# POWER GENERATING STATION

## ELECTRICAL POWER - II

## $6^{TH}$ SEMESTER ELECTRICAL ENGG.

# Topics

- Introduction
- Advantages of Electrical energy
- Natural Sources of Energy

1. Water
2. Fuels
3. Nuclear energy
4. Sun
5. Wind
6. Sea Waves
7. Tides
8. Biomass

# Topics

- Non Renewable & Renewable Sources of Energy
- Major Generating Stations
  1. Hydro Electric Power Stations
  2. Steam Power Station
  3. Diesel Power Station
  4. Nuclear Power Station
- Operating Costs
- Comparison between Various Power Stations
- Examples

# Introduction

- Electricity plays very important role in our daily life. All our activities are directly or indirectly related to electricity. Electricity come in India in 1897 at Darjeeling. In Delhi the first electricity generating plant was established on 1905 for public.
- We know the demand of electricity keeps on increasing as the dependence of man kind increasing day by day.

# Introduction

- The electrical energy is generated at far away places and consumed by different consumers in cities, towns and villages. When the energy is transmitted and distributed to various consumers there is loss of energy called transmission losses.
- In fact, in India, a large portion of these losses is due to theft of electrical energy.

# Advantages of Electrical Energy

The different forms of energy available from various natural sources are converted into Electrical energy . It is because of the following merits of electrical energy over the other forms

1. Economical : It is more economical than the other forms because of low losses.
2. Easy to handle : It can be handled very easily over a long distance, through conductors.
3. Flexible : Electrical system is very flexible. It can be taken easily to any corner of house, factory, street etc using flexible conductors.

# Advantages of Electrical Energ

4. Cleanliness : Electrical energy , heating and electrical gadgets do not produce any smoke, dust etc.
5. No poisonous Gases : Electrical energy is not associated with smoke, fumes or other harmful gases. So it can be used safely for domestic and industrial purposes.
6. Easy to operate : Electrical systems starting, control and operation is very simple.

# Natural Sources of Energy

1. Water
2. Fuels
3. Nuclear Energy
4. Sun
5. Wind
6. Sea waves
7. Tides
8. Biomass etc.

# Water

The potential energy of water collected at higher level or the kinetic energy of water flowing at high velocity can be used to run the turbines. These turbines or prime- movers are known as hydraulic turbines. Generators are coupled to these turbines which converts mechanical energy into electrical energy.

The capital investment is high but the running cost is low as no fuel is used. So this type of system is more popular.

# Water

In India, one of the major hydro electric power project is Bhakra Nangal Project. The dam is erected across the river Sutlej and a lake called Gobind Sagar is created behind it. This project has two power houses :

The capacity of left bank is 540 MW and capacity of right bank is 660 MW and overall capacity is 1200 MW.

# Water

The energy flow diagram is as under:

# Fuel

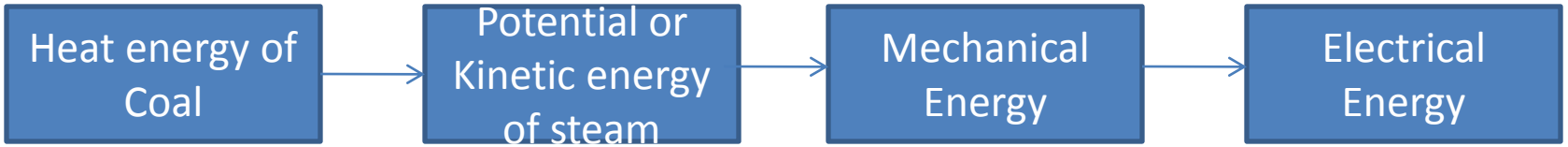
The most common source of energy is fuel and is available as under :

1. Solid fuels
2. Liquid fuels
3. Gaseous fuels

The initial cost of these power stations are low but the operating cost is high.

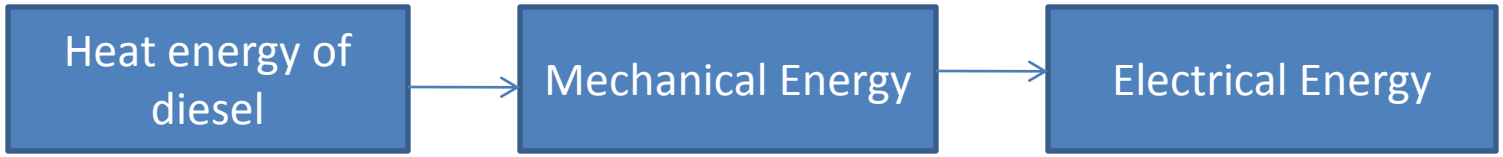
# Solid Fuels

The main solid fuel is coal, which is available in nature in huge quantity. By the combustion of coal in the boiler, heat energy is produced which is utilized to convert water into steam. This steam is used to run the turbines, to which generator is coupled. Thus electrical energy is generated. This type of energy generation is very popular in India.



# liquid Fuels

The main liquid fuel is diesel. The diesel is injected into the piston cylinder of diesel engine, where burning of diesel take place which develops mechanical energy. A generator is coupled to diesel engine and this mechanical energy is converted into electrical energy. The running cost of these systems is very high.



# Gaseous Fuels

Natural gas, when available is used to run the gas turbines or it is burnt to produce steam which is used to run the turbines. Thereafter, a generator is coupled to the turbine to generate electrical energy. Except at the site where it is available in abundance, it is rarely used.

# Nuclear Energy

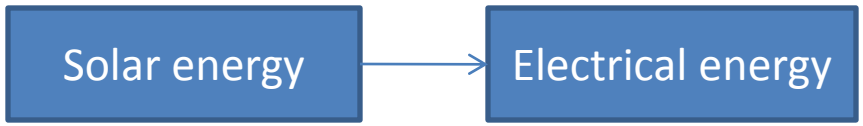
The heavy substance whose nucleus can be broken into fragments is called nuclear fuel. The only substance found in nature which fissions and is capable of propagating nuclear chain reaction is Uranium. By fission of nuclear of Uranium, binding energy is released in the form of heat energy, which is used for conversion of water into steam. Steam is used to run turbines, and a coupled generator produces electrical energy. The operating cost is very low, however limited availability of material and high initial cost are the main drawbacks.

# Sun

This is the primary source of energy. Sun radiates energy in the form of electro magnetic waves, which includes heat, light and lot of ultra violet radiations. Heat energy received by the upper layer of atmosphere is of the order of 1000 Kcal/$m^{2.}$ This heat energy may be converged at the boiler by using reflectors. This is used to run steam turbines, which coupled with generator and hence produce electrical energy.

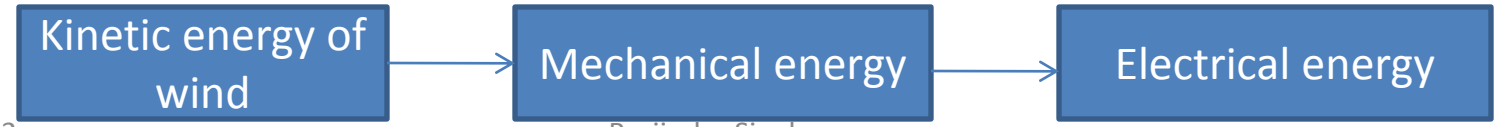
# Sun

Usually for small energy conversion, solar cells are used. The panel of solar cells converts solar energy into electrical energy. This energy is stored in batteries. The electrical energy supplied by the batteries is utilized for the operation of various electronic circuits such as street lights , watches, satellites, calculators etc.



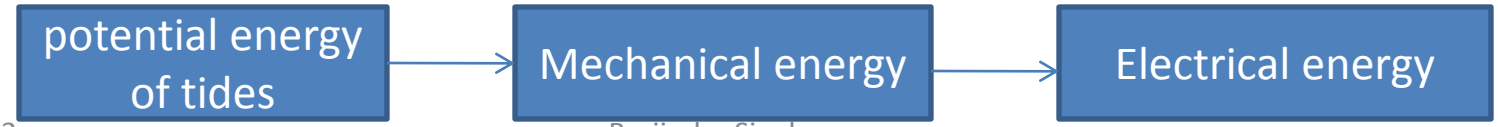
# Wind energy

Wind pressure is developed due to heating and cooling of atmosphere and this wind energy is utilized in wind mills to drive small generators. This energy generated is used to charge the bank of batteries for continuous use. Power generation in this case is limited and depend upon velocity of wind. The electrical energy in this case is very economical.



# Sea Waves

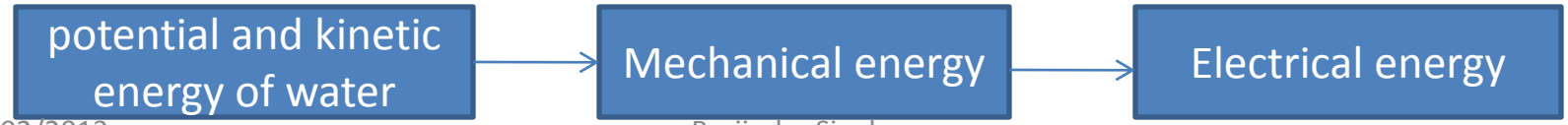
Considerable energy is possessed by the waves of ocean in the form of potential energy. The amount of energy depends upon the amplitude and pitch of waves. In india, a wheel is kept in box and placed at the bottom of a ship. Depending upon the amplitude of wave the ship tilts in any direction , wheel starts rotating and a generator is coupled which gives electrical energy. In this case, the generated electrical energy is very small and use for charging the batteries.

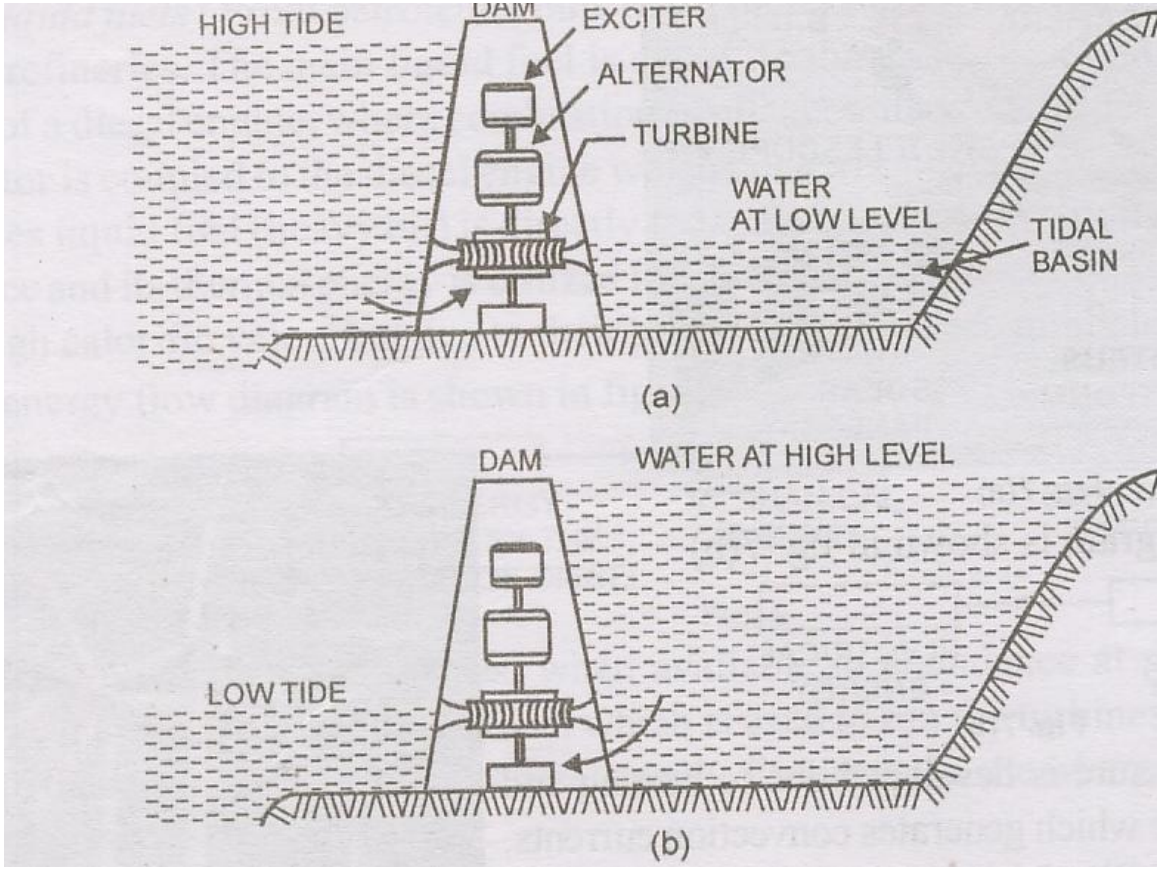


# Tides

Water is stored in the tidal basin during high tides, while it is discharged during the low tides. Due to the difference of level , potential energy of water is utilized for the generation of electrical energy.

A dam is erected at the sea shore. At the time of high tide the water flows from sea to tidal basin and rotate the turbine and increase the level of water in tidal basin. Similarly, at low tide, water flows from tidal basin to sea and rotate turbine and decrease level of water in tidal basin. A generator is coupled to turbine which produce electrical energy. However, when both level same no energy is produced.





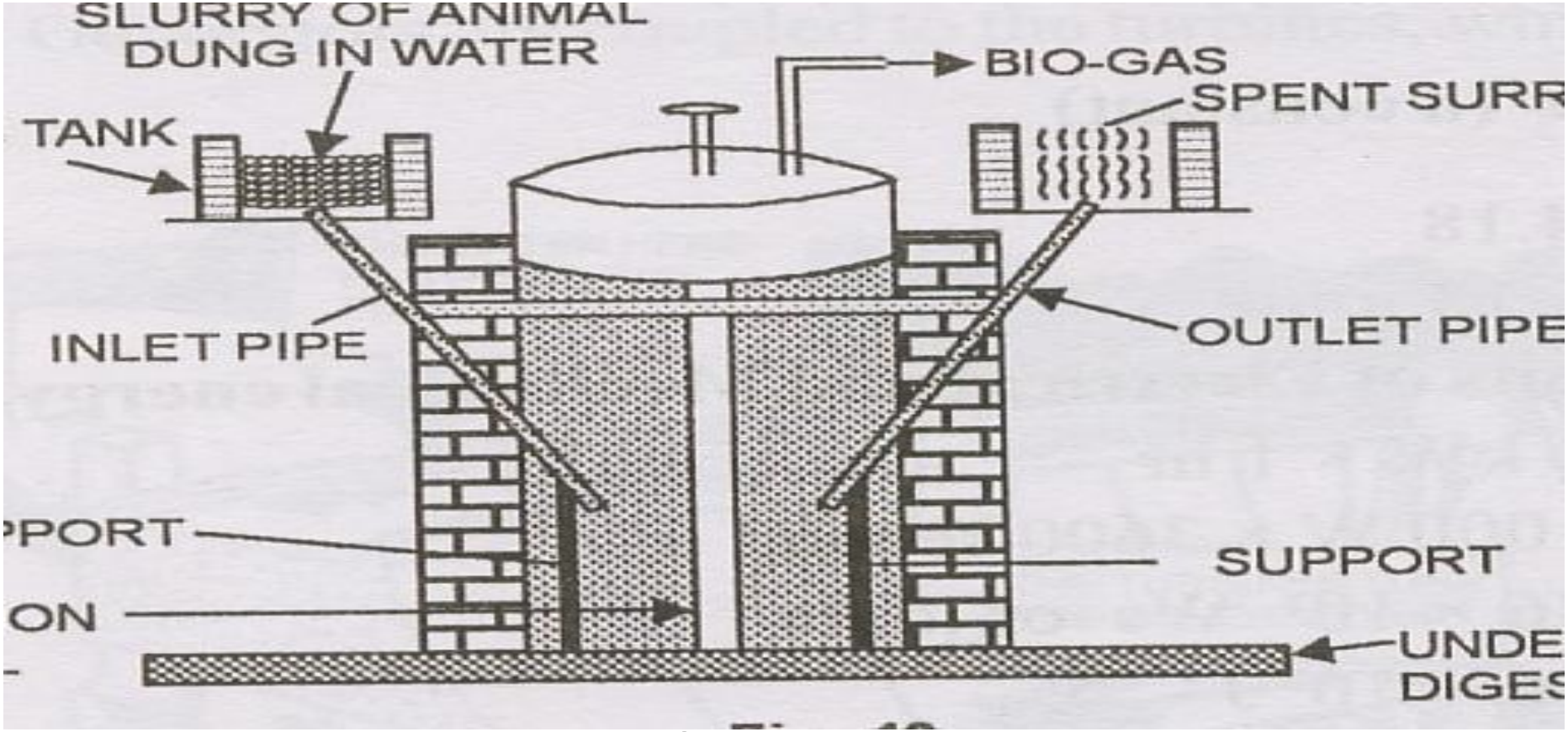

# Tides

Although in this case the potential head of water is small, but by increasing capacity of tidal basin , huge power can be generated e.g. 300 MW.

# Biomass

Biomass contain chemical energy. We have seen people in villages burning cowdung cakes as fuel. A better method is to convert biomass into gas called biogas. This gas is prepared in biogas plants. In this case, biomass is mixed with water and slury is made. It is an excellent fuel for cooking.

It can also used as street lighting and running engines in villages.




# Biomass

Bio gas plant

# Source of energy

1. Non renewable sources : The sources of energy which once used can not be replaced are called as non renewable source of energy such as coal, petroleum etc.
2. Renewable sources : The source of energy which will never runout are called renewable source of energy such as sun, water, wind, tides and biomass etc.

# Units of Energy

The capacity to do work is known as energy.

The most important form of energy are mechanical energy, electrical energy and thermal energy.

1 calories = 4.18 joule

1 kWh = 36 X $10^5$ Nm

1 kWh = 860 k calories

# Generation of Electrical Energy

Since energy can neither be created nor destroyed but it can only be transformed from one type to an other.

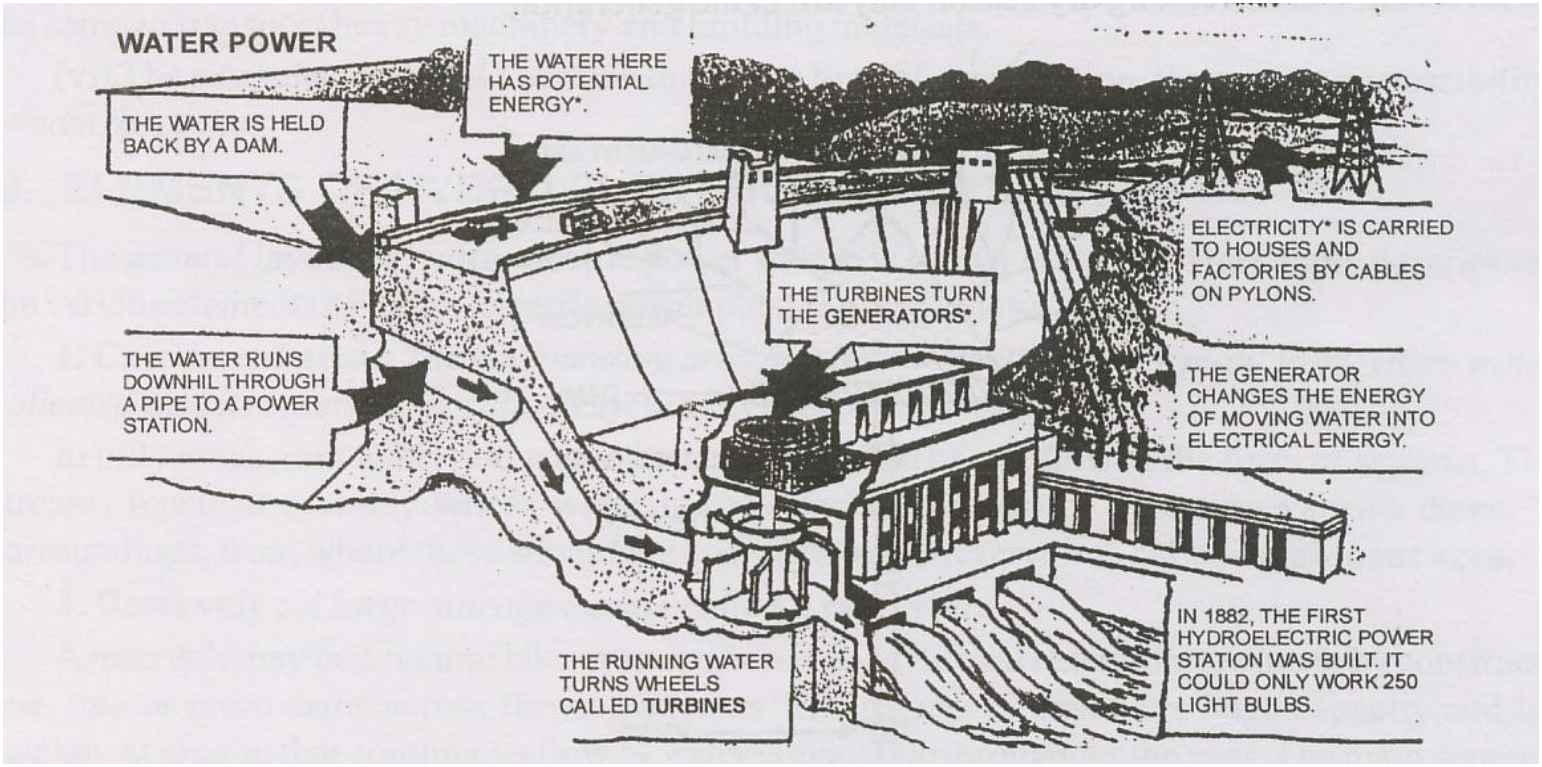
Thus, the conversion of energy available in different forms in nature into electrical energy is known as Generation of Electrical Energy. Major types of generations are as under :

1. Hydro electric power station
2. Steam power station
3. Diesel power station
4. Nuclear power station.

# Hydro-Electric Power Station

A power station in which potential energy of water is converted into electrical energy is called hydro-electric power station. In this type of station, a huge quantity of water at sufficient head must be available. So it is located in hilly areas where dams can built at suitable place to store large quantity of water in artificial reservoirs. When the water falls, through pen stock, on the blade of turbines , potential energy is converted into mechanical energy. Generators are coupled with turbine which convert mechanical energy into electrical energy.

# Hydro-Electric Power Station



# Advantages of Hydro-Electric Power Station

Due to limited reserves of fuels and increasing demand of electrical power, the hydro- electric power stations are becoming more and more popular.

Advantages :Following are the main advantages:

1. As no fuel is used , so no charge for transportation.
2. Operating cost is low because only operators are required.
3. Low maintenance cost
4. As these are in hilly areas so cost of land is small.

# Advantages of Hydro-Electric Power Station

5. The efficiency is high approximately 80 to 90 %.
6. It is very neat and clean as there is no smoke, ash and dust.
7. It can be put into service instantly.
8. The plant has long life.
9. The plant has constant frequency.
10. These plants are flood control and use for irrigation purposes.

# Disadvantages of Hydro-Electric Power Station

1. The capital cost is high.
2. As it built in hilly areas, so the cost of transmission power is high.
3. The power generation depends on nature and in dry season the generation of power reduces.
4. It requires large area for reservoir and dam.
5. It takes long time for erection.

# Selection of site for hydro –electric Power Plant

The following are the main factors for selection of site :

1. The plants should be installed where adequate quantity of water is available.
2. The reservoir should have huge capacity and large catchment area.
3. Water collected behind dam has sufficient head to deliver more potential energy.
4. Land should be strong to withstand weight of dam.
5. Transportation facilities are available.

# Elements of hydro power station

1. Catchment area
2. Reservoir
3. Dam
4. Spillways
5. Valve house
6. Surge tank
7. Racks
8. Penstock

# Elements of hydro power station

9. Water turbines
10. Draft tube
11. Tail race
12. Alternator
13. Control room
14. Switch yard

# Catchment Area

The surrounding area of a hydro-electric plant from where water is collected into reservoir is called catchment area.

In hilly areas, rain water and water from melting of ice . These reach to valley where water is collected by erecting the dams. The surrounding from where these stream are coming into reservoir is called catchment area.

# Reservoir

A large storage tank of water is called reservoir.

A reservoir may be natural or artificial lake. The reservoir must have huge capacity and large catchment area so that continuous flow of water is available throughout the year. The main source of water are rainfall in the catchment area and melting of snow in the mountains.

# Dam

A strong wall with large base, behind which water is stored is called a dam

A dam , according to its structural material, performs two following functions ;

1. It creates the necessary water head
2. Store water in the reservoir

Dam is suitably designed to resist against sliding, overturning and rupturing.

# Spillways

The ways or passages for water to be released from the dam, when water increases beyond its safe level are called spillways.

At a particular level spillways are constructed on the dams. They act as safely valves for the dam. During rainy seasons, water reaching in the reservoir increases beyond the capacity of reservoir, then surplus water is released through these spillways to the downstream.

# Valve house

The cabin in which controls are kept to operate the valves of the gates of the penstocks is called valve house. It is situated at the start of penstock and contains main valve which control the flow of water.

# Surge Tank

An open tank connected to the penstock which regulates water supply through the penstock is called surge tank.

A surge tank is built just before the turbine. In case sudden closing of water turbine, the surge tank absorbs the water hammerage by increasing water level in it.

If it is not provided the water hammerage damage the penstock.

# Racks

At the entrance of tunnel racks are provided to prevent the floating and other maters to the turbine.

The space between the bars varies from 40 mm to 200 mm in accordance with the minimum width of water passage through the turbine.

# Penstocks

Huge steel or reinforced steel pipes that carries large quantity of water from valve house to the scroll case of the turbines are called penstocks.

In case of low and medium head power plants each turbine is provided with its own penstock, whereas in case of high head power plants a single penstock is used.

# Water Turbines

A device that converts the potential energy of water into mechanical energy is called water turbine. The type of turbine use depends upon the head of water.

According to action , they are classified as :

Impulse turbine

Reaction turbine

# Impulse Turbines

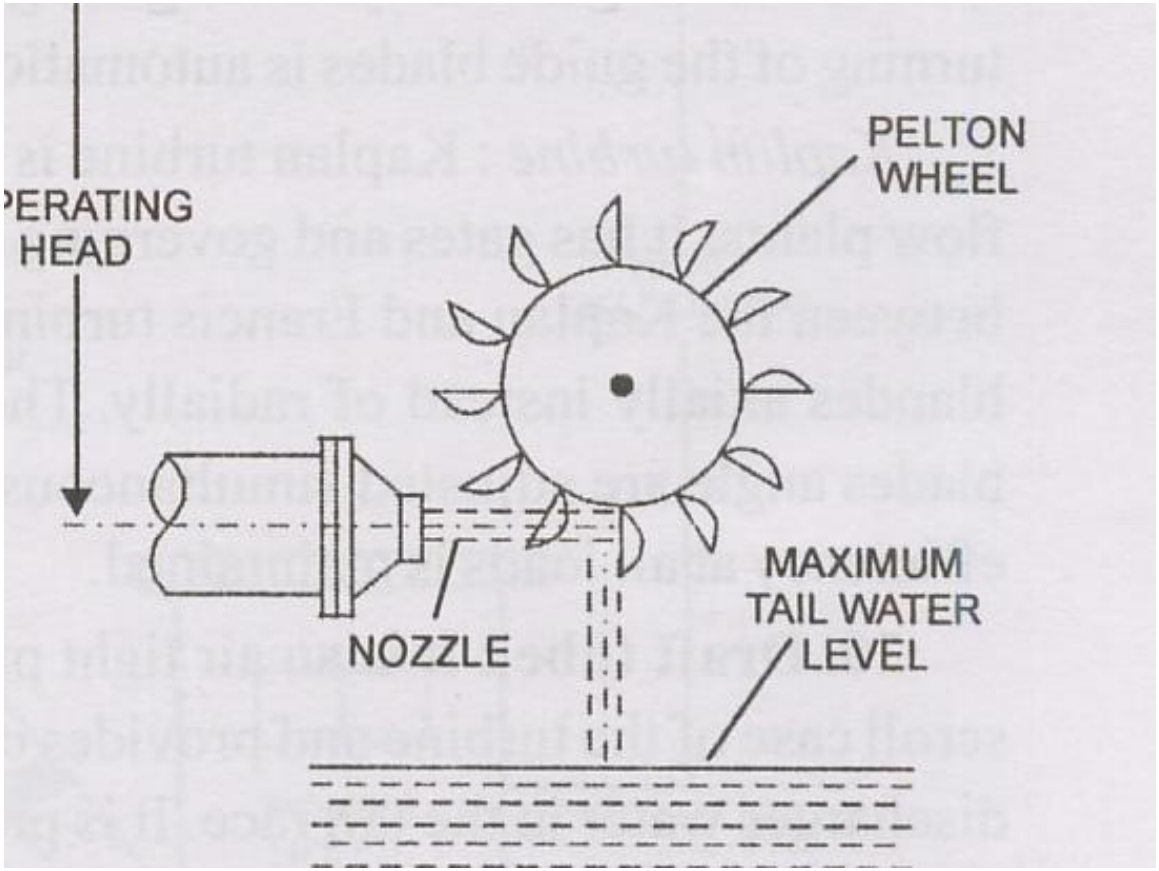
In an impulse turbine the whole head of water is converted into kinetic energy before it enters the wheel. During flow, pressure remains same and due to change of velocity both direction and magnitude, the water exerts a driving force on wheel and thus kinetic energy is converted into mechanical energy.

Impulse turbines are usually employed in high head power plants.

# Reaction Turbines

In the reaction turbine water may enter the wheel partly with pressure energy and partly with velocity head. During the passage through wheel both pressure and velocity of water are reduced and water gives up its energy to the wheel, which converts into mechanical energy.

Impulse turbines are usually employed in low and medium head power plants.




# Turbine

When water flows from penstock to turbine, it rotates and thus produce mechanical energy.

# Turbines

Pelton Turbine : It is a impulse turbine and used for low flow and high head.

Francis Turbine : It is a reaction turbine and used for low and medium head plant.

Kaplan Turbine : It is a reaction turbine and used for low head and large flow plants.

# Draft Tube

It is an air tight pipe of suitable diameter. It is connected at the bottom of the scroll case of turbine and provide outlet for water coming from turbine . It discharge the water in the tail race.

# Tail Race

Draft tube discharges water in the tail race, which may lead it to the same stream or to another.

# Alternator

An alternator is coupled to the turbine, which converts mechanical energy into electrical energy. The alternators employed in these power plants are of salient pole type, operating at slow speeds.

# Control Room

In the control room all the controlling equipments, protective devices, indicating instruments etc. are placed on the pannels.

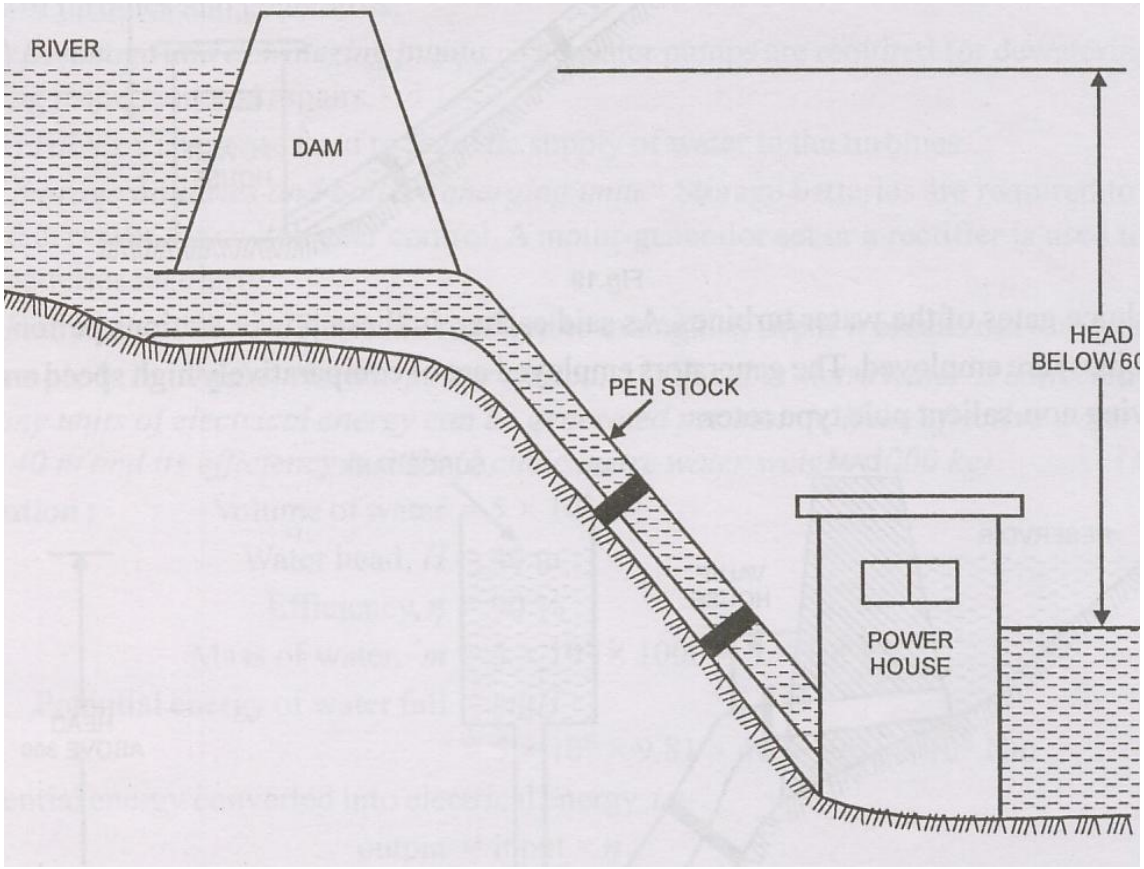
Electrical equipments like transformers, circuit breakers, CT's, PT's etc. are installed in switch yard.

# Classification of hydro station

On the basis of operating head, hydro –electric power stations may be classified as :

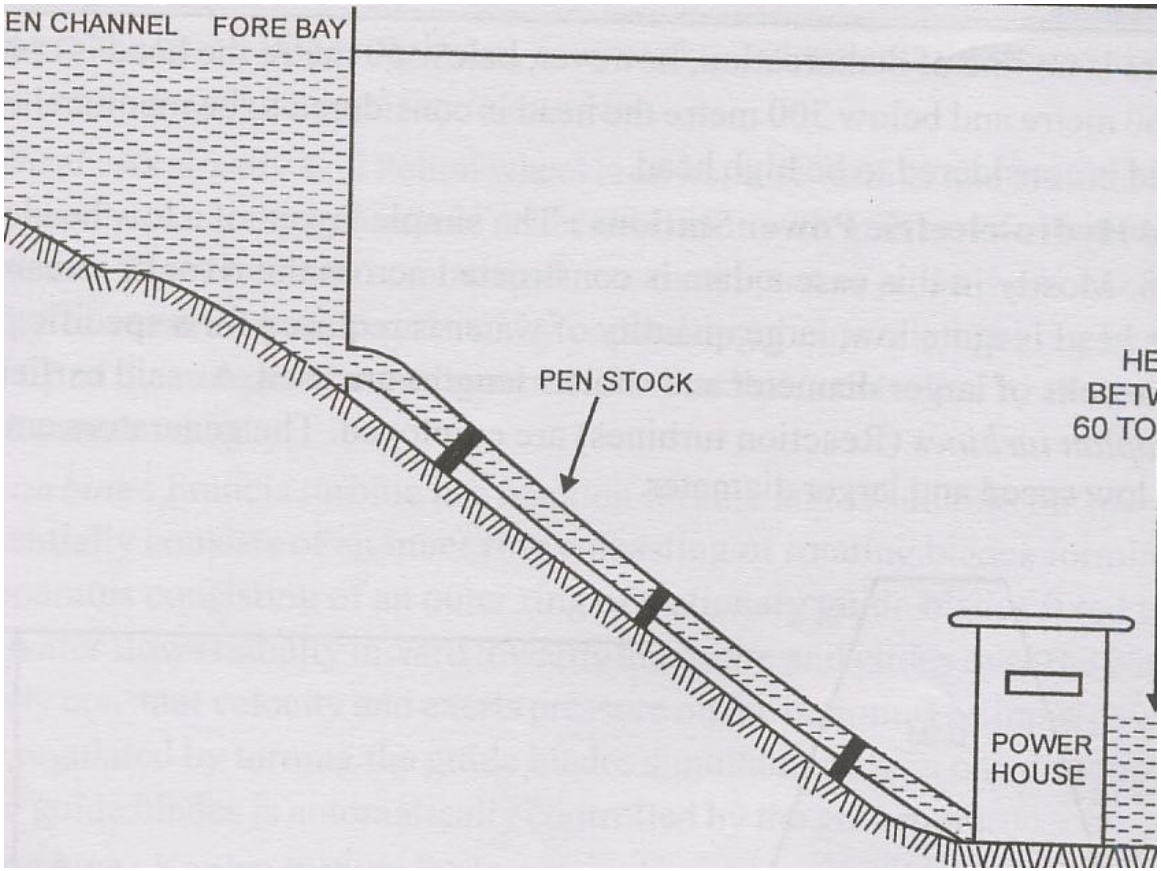
1. Low head power stations
2. Medium head power stations
3. High head power stations

Below 60 meter head is considered as low head, between 60 to 300 meter the head is medium and above 300 meter head is considered as high head.



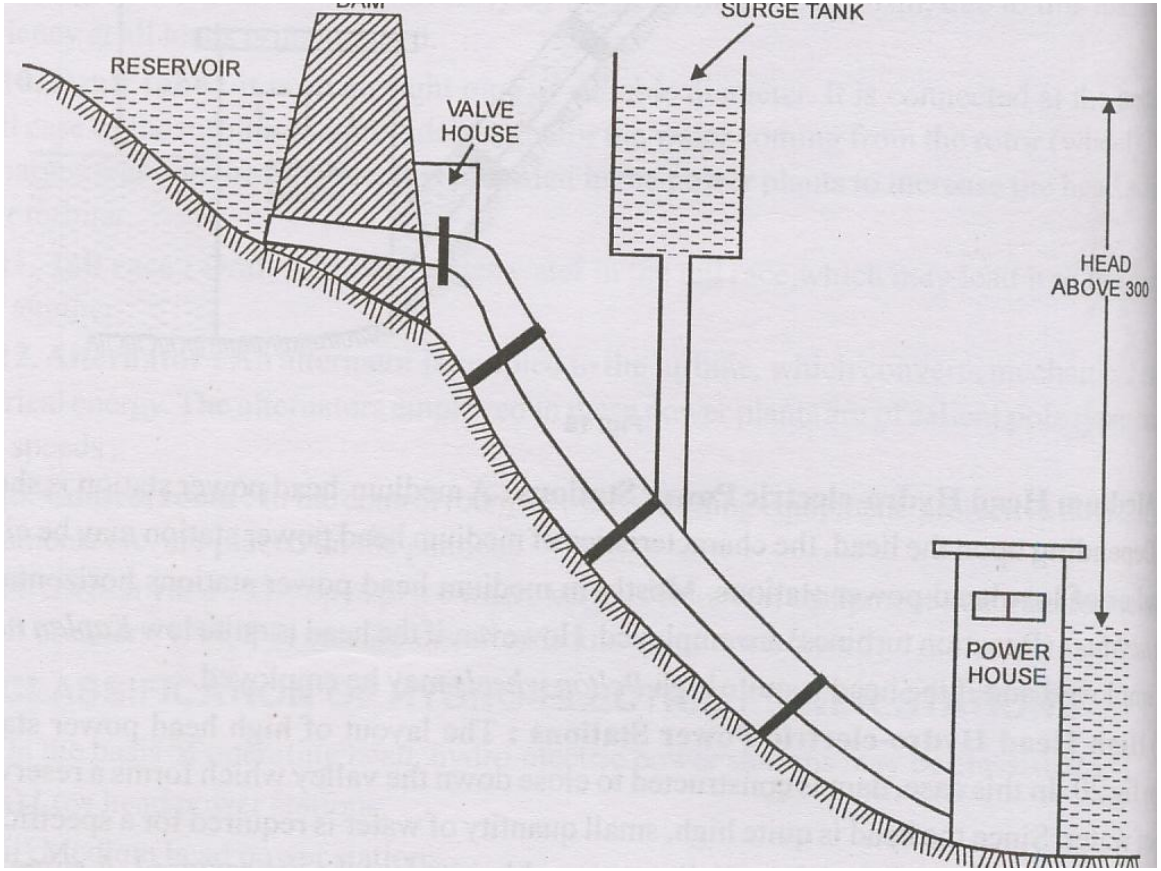

# Low head power station

The dam is constructed across the river. As the head is low large quantity of water is required for specific power output , therefore penstock of large diameter and short in length.




# Medium head power station

Depending upon the head, these power stations are either high head or low head power stations.




# High head power station

Since the head is quite high, small quantity of water is required for specific power output. Thus penstock of small diameter and longer lengths are required.

# Calorific value of Fuels

The amount of heat produced by the complete combustion of a unit mass of the fuel is called the calorific value.

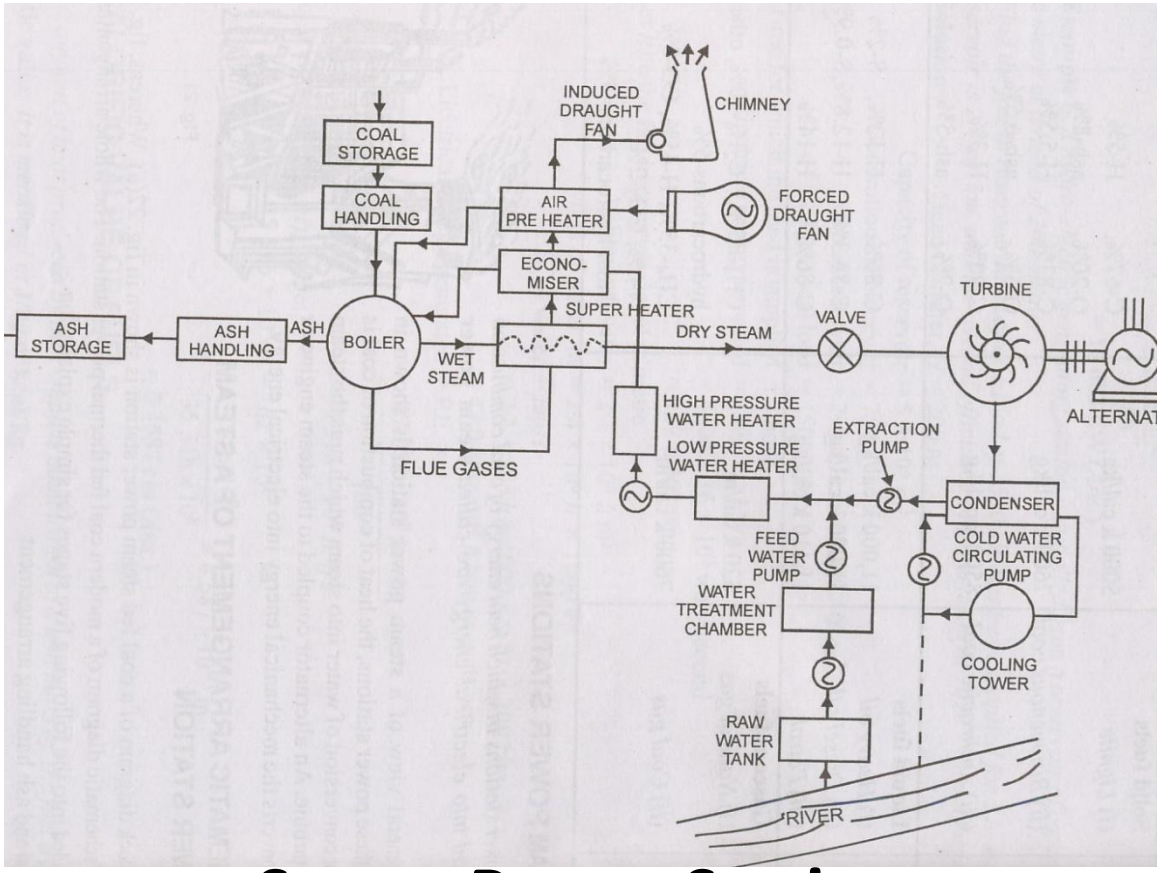
It is measured in J/Kg or Kcal/Kg.

The calorific value of a fuel represents the amount of heat available by the complete combustion of that fuel. The greater the calorific value, smaller the quantity of that fuel required for generation.

# Steam power Station

The power stations in which heat energy of coal combustion is converted into electrical energy are called steam power station.

In these power stations, the heat of combustion of coal is utilized for conversion of water into steam which run the steam engine or turbine. An alternator coupled to the steam engine or turbine, converts mechanical energy into electrical energy.




# Steam Power Station

Following arrangements are required for this power station ;

1. Coal and ash handling arrangement
2. Air and flue gas arrangement
3. Cooling arrangement
4. Electrical plant

# Advantages of Steam Power Plant

1. The fuel used is of low cost.
2. Less initial cost as compared to other.
3. The cost of generation is less.
4. They can be installed anywhere.
5. It requires less space.
6. Transmission line cost is less as located near load centre.

# Disadvantages of Steam Power Plant

1. Atmosphere is polluted due to smoke and fumes.
2. Running cost is high as compared to hydro electric power plant.
3. These requires more maintenance as compared to hydro power station.

# Selection of site for Steam Power Plant

1. The site should be near the coal site as possible.
2. The site should have sufficient supply of cooling water  or near canal.
3. The land should be of low cost.
4. The site should be away from the populated areas.

# Elements of Steam Power Plant

1. Boiler
2. Super heater
3. Economizer
4. Air pre-heater
5. Condenser
6. Prime mover

# Boiler

There are two type of boilers used in steam power plants namely fire tube and water tube boiler. In fire tube boilers, the hot gases circulate inside the tubes, which are surrounded by water. These types has low cost and used in small power stations due to low pressure. In case of water tube boiler, water circulates in tube and hot gases outside the tube. These type of boilers are used for large capacity due to high pressure , safe in operation, less space, and better overall control.

# Super heater

It is a part of a boiler which consists of number of special steel tubes. Depending upon the temperature of steam the diameter of tubes ranges from 25 mm to 64 mm.

The wet steam from the boiler is passed through the tubes of super heater where it is dried and super heated by the flue gases on their way to chimney. Thus the waste heat energy of flue gases is utilized.

# Economizer

It consists of large number of tubes made of special steel depending upon the temperature of steam. The feed water is passed through economizer before supplying to boiler.

Thus the temperature of feed water is raised by using the heat energy of waste flue gases.

# Condenser

The function of the condenser is to permits expansion of steam in the prime mover to a very low pressure and increases the efficiency of the power plant.

The exhausted steam is condensed in the condenser, which is again feed to the boiler.

# Primer mover

According to the action of steam on the moving blades, there are two types of turbines :

1. Impulse turbine : In this turbines, steam expands in nozzles only and when passes over the blade its pressure remains constant. It converts kinetic energy into mechanical energy.
2. Reaction turbine : In these turbines, steam expands as it flow over the blades, the blades itself act as nozzles. It converts heat energy into mechanical energy.

# Diesel Power Station

A power station in which diesel engines are used as prime mover and energy produced by the combustion of diesel oil is converted into electrical energy is called as diesel power station.

In these power stations the gases produced by the combustion of diesel oil are used to produce mechanical energy. An alternator is coupled to the diesel engine , which converts mechanical energy into electrical energy.

# Advantages of Diesel Power Station

1. less space is required for installation.
2. design and installation is simple.
3. Less quantity of water is required for cooling purposes.
4. Over all initial cost is low.
5. It is quickly started in operation.
6. These types of plants are located near load centre.
7. Cost of transportation diesel oil and transmission of power is low.

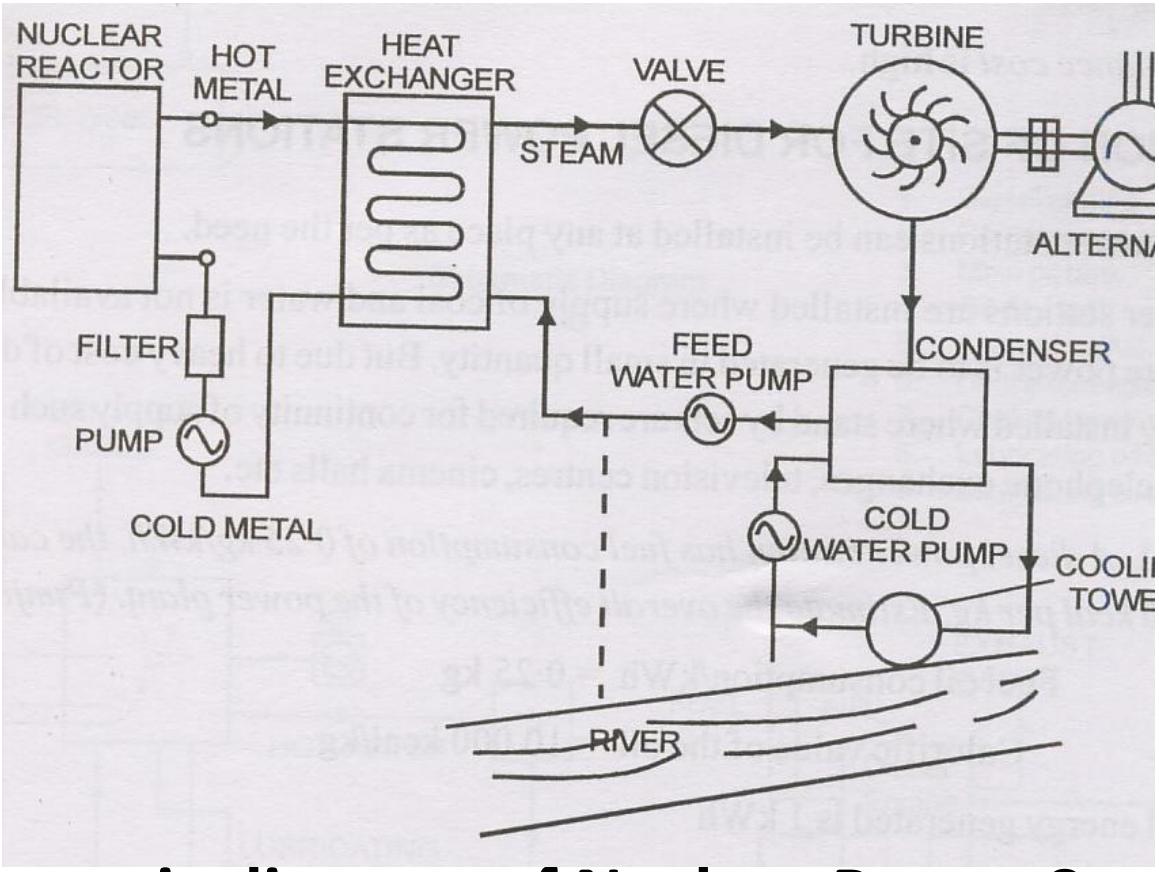
# Disadvantages of Diesel Power Station

1. Diesel is costly, thus running cost is high.
2. Capacity of diesel engine is limited.
3. Maintenance cost of diesel engine is more.

# Nuclear Power Station

A power station in which nuclear energy is used to produced electrical energy is called a nuclear power station.

It is interesting to know that 1 kg of nuclear fuel produces the same amount of heat which is produced by 2700 tons of coal.




# Schematic diagram of Nuclear Power Station

It is basically a steam power station in which steam boiler is replaced by nuclear reactor. A reactor is part of plant in which chain reaction of nuclear fission is controlled. The heat produce converts water into steam and rotate the turbine. Steam after giving heat is condensed and again feed.

# Advantages of Nuclear Power Plant

1. Amount of fuel requires is very small thus transportation cost reduces.
2. It requires less space.
3. The running cost is very low so it most economical.

# Disadvantages of Nuclear Power Plant

1. The danger of radioactivity is always there.
2. Initial cost is high.
3. Maintenance cost is more.
4. More time is required for installation.

# Elements of Nuclear power Plants

The following are the important parts of nuclear power plant :

1. Nuclear Reactor
2. Heat exchanger
3. Steam turbine
4. Alternator

# Nuclear Reactor

It is a nuclear furnace for carrying out controlled fission of radioactive material like Uranium-235.

It provides neutrons with sufficient energy so that it is absorbed by the nuclei and causing fission.

It also controls the chain process.

# Heat Exchanger

It is an arrangement by which heat produced due to nuclear fission.

Heat produced in the nuclear reactor is given to the coolant and it convert water into steam.

After giving up heat, the coolant is again back to the reactor.

# Steam Turbine

The steam produced by the heat exchanger is fed to the steam turbine through valve, which converts heat energy into mechanical energy.

# Alternator

An alternator is coupled to the steam turbine which converts mechanical energy into electrical energy.