitable to the generator for the generation of electricity. When the rotor of the turbine rotates it drives a generator through a setup gearbox causing the generator to produce electrical energy.



- **Blades** are usually made of fiberglass or balsa wood. Most turbines have either two or three blades.
- **Rotor**: It includes the blades and the hub together. The blades spin the rotor, which is attached to a shaft that transfers the torque it creates into the gearbox. The rotor provides pitch regulation for power output optimization and control. Its speed is variable to maximize aerodynamic efficiency.
- **Pitch** turns blades out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.
- **Brake** is a disc that can be applied aerodynamically, electrically, or hydraulically to stop the rotor in emergencies. A brake shuts down the turbine if the winds become strong enough to impact the turbine's internal components.
- **Low-Speed Shaft:** The rotor turns the low-speed shaft at about 15 to 30 rotations per minute.
- **Gear box** connect the low-speed shaft to the high-speed shaft and increases the rotational speeds from about **15 to 30 rotations per minute (rpm)** to about **1000 to 1800 rpm,** the rotational speed required by most generators (alternators) to produce electricity. This is an expensive and heavy part of wind turbines.
- **Generator** is usually an induction generator that produces **50-cycle AC electricity.**
- **Controller** starts up the machine at wind speeds of about **8 to 16 miles per hour (mph)** and shuts off the machine at about **55 mph.** Turbines do not operate at wind speeds above about **55 mph** because that might damage them.
- **Anemometer**: It measures the wind speed and transmits the data to the controller. The controller then corrects the turbine's direction, pitch, and yaw to best harvest the available wind energy.

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- **Wind vane** measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.
- **Nacelle** sits at the top of the tower and contains the gear box, low- and high-speed shafts generator, controller, and brake. It is essentially the cover for the machinery that translates wind power into electrical power.
- **High-Speed Shaft:** Drives the generator Yaw drive in upward turbines face into the wind. The yaw drive keeps the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind Yaw Motor powers the yaw drive
- **Tower** is usually made from tubular steel, concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

ESTIMATION OF ELECRICITY 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 CONSUMTION OF ELECTRICAL HOME APPLIANCES

Let us consider different home appliances to calculate approximate total energy consumption of house per month.

Sl 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 rate at which electrical energy is supplied to a consumer is known as tariff. Although tariff should include the total cost of producing and supplying electrical energy plus the profit, yet it cannot be the same for all types of consumers. It is because the cost of producing electrical energy depends to a considerable extent upon the magnitude of electrical energy consumed by the user and his load conditions. Therefore, in all fairness, due consideration has to be given to different types of consumers (e.g., industrial, domestic and commercial) while fixing the tariff. This makes the problem of suitable rate making highly complicated.

Objectives of tariff:

- Recovery of cost of producing electrical energy at the power station.
- Recovery of cost on the capital investment in transmission and distribution systems.
- Recovery of cost of operation and maintenance of supply of electrical energy e.g., metering equipment, billing etc.
- A suitable profit on the capital investment

Two-part tariff:

When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called a two-part tariff.

In two-part tariff, the total charge to be made from the consumer is split into two components viz., fixed charges and running charges. The fixed charges depend upon the maximum demand of the consumer while the running charges depend upon the number of units consumed by the consumer. Thus, the consumer is charged at a certain amount per kW of maximum demand plus a certain amount per kWh of energy consumed i.e.

$$\text{Total charges} = \text{Rs} \ (b \times kW + c \times kWh)$$

where, b = charge per kW of maximum demand

c = charge per kWh of energy consumed

This type of tariff is mostly applicable to industrial consumers who have appreciable maximum demand.

Advantages:

- It is easily understood by the consumers.
- It recovers the fixed charges which depend upon the maximum demand of the consumer but are independent of the units consumed.

Disadvantages:

- The consumer has to pay the fixed charges irrespective of the fact whether he has consumed or not consumed the electrical energy.
- There is always error in assessing the maximum demand of the consumer.

CALCULATION OF ELECTRICITY BILL FOR DOMESTIC CONSUMERS

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 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 x4.1 + 50 x 5.55+ 20 x 7.1] = 624 rs

(**Note:** For 0- 50 units – 4.1 rs per unit, 50- 100 units – 5.55 rs , 100- 200 units – 7.1rs)

Therefore Total Electricity bill for given example is

= 275 +624+ Tax.

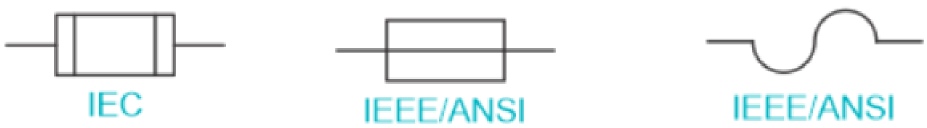
EQUIPMENT SAFETY MEASURES

WORKING PRINCIPLE OF A ELECTRICAL FUSE

An **Electrical Fuse** is a safety device to limit the current in an electric circuit. Excess electric flow can cause damage without the fuse in place. Hence, the Electrical Fuse protects the circuit from damage while exceeding current or voltage fluctuations.

It protects electrical appliances from overloads and short circuits. It protects high voltage up to 400 kV and low voltage up to 66 kV.

Symbol of Fuse:

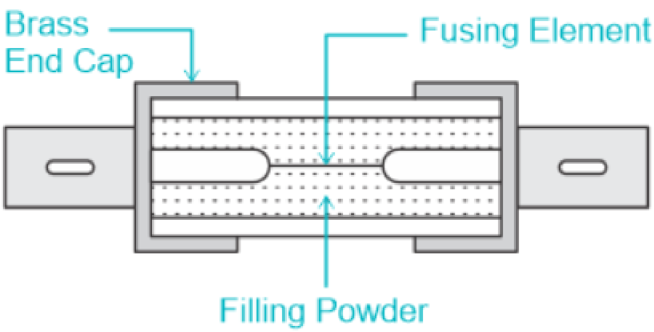


We can replace the fuse in an electric circuit using a new fuse with the same power rating. A new fuse can be constructed using elements like copper, zinc, silver and Aluminium., The parts of the electrical fuse diagram are the brass end cap, the fusing element and the filling powder.

The fuse end cap provides the electrical connection between a fuse and an electric conductor.

The fuse element is the part that melts due to excessive current flow in the circuit. The fuse element is made up of materials that have a low melting point and low ohmic losses like tin, lead, and zinc.

Filling powder fills the internal space of the fuse body. The filling powder materials used in fuse are quartz, Plaster of Paris, dust, marble, and chalk.



Electrical Fuse Working Principle

An electric fuse's working principle is based on the heating effect of the current. In normal conditions, the current passes through the fuse. The heat developed In the fuse gets dissipated, and the temperature becomes below the melting point.

The thickness of the fuse wire varies depending on the amount of current flowing through it. Electric fuse wire is made up of alloy of tin and lead. When an electric short circuit occurs, the current passes through the fuse. Hence, the fuse melts and breaks. Remember that in electrical wiring, fuse should be attached to the live wire.

Functions of Electric Fuse

The function of an electric fuse is to protect electrical circuits and devices from excessive current or short circuits. It is a safety device that acts as a sacrificial element in the circuit. Some of its main functions are as follows.

- The electric fuse acts as a protective barrier between the electrical circuit and the human body.
- It safeguards against device failure resulting from faulty circuit operation.
- The fuse prevents short circuits from occurring.
- It helps prevent overloads and blackouts.
- The fuse safeguards against damage caused by mismatched loads.

Advantages of Electrical Fuse

- Protect circuits and wiring
- Simple and reliable
- Low cost
- Easy to replace
- Fuses come in a wide range of current and time ratings to match the requirements of different circuits

Disadvantages of Electrical Fuse

- Manual intervention is required as there is no automatic reset.
- Components can still be damaged in the short time before the fuse interrupts excessive current
- Fuses completely interrupt power to the circuit when they blow, disrupting the operation of connected devices.
- A single fuse protects an entire circuit. If it fails for any reason, the whole circuit loses power

WORKING PRINCIPLE OF MINIATURE CIRCUIT BREAKER

An **MCB or Miniature Circuit Breaker** is an electromagnetic device that is enclosed in moulded insulating material. A **Miniature Circuit Breaker** (**MCB**) is an automatically operated electrical switch used to protect low voltage electrical circuits from damage caused by excess current from an overload or short circuit. MCBs are typically rated up to a current up to 125 A, do not have adjustable trip characteristics, and can be thermal or thermal-magnetic in operation.

The operating mechanism incorporates both magnetic tripping and thermal tripping arrangements. The magnetic tripping arrangement essentially comprises a composite magnetic system with a spring-loaded dashpot containing a magnetic slug in a silicon fluid, along with a normal magnetic trip. A current-carrying coil in the trip arrangement moves the slug against the spring towards a fixed pole piece. The magnetic pull is developed on the trip lever when a sufficient magnetic field is produced by the coil.

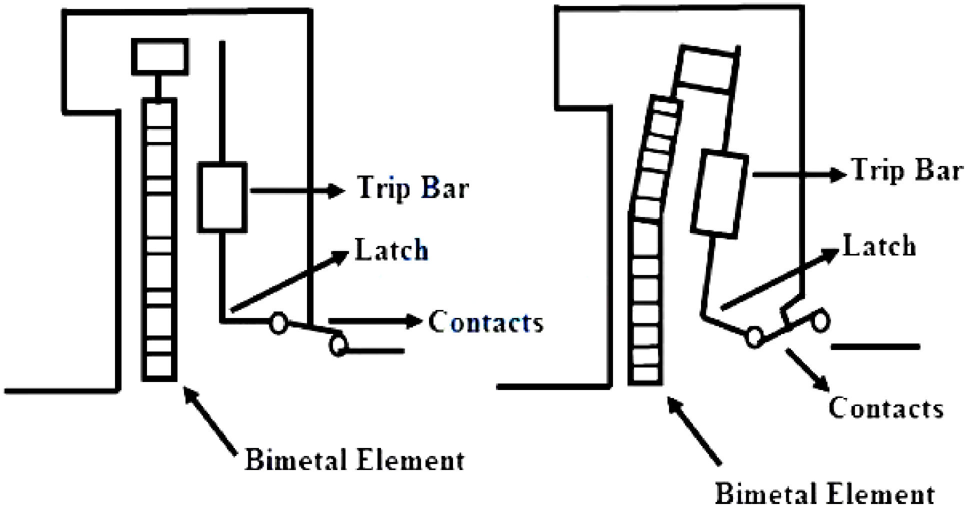
In the case of short circuits or heavy overloads, the strong magnetic field produced by the coils (solenoid) is sufficient to attract the armature of the trip lever, irrespective of the position of the slug in the dashpot.

The thermal tripping arrangement consists of a bimetallic strip around which a heater coil is wound to generate heat depending on the flow of current. The heater design can be either direct, where current passes through a bimetal strip affecting part of the electric circuit, or indirect, where a coil of a current-carrying conductor is wound around the bimetallic strip. The deflection of the bimetallic strip activates the tripping mechanism in the case of certain overload conditions.

The bimetal strips are made up of two different metals, usually brass and steel. These metals are riveted and welded along their length. They are designed in such a way that they will not heat the strip to the tripping point for normal currents. However, if the current exceeds the rated value, the strip is warmed, bent, and trips the latch. Bimetallic strips are chosen to provide specific time delays under certain overloads.

Under normal working conditions, an MCB operates as a manual switch to turn the circuit ON or OFF. In the event of an overload or short circuit, it automatically trips to interrupt the current flow in the load circuit.

The visual indication of this trip can be observed by the automatic movement of the operating knob to the OFF position. This automatic operation in an MCB can be achieved in two ways, as we have seen in MCB construction: magnetic tripping and thermal tripping.



Under overload conditions, the current passing through the bimetal causes its temperature to rise. The heat generated within the bimetal itself is sufficient to cause deflection due to the thermal expansion of metals. This deflection further releases the trip latch, leading to the separation of contacts.

In some MCBs, the magnetic field generated by the coil causes it to exert pull on the bimetals, resulting in deflection that activates the tripping mechanism.

Under short circuit or heavy overload conditions, the magnetic tripping arrangement comes into play. During normal working conditions, the slug is held in position by a light spring because the magnetic field generated by the coil is not sufficient to attract the latch.

When a fault current flows, the magnetic field generated by the coil becomes strong enough to overcome the spring force holding the slug in position. Consequently, the slug moves and actuates the tripping mechanism.

Most miniature circuit breakers implement a combination of both magnetic and thermal tripping mechanisms. In both magnetic and thermal tripping operations, an arc is formed when the contacts start separating. This arc is then directed into arc splitter plates via an arc runner. These arc splitter plates, also called arc chutes, transform the arc into a series of arcs while simultaneously extracting and cooling its energy. This arrangement ensures effective arc extinction.

ADVANTAGES:

- MCBs have more sensitive to current then fuse.
- It has quick work against short circuits.
- It works quickly on overloading and under voltage.
- It is reusable hence less maintenance cost and less replacement cost.
- It is very simple to resume the supply.
- It can be easily used circuit control switch when needed.
- Handling MCB is electricity safer than handling fuse, in case of MCB.
- It has reliable.
- MCB provides a better interface.
- MCB performance immediate indication of faculty circuit.
- The performance of MCB is good in case of earth leakage.
- In the case of surge current, The MCB has time delay characteristics, therefore, it works properly.
- Shorter tripping time under moderate over current than with fuses.
- When the use of MCB, the faulty zone of the electrical circuit can be easily identified.

DISADVANTAGES:

- The cost of the MCB is greater than the fuse.
- The cost of the MCB distribution board is greater than the rewireable fuse board.
- The risk of overloading of the circuit due to unqualified of the person operating than completing removed.

COMPARISON BETWEEN FUSE AND MCB:

	MCB (Miniature Circuit Breakers)	FUSE
1	MCB trips off in case of excessive load.	Fuse melts/fuses in case of excessive load.
2	MCB is to be just put-on after correcting the fault in wiring.	Fuse needs to be replaced with a new one.
3	Since we do not change the MCB, there is no risk of putting on the MCB/switch even if the fault is not correctly repaired.	There is a risk of putting on the switch in case; due to ignorance higher capacity fuse-wire is positioned.
4	Compact, small equipment.	Porcelain base and top. Not attractive.
5	Works on Bi-metal expansion or induced magnetism.	Works on melting/fusing due to high temperature.
6	Relatively costlier than fuse.	Relatively cheaper than MCB.

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

There are different types of earthing system mostly used. They are

i) Plate earthing ii) Pipe earthing iii) Rod earthing

PLATE EARTHING:

The plate material is of either copper or galvanized iron is used in the plate earthing system. This plate selected should of certain specified dimensions, which is placed inside the earth at a depth less than 3 meters from the bottom. This plate is connected to the electrical conductors to divert the electric charge inside the earth. The diagram of Plate Earthing is given below.

Earthing plate

PIPE EARTHING:

A galvanized iron pipe is selected should be such that it has holes pierced at regular intervals and the pipe is narrow at the bottom end.

A clamp is attached to the G.I pipe to which an earth wire is connected. This pipe diverts the electrical conductance inside the earth. Pipe Earthing is shown in the figure.

earthing pipe

The pipe is placed in the earth pit at a depth not less than 3 meters. The space inside the G.I pipe is filled by the alternate layers of salt and charcoal up to the clamp level.

The top portion of the G.I pipe is left open for maintenance when required by constructing a chamber with bricks. Water is poured into the G.I pipe to maintain earthing resistance within the specified limits.

A galvanized steel and a pipe that has holes at regular intervals are kept inside the earth. Keeping in view its low-cost Pipe earthing is commonly used for all domestic purposes.

ROD EARTHING:

This type of earthing is similar to pipe earthing, but a rod made of galvanized steel is used in this case. The rod used for this purpose is buried inside the earth at a certain depth. As it is of low resistive material, the short circuit current will be diverted to the ground safely. The rod earthing diagram is given the following figure.

Earthing rod