
GENERATION OF POWER

# POWER GEBNERATION

- **Conventional Energy Resources**:

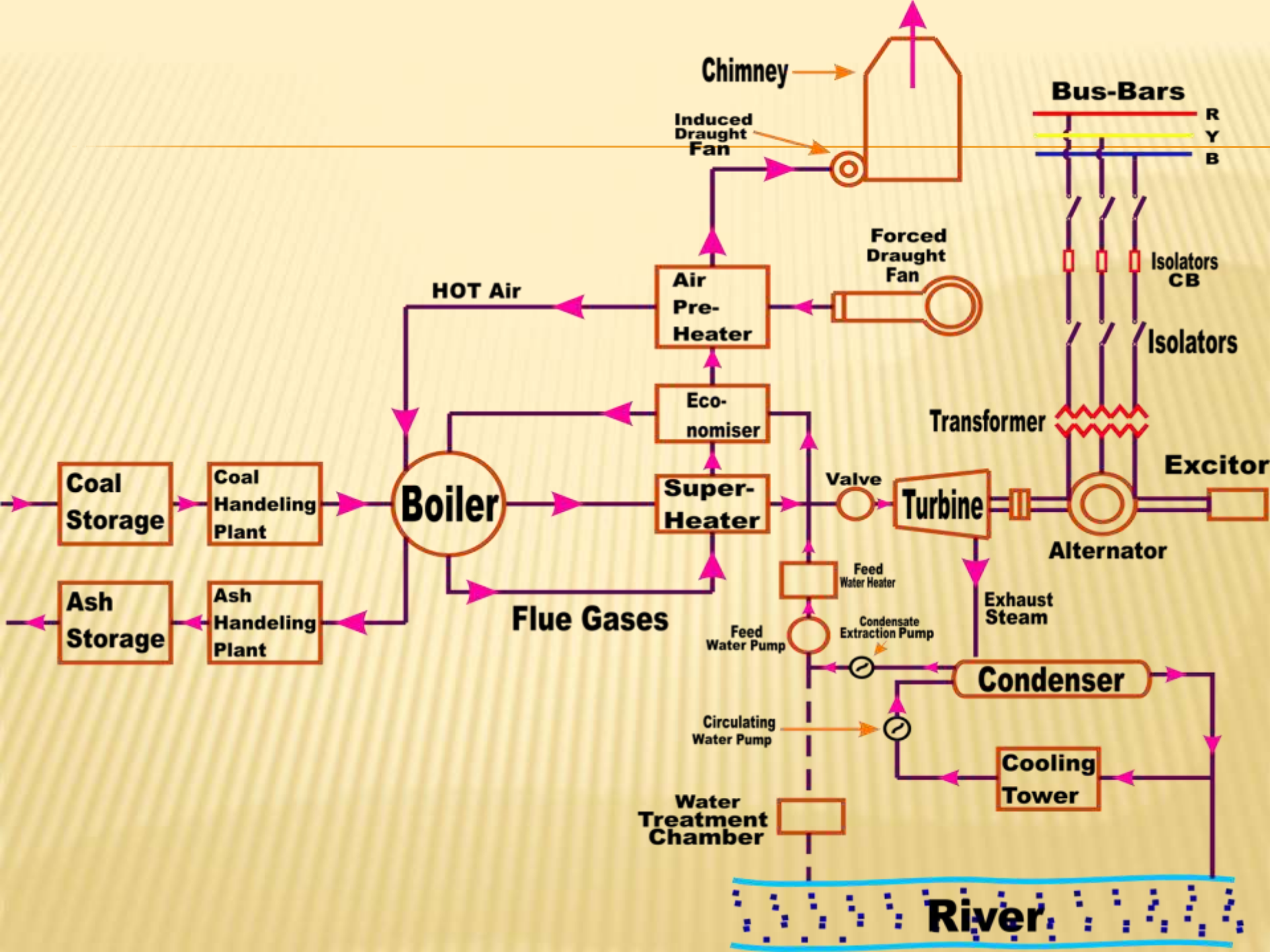
  Convection energy sources are naturally present and have been in use for years. The use of conventional sources is done for heating, lighting, cooking, running machinery, and provision of electricity. The examples for which include firewood, fossil fuels, and others.

- **Nonconventional Energy resources**:

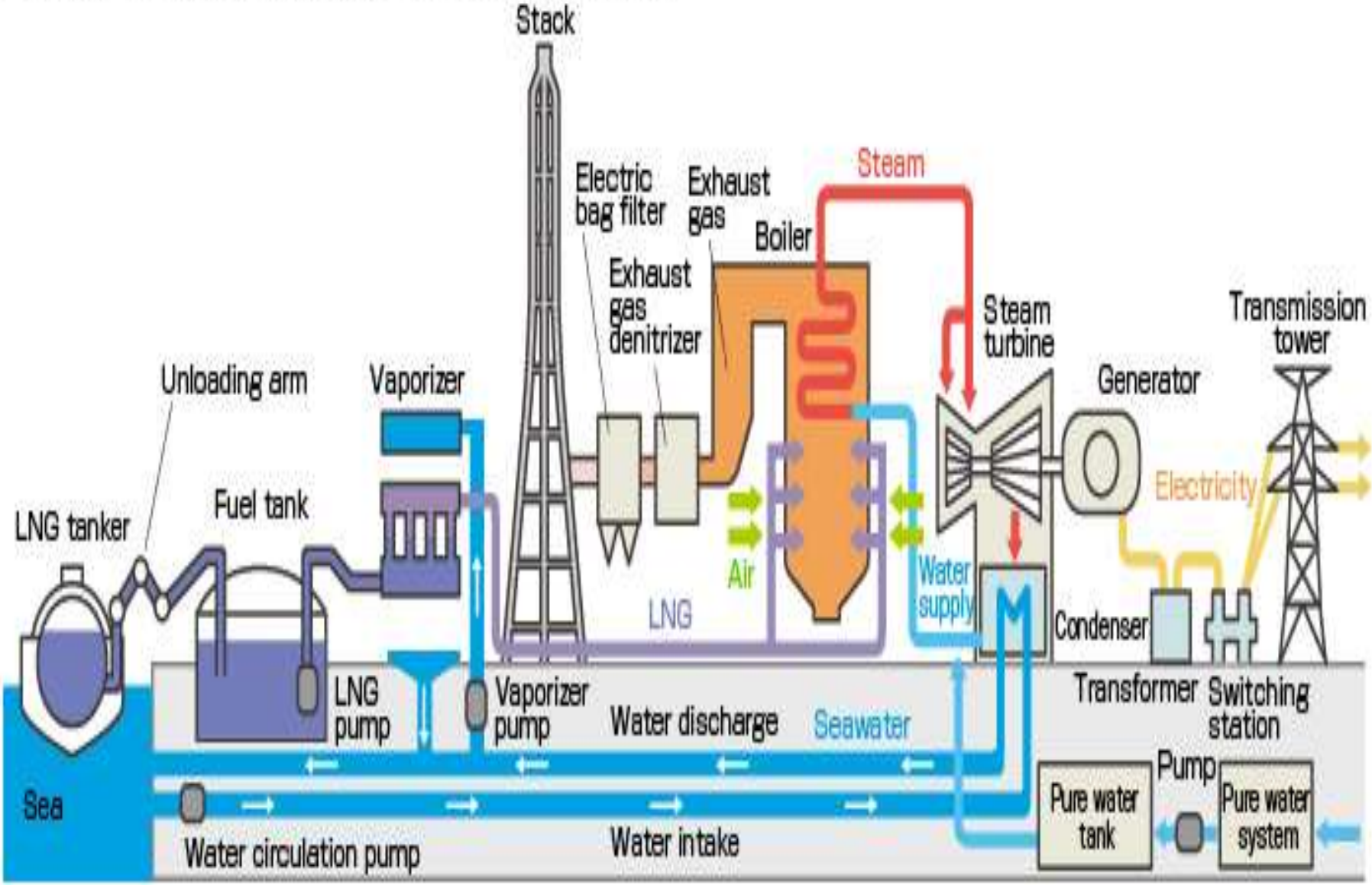
  Non- Conventional energy sources are the best alternatives to conventional sources while also non- polluting. Non-conventional sources could be obtained from sun, wind , Bio-mass, hot springs etc.

# THERMAL POWER STATION

- Thermal power generation consists of **using steam power created by burning oil, liquid natural gas (LNG), coal, and other substances to rotate generators and create electricity.**
- Almost all **coal-fired power stations, petroleum, nuclear, geothermal, solar thermal electric, and waste incineration plants, as well as all natural gas power stations** are thermal.
- The  block diagram wit energy flow is shown below:


Chimney
Induced Draught Fan
Bus-Bars
R
Y
B
Forced Draught Fan
Isolators CB
Isolators
HOT Air
Air Pre-Heater
Eco-nomiser
Transformer
Excitor
Coal Storage
Coal Handeling Plant
Boiler
Super-Heater
Valve
Turbine
Alternator
Ash Storage
Ash Handeling Plant
Flue Gases
Feed Water Heater
Exhaust Steam
Feed Water Pump
Condensate Extraction Pump
Condenser
Circulating Water Pump
Cooling Tower
Water Treatment Chamber
River

# Steam power generation (conceptual diagram)



- **Coal:** In a coal based thermal power plant, coal is transported from coal mines to the generating station. Generally, bituminous coal or brown coal is used as fuel. The coal is stored in either 'dead storage' or in 'live storage'. Dead storage is generally 40 days backup coal storage which is used when coal supply is unavailable. Live storage is a raw coal bunker in boiler house. The coal is cleaned in a magnetic cleaner to filter out if any iron particles are present which may cause wear and tear in the equipment. The coal from live storage is first crushed in small particles and then taken into pulverizer to make it in powdered form. Fine powdered coal undergoes complete combustion, and thus pulverized coal improves efficiency of the boiler. The ash produced after the combustion of coal is taken out of the boiler furnace and then properly disposed. Periodic removal of ash from the boiler furnace is necessary for the proper combustion.

**Boiler**: The mixture of pulverized coal and air (usually preheated air) is taken into boiler and then burnt in the combustion zone. On ignition of fuel a large fireball is formed at the center of the boiler and large amount of heat energy is radiated from it. The heat energy is utilized to convert the water into steam at high temperature and pressure. Steel tubes run along the boiler walls in which water is converted in steam. The flue gases from the boiler make their way through superheater, economizer, air preheater and finally get exhausted to the atmosphere from the chimney.

- **Superheater:** The superheater tubes are hanged at the hottest part of the boiler. The saturated steam produced in the boiler tubes is superheated to about 540 °C in the superheater. The superheated high pressure steam is then fed to the steam turbine.
- **Economizer:** An economizer is essentially a feed water heater which heats the water before supplying to the boiler.
- **Air pre-heater:** The primary air fan takes air from the atmosphere and it is then warmed in the air pre-heater. Pre-heated air is injected with coal in the boiler. The advantage of pre-heating the air is that it improves the coal combustion.

- **Steam turbine**: High pressure super heated steam is fed to the steam turbine which causes turbine blades to rotate. Energy in the steam is converted into mechanical energy in the steam turbine which acts as the prime mover. The pressure and temperature of the steam falls to a lower value and it expands in volume as it passes through the turbine. The expanded low pressure steam is exhausted in the condenser.

- **Condenser**: The exhausted steam is condensed in the condenser by means of cold water circulation. Here, the steam loses it's pressure as well as temperature and it is converted back into water. Condensing is essential because, compressing a fluid which is in gaseous state requires a huge amount of energy with respect to the energy required in compressing liquid. Thus, condensing increases efficiency of the cycle.

- Alternator: The steam turbine is coupled to an alternator. When the turbine rotates the alternator, electrical energy is generated. This generated electrical voltage is then stepped up with the help of a transformer and then transmitted where it is to be utilized.

# ADVANTAGES AND DISADVANTAGES OF A THERMAL POWER PLANT

- **Advantages:**
- Less initial cost as compared to other generating stations.
- It requires less land as compared to hydro power plant.
- The fuel (i.e. coal) is cheaper.
- The cost of generation is lesser than that of diesel power plants.
- **Disadvantages:**
- It pollutes the atmosphere due to the production of large amount of smoke. This is one of the causes of global warming.
- The overall efficiency of a thermal power station is low (less than 30%)

# HYDRO-ELECTRIC POWER PLANT

- A conventional dam holds water in a man-made lake, or reservoir, behind it. **When water is released through the dam, it spins a turbine connected to a generator that produces electricity.** The water returns to the river on the downstream side of the dam

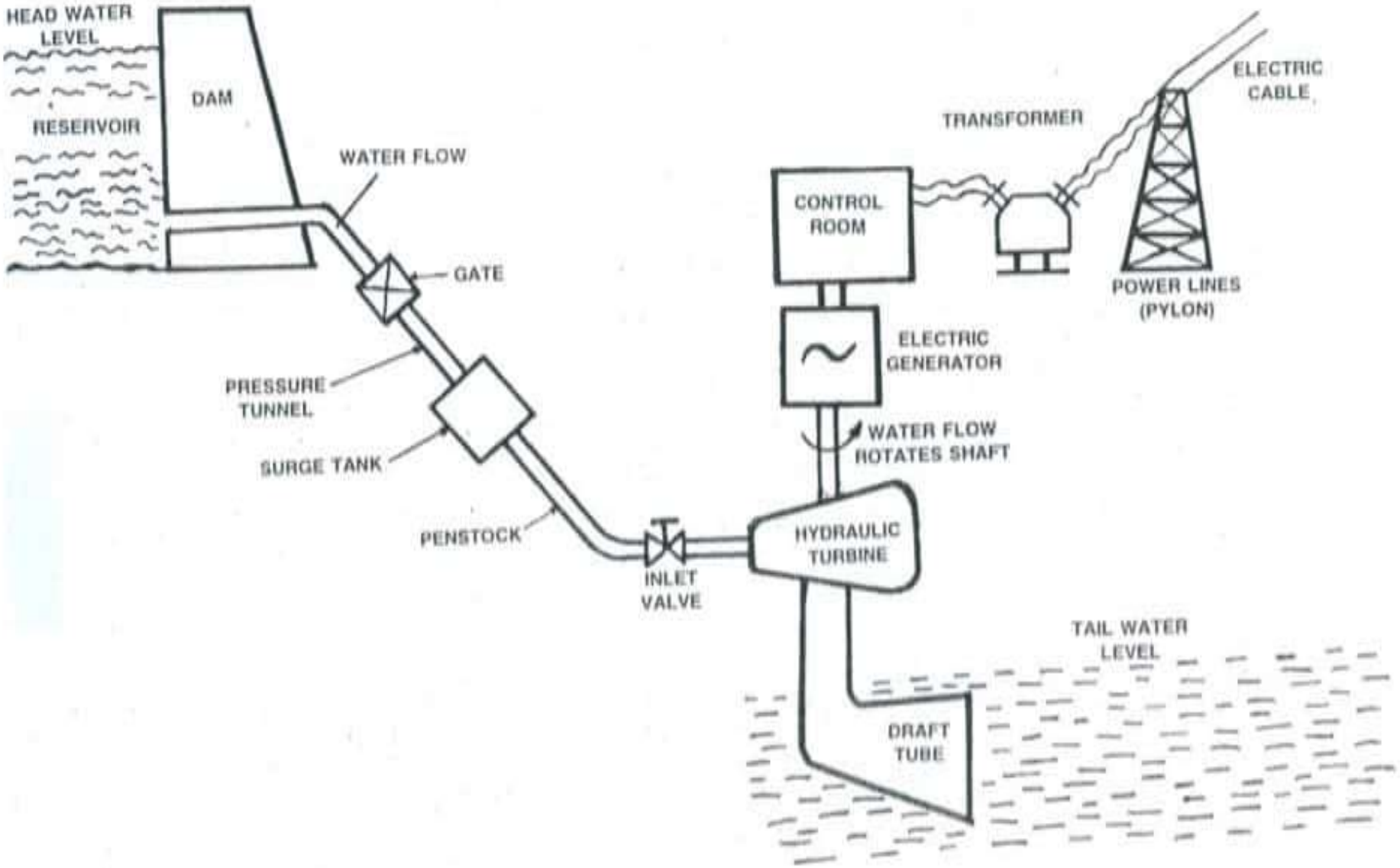
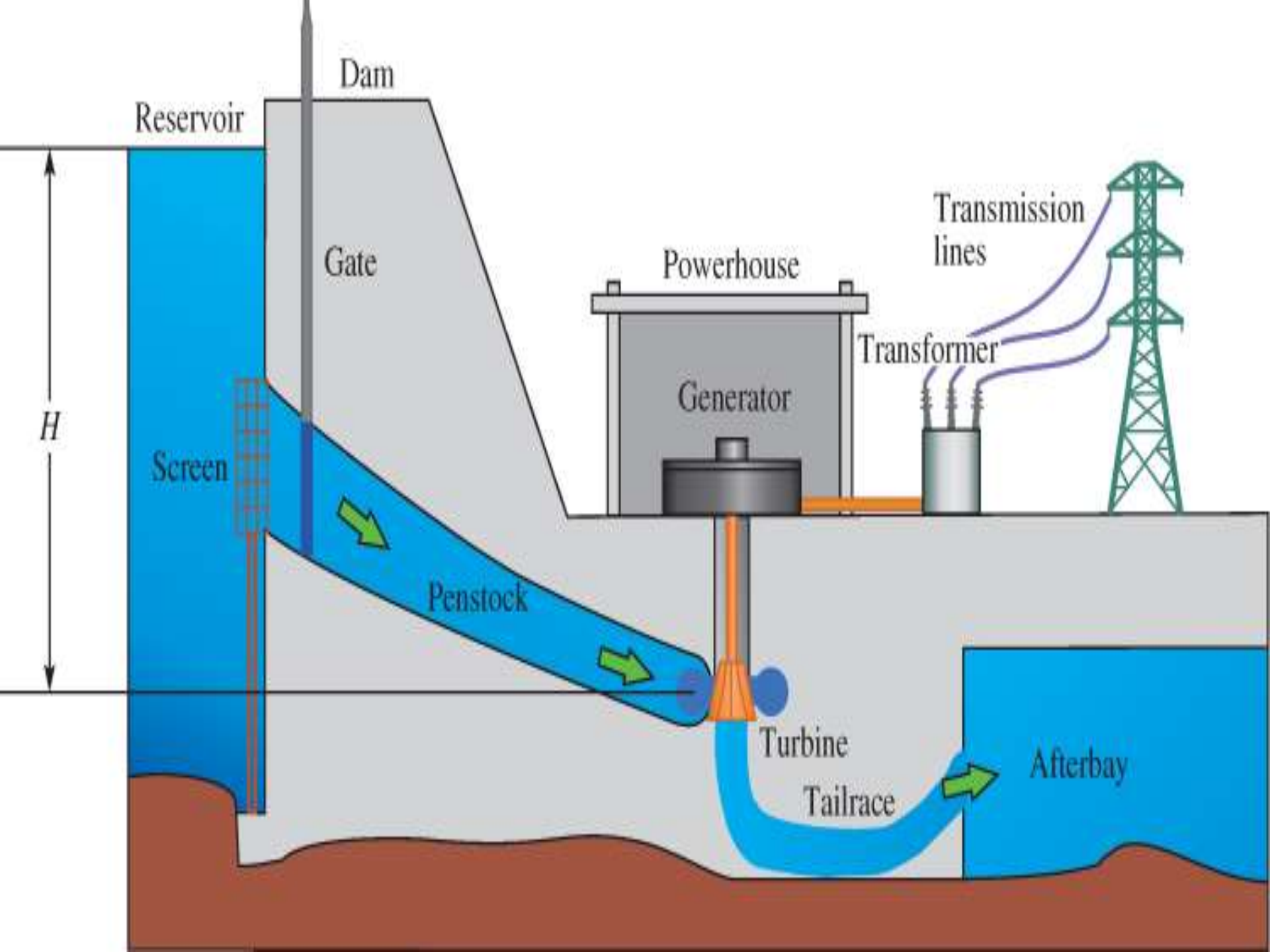



Fig.Layout of Hydro electric Power plant


Dam
Reservoir
Gate
Powerhouse
Transmission lines
Transformer
Generator
H
Screen
Penstock
Turbine
Tailrace
Afterbay

# PARTS OF HYDROELECTRIC POWER PLANT

- A hydroelectric power plant has the following parts:
- Dam or weir: it contains the river water, forming a reservoir behind it and thus creating a water drop that is used to produce energy. Dams can be made of earth or concrete (the latter is the most common one).
- Spillways: They release part of the impounded water without passing through the turbines; water can then be used for irrigation purposes. They are located on the main wall of the dam and can be at the top or at the bottom. Most of the water goes into a plunge pool at the toe of the dam, to prevent scour damage by the falling water.
- Water intakes: they let in the impounded water towards the turbines through a penstock. Water intakes have gates to control the amount of water that reaches the turbines and grids to filter out any debris such as trunks, branches, etc.

- Powerhouse: it houses the hydraulic and electrical equipment (turbines, generators, transformers) and the service area with control and testing rooms. It has inlet and outlet gates to ensure the equipment area can be dry in case of repairs or disassembling equipment.
- Turbines: they harness the energy of the water that goes through them to rotate around a shaft. There are three main types of turbines: Pelton, Francis and Kaplan turbines (propeller type).
- Transformers: electrical devices to increase or decrease the voltage in an alternating current circuit, while maintaining the electric power.
- Electrical power transmission lines: cables to transmit the electricity generated.

# ADVANTAGES AND DISADVANTAGES OF HYDROPOWER PLANTS

Here are a few advantages of hydropower plants :

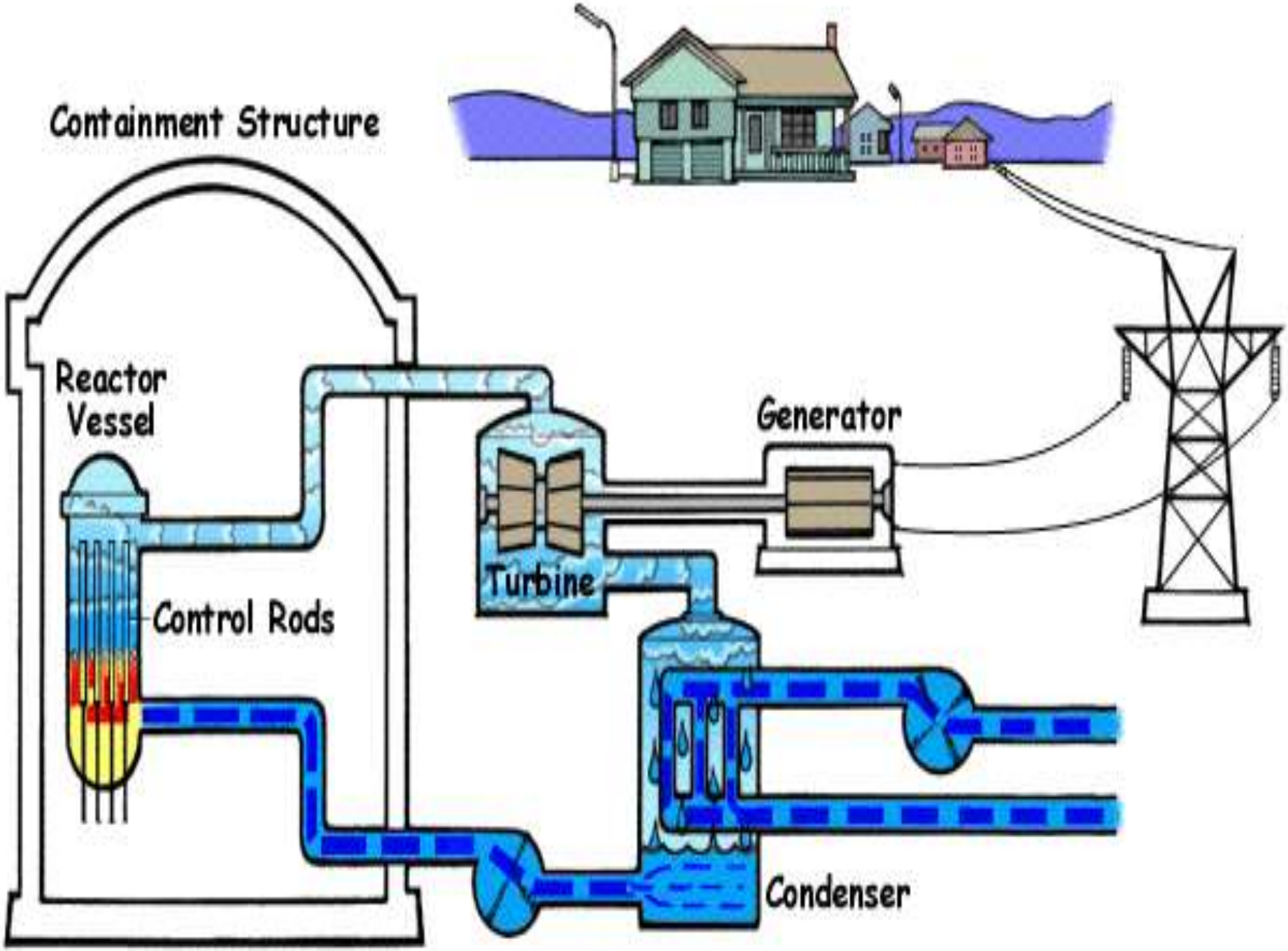
- Water is available throughout the year
- Operational and maintenance cost is lower than other power plants
- The cost of fuel is nil
- Hydro Plants are made for multiple purposes
- The requirement of working staff is less. The cost of expenses is lower as compared to other plants.

Listed are a few Disadvantages of Hydropower Plants.

- Embankment construction cost is high
- Land space requirement for set up is large
- Water must be abundant to continue the process
- Aquatic life is effected
- Embankment areas need to be evacuated for flood plains

# NUCLEAR POWER PLANTS

- Nuclear power plants are **a type of power plant that use the process of nuclear fission in order to generate electricity.** They do this by using nuclear reactors in combination with the Rankine cycle, where the heat generated by the reactor converts water into steam, which spins a turbine and a generator.


Containment Structure
Reactor Vessel
Control Rods
Turbine
Generator
Condenser

# BASIC COMPONENTS OF A NUCLEAR POWER PLANT

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 neighboring 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 -**
  **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.

- **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.
- 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.

# COMPARISION OF VARIOUS POWER PLANTS

| S.No. | Item | Steam Power Station | Hydro-electric Power Plant | Diesel Power Plant | Nuclear power Plant |
|---|---|---|---|---|---|
| 7. | *Overall efficiency* | Least efficient. Overall efficiency is about 25%. | Most efficient. Overall efficiency is about 85%. | More efficient than steam power station. Efficiency is about 35%. | More efficient than steam power station. |
| 8. | *Starting* | Requires a lot of time for starting. | Can be started instantly. | Can be started quickly. | Can be started easily. |
| 9. | *Space required* | These plants need sufficient space because of boilers and other auxiliaries. | Require very large area because of the reservoir. | Require less space. | These require minimum space as compared to any other plant of equivalent capacity. |
| 10. | *Maintenance cost* | Quite high as skilled operating staff is required. | Quite low. | Less | Very high as highly trained personnel are required to handle the plant. |
| 11. | *Transmission and distribution cost* | Quite low as these are generally located near the load centres. | Quite high as these are located quite away from the load centres. | Least as they are generally located at the centre of gravity of the load. | Quite low as these are located near load centres. |
| 12. | *Standby losses* | Maximum as the boiler remains in operation even when the turbine is not working. | No standby losses. | Less standby losses. | Less. |

# ECONOMICS OF GENERATION

## Fixed Cost

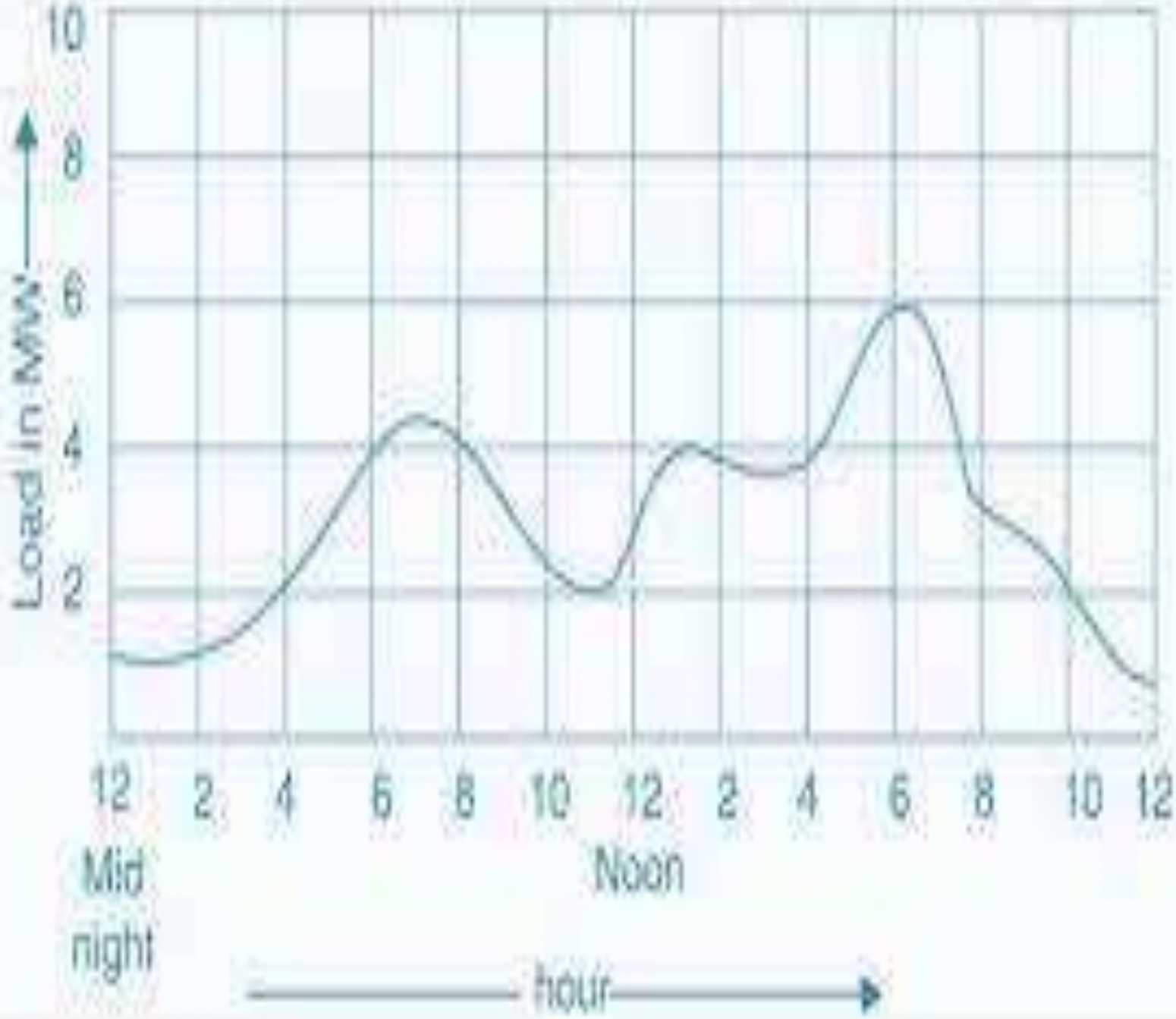
- As the name implies, such cost remains constant. It is independent of the maximum demand, the plant capacity and the energy generated.
  Fixed cost includes:
  Annual charges of the central organization management
- Salary of the employees (usually higher officials)
- Interest on the land costs
- All of these costs are fixed, and hence, fixed cost remains constant under all conditions.

## Semi-Fixed Cost

- Such charges are independent of the energy (kWh) generated but depend upon the maximum demand.Higher the max demand, the greater the semi-fixed costs.
  Semi-fixed cost includes:
  Interest and depreciation on the capital costs (investment and insurance) on the land, the buildings (construction costs) and the costs of the equipment needed for generation, transmission and distribution of the electricity.
- The capital investment of the plant is huge and usually loaned.
- The interest of this loaned amount is considered in the cost of production.
- Such interest may range up to 8% depending upon the market conditions.
- The depreciation mentioned above relates to the reduction in value of the equipment that are used constantly.
- Due to wear and tear, the depreciation occurs and such depreciation costs are also included in the fixed and semi-fixed charges.
- Semi-fixed charges will also include the salaries of the management and other (clerical) staff, since these depend upon the size (and cost) of installation which again depends on the max demand.

# LOAD CURVE

- A graphical plot showing the variation in demand for energy of the consumers on a source of supply with respect to time is known as the **load curve.**
- If this curve is plotted over a time period of 24 hours, it is known as **daily load curve.** If its plotted for a week, month, or a year, then its named as the **weekly, monthly or yearly load curve** respectively. The **load duration curve** reflects the activity of a population quite accurately with respect to electrical power consumption over a given period of time. To understand the concept better its important that we take the real life example of load distribution for an industrial load and a residential load, and have a case study on them, to be able to appreciate its utility from the perspective of an electrical engineering


10
8
6
4
2
Load in MW
12
2
4
6
8
10
12
2
4
6
8
10
12
Mid night
Noon
hour

# DEMAND FACTOR

- The demand factor of an electric power station is defined as the ratio of maximum demand on the power station to its connected load, i.e.,

DemandFactor=MaximumDemand/ConnectedLoad

- Generally, the value of demand factor is less than 1. It is because the maximum demand on the power station is usually less than the connected load to the power station. The knowledge of demand factor is important in determining the capacity of equipment of the power plant.

# LOADFACTOR

- The load factor of a power station is defined as the ratio of average load to the maximum demand on the power station during a given period. he load factor can be *daily load factor, monthly load factor* or annual load factor if the time period (T) considered is a day or a month or a year respectively. The load factor of a power station is always less than 1. It is because the average load on the power station is smaller than the maximum demand. The load factor is very important because it is used to determine the overall cost per unit generated, i.e., if the load factor of the power station is higher, then the cost per unit generated will be lesser.

# DIVERSITY FACTOR

- The diversity factor of the power station is defined as the ratio of sum of individual maximum demands to the maximum demand on the power station.
- The diversity factor of a power station is always greater than 1. The diversity factor plays a vital role in the determination of cost of generation of power. The greater is the diversity factor, the lesser is the cost of generation of power.

# PLANT USE FACTOR AND RESERVE CAPACITY

- It is **the ratio of units generated to the product of plant capacity and the number of hours for which the plant was in operation.**
- is **a backup energy generation capacity that is used by the electric grid in the occurrence of unexpected fault such as the unavailability of a power plant.** Energy storage systems have the ability to provide this service and are used to offset or reduce costs incurred for generation of reserve capacity.

# IMPORTANCE OF LOAD FACTOR

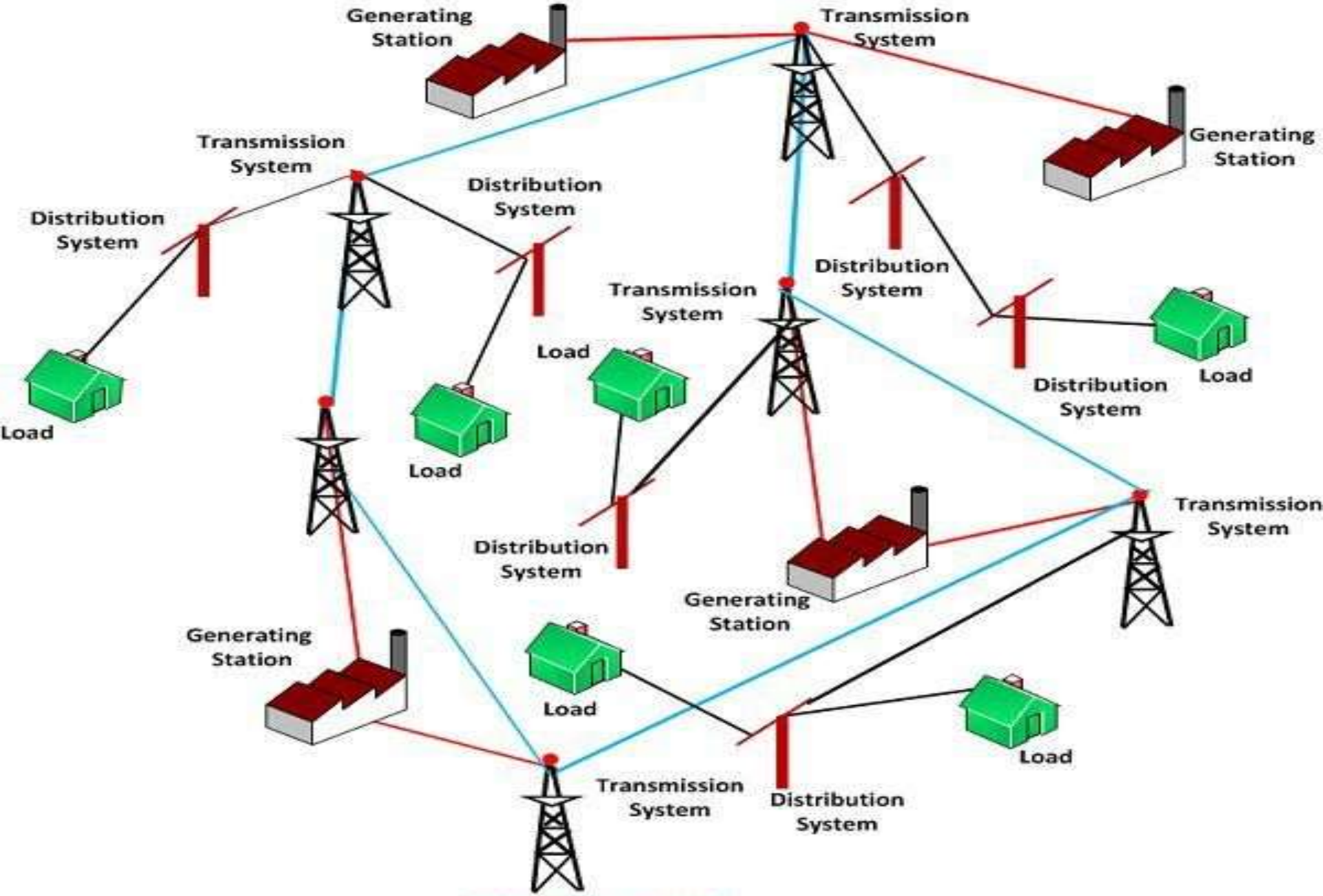
- Higher value of load factor means lower will be cost per unit generated and vice versa it is desirable that the value of load factor always higher.
- Higher the load factor means lower maximum demand or higher average demand ( or higher number of unit generation for a given time )
- As tariff charges depends upon fixed part-maximum demand and variable part number of units consumption.
- Lower value maximum demand, resulting lower fixed charges of tariff which is distributed among large number of units generated therefore overall cost per unit generation is reduced.
- As the number of unit generation for a given time increases, the load factor also increases.
- Greater number of unit generation for a given plant, means cost per unit decreases.

# IMPORTANCE OF DIVERSITY FACTOR

- Lower the value of maximum demand, higher the diversity factor as vice versa.
- The capital cost of power station depends upon capacity of the power station.
- Lower the maximum demand, lower the capital required for the power station.
- For a given number of consumers, higher the diversity factor of load, smaller will be capacity of the plant therefore fixed charges for the plant will be reduced.
- Therefore the utility company always tries to increases load factor as well as diversity factor.

# TYPES OF ELECTRICAL GRID

- The power station of the grid is located near the fuel source which reduces the transportation cost of the system. But it is located far away from the populated areas. The power which is generated at high voltage is stepped down by the help of step down transformer in the substation and then supply to the consumers.The electrical grid is mainly classified into two types. They are
- **Regional Grid** – The Regional grid is formed by interconnecting the different transmission system of a particular area through the transmission line.
- **National Grid** – It is formed by interconnecting the different regional grid.




Electrical Grid

# ADVANTAGES OF INTERCONNECTED POWER SYSTEM

- 1) Use of older plants
- 2) Economical operation
- 3) Increase reliability of power supply
- 4) Exchange of peak load
- 5) Increase diversity factor
- 6) Reduce plant reserve capacity
- 7) Reduce capital and operating cost

# TRANSSMISSION SYSTEM

- Transmission lines **carry electric energy from one point to another in an electric power system.** They can carry alternating current or direct current or a system can be a combination of both.

**Different types of transmission systems**

- Single phase AC system. single phase, two wires. single phase, two wires with midpoint earthed. ...
- Two phase AC system. two-phase, three wires. two-phase, four wires.
- Three phase AC system. three-phase, three wires. three-phase, four wires.
- DC system. DC two wires.

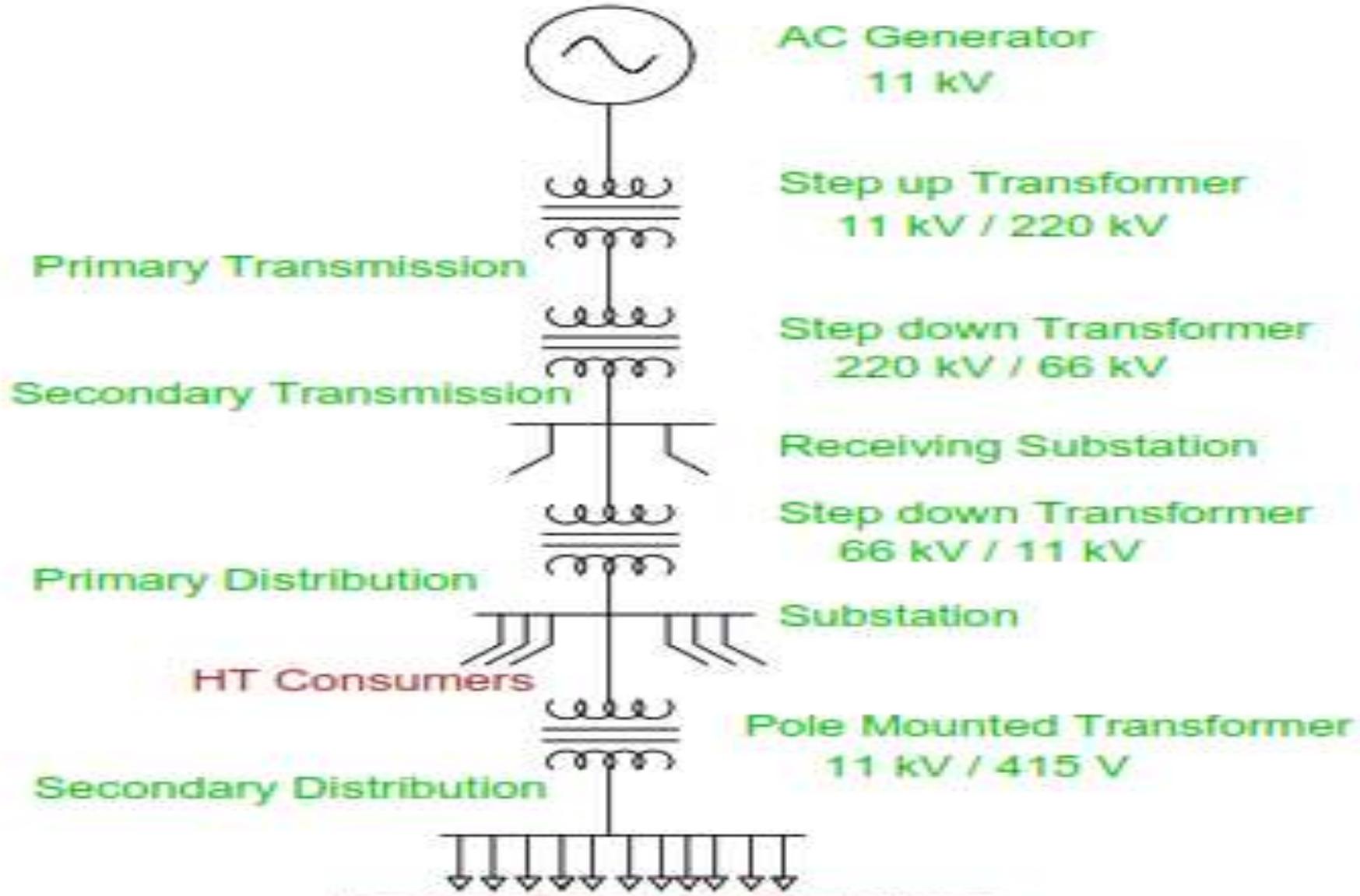



FIG : Single Line Diagram of Power Supply System

# ADVANTAGES OF DC TRANSMISSION

- There are two conductors are used in DC transmission while three conductors are required in AC transmission.
- There are no inductance and surges (High Voltage waves for very short time) in DC transmission.
- Due to the absence of inductance, there are very low voltage drop in DC transmission lines as compare to the AC (if both Load and Sending end Voltage is same)
- There is no concept of Skin effect in DC transmission lines. Therefore, conductor having small cross sectional area is required in DC transmission line.
- A DC System has a less potential stress over AC system for same Voltage level. Therefore, a DC line requires less insulation.
- In DC System, there is no interference with other communication lines and systems.
- In DC Line, Corona losses are very low as compared to the AC transmission lines.
- In High Voltage DC (HVDC) Transmission lines, there are no dielectric losses.
- In DC Transmission system, there are no difficulties in synchronizing and related stability problems.
- DC system is more efficient than AC, therefore, the rate of price of Towers, Poles, Insulators, and conductor are low so the system is economical.
- In DC System, the speed control range is greater than AC System.
- There is low insulation needed in the DC system (about 70%).
- The price of DC cables is low (due to low insulation).
- In DC Supply System, the Sheath losses in underground cables are low.
- DC system is suitable for High Power Transmission based on High Current transmission.
- In DC System, The Value of charging current is quite low, therefore, the length of the DC Transmission lines is greater than AC lines.

# DISADVANTAGES OF DC TRANSMISSION:

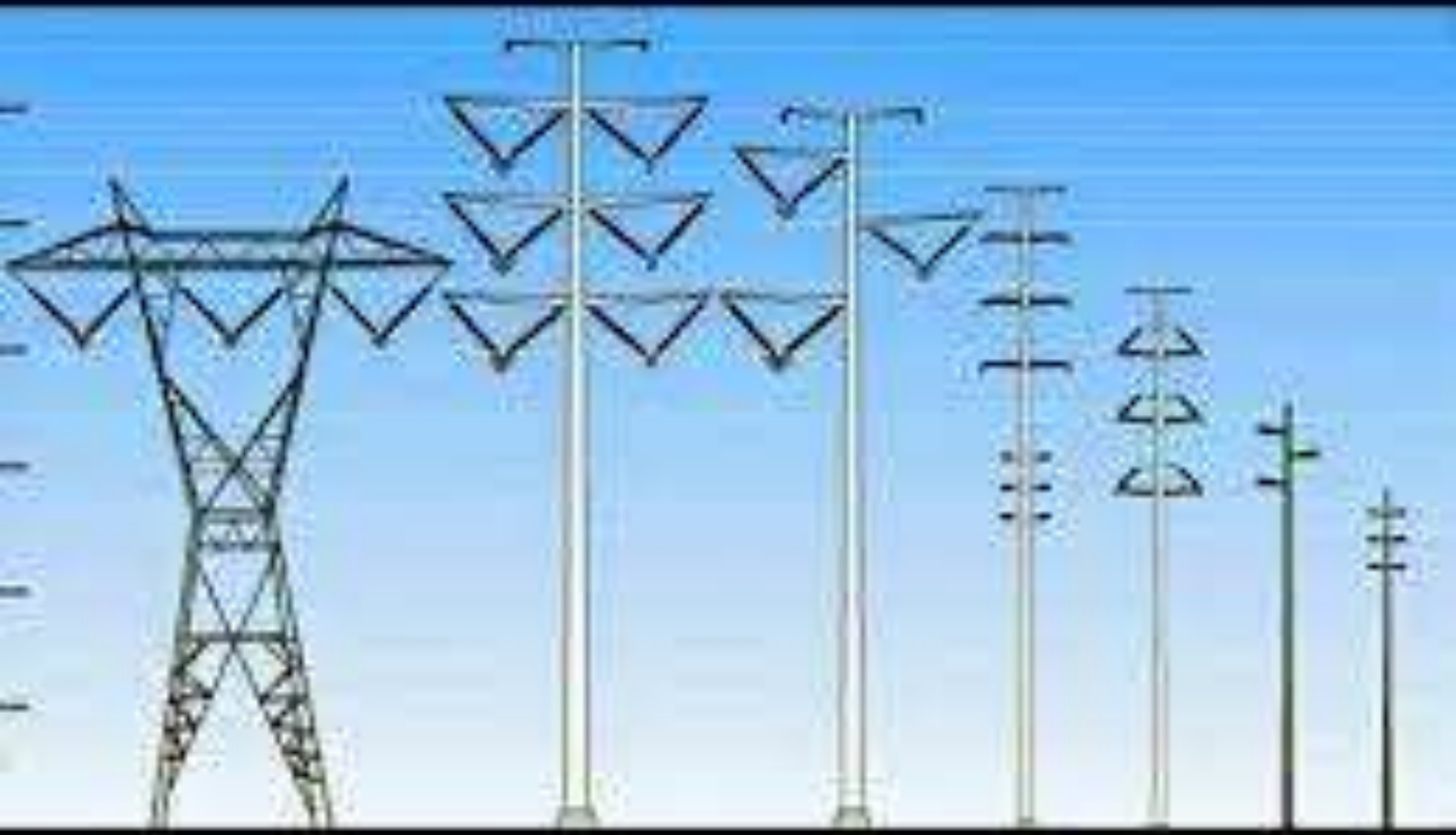
- Due to commutation problem, electric power can't be produced at High (DC) Voltage.
- In High Voltage transmission, we cant step-up the level of DC Voltage (As Transformer won't work on DC).
- There is a limitation of DC switches and circuit breakers (and they are costly too).
- The motor generator set is used to step down the level of DC voltage and the efficiency of Motor-generator set is lower than a transformer.
- DC transmission system is more complex and costly as compared to the AC transmission system..
- The level of DC Voltage can not be changed (step-up or step-down) easily. So we can not get desire voltage for electrical and electronics appliances (such as 5 Volts, 9 Volts 15 Volts, 20 and 22 Volts etc) directly from the transmission and distribution lines.

# CONSTRUCTION FEATURES OF A TRANSMISSION LINE

- These transmission lines will use **a combination of lattice towers and support poles.** The materials for construction needed for each tower are brought to site and distributed along the right-of-way where the towers will be built. Smaller poles are placed between the towers to support the transmission cables

# SUPPORTING STRUCTURES

- The supporting structures used for overhead transmission line conductors, such as **poles and towers**, are called the transmission line supports. The line supports should have high mechanical strength so that it can withstand the weight of conductors and wind loads.



# INSULATOR

- A material that does not let electricity and heat travel through it is known as an insulator. The electrical insulator is a protector or protective device that finds a use for connecting many electrical components. It plays a notable role in the making of various electrical and electronic circuits and overhead power systems.
- The overhead line conductors on the poles are supported by an Insulator, which prevents current flow toward the ground. The transmission lines must function properly. Different materials, such as rubber, wood, plastic, mica, and others, can be used to create an insulator

- **Insulator properties**
- Insulators have some specific properties that make them different from other electrical devices. These are some features of insulators:
- High resistivity
- Good mechanical strength for the conductor load
- The high relative permittivity of insulator material
- Good dielectric strength
- Waterproof or non-porous
- Types of insulator materials
- Insulators consist of different types of insulator materials like plastic, rubber, mica, wood, glass, etc. In the electrical system, specific insulating materials are used like porcelain, glass, steatite, polymer, ceramic, PVC.

- **The importance of insulators**
- Help to protect from heat, noise, and electricity
- Support the overhead conductor
- Insulate the live parts of equipment or conductor from the earth
- Help to save switchgear, transformer, and other systems in a substation
- **Types of insulator**
- 4 Main Types of Insulator are:
- **Pin insulator**
- **Post insulator**
- **Suspension insulator**
- **Shackle insulator**

# PIN TYPE INSULATOR

An insulator that isolates a wire from physical support, such as a pin on a utility pole or tower, is known as pin type insulator. It is the first developed insulators and being used for overhead lines. As the name suggests, the pin insulator is secured to the cross-arm on the pole. A pin insulator consists of nonconducting material such as porcelain, glass, plastic, polymer, or wood. Pin type insulators find a use for transmission and distribution of electric power at voltages up to 33 kV. Beyond operating voltage of 33 kV, the pin type insulators become too bulky and hence uneconomical.

- Pin insulator specifications
- It has high mechanical strength.
- It requires less maintenance as compared to other insulator types.
- Pin insulator pros
- Good creepage distance
- Simple in construction and cheap in cost
- Easy maintenance
- Can be used both vertically & horizontally
- Applicable to a high voltage transmission line.
- The mechanical strength of this insulator is high.

# SUSPENSION TYPE INSULATORS

These insulators **consist of a number of porcelain discs connected in series by metal links in the form of a string.** The line conductor is suspended at the bottom end of this string and the other end of the string is fixed to the cross-arm of the steel tower

# ADVANTAGES OF SUSPENSION INSULATORS:

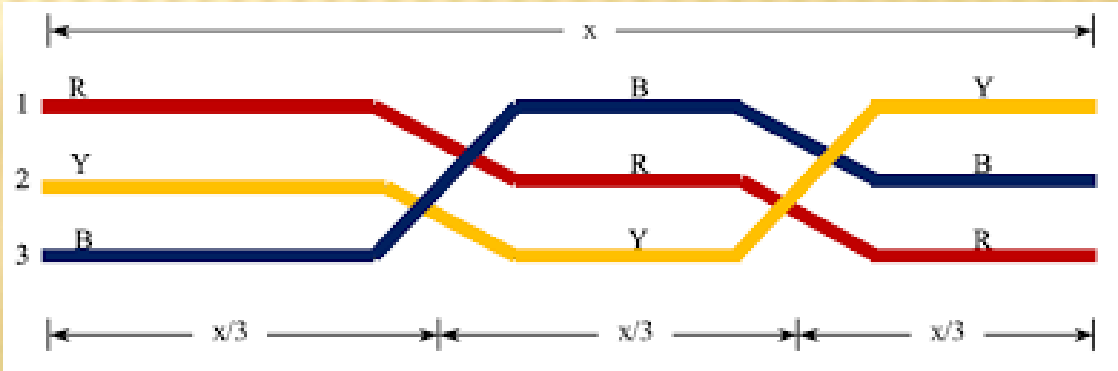
- Suspension insulators are cheaper  in cost compared to pin type insulators for operating voltage above 50kV
- Each unit of suspension insulators (insulator disc) is designed for comparatively low voltage (11kV) and can be increase the insulation strength by connecting these insulator disc modules in series. The number of insulator discs require depends on the operating voltage
- Suspension type insulators give more flexibility to the line and mechanical stresses due to wind and other factors are reduced in this suspension type insulator arrangement. The connection at the cross arm is such a way that the insulator string is free to swing in any direction and thus takes up a position where it experiences only a pure tensile stress
- The suspension type insulators when used in conjunction with steel supporting structure has the advantage of rendering the conductor less liable to the affected by cross-arm thus enabling the tower to function as lightning ro

# SHACKLE INSULATOR

- An insulator that is used in distribution networks that works with low voltage is known as a shackle insulator. This insulator is also known as a spool insulator. These insulators can be worked in two positions like horizontal otherwise vertical. At present, the usage of this insulator has decreased because of the underground cable used in distribution purposes.

# TRANSPOSITION OF CONDUCTORS

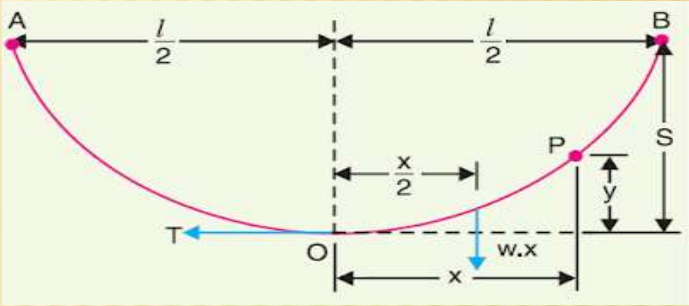
- Transposition is **the periodic swapping of positions of the conductors of a transmission line, in order to reduce crosstalk and otherwise improve transmission.** In telecommunications this applies to balanced pairs whilst in power transmission lines three conductors are periodically transposed.



# SAG

- In a transmission line, **sag** is defined as the vertical difference in level between points of support (most commonly transmission towers) and the lowest point of the conductor. The calculation of sag and tension in a transmission line depends on the span of the overhead conductor.
- Span having equal level supports (i.e. towers of the same height) is called **level span**. Conversely, when the span has unequal levels of support, this is known as **unequal level span**.

- Let us consider an overhead line supported at two different towers which are at same level from ground. The point of support are A and B as shown in figure below. O in the figure shows the lowest point on the conductor. This lowest point O lies in between the two towers i.e. point O bisects the span equally.

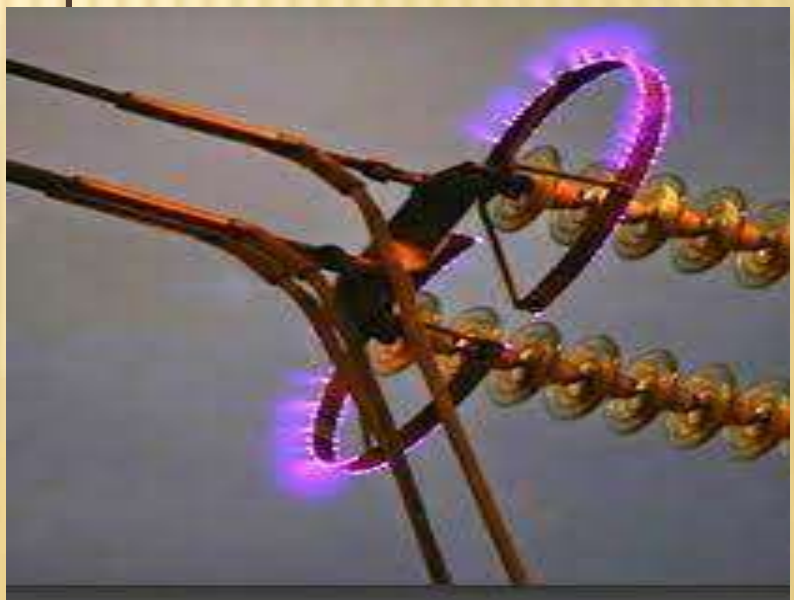



Let,
L = Horizontal distance between the towers i.e. Span
W = Weight per unit length of conductor
T = Tension in the conductor
Let us take any point P on the conductor. Assuming O as origin, the coordinate of point P will be (x,y).
Therefore, weight of section OP = Wx acting at distance of x/2 from origin O.

As this section OP is in equilibrium, hence net torque w.r.t point P shall be zero.
Torque due to Tension T = Torque due to weight Wx
$Ty = Wx(x/2)$
Therefore, $\mathbf{y = Wx^2 / 2T}$ .....(1)
For getting Sag, put x = L/2 in equation (1)
$\mathbf{Sag = WL^2/8T}$

# CORONA

- **This phenomenon occurs when the electrostatic field across the transmission line conductors produces the condition of potential gradient.** The air gets ionized when the potential gradient at the conductor surface reaches the value of 30kV/cm at normal pressure and temperature



- **Factors Affecting Corona Discharge:**
- Supply Voltage: As the electrical corona discharge mainly depends upon the electric field intensity produced by the applied system voltage. ...
- Conductor Surface: The corona effect depends upon the shape, material and conditions of the conductors

# METHODS OF REDUCING CORONA EFFECT:

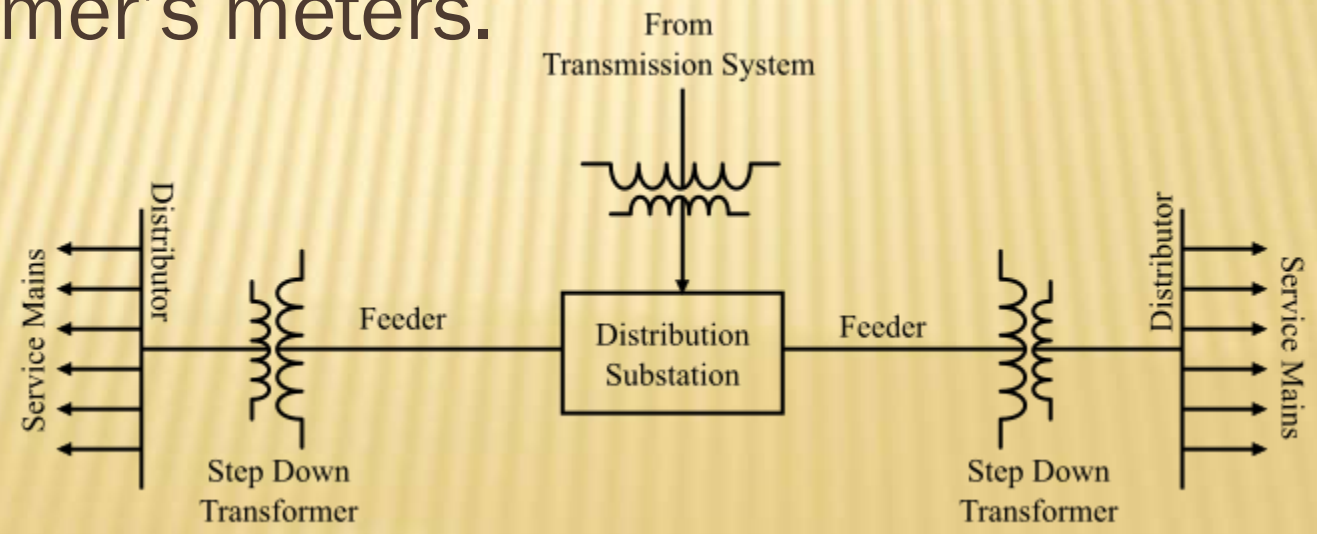
It has been seen that intense **corona effects** are observed at a working voltage of 33 kV or above.Therefore, careful design should be made to avoid corona on the sub-stations or bus-bars rated for 33kV and higher voltages otherwise highly ionised air may cause flash-over in the insulators or between the phases, causing considerable damage to the equipment. The following are the **methods of reducing corona effect** :

(i) **By increasing conductor size :** By increasing conductor size, the voltage at which corona occurs is raised and hence corona effects are considerably reduced.This is one of the reasons that ACSR conductors which have a larger cross-sectional area are used in transmission lines.

(ii) **By increasing conductor spacing :** By increasing the spacing between conductors, the voltage at which corona occurs is raised and hence **corona effects** can be eliminated.However, spacing cannot be increased too much otherwise the cost of supporting structure (e.g., bigger cross arms and supports) may increase to a considerable extent.

# DISTRIBUTION SYSTEM

- The part of the power system that distributes electric power for local use is called as *distribution system*. Generally, a distribution system is the electrical system between the substation fed by transmission system and the consumer's meters.



# COMPONENTS OF DISTRIBUTION SYSTEM

- **Distribution Sub-Station** – A distribution sub-station is the electrical system which transfers power from transmission system to the distribution system of an area.
- **Feeders** – A feeder is a conductor which connects the distribution sub-station to the area where power is to be distributed. The current in a feeder remains the same throughout its length because no tapings are taken from it. The main consideration in the design of a feeder being its current carrying capacity.
- **Distribution Transformers** – The distribution transformer is a step-down transformer in which primary and secondary are delta and star connected respectively. It is also termed as *service transformer*. The output voltage of distribution transformer is 440 V in 3-phase system whereas 230 V in 1-phase system in India.
- **Distributor** – A distributor is a conductor from which tapings are taken for supply to the consumers. Due to the taping is done at various places in a distributor, the current being not same throughout its length. The main design consideration of a distributor is the voltage drop across its length because the statutory limit of voltage variations is ± 6 % of rated voltage at the consumer's terminals.
- **Service Mains** – Service Mains is a small cable which connects the distributor to the consumer's meter.

# CLASSIFICATION OF DISTRIBUTION SYSTEM

- Classification based on the *nature of current* –
- DC distribution system
- AC distribution system
- Classification based on the *type of construction* –
- Over-head system
- Under-ground system
- Classification based on the *scheme of connection* –
- Radial system
- Ring main system
- Inter-connected system
- Types of AC Distribution System
- Primary Distribution System
- The primary distribution system is the part of AC distribution system which operates at voltages slightly higher than general utilization. The voltage used for primary distribution depends upon the amount power to be transferred and distance of substation required to be fed. The commonly used primary distribution voltages are 11 kV, 6.6 kV and 3.3 kV. The primary distribution is done by 3-phase 3-wire system because of economic considerations.
- Secondary Distribution System
- The secondary distribution system includes those ranges of voltage at which consumer utilises the electrical energy. In India, the secondary distribution employs 440V (3-phase) & 230V (1-phase), 3-phase 4-wire system.

# REQUIREMENTS OF A DISTRIBUTION SYSTEM

Some of the requirements of a good distribution system are –

- **Proper Voltage** – The voltage variations at consumer's terminals should be as low as possible. The statutory limit of voltage variations is ± 6 % (India) of the rated voltage at consumer's terminals.
- **Availability of Power on Demand** – The electric power must be available to the consumers in any amount that they may require from time to time.
- **Reliability** – The modern industry is almost dependent on electric power for its operation. This calls for reliable service as much possible.

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