Unit -1
Introduction to Electrical Power

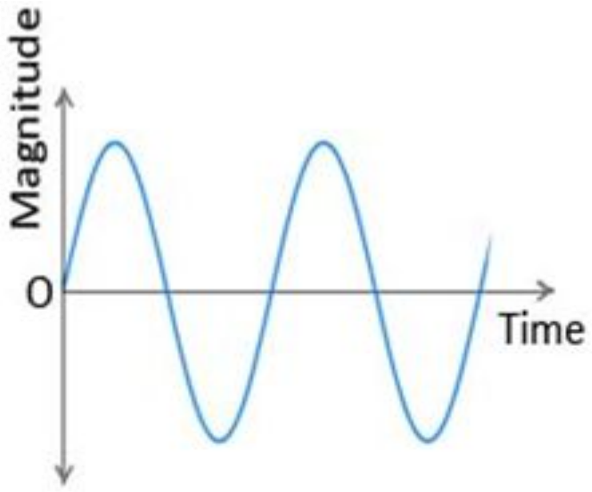
Electric Current and Voltage

- Electric current – the rate of flow of charges due to drift of electrons and it is given by,

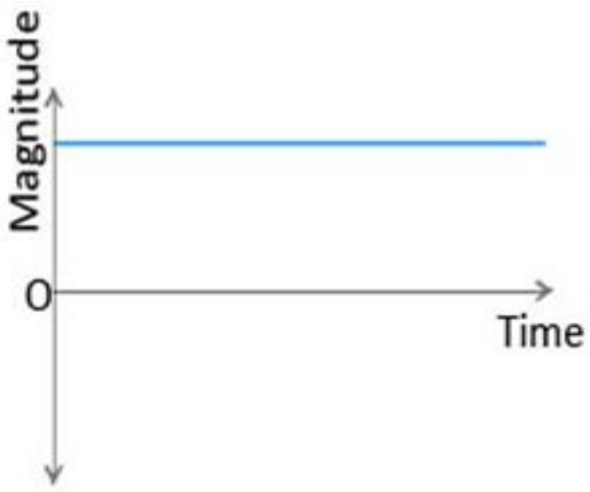
I = Q/t in Amps, Example: 1 Amperes = 1 coulomb/second

Electric Voltage – the potential difference between 2 points in an electrical circuit and it is given by,

V = W/Q in Volts, Example: 1 Volts = 1 Joule/coulomb



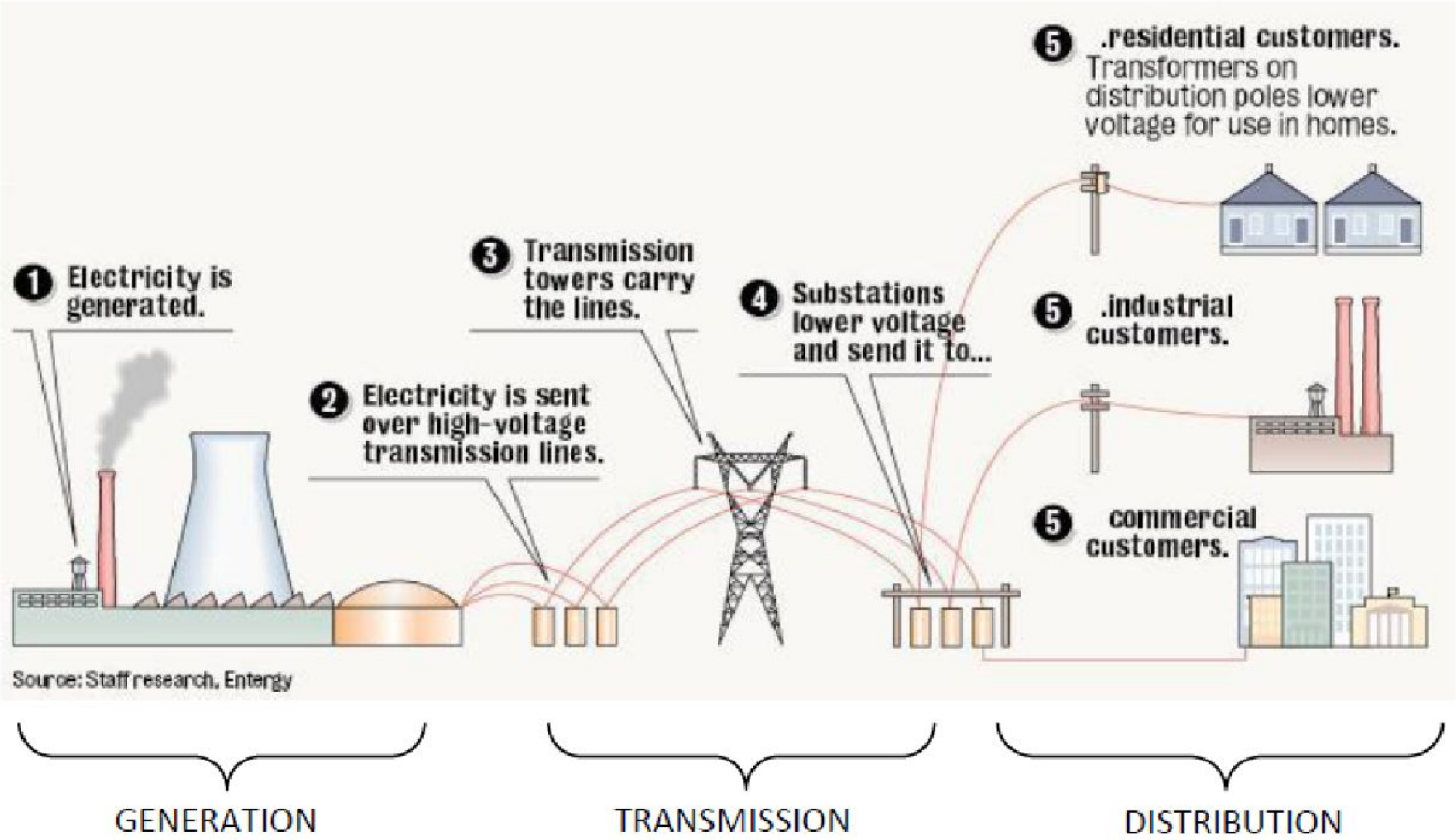
Alternating Current



Direct Current

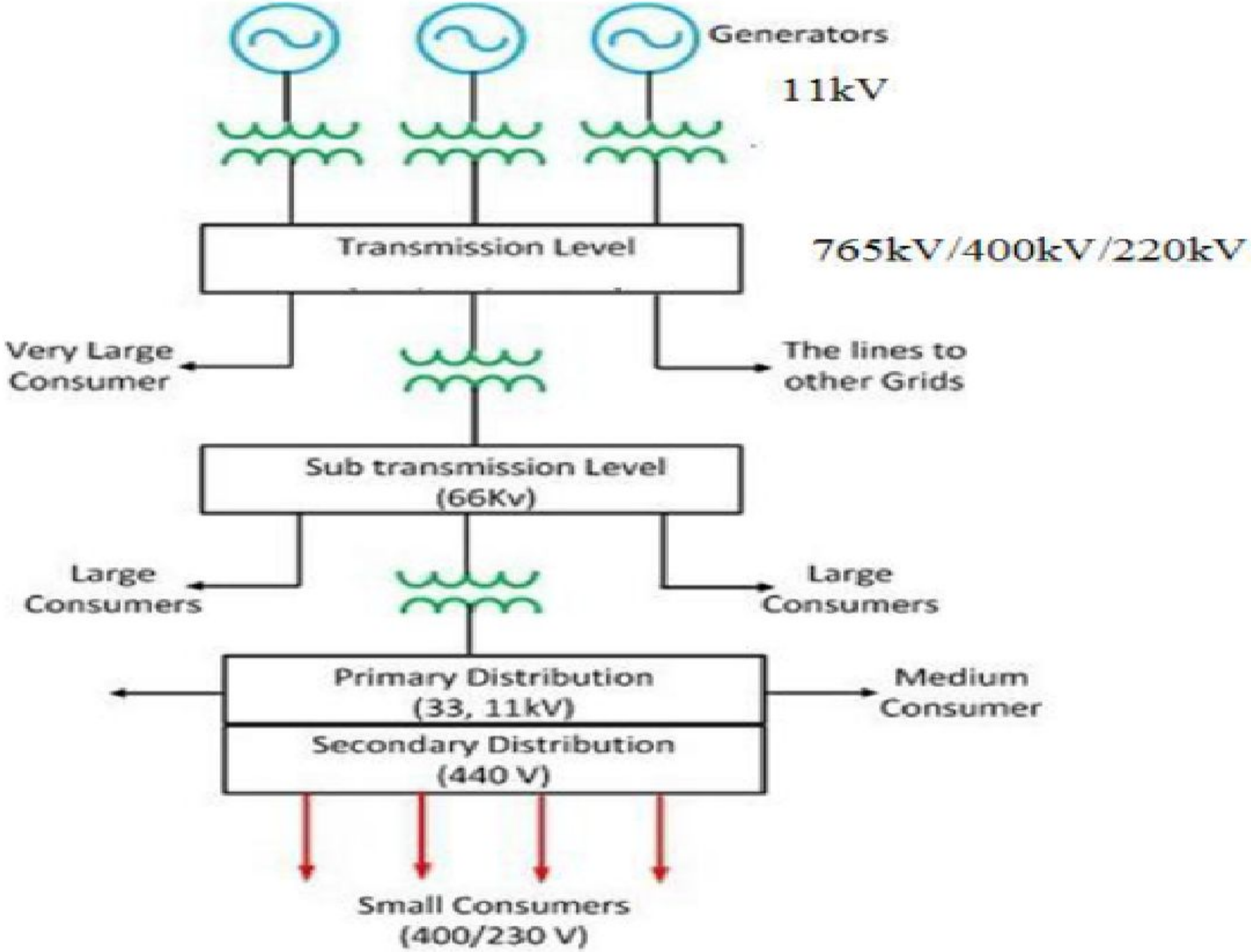
ELECTRIC POWER SYSTEM:

The complete network from a power station to consumer premises is known as electric power system shown below.



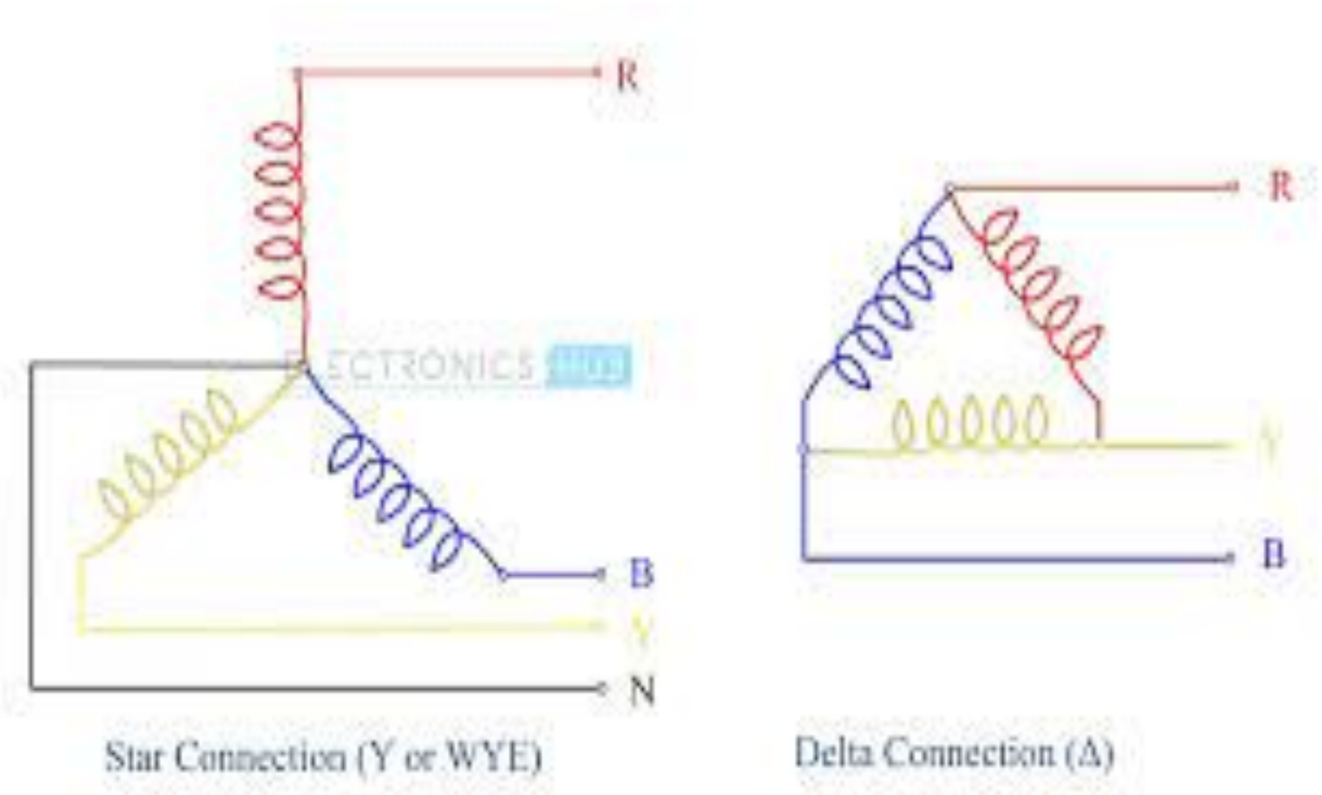
SINGLE LINE REPRESENTATION OF POWER SYSTEM:

Generation – Transmission – Distribution – Consumers



GENERATION OF ELECTRIC POWER:

- Electricity for commercial and domestic use is generated in power stations by converting primary sources of energy to electricity.
- These energy resources fall into two main categories, often called renewable and non-renewable energy resources.
- Non-renewable energy resources - coal, oil and natural gas, nuclear fuel etc.
- Renewable energy resources - solar, hydro, wind, biomass, tidal, geothermal, ocean thermal etc.
- A.C power can be generated as a single phase or as a balanced poly-phase system.
- Present day three phase generators, used to generate 3-phase power are called alternators (synchronous generators).
- A turbine is used to rotate these generators. Turbine may be of two types, namely steam turbine and water turbine.

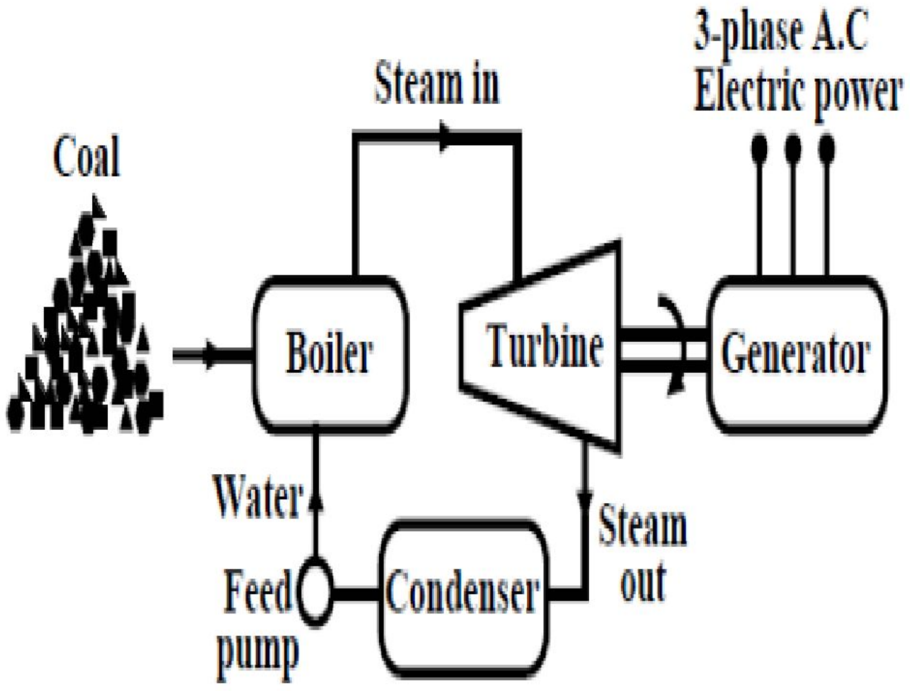


Three Phase System

Non-renewable/ Conventional energy resources :

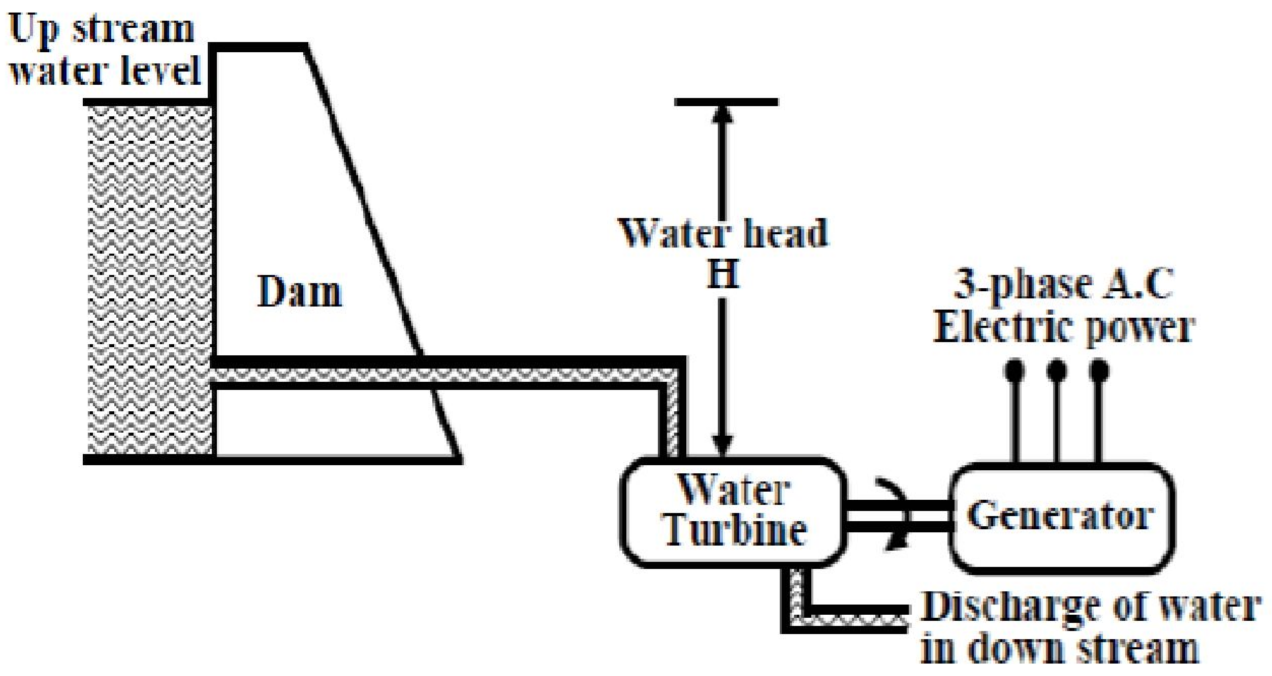
Thermal Power Plant:

- Chemical energy in coal - heat energy - mechanical energy - electrical energy.
- Boiler - Heat energy is used to boil water to produce steam.
- Turbine - Steam is passed through the turbine to produce rotational motion.
- Condenser - Steam condensed into Water and again fed to boiler to repeat the cycle.
- Generator – Turbine makes generator to run to produce 3-phase electric power.
- 78% Generation in our country.



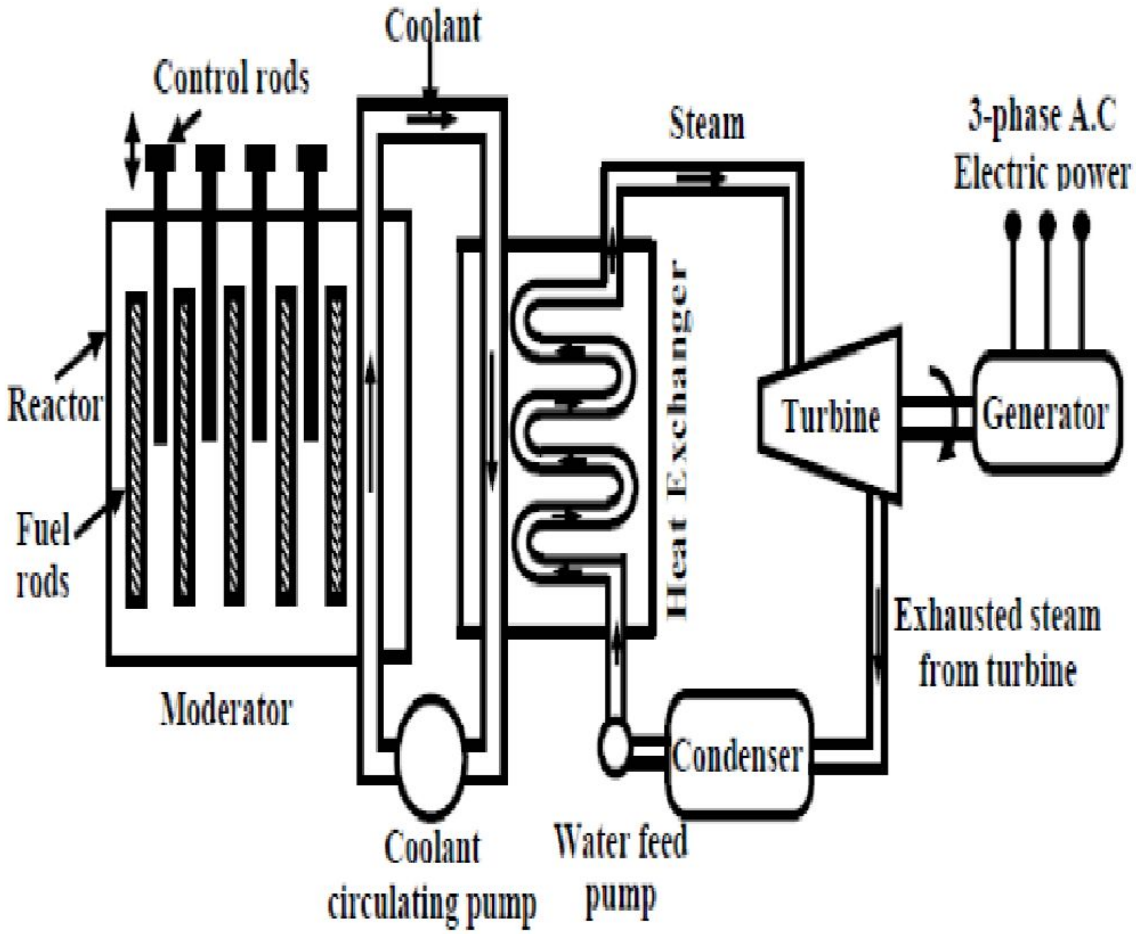
Hydro Power Plant:

- Potential energy of water- mechanical energy - electrical energy.
- Potential energy of water stored is proportional to the volume of water stored and the head(difference in height between the reservoir surface and the outflow to the turbine).
- Water is released through the penstock driving the water turbine and the generator.
- 12% Generation in our country.



Nuclear Power Plant:

- Chemical energy in Uranium 235 - heat energy - mechanical energy - electrical energy.
- 3% Generation in our country.
- nuclear power plants work on the principle of nuclear fission of ^{235}U.
- ^{235}U is bombarded by neutrons a lot of heat energy along with additional neutrons are produced.
- new neutrons further bombard ^{235}U producing more heat and more neutrons. Thus a chain reaction sets up.
- Moderators such as heavy water (deuterium) or very pure carbon ^{12}C are used to reduce the speed of neutrons.
- To control the number neutrons, control rods made of cadmium or boron steel are inserted inside the reactor.



Renewable/ Non-Conventional energy resources :

Wind Power Plant:

- Kinetic energy of wind - mechanical energy - electrical energy.
- Gear box – control the speed of

wind.

- Wind results from temperature

gradients between the equator and

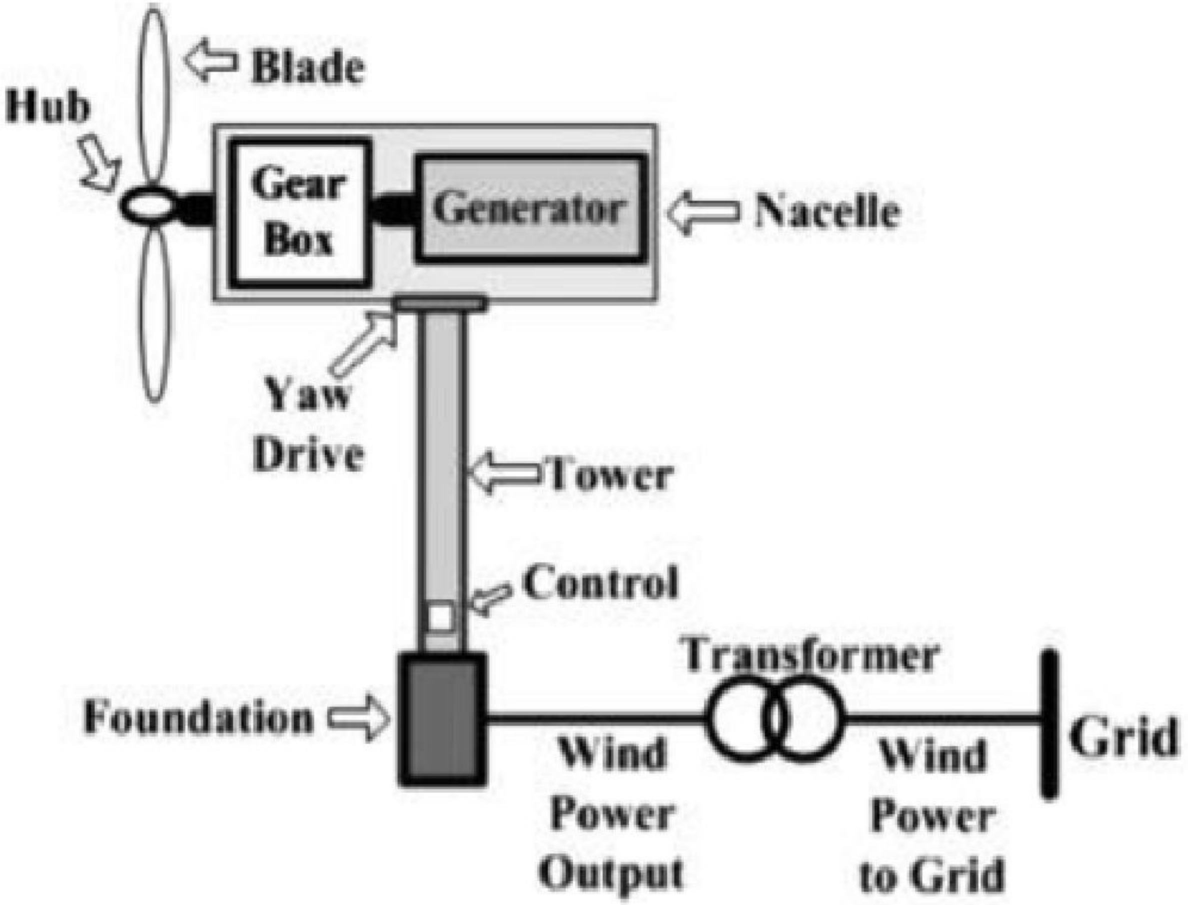
the poles and between land and sea.

- Wind energy system converts the
- kinetic energy of wind into electricity

by using wind turbines combined with a

generator.

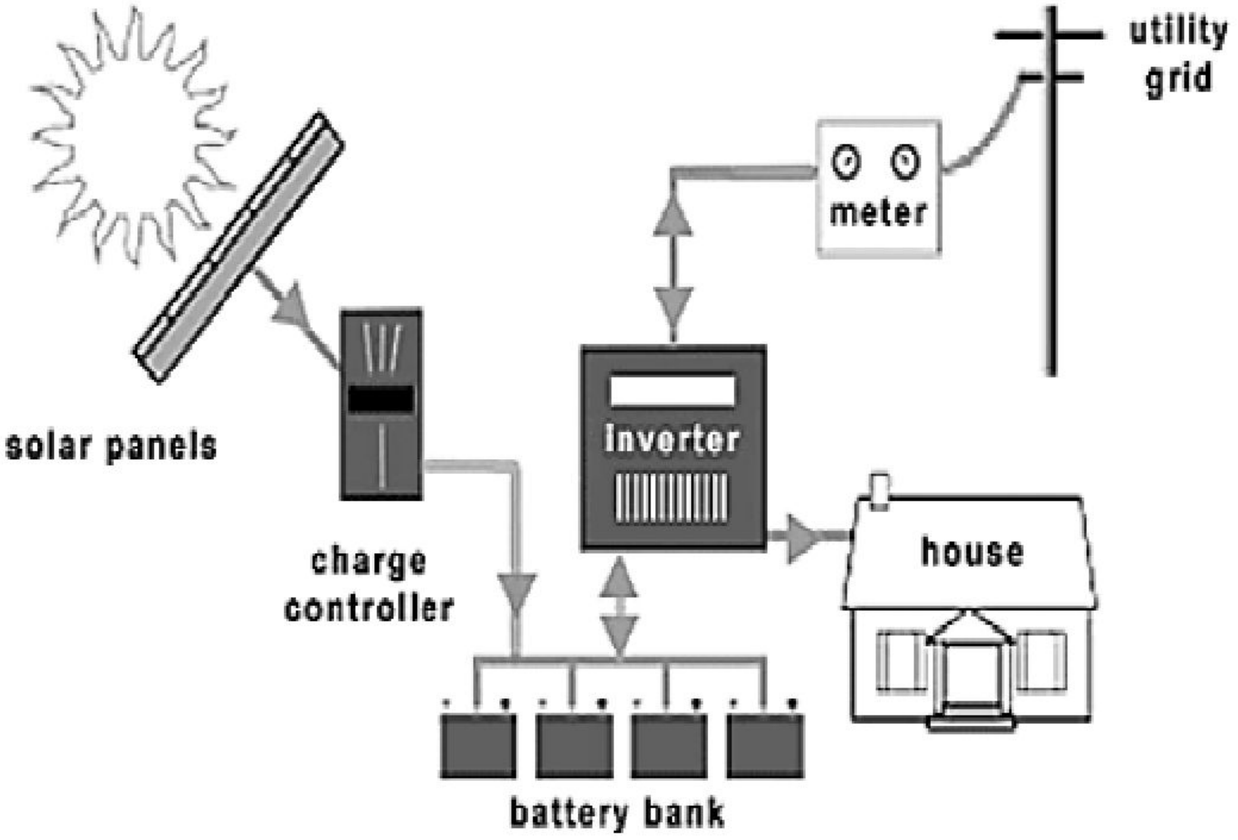
- The wind velocity of a particular location
- depends of the height and nature of the
- terrain.



Solar Power Plant:

- Sunlight energy- electrical energy.
- A solar PV cell is made up of silicon which releases electrons when exposed to light.
- Individual solar cells are connected

together to form a panel or module which in turn can be connected in series and parallel to produce large amount of electricity.



TRANSMISSION OF ELECTRIC POWER:

The transmission of electric power is carried at high voltages due to the following reasons:

- It reduces the volume of conductor material.
- It reduces the I2R losses and hence increases the transmission efficiency.
- It decreases the percentage line voltage drop.

However high voltage transmission results in

- Increased cost of insulating the conductors.
- Increased cost of transformers, switchgear and other terminal equipment.

Therefore, there is a limit to the higher transmission voltage which can be economically employed in any case.

DISTRIBUTION OF ELECTRIC POWER:

- Power received at a 33 kV substation is first stepped down to 11 kV and with the help of underground cables or Overhead lines.
- At the last level, step down transformers are used to step down the voltage form 11 kV to 400 V. These transformers are called distribution transformers.
- From the secondary of these transformers 4 terminals (R, Y, B and N) come out. N is called the neutral and taken out from the common point of star connected secondary.
- Voltage between any two phases i.e R-Y, Y-B and B-R is 400 V and between any phase and neutral is 230 V ($=400/\sqrt{3}$).
- Residential buildings are supplied with single phase 230V, 50Hz. So individual are to be supplied with any one of the phases and neutral.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Electric/Power Grid:

- Electrical grid or power grid is defined as the network which interconnects the generation, transmission and distribution unit. It supplies the electrical power from generating unit to the distribution unit.
- It consists of,

1) Generating stations that produce electrical power.

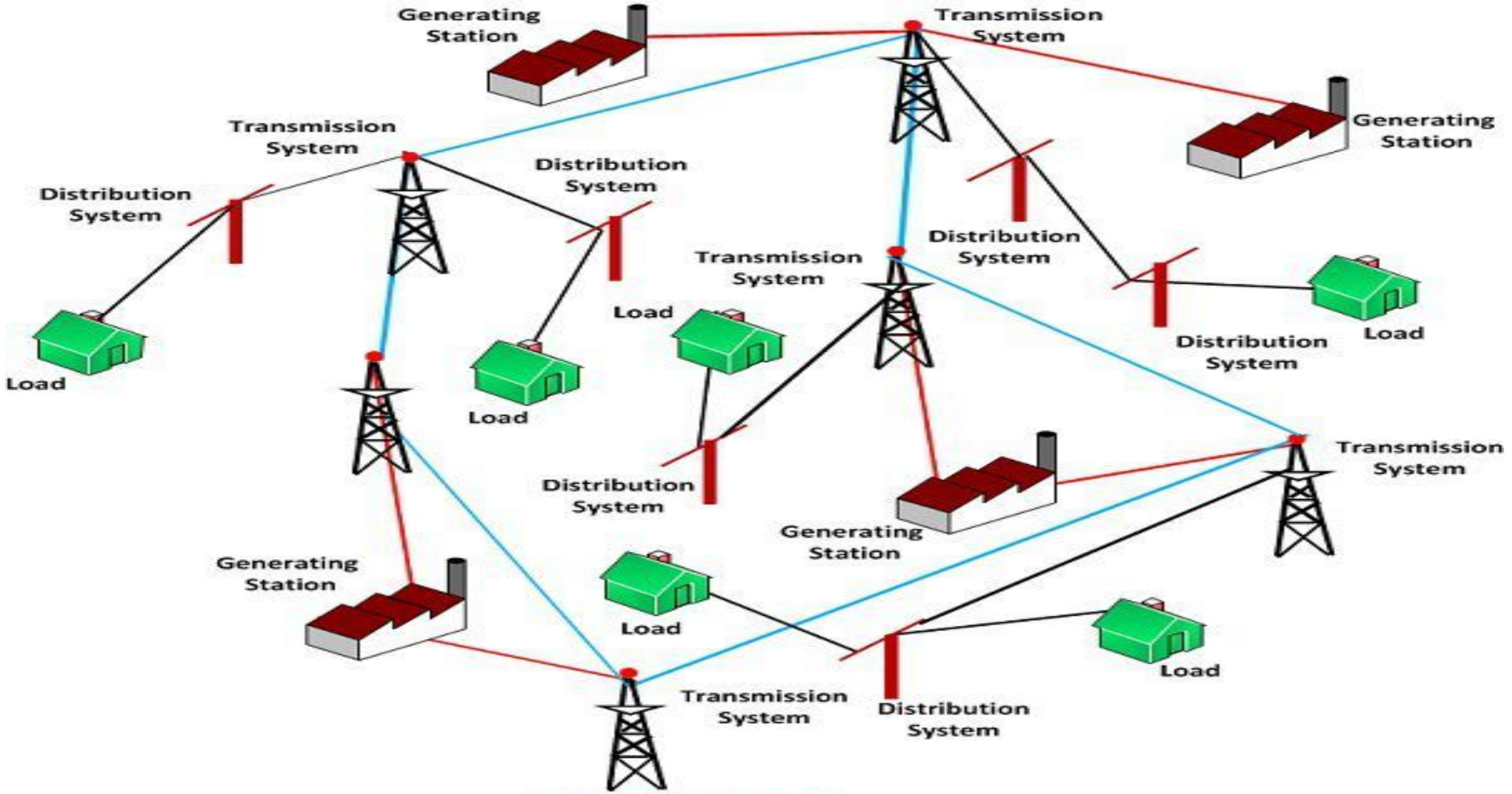
2) High voltage transmission lines that carry power from distant sources to demand centers.

3) Distribution lines that connect individual customers.

- The electrical grid is mainly classified into two types. They are

1) **Regional Grid** – The Regional grid is formed by interconnecting the different transmission system of a particular area through the transmission line.

2) **National Grid** – It is formed by interconnecting the different regional grid.



Electrical Grid

Circuit Globe

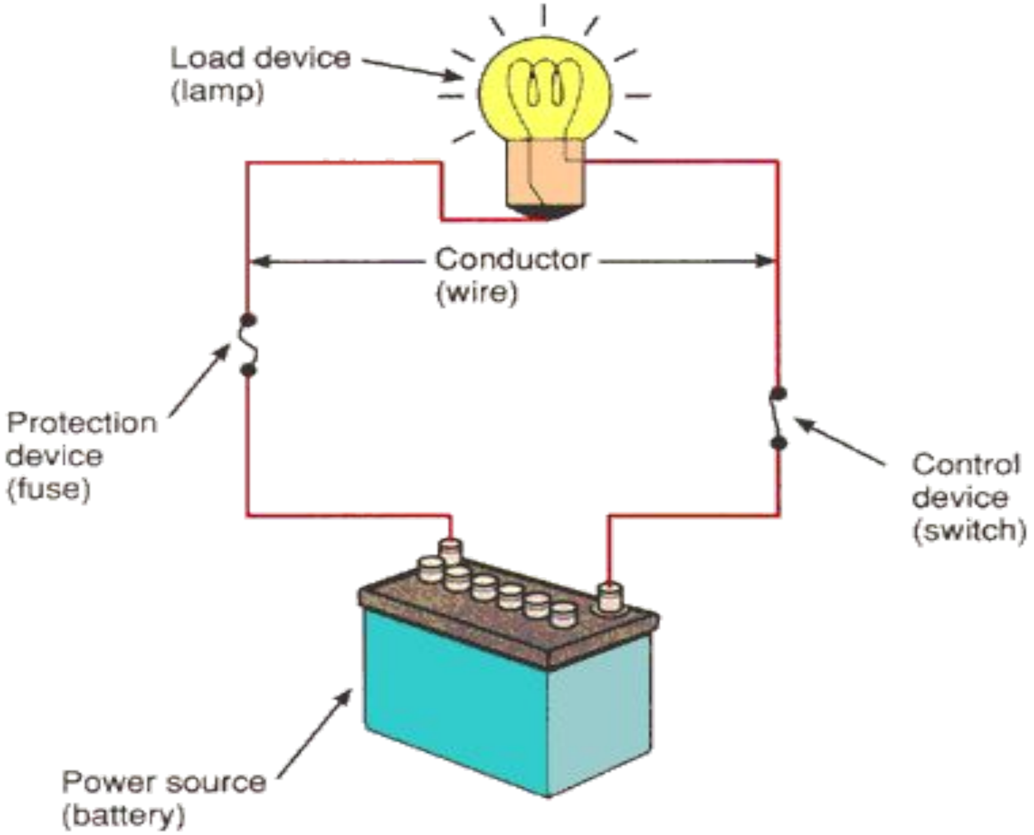
Conditions for Interconnection of Grids:

There are five conditions that must be met before the synchronization process takes place.

- The source (generator or sub-network) must have equal **line voltage, frequency, phase sequence, phase angle, and waveform** to that of the system to which it is being synchronized.
- Waveform and phase sequence are fixed by the construction of the generator and its connections to the system.
- During installation of a generator, careful checks are made to ensure the generator terminals and all control wiring is correct so that the order of phases (phase sequence) matches the system.
- Connecting a generator with the wrong phase sequence will result in a circulating current as the system voltages are opposite to those of the generator terminal voltages.
- The voltage, frequency and phase angle must be controlled each time a generator is to be connected to a grid.

Electrical Load:

An electrical load is an electrical component/device or portion of a circuit that consumes electric power.

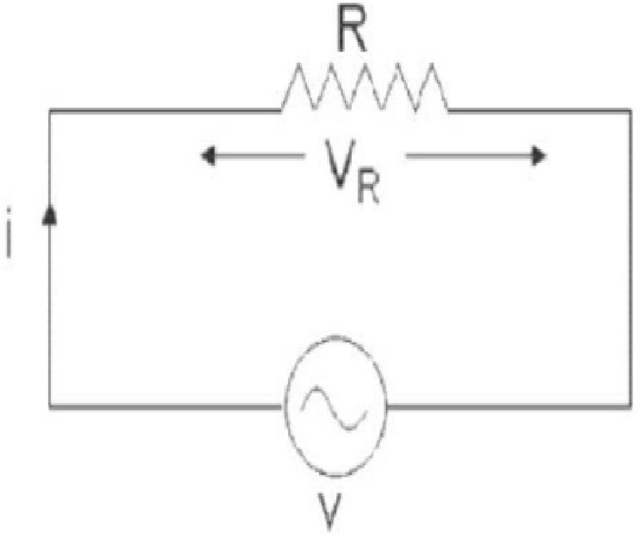


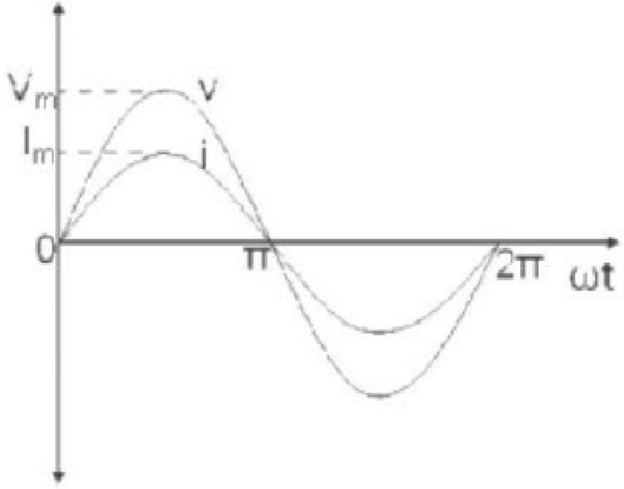
Types of Electrical Load:

Based on Nature of Load:

1. Resistive Load :

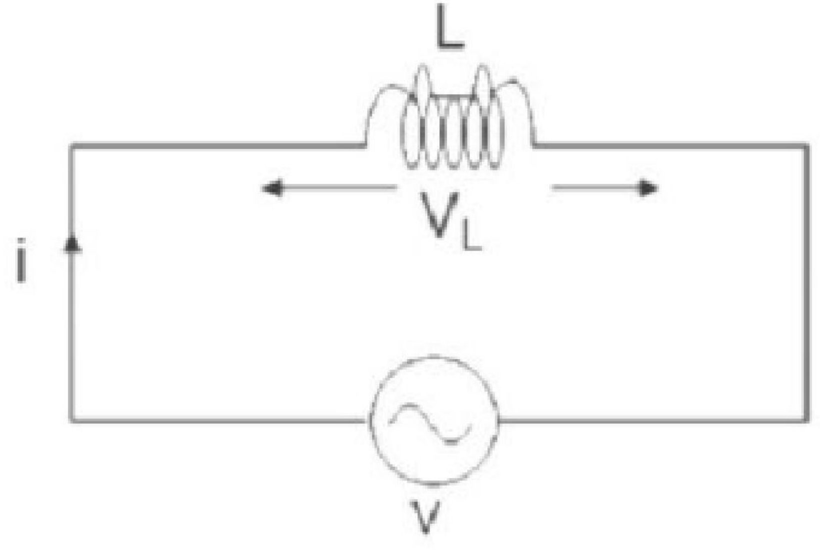
- The resistive load obstructs the flow of electrical energy in the circuit.
- The resistive loads take power in such a way so that the current and the voltage wave remain in the same phase.
- The power factor of the resistive load is unity. Loads consisting of any heating element are classified as resistive loads. These include incandescent lights, toasters, ovens, space heaters, coffee makers, geyser etc.,

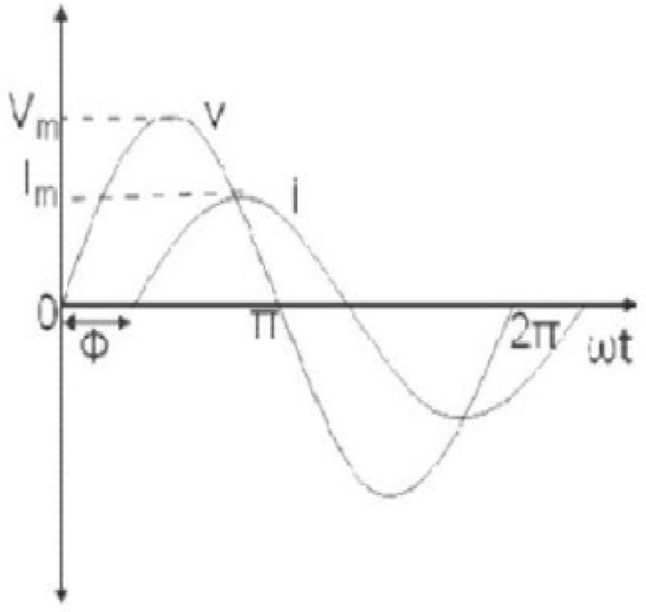


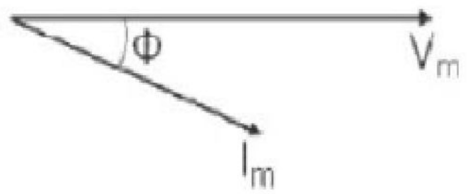


2. Inductive Load:

- The inductive load has a coil which stores magnetic energy when the current pass through it.
- The current wave of the inductive load is lagging behind the voltage wave, and the power factor of the inductive load is also lagging.
- Electrical motors can be classified as inductive loads. Electrical motors are found in a variety of household appliances such as fans, vacuum cleaners, dishwashers, washing machines, compressors, refrigerators and air conditioners etc.

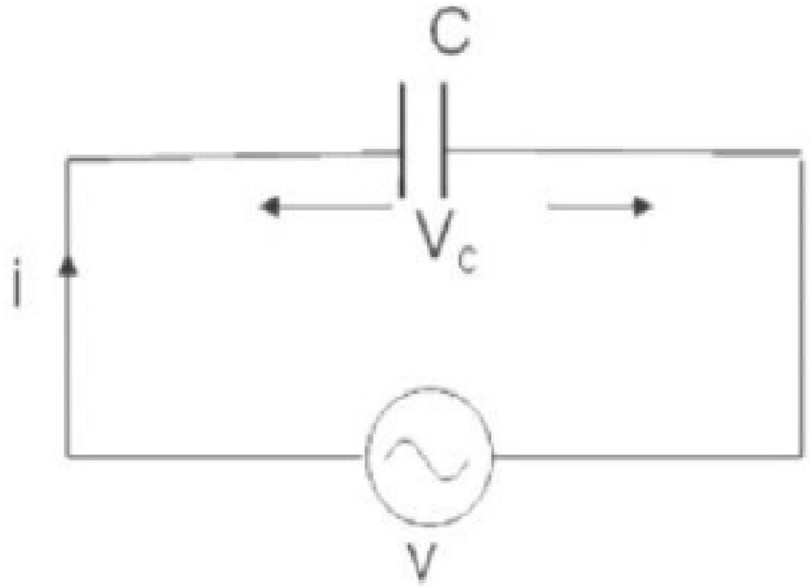


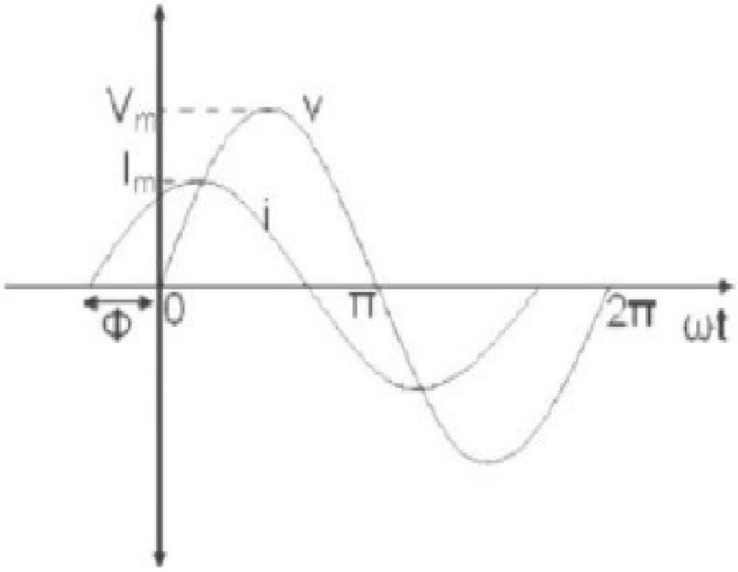


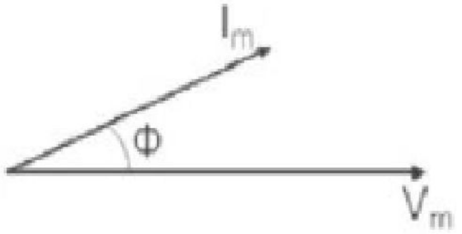


3. Capacitive Load:

- The capacitive load stores the magnetic energy in the form of voltage.
- The current wave of the capacitive load is leading behind the voltage wave, and the power factor of the capacitive load is also leading.
- capacitive load banks are used in a variety of industries and applications. Some examples include telecommunications, IT, manufacturing and mining. Some of the examples for Capacitive loads are Radio Circuits, Synchronous Motor, Capacitor Bank, TV picture tubes, Buried cables, Motor starter circuit etc.,.







Based on type of utility:

1. Domestic Load :

- The domestic load is defined as the energy consumed by the electrical appliances in the household work.
- The domestic loads mainly consist of lights, fan, refrigerator, air conditioners, mixer, grinder, heater, ovens, small pumping motor, etc. The domestic load consumes very little power. This load largely consists of lighting, cooling or heating.

2. Commercial Load:

- The energy consumed by the commercial establishments such as market, office, amusement parks, malls, cinema theatre, restaurants, etc. are considered as a commercial load.
- This load largely consists of fans, Heaters, air conditioners and many other electrical appliances used in these establishments.

3. Industrial Load:

- The energy consumed by cottage, small, medium and heavy industries are classified as Industrial load.
- The induction motor forms a high proportion of the composite load.

4. Agricultural load: The energy consumed in farming activities is termed as agricultural load. This type of load mainly consists of submersible motor for irrigation purposes.