RADHIKA.S
LECTURER, E&E DEPT.
BAPUJI POLYTECHNIC SHABANUR
DAVANGERE

UNIT-I: HYDRO ELECTRIC AND THERMAL POWER PLANT

In this modern world, the dependence on electricity is so much that it has become a part and parcel of our life. The ever increasing use of electric power for domestic, commercial and industrial purposes necessitates to provide bulk electric power economically. This is achieved with the help of suitable power producing units, known as *Power plants or Electric power generating stations.*

A generating station essentially employs a prime mover coupled to an alternator for the production of electric power.

According to the law of conservation of energy , the energy can neither be created nor be destroyed , but can be converted from one form to other . so the generation of electrical energy is nothing but the conversion of various other forms of energy such as burning coal , oil or natural gas, water stored in dams, diesel oil, nuclear power into an electrical energy .

Bulk electric power is produced by special plants known as generating stations or power plants.

VARIOUS SOURCES OF ENERGY AVAILABLE IN NATURE:-

The energy sources can be classified as,

i] Conventional type of energy sources.

ii] Non-Conventional type energy sources.

Conventional type of energy sources:-[Non renewable]

The energy sources which once used cannot be recovered any more are called conventional energy sources.

Conventional energy sources are,

1. coal

2.petroleum products like petrol, diesel, kerosene etc.

3.Natural gas

4.Nuclear energy

Non-Conventional type energy sources:-[Renewable]

The energy sources available in nature abundantly and can be reused again are called non-Conventional type energy sources.

Non-Conventional type energy sources are,

1. Solar energy

2. Wind energy

3. Hydrallic energy

4. Tidal energy

5. Ocean wave energy

6. Geothermal energy

7. Biomass energy

HYDRO ELECTRIC POWER PLANT:-

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a **hydro-electric power station.**

Choice of Site for Hydro-electric Power Stations:

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

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

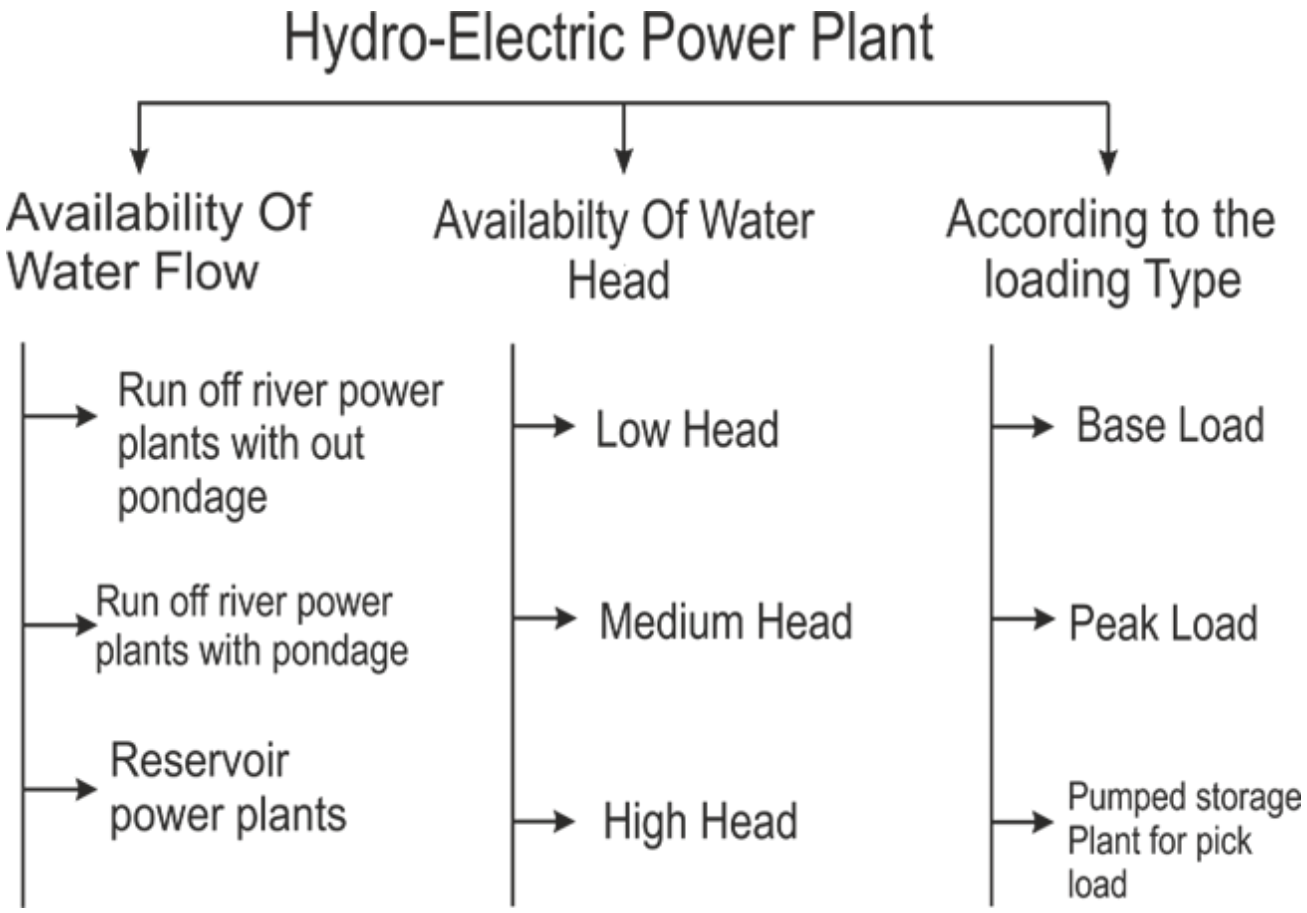
(*ii*) *Storage of water:* There are wide variations in water supply from a river or canal during the year. This makes it necessary to store water by constructing a dam in order to ensure the generation of power throughout the year. The storage helps in equalising the flow of water so that any excess quantity of water at a certain period of the year can be made available during times of very low flow in the river. This leads to the conclusion that site selected for a hydro-electric plant should provide adequate facilities for erecting a dam and storage of water.

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

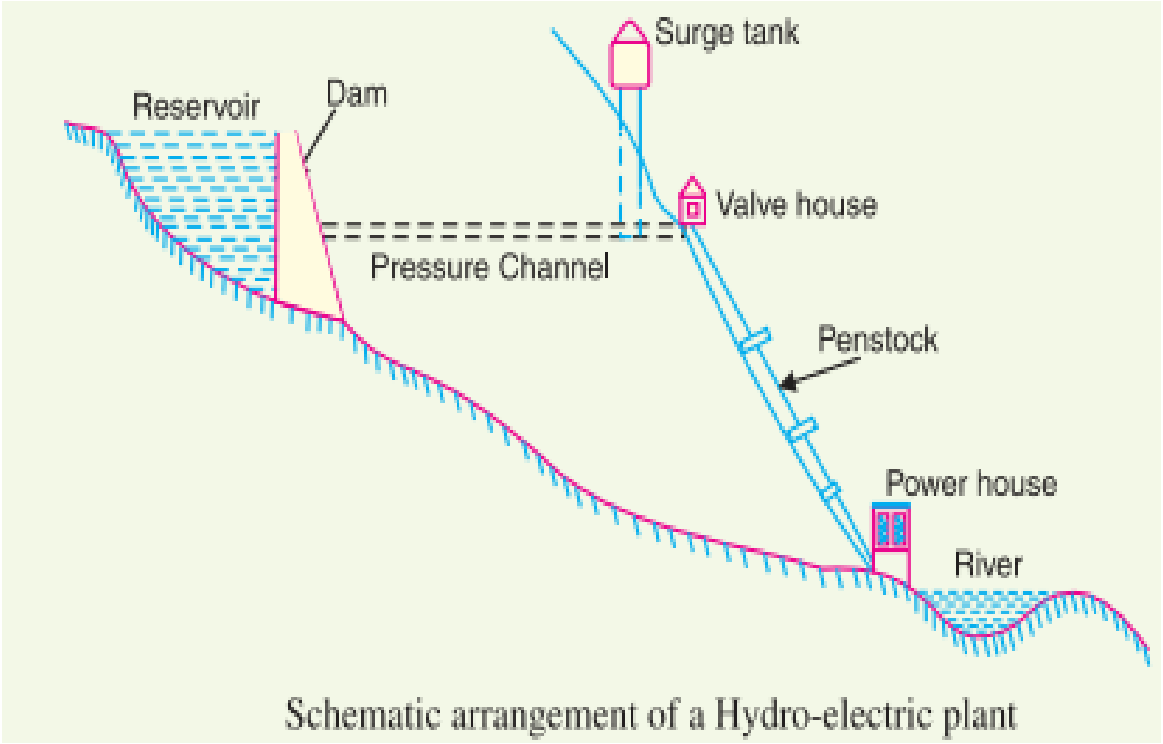
(*iv*) *Transportation facilities:* The site selected for a hydro-electric plant should be accessible by rail and road so that necessary equipment and machinery could be easily transported. It is clear from the above mentioned factors that ideal choice of site for such a plant is near a river in hilly areas where dam can be conveniently built and large reservoirs can be obtained.

(*v*) *Nearness to load centres:* In order to reduce the transmission cost, the plant should be located near the centre of the load. It is because *a.c*. power can be transmitted at high voltages with consequent reduced transmission cost.

CLASSIFICATION OF HYDRO ELECTRIC POWER PLANT:



SCHEMATIC ARRANGEMENT OF HYDRO-ELECTRIC POWER STATION:



Schematic arrangement of a Hydro-electric plant

A hydro-electric power station involves the conversion of hydraulic energy into electrical energy. The schematic arrangement of a modern hydro-electric plant is shown in Figure.

The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock. The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as *penstock*. The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.

A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close due to electrical load being thrown off. When the gates close, there is a sudden stopping of water at the lower end of the penstock and consequently the penstock can burst like a paper log. The surge tank absorbs this pressure swing by increase in its level of water.

FUNCTIONS OF MAIN COMPONENTS OF HYDRO POWER STATION:-

The main components of the hydro-electric power plant are as follows:-

1.CATCHMENT AREA:

The area of land where rain water converges at the exit of basin from where it joins another water body like river , reservoir , lake etc., is called catchment area. The complete area behind the dam draining into a stream or river across which the dam is constructed at a suitable place is nothing but the catchment area.

2. RESERVOIR:

It is the prime requirement of a hydro electric power plant .it stores water which is further used for power generation by running water turbines. It stores water during rainy season and supplies during dry season.

3. DAM:

A dam is a barrier which stores water and creates water head. Dams are built of concrete or stone masonry, earth or rock fill. The type and arrangement depends upon the topography of the site. Dam diverts the water flow from river to turbines increasing the water head.

4. FORE BAY:

It is regulating reservoir which stores water temporarily when the load on plant is reduced. When the load on turbine increases, fore bay provides water withdrawal through a canal.

It is an enlarged section of canal, which is spread out at the end of canal to divert sufficient required amount of water.

5. TRASH RACK:

The trash rack prevents the debris from dam or fore bay to enter into water intake because debris may damage gates, turbine runners and nozzles of turbine.

The debris from trash rack can be removal using either manual cleaning or mechanical cleaning.

6. SURGE TANK:

A surge tank is located near the beginning of the penstock. When the turbine is running at a steady load, there are no surges in the flow of water through the penstock *i.e*., the quantity of water flowing in the penstock is just sufficient to meet the turbine requirements. However, when the load on the turbine decreases, the governor closes the gates of turbine, reducing water supply to the turbine. The excess water at the lower end of the penstock rushes back to the surge tank and increases its water level. Thus the penstock is prevented from bursting. On the other hand, when load on the turbine increases, additional water is drawn from the surge tank to meet the increased load requirement. Hence, a surge tank overcomes the abnormal pressure in the penstock when load on the turbine falls and acts as a reservoir during increase of load on the turbine

7. PENSTOCK:

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

Various devices such as automatic butterfly valve, air valve and surge tank are provided for the protection of penstocks.

8. SPILLWAYS:

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

9. POWER HOUSE:

The power house should have stable structure and the layout should be such that maintenance and repairing work may be carried out easily.

It comprises mainly two parts as follows:-

i) Substructure which supports hydraulic and electric equipments.

ii) Superstructure which houses and protects all equipments.

10. TAIL RACE:

A tail race is an open channel or a tunnel depending upon the power house location. The water is discharged into the tailrace after passing through the turbine, which carries it into the river.

11. PRIME MOVER or TURBINE:

The head of water is converted into the kinetic energy in prime mover, which rotates the shaft of the electric power generators. Thus, a prime mover, also

called a turbine, that converts the kinetic and potential energy of water into the mechanical energy.

The principal types of water turbines are:

(*i*) Impulse turbines **(*ii*)** Reaction turbines

12. DRAFT TUBE:

The draft tube is a pipe which connects the runner exit to the tailrace where the water is being finally discharged from the turbine. The primary function of the draft tube is to reduce the velocity of the discharged water to minimize the loss of kinetic energy at the outlet.

13. ALTERNATOR:-

An alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. Alternators in power stations driven by turbines.

Advantages of hydro-electric power plant:

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

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

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

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

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

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

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

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

Disadvantages of hydro-electric power plant:

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

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

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

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

ENVIRONMENTAL IMPACT OF HYDRO-ELECTRIC POWER PLANT:-

The major environmental impacts of hydro-electric power plant are as follows:

1. By destroying forest, power plant is built and it will impact on life of wild animals.
2. Aquatic animals like fishes and other organisms injured and killed and thus affects on the population and generation of fishes.
3. Dams have major impacts on the physical, chemical and geomorphologic properties.
4. Dams and river diversion can impact fresh water, as well as marine fisheries.
5. Reservoir may cover people's homes, important natural areas, and agricultural land archeological sites. So building dams can require relocating people.
6. Water is lost through evaporation in dammed reservoirs at a much higher than in flowing river.
7. Both the river and ecosystem of the surrounding land area will be altered as soon as dam construction begins.
8. After the flooded the vegetation and soil in these areas decomposes and release both carbon-dioxide and methane.

WATER HAMMER AND ITS EFFECT:-

The load on a generator keeps on fluctuating. Therefore water intake to the turbine has to be regulated according to the load. There is sudden increase of pressure in the penstock due to the sudden decrease in the rate of water flow to the turbine when the gates admitting water to the turbines are suddenly closed owing to the action of the governor. This happens when the load on the generator

decreases. This sudden rise of pressure in the penstock above normal due to reduced load on the generator is called water hammer.

If there is no means are provided to prevent this water hammer which leads to damage of penstock pipes. The effect of water hammer can be prevented by constructing a surge tank that helps in stabilizing the velocity and pressure in the penstock and reduces water hammer.

THERMAL POWER PLANT

A generating station which converts heat energy of coal combustion into electrical energy is known as a thermal power plant OR steam power station.

A steam power station basically works on the Rankine cycle. Steam is produced in the boiler by utilizing the heat of coal combustion. The steam is then expanded in the prime mover (i.e., steam turbine) and is condensed in a condenser to be fed into the boiler again. The steam turbine drives the alternator which converts mechanical energy of the turbine into electrical energy.

CHOICE OF SITE FOR STEAM POWER STATIONS:

In order to achieve overall economy, the following points should be considered while selecting a site for a steam power station:

(i)Availability of fuel: The steam power station should be located near the coal mines so that transportation cost of fuel is minimum. However, if such a plant is to be installed at a place where coal is not available, then care should be taken that adequate facilities exist for the transportation of coal.

(ii) Availability of water: As huge amount of water is required for the condenser, therefore, such a plant should be located at the bank of a river or near a canal to ensure the continuous supply of water.

(iii) Transportation facilities: A modern steam power station often requires the transportation of material and machinery. Therefore, adequate transportation facilities must exist i.e., the plant should be well connected to other parts of the country by rail, road. etc.

(iv) Cost and type of land: The steam power station should be located at a place where land is cheap and further extension, if necessary, is possible. Moreover, the bearing capacity of the ground should be adequate so that heavy equipment could be installed.

(v) Nearness to load centres: In order to reduce the transmission cost, the plant should be located near the centre of the load. This is particularly important if d.c. supply system is adopted. However, if a.c. supply system is adopted, this factor

becomes relatively less important. It is because a.c. power can be transmitted at high voltages with consequent reduced transmission cost. Therefore, it is possible to install the plant away from the load centres, provided other conditions are favourable.

(vi) Distance from populated area: As huge amount of coal is burnt in a steam power station, therefore, smoke and fumes pollute the surrounding area. This necessitates that the plant should be located at a considerable distance from the populated areas.

SCHEMATIC ARRANGEMENT OF STEAM [THERMAL] POWER STATION:

The schematic arrangement of a modern steam power station is shown in Figure. The whole arrangement can be divided into the following stages:

1. Coal and ash handling arrangement
2. Steam generating plant
3. Steam turbine
4. Alternator
5. Feed water
6. Cooling arrangement

1. Coal and ash handling plant. The coal is transported to the power station by road or rail and is stored in the coal storage plant. Storage of coal is primarily a matter of protection against coal strikes, failure of transportation system and general coal shortages. From the coal storage plant, coal is delivered to the coal handling plant where it is pulverized (*i.e.*, crushed into small pieces) in order to increase its surface exposure, thus promoting rapid combustion without using large quantity of excess air. The pulverized coal is fed to the boiler by belt conveyors. The coal is burnt in the boiler and the ash produced after the complete combustion of coal is removed to the ash handling plant and then delivered to the ash storage plant for disposal.

2. Steam generating plant. The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment for the utilisation of flue gases.

(*i*) *Boiler*: The heat of combustion of coal in the boiler is utilised to convert water into steam at high temperature and pressure. The flue gases from the boiler make

their journey through superheater, economiser, air pre-heater and are finally exhausted to atmosphere through the chimney.

(*ii*) *Superheater*: The steam produced in the boiler is wet and is passed through a superheater where it is dried and superheated by the flue gases on their way to chimney.The superheated steam from the superheater is fed to steam turbine through the main valve.

(*iii*) *Economiser*: An economiser is essentially a feed water heater and derives heat from the flue gases for this purpose. The feed water is fed to the economiser before supplying to the boiler. The economiser extracts a part of heat of flue gases to increase the feed water temperature.

(*iv*) *Air preheater*: An air preheater increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced draught fan and is passed through air preheater before supplying to the boiler furnace.

3. Steam turbine: The dry and superheated steam from the superheater is fed to the steam turbine through main valve. The heat energy of steam when passing over the blades of turbine is converted into mechanical energy. After giving heat energy to the turbine, the steam is exhausted to the *condenser* which condenses the exhausted steam by means of cold water circulation.

4. Alternator: The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy. The electrical output from the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.

5. Feed water: The condensate from the condenser is used as feed water to the boiler. Some water may be lost in the cycle which is suitably made up from external source. The feed water on its way to the boiler is heated by water heaters and economiser. This helps in raising the overall efficiency of the plant.

6. Cooling arrangement: In order to improve the efficiency of the plant, the steam exhausted from the turbine is condensed by means of a condenser. Water is drawn from a natural source of supply such as a river, canal or lake and is circulated

through the condenser. The circulating water takes up the heat of the exhausted steam and it becomes hot. This hot water coming out from the condenser is discharged at a suitable location down the river. In case the availability of water from the source of supply is not assured throughout the year, *cooling towers* are used. During the scarcity of water in the river, hot water from the condenser is passed on to the cooling towers where it is cooled. The cold water from the cooling tower is reused in the condenser.

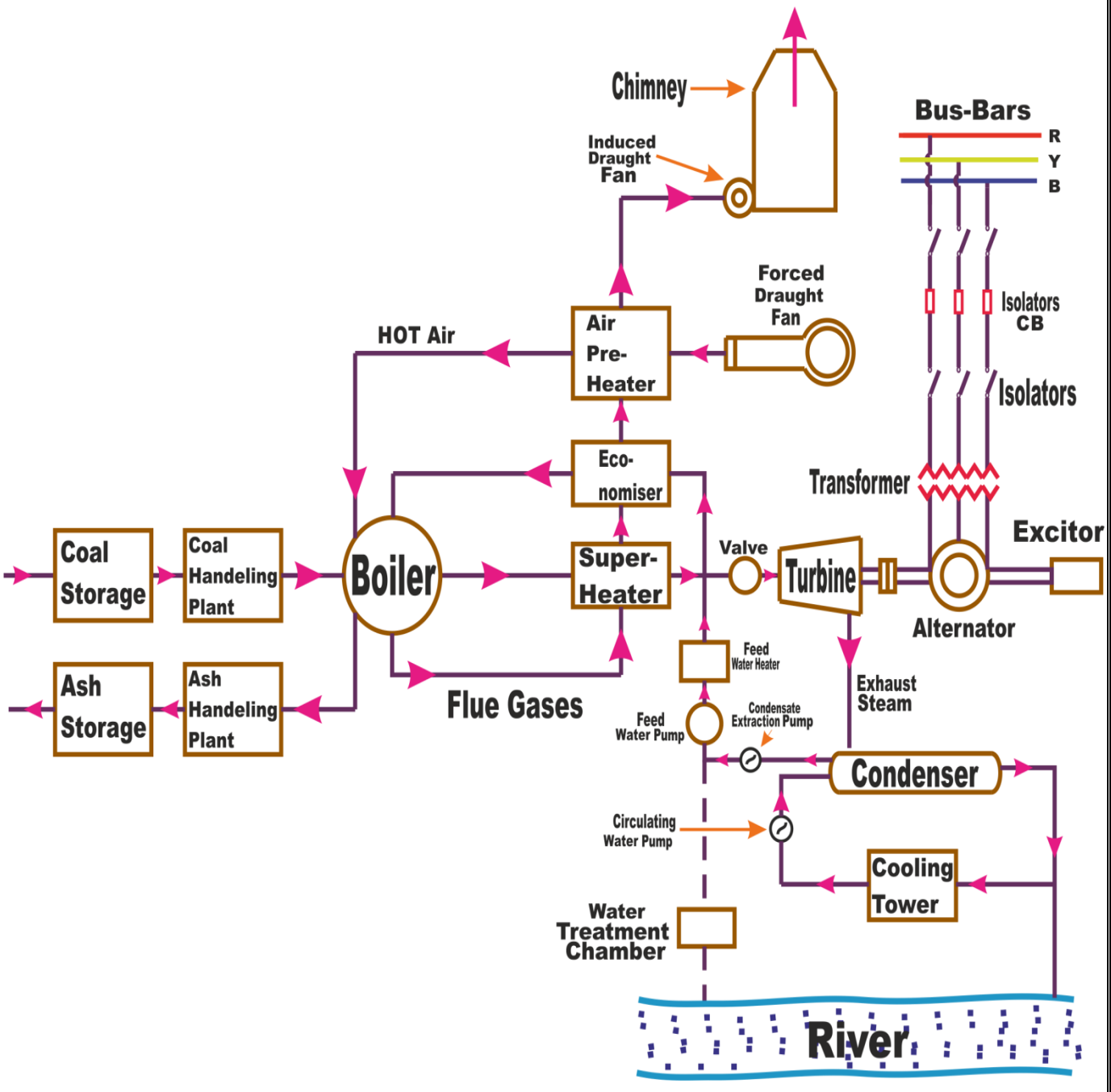


Figure: schematic arrangement of steam [thermal] power station

Advantages:

(*i*) The fuel (*i.e.*, coal) used is quite cheap.

(*ii*) Less initial cost as compared to other generating stations.

(*iii*) It can be installed at any place irrespective of the existence of coal. The coal can be transported to the site of the plant by rail or road.

(*iv*) It requires less space as compared to the hydroelectric power station.

(*v*) The cost of generation is lesser than that of the diesel power station.

Disadvantages:

(*i*) It pollutes the atmosphere due to the production of large amount of smoke and fumes.

(*ii*) It is costlier in running cost as compared to hydroelectric plant.

.9. COMPARISON AND SELECTION

Thermal power plant Vs Hydro-plant:

Sl. No.	*Thermal power plant*	*Hydro power plant*
1.	Initial cost is low.	Initial cost is high.
2.	Located near to load center.	Not like that.
3.	Transmission losses are less.	Transmission losses are high.
4.	Power production is not dependent on nature's mercy.	It is only dependent on nature's mercy.
5.	Construction time is less.	Initial construction requires long time.
6.	Power generation cost is high.	Power generation cost is less.
7.	Air pollution is more.	No air pollution.
8.	Fuel transportation is difficult.	No fuel transportable
9.	Life of the plant is less.	Life of the plant is high.
10.	Efficiency of the plant is less.	Efficiency of the plant is high.
11.	Not suitable for peak load plant.	It is suitable.

ENVIRONMENTAL IMPACT OF THERMAL POWWER PLANT:

1. **Impact of Sulphur Dioxide [SO2]:** This is a product of combustion and depends on the amount of sulphur in coal. Power plants are the largest emitters of SO2. In the presence of other gases SO2 forms sulphuric acid and can participate down as acid rain leading to destruction of ecosystem. It creates health problems related to irritation of respiratory system.
2. **Impact of Nitrogen oxide [NO2]:** Nitrogen oxide, emitted with flue gases, result due to interaction between atmospheric nitrogen and oxygen in the presence of heat emitted from stacks NO2 is a strong irritant. It causes respiratory and cardiovascular diseases deprive body tissue of oxygen and form acid in lungs.
3. **Air Borne Particulates Impacts:** Air borne particulates matter which includes dust, dirt, smoke and liquid droplets emitted into the air and suspended in the atmosphere. These particulates pose a significant threat to human health. The hazard includes bronchitis, respiratory diseases and excessive death rate.
4. **Cooling Tower Emissions:** At most of power plant sites, water is shortage and cooling towers have to be used. Under unfavorable metrological conditions the tower plume can produce drift deposits and fog and even alter the climate of the region in which they are situated.

   When the surrounding air cannot absorb moisture some droplets of circulating water escape from the tower. The droplets called drift carry with them salt and chemicals. Upon being deposited, the salt and chemicals can damage vegetation cause weathering and corrosion of metals and may even change soil properties.

   The cooling tower water when added to atmosphere may condense and form fog at ground level.

Cooling tower may even produce visible plumes. Cold weather and high humidity are most conductive to formation of long visible plumes.

5. **Air Pollution and Stack Emissions:** Air pollution is the pollution of air. It can affect people and other living things. Air pollution occurs when gases, dust particles, fumes or smoke are introduced in the atmosphere in a way that makes it harmful to humans, animals and plants.

   Thermal plants using fossil fuels emit a number of harmful substances like SO_2, NO_2, particulates, hydrocarbons, carbon monoxide and traces of organic compounds. These pollutants are emitted from power plant stacks with flue gases. The atmospheric turbulence disperses the plume content and spreads it over wide region.