

Energy Engineering

Power plant engineering

Energy conversion devices

Introduction

- Electricity or power is the only form of energy which is easy to produce, easy to use, easy to transport and easy to control.
- It plays significant role in each and every field.
- Electricity or power consumption per capita indicates the standard of living of people.
- Electricity or power in bulk quantities is produced or generated in power plants.

- Sources of Energy:

Non-Conventional Energy Sources

Solar

Wind

Ocean

Tidal

Geo-Thermal, etc

Conventional Energy Sources

Coal

Water

Nuclear Energy

Petroleum Products

Natural gas

- Non-Conventional Energy Sources:

Sources

Solar

Wind

Ocean

Tidal

Geo-Thermal, etc

ADVANTAGES

Easily available in nature.

Available in large quantity.

Not pollutant.

Less maintenance cost.

DIS-ADVANTAGES

Available in Low intensity.

Available in particular period only.

Less efficiency of power plant.

High initial cost.

- Conventional Energy Sources

Sources

Coal

Water

Nuclear Energy

Petroleum Products

Natural gas

ADVANTAGES

Thermal Efficiency is more

Initial cost is less.

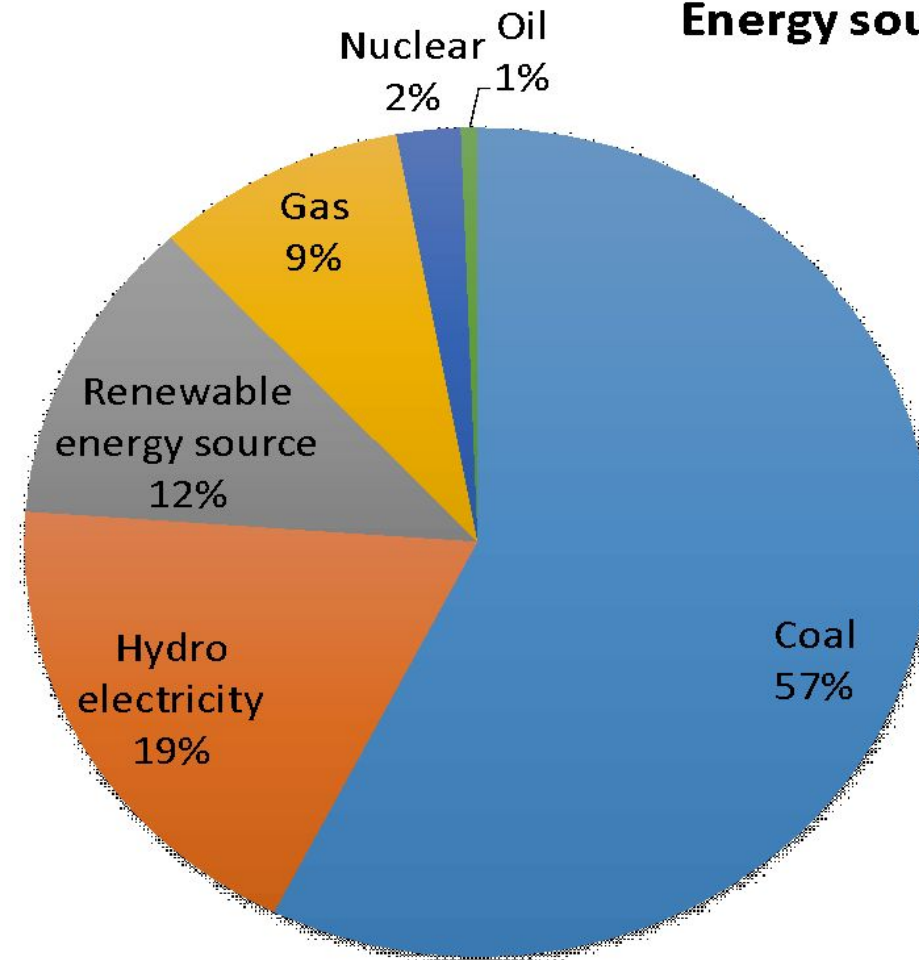
Intensities are high.

DIS-ADVANTAGES

Running and maintenance cost
is high

Pollution in atmosphere.

Energy sources in India



- Power Plants:
- Thermal/ Steam Power plants
- Hydroelectric Power Plant
- Solar Power System
- Wind Power Plant

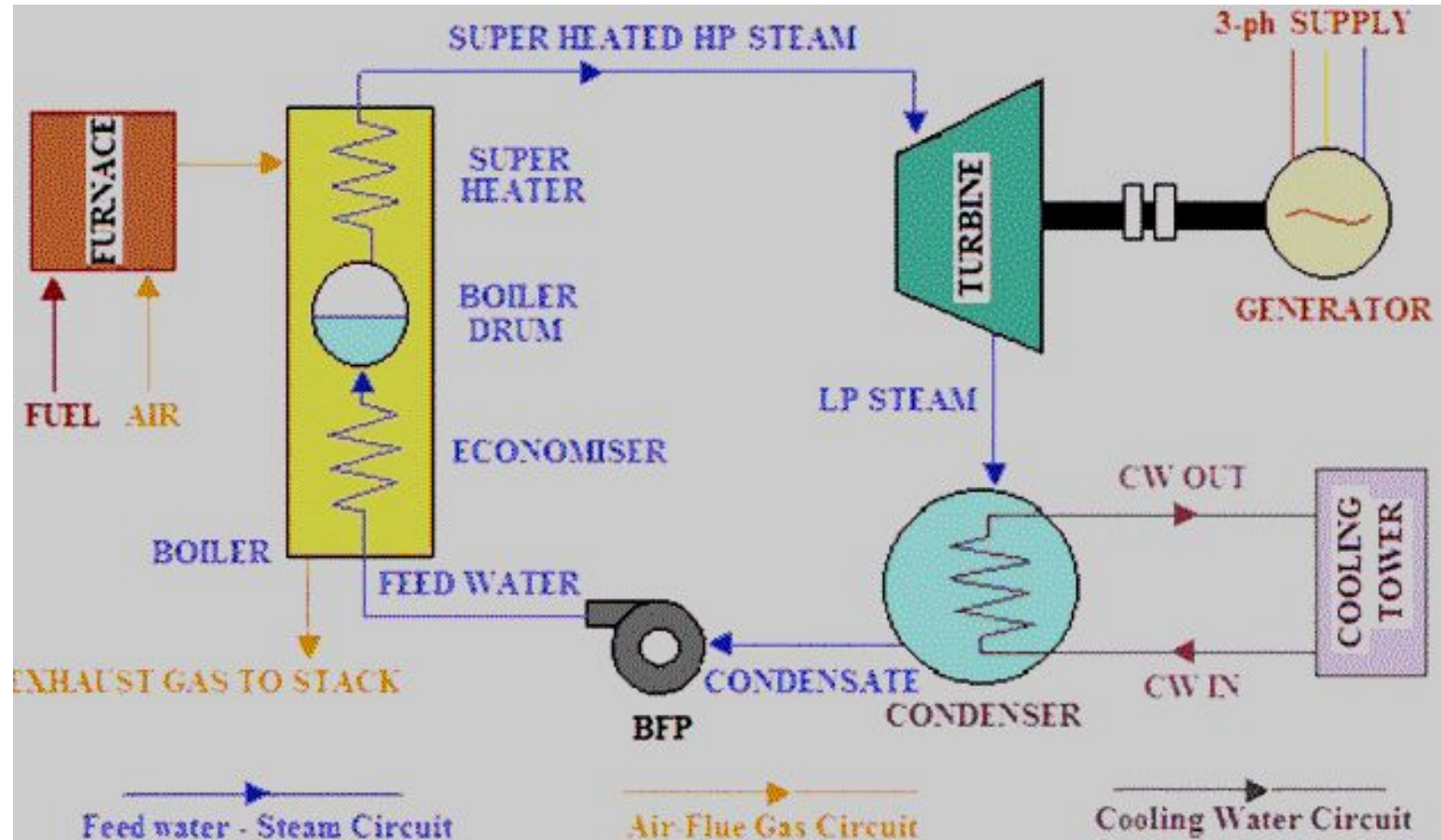
Thermal Power Plant

- Thermal power is the largest source of power in India. About 75% of electricity consumed in India are generated by Thermal power plants. There are different types of Thermal power plants based on the fuel used to generate the steam such as coal, gas, diesel etc.
- Coal-fired plants account for 56% of India's installed electricity capacity.
- ***The thermal energy available in the steam is converted into mechanical energy and is used for driving steam turbines. Steam turbines is coupled to generator and hence power is produced whenever turbine is rotated.***

- **Prime factors for starting a steam power plant**

- Availability of fuel, Coal
- Availability of water
- Availability of strong foil foundation
- Availability of transport facility
- Availability of labors and engineers
- Availability of sufficient space for power plant equipments, space for disposing ash, space for storing coal etc.

- Working Principle:



Elements of thermal power plants

❑ Boiler/ steam generator

- ❑ Used to generate high pressure and high temperature steam.
- ❑ For better efficiency of power plant, boiler consists of superheater, economiser, preheater, etc.

❑ Steam turbine

- ❑ It converts high pressure and high temperature steam into the shaft work and low temperature steam is exhausted to a condenser.

❑ Generator

- ❑ The shaft of steam turbine is coupled to the shaft of generator and the mechanical energy of steam turbine is converted into electrical energy.

Elements of thermal power plants

❑ Condenser

- ❑ Steam exhausted from steam turbine is collected in the condenser and condensed by using recirculating cooling water.
- ❑ The condensed amount of water is called as *condensate*.

❑ Feed pump

- ❑ The collected amount of condensate is again fed back to the boiler with the help of feed pump.
- ❑ This condensate is already a bit hot, hence there is less amount of heat required in the boiler while converting it into the steam.

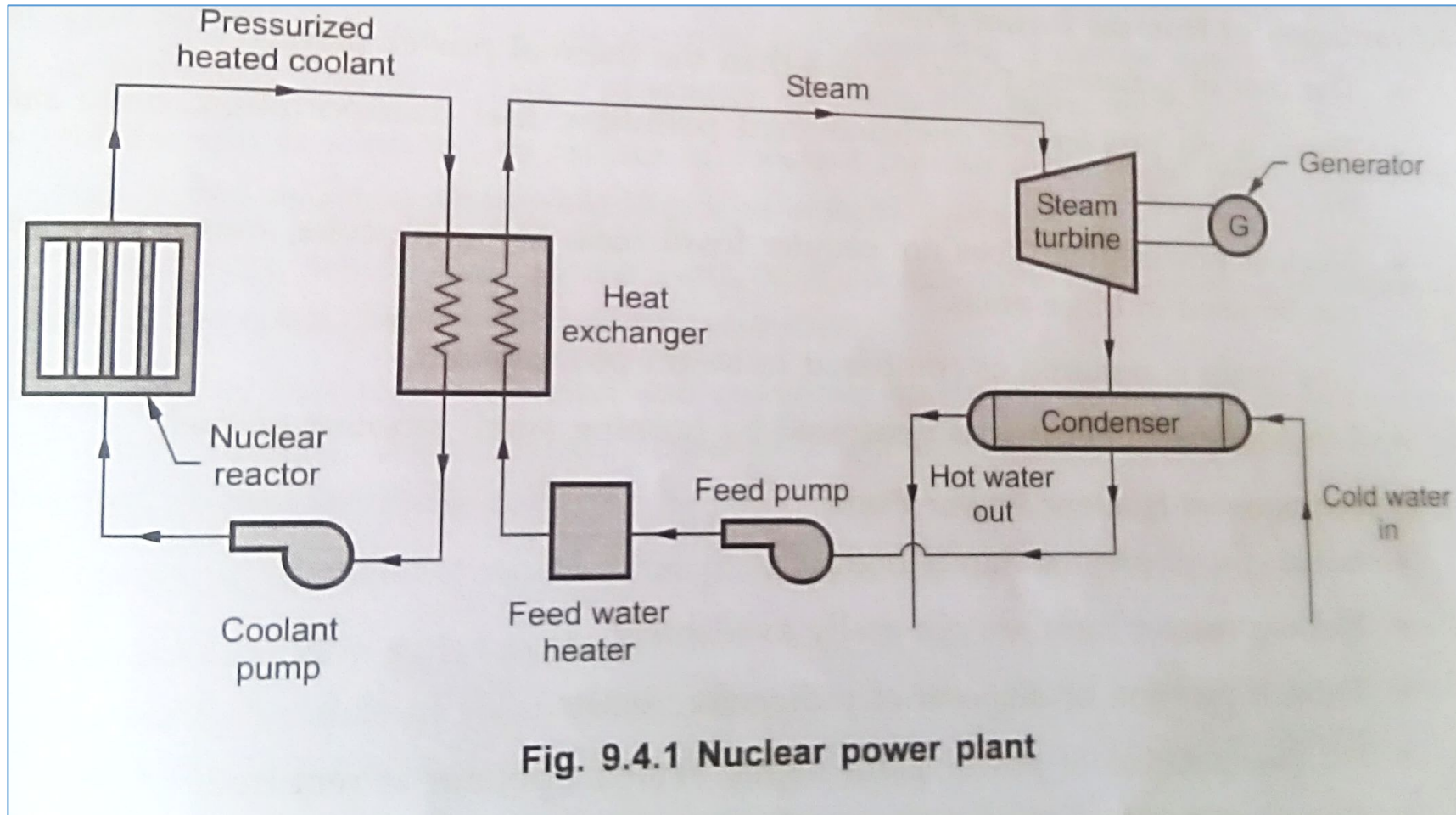
- Advantages-

- Fuel is cheaper
- Less space is required as compared with Hydro-electric power plant
- Cheaper in production cost and initial cost compared with diesel power plant
- Transmission Costs are reduced as these plants can be set up near the industry.

- Disadvantages:-

- The Cost of plant is increases with the increase in temperature and pressure.
- Maintenance and operating cost is high.
- Long Time is required for erecting and put in action.
- Large quantity of water is required.
- Coal and ash handling poses a serious problem.
- Pollution causes health problem to workers and habitants near the thermal power plant

Nuclear power plant



Elements of nuclear power plant

❑ Nuclear reactor

- ❑ In this, nuclear energy is produced by nuclear fission of unstable atoms like uranium.
- ❑ This energy is transferred to circulating coolant.
- ❑ Uranium is in the form of thin rods or plates.

❑ Heat exchanger

- ❑ This acts as boiler for power plant.
- ❑ Heat absorbed by coolant in the reactor is transferred to the water and steam is generated.
- ❑ Commonly used coolants are carbon dioxide, helium, liquid metals like sodium, potassium, etc.

Elements of nuclear power plant

☐ Steam turbine

- ☐ It converts high pressure and high temperature steam supplied by the heat exchanger into shaft work.

☐ Generator

- ☐ The mechanical energy of turbine is converted into electrical energy with the help of this.

☐ Condenser

- ☐ Steam exhausted from steam turbine is collected in the condenser and condensed by using recirculated water.

☐ Feed pump

☐ Feed water heater

☐ Coolant pump

Advantages and disadvantages

□ Advantages

- The cost of generated power is less than the thermal power plant.
- There is no problem of environmental pollution, fuel transportation, mine safety, etc.
- It does not require fossil fuels like coal, coke, natural gas which can be used in other areas.
- Less space is required compared to steam power plant.
- Large amount of energy is generated by burning small amount of fuel.

□ Disadvantages

- High initial cost
- Nuclear reactor fuels are not easily available.
- There is problem of disposal of radioactive waste.
- Cost of nuclear fuels is also high.
- During the operation, nuclear radiations are produced hence high degree of safety is required for operators.

Hydro-Electric Power Plant

- In Hydro Power Plant the water is utilized to move the turbines which in turn run the electric generator's.
- The Potential energy of the water stored in the dam gets converted into the Kinetic Energy of the moving water in the penstock. And this Kinetic Energy gets converted into the Electrical Energy with the help of Turbine & Generator (T-G) combination.
- Hydro Power Plant was invented by H.F. Rogers
- Hydro Power Plant fulfills the 30% of the total energy needs of the world.
- Total hydro potential of the world = 5000 GW

- First Hydro Power Plant was constructed at Darjeeling in 1898 named as “**SIDRAPONG**” of capacity 130 KW.
- Second Hydro Power Plant was constructed at Mysore in 1902 named as “**SIVARAMUDRAM**” having capacity 4.5 MW.

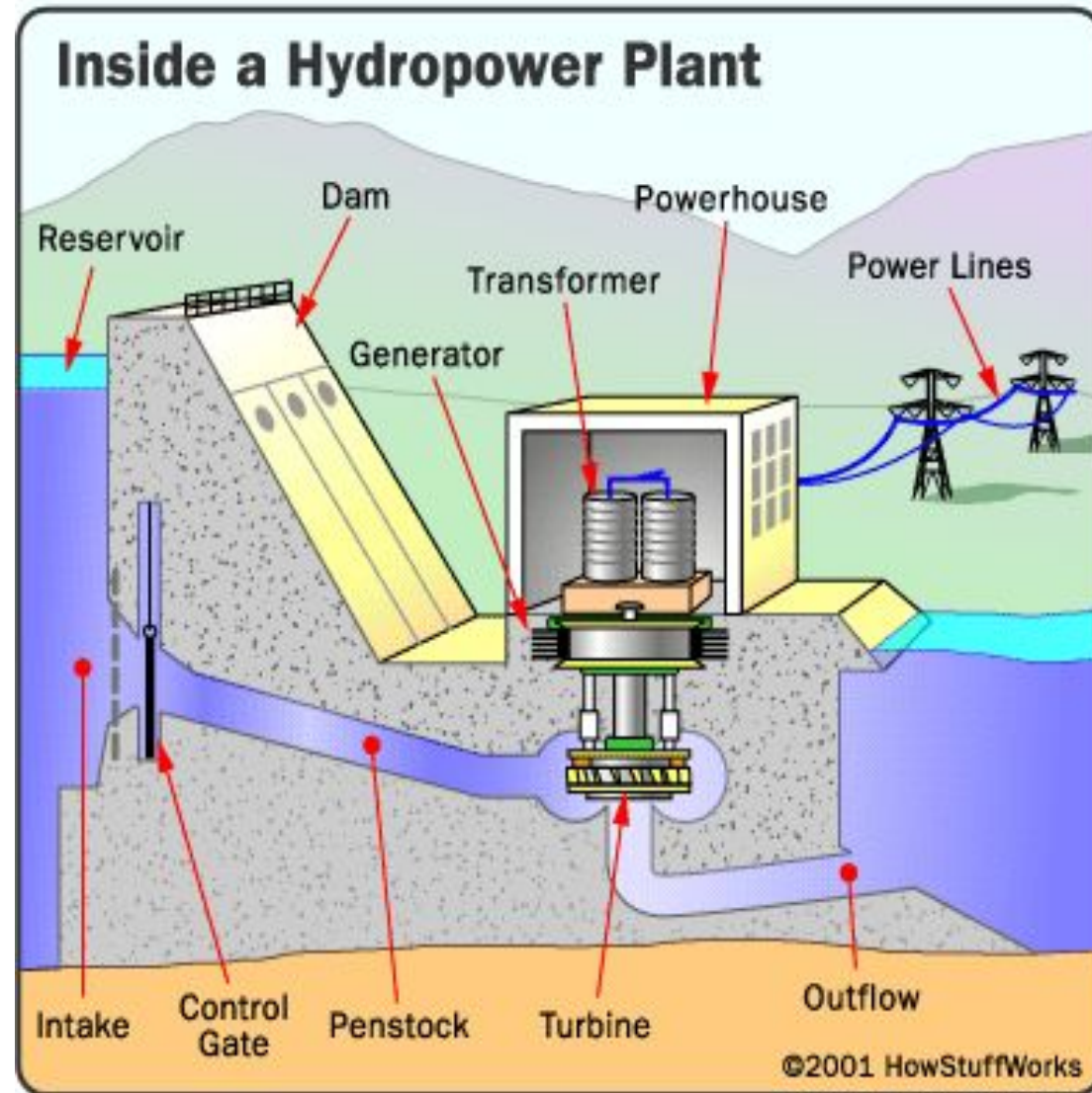
- **Essential Elements of Hydro-Electric Power Plant.**

- **PRIMARY ELEMENT'S**

- CATCHMENTS AREA
- RESERVOIR
- DAM
- PRIME MOVERS
- DRAFT TUBES
- POWER HOUSE & EQUIPMENT

- **SAFETY DEVICE'S**

- SPILL WAY'S
- SURGE TANK
- TRASH RACK



- 1.Catchment Area:

- The whole area behind the dam training into a stream as river across which the dam has been built at suitable place is called catchments area

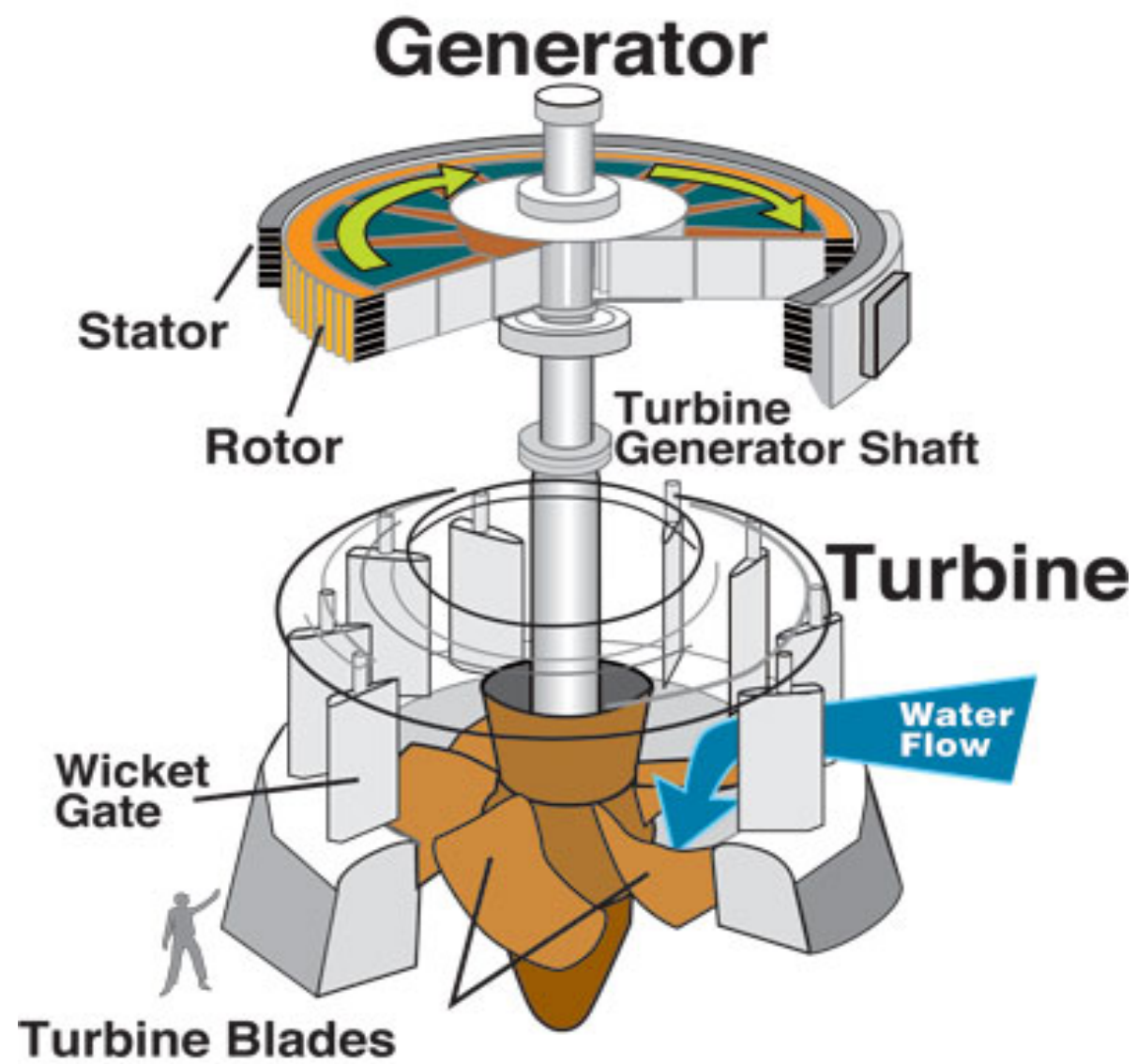
- 2.Reservoir:

- A reservoir is employed to store water which is further utilized to generate power by running the hydroelectric turbines.

- 3.Dam:

- - A dam is a barrier which confines or raise water for storage or diversion to create a hydraulic head.
- - Dam's are generally made of concrete, Stone masory, Rockfill or Timber.
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- 4. Turbine and Generator:
- Turbine & Generator is the most important part of any power plant
- This combination is known as **THE HEART OF THE POWER PLANT.**
- **TURBINE** :- Turbine is a very light fan like structure having many number's of blades . It has an ability to rotate on its axis when water passes through it.
- **GENERATOR** :- Generator is a device in which when there is rotation of coil between the strong Magnetic Field then it produces an Alternating Current.



- 5. Penstock:

- Penstock is the connecting pipe between the dam & the turbine house.
- It helps to increase the kinetic energy of the water coming from the dam.
- Penstock is made up of a very strong material which can sustain the high pressure of water.

- 6. Draft Tube:

- - Draft Tube is an empty structure made beneath the Turbine. It serves in following 2 purpose's :
- It allows the turbine to be set above tail water level without loss of head, to facilitate inspection and maintenance.
- It regains by diffuser action, the major portion of the kinetic energy delivered to it from the runner.
- It increases the output power.
- It increases the efficiency of Hydro Power Plant

- 7. Power House & Equipment

- - Some more components are required for the proper, user friendly & smooth functioning of the power plant. These components are as follow:
- VALVE :- This the instrument which is used to control the pressure of flow of water .
- PUMPS :- This device is used to send water or any fluid from lower potential to higher potential.

- 8. Spillway:

- Spill Way's is a kind of canal provided besides the dam.
- Spill Way's is used to arrange the excess of accumulation of water on the dam because excess accumulation of water may damage the dam structure

- 9. Surge Tank:

- ☐ When there is a sudden close or decrease in pressure due to control valve then there is a back flow of water. This creates a high pressure zone in the penstock due to which it may burst . This effect is known as **WATER HAMMERING EFFECT** .
- ☐ To avoid this a tank is attached to the penstock which stores water in it . This tank is called as Surge Tank.

- Working Principle:

- Initially the water of the river is in Catchments Area.
- From catchments area the water flows to the dam.
- At the dam the water gets accumulated . Thus the potential energy of the water increases due to the height of the dam .
- When the gates of the dam are opened then the water moves with high Kinetic Energy into the penstock.
- Through the penstock water goes to the turbine house.
- Since the penstock makes water to flow from high altitude to low altitude, Thus the Kinetic Energy of the water is again raised.
- In the turbine house the pressure of the water is controlled by the controlling valves as per the requirements.
- The controlled pressurized water is fed to the turbine.
- Due to the pressure of the water the light weight turbine rotates.

- Due to the high speed rotation of the turbine the shaft connected between the turbine and the generator rotates .
- Due to the rotation of generator the ac current is produced.
- This current is supplied to the powerhouse .
- From powerhouse it is supplied for the commercial purposes.

•Advantages:-

- No fuel charges.
- Less supervising staff is required.
- Maintenance & operation charges are very low.
- Running cost of the plant is low.
- The plant efficiency does not changes with age.
- It takes few minutes to run & synchronize the plant.
- No fuel transportation is required.
- No ash & flue gas problem & does not pollute the atmosphere.
- These plants are used for flood control & irrigation purpose.
- Long life in comparison with the Thermal & Nuclear Power Plant.

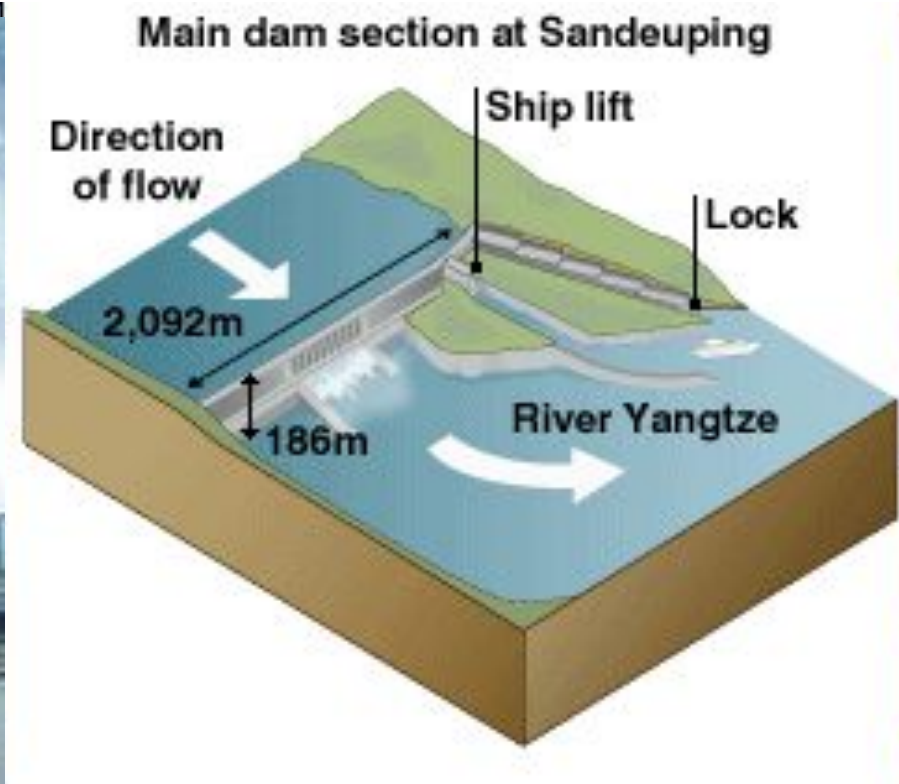
- Disadvantages:
- The initial cost of the power plant is very high.
- Takes long time for construction of the dam.
- Generally, Such plant's are located in hilly area's far away from load center & thus they require long transmission lines & losses in them will be more.
- Power generation by hydro power plant is only dependant on natural phenomenon of rain .Therefore at the time of drought or summer session the Hydro Power Plant will not work.

Three Gorges Dam China

The largest hydro-electric power station in the world



- Installed Capacity: 22,500 MW ,
- Total cost of \$26 Billion = Approx. Rs 1,30, 000 Crore
- 32 turbines (Francis Turbines) of capacity: 700 MW and
- 2 turbines of 50 MW capacity.





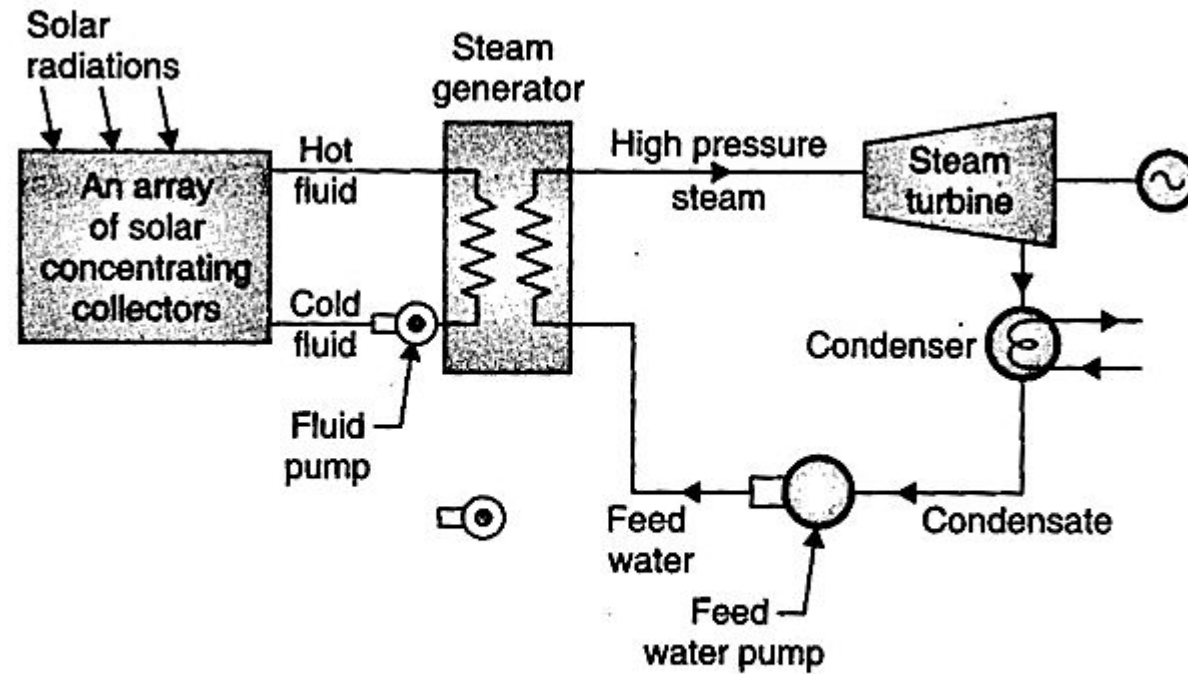
- The **Tehri Dam** is the highest dam in India, 5th highest in Asia and 10th highest in world on the Bhagirathi river near Tehri in Uttarakhand, India. It is the primary dam of the THDC India Ltd. The Tehri Dam withholds a reservoir for irrigation, municipal water supply and the generation of 2,400 MW of hydroelectricity.



Solar Power Plant

- ❑ The intensity of solar radiation are weather dependent. On cloudy days , the intensity is very low.
- ❑ Average power available is only 1 kW/m² in hottest regions. Thus large collection area is required.
- ❑ It is intermittent source of energy since it is not available in night.

- Working Principle:



Block Diagram for Power Generation using Solar Energy

- Gujarat Solar Park the largest solar park in the India. It's the biggest solar farm in the world, covering 2,000 hectare (4900 acres) of northern Gujarat, India, and it has the capacity to generate 600 MW.

600 MW of solar panels will save around 8 million tonnes of carbon dioxide from being released into the atmosphere and save around 900,000 tonnes of coal & Natural gas per year.

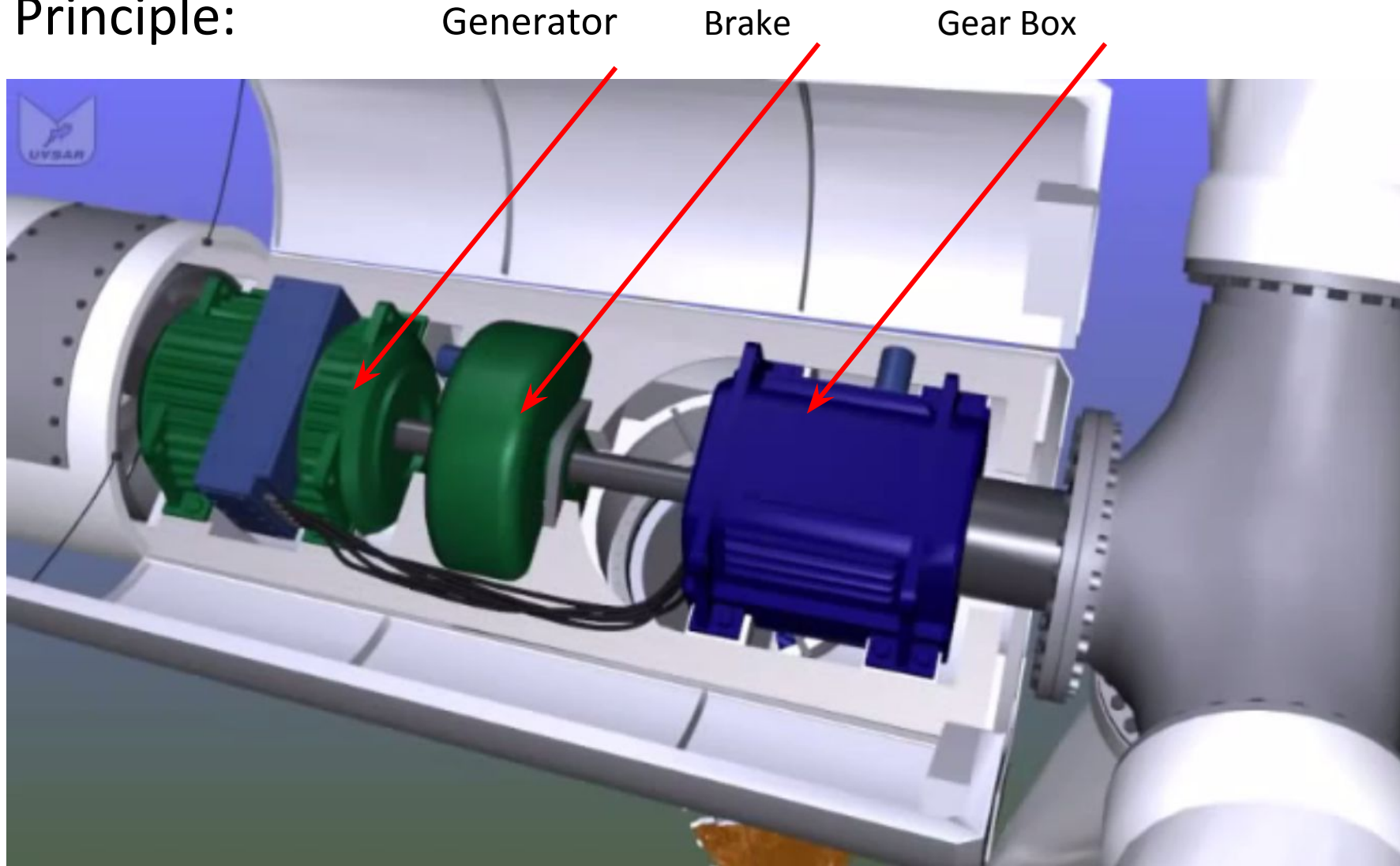


Wind Power

- The wind power can be generated where the wind velocities are more than 8 kmph.
- Such winds are available along the sea coast and at high altitudes in hilly region.
- The wind power is clean and non-polluting
- It has low maintenance cost and low power generation cost of about Rs. 2.25/kWh.
- It needs high capital cost of about 3.5crores/MW.



- Working Principle:



- Advantages:-
 - Non polluting.
 - No fuel is required.
 - The cost of generation is low.

Disadvantages:-

- More noisy.
- Weight of system is high.
- Does not provide constant output due to velocity fluctuations.

- The efficiency of a power plant describes the output of the power plant relative to the heat value of the fuel used (total electrical efficiency).
- The greater the efficiency, the better the utilisation of the fuel. The efficiency describes the percentage of energy contained in the fuel that is converted into electricity. The rest is lost during conversion or in the form of exhaust heat.
- The greater the efficiency, the less carbon dioxide (CO_2) released per generated kilowatt-hour.

- Numerical:

1. A 500 MW thermal power plant consumes coal at the rate of 3 Tonnes per minute having calorific value of 32000 KJ/Kg. Determine the overall efficiency of the power plant

2. A diesel power plant has efficiency 35%. Determine the quantity of fuel consumed per minute if the plant produces a power output of 5 MW. The CV of diesel is to be assumed as 42000 KJ/Kg.