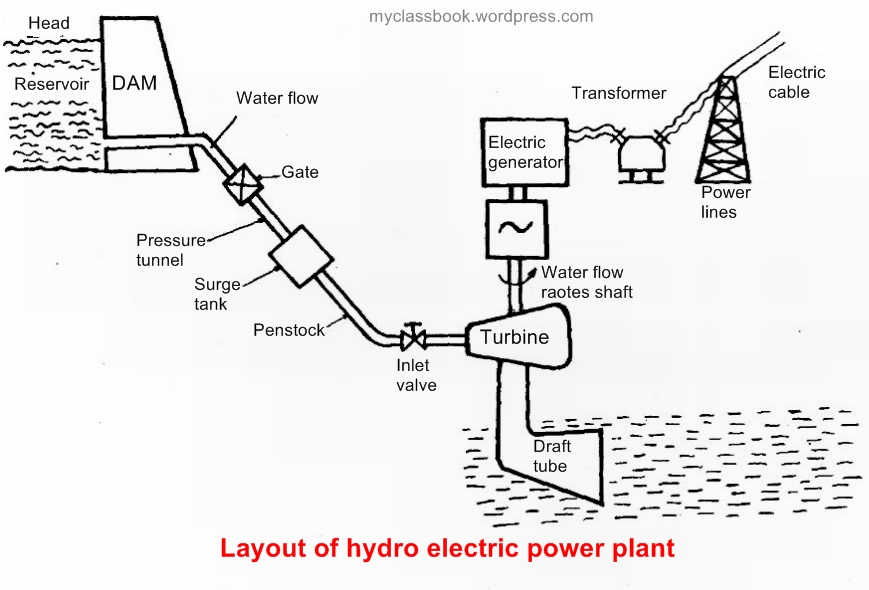
**HYDRAULIC POWER PLANT**

Power system mainly contains three parts namely generation, transmission and distribution. Generation means how to generate electricity from the available source and there are various methods to generate electricity but in this article we only focused on generation of electricity by the means of **hydro** or water (**hydro 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 hydro-electric power station. As we know that the [power plant](https://www.electrical4u.com/power-plants-types-of-power-plant/) is defined as the place where power is generated from a given source, so here the source is hydro that’s why we called it hydro power plant.



In **hydro power plant** we use gravitational force of fluid water to run the turbine which is coupled with electric generator to produce electricity. This power plant plays an important role to protect our fossil fuel which is limited, because the generated electricity in hydro power station is the use of water which is renewable source of energy and available in lots of amount without any cost.

The big advantage of hydro power is the water which the main stuff to produce electricity in hydro power plant is free, it not contain any type of pollution and after generated electricity the price of electricity is average not too much high.

**Construction and Working of Hydro Power Plant**

Fundamental parts of hydro power plant are

1. Area
2. Dam
3. Reservoir
4. Penstock
5. Storage tank
6. Turbines and generators
7. [Switchgear and protection](https://www.electrical4u.com/electrical-switchgear-protection/)

For **construction of hydro power plant** first we choose the area where the water is sufficient to reserve and no crisis of water and suitable to build a dam. The main function of dam is to stop the flow of water and reserve the water in reservoir. Mainly dam is situated at a good height to increase the force of water. Reservoir hold lots of water which is employed to generate power by means of turbines. Penstock, the pipe which is connected between dam and turbine blades and most important purpose of the penstock is to enlarge the kinetic energy of water that’s why this pipe is made up of extremely well-built material which carry on the pressure of water. To control the pressure of water means increase or decrease water pressure whenever required, we use a valve. Storage tank comes in picture when the some reason the pressure of water in reservoir is decreases then we use storage tank it is directly connected to penstock and use only in emergency condition. After that we employ turbine and generator. Turbine is the main stuff, when water comes through the penstock with high kinetic energy and falls on turbine blades, turbine rotates at high speed. As we know that the turbine is an engine that transfers energy of fluid into mechanical energy which is coupled with generator and generator converts mechanical energy into electrical energy which we utilize at the end. In hydro power plant we also add switchgears and protections which control and protect the whole process inside the plant. The control equipments consists control circuits, control devices, warning, instrumentation etc and connect to main control board. After generating electricity at low voltage, we use step up transformer to enlarge the level of [voltage](https://www.electrical4u.com/voltage-or-electric-potential-difference/) (generally 132 KV, 220 KV, 400 KV and above) as per our requirement. After that we transmit the [electric power](https://www.electrical4u.com/electric-power-single-and-three-phase/) to the load center, and then we step down the voltage for industrial and large consumer and then again we step down the voltage to distribute electricity at domestic level which we used at home. This is the whole process of generating electricity by the means of hydro (hydro power plant) and then transmitting and distributing electricity.

**History of Hydro Power Plant**

First hydro power is used by the Greeks to spin water wheels for crushing wheat into flour before more than 2000 years ago. In the 1700's, hydropower was generally used for pumping irrigation (non-natural use of water on the way to the land) water. We start to generate electricity from hydro power in 1882 when United States (U S) establishes a first **hydro power station** which generate 12.5 kilowatts (KW) of power. The rapid growth of hydro power comes in 1900’s when hydraulic reaction turbine comes in picture as a result in 1900’s hydro power plants fulfill the requirement of 40% of total United States' electricity. In between 1905-1911 largest hydro power station (Roosevelt Dam) is built by the united state and its generated capacity is increased from 4500 kW to 36,000 kW.

If we compare the countries on the basis of generated electricity by the means of **hydro power**, Canada on the top after that United State then Brazil then Russia then China then Norway and at 7th number India is present. India fulfills the 3.5 % power to the total world power through hydro power plants. In India scope of hydro power is very good, first hydro power station, capacity of 130kW establishes in Asia at mounts of Darjeeling in 1898 and after that in 1902 Shimsh (Shivanasamudra) is established and both located in India. Now a day in India the leading hydro power plant is located of river Naptha Jhakri hydro project of 1500MW in Himachal Pradesh. In India main boost come in the field of hydro power in august 1998 when the Government of India publicized a plan on ‘Hydro Power Development’ after that in November 2008 once again Indian government announced this plan and as a result India become leading country list to produce hydro power. This is a general idea about **hydro power plant**.

**THERMAL POWER PLANT**

**Theory of Thermal Power Station**

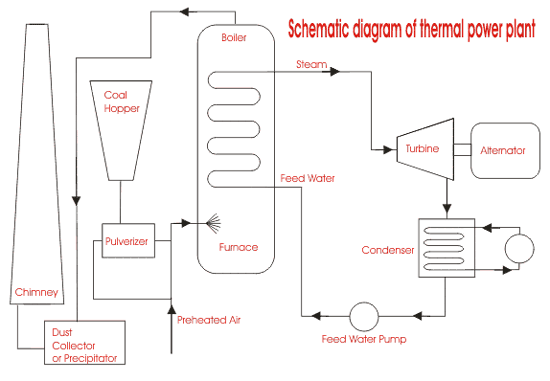
**Thermal power generation plant** or thermal power station is the most conventional source of [electric power](https://www.electrical4u.com/electric-power-single-and-three-phase/). Thermal power plant is also referred as **coal thermal power plant** and steam turbine **power plant**. Before going into detail of this topic, we will try to understand the line diagram of **electric power generation plant**.

The theory of **thermal power station** or **working of thermal power station** is very simple. A **power generation plant** mainly consists of [alternator](https://www.electrical4u.com/alternator-or-synchronous-generator/) runs with help of steam turbine. The steam is obtained from high pressure boilers. Generally in India, bituminous coal, brown coal and peat are used as fuel of [boiler](https://www.electrical4u.com/steam-boiler-working-principle-and-types-of-boiler/). The bituminous coal is used as boiler fuel has volatile matter from 8 to 33 % and ash content 5 to 16 %. To increase the thermal efficiency, the coal is used in the boiler in powder form.

In **coal thermal power plant**, the steam is produced in high pressure in the [steam boiler](https://www.electrical4u.com/steam-boiler-working-principle-and-types-of-boiler/) due to burning of fuel (pulverized coal) in boiler furnaces. This steam is further supper heated in a super heater. This supper heated steam then enters into the turbine and rotates the turbine blades. The turbine is mechanically so coupled with alternator that its rotor will rotate with the rotation of turbine blades. After entering in turbine the steam pressure suddenly falls and corresponding volume of the steam increases. After imparting energy to the turbine rotor the steam passes out of the turbine blades into the condenser. In the condenser the cold water is circulated with the help of pump which condenses the low pressure wet steam. This condensed water is further supplied to low pressure water heater where the low pressure steam increases the temperature of this feed water, it is again heated in high pressure. For better understanding we furnish every step of function of a thermal power station as follows,

1. First the pulverized coal is burnt into the [furnace of steam boiler](https://www.electrical4u.com/steam-boiler-furnace-grate-firebox-combustion-chamber-of-furnace/).
2. High pressure steam is produced in the boiler.
3. This steam is then passed through the super heater, where it further heated up.
4. This supper heated steam is then entered into a turbine at high speed.
5. In turbine this steam force rotates the turbine blades that means here in the turbine the stored potential energy of the high pressured steam is converted into mechanical energy.

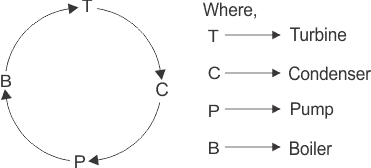
### Line Diagram of Power Plant



1. After rotating the turbine blades, the steam has lost its high pressure, passes out of turbine blades and enters into a condenser.
2. In the condenser the cold water is circulated with help of pump which condenses the low pressure wet steam.
3. This condensed water is then further supplied to low pressure water heater where the low pressure steam increases the temperature of this feed water, it is then again heated in a high pressure heater where the high pressure of steam is used for heating.
4. The turbine in thermal power station acts as a prime mover of the alternator.

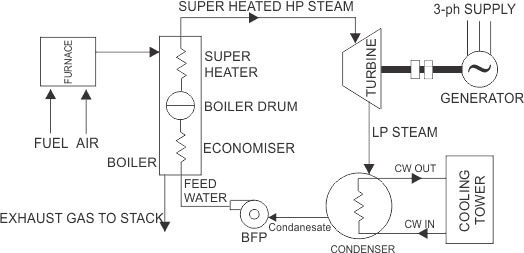
### Overview of Thermal Power Plant

A typical Thermal Power Station Operates on a Cycle which is shown below.



The working fluid is water and steam. This is called feed water and steam cycle. The ideal Thermodynamic Cycle to which the operation of a **Thermal Power Station** closely resembles is the [RANKINE CYCLE](https://www.electrical4u.com/rankine-cycle/). In steam boiler the water is heated up by burning the fuel in air in the furnace & the function of the boiler is to give dry super heated steam at required temperature. The steam so produced is used in driving the steam Turbines. This turbine is coupled to [synchronous generator](https://www.electrical4u.com/alternator-or-synchronous-generator/) (usually three phase synchronous alternator), which generates electrical energy. The exhaust steam from the turbine is allowed to condense into water in [steam condenser of turbine](https://www.electrical4u.com/steam-condenser-of-turbine/), which creates suction at very low pressure and allows the expansion of the steam in the turbine to a very low pressure. The principle advantages of condensing operation are the increased amount of energy extracted per kg of steam and thereby increasing efficiency and the condensate which is fed into the boiler again reduces the amount of fresh feed water.

The condensate along with some fresh make up feed water is again fed into the boiler by pump (called the boiler feed pump). In condenser the steam is condensed by cooling water. Cooling water recycles through cooling tower. This constitutes cooling water circuit. The ambient air is allowed to enter in the boiler after dust filtration. Also the flue gas comes out of the boiler and exhausted into atmosphere through stacks. These constitute air and flue gas circuit. The flow of air and also the static pressure inside the steam boiler (called draught) is maintained by two fans called **Forced Draught (FD)** fan and **Induced Draught (ID)** fan. The total scheme of a typical thermal power station along with different circuits is illustrated below.



Inside the boiler there are various heat exchangers, viz. **Economiser**, **Evaporator** (not shown in the fig above, it is basically the water tubes, i.e. downcomer riser circuit), **Super Heater** (sometimes **Reheater**, **air preheater** are also present). In Economiser the feed water is heated to considerable amount by the remaining heat of flue gas. The Boiler Drum actually maintains a head for natural circulation of two phase mixture (steam + water) through the water tubes. There is also Super Heater which also takes heat from flue gas and raises the temperature of steam as per requirement.

### Efficiency of Thermal Power Station or Plant

Overall efficiency of steam power plant is defined as the ratio of heat equivalent of electrical output to the heat of combustion of coal. The overall efficiency of a **thermal power station** or plant varies from **20%** to **26%** and it depends upon plant capacity.

|  |  |
| --- | --- |
| **Installed plant capacity** | **Average overall thermal efficiency** |
| upto 1MW | 4% |
| 1MW to 10MW | 12% |
| 10MW to 50MW | 16% |
| 50MW to 100MW | 24% |
| above 100MW | 27% |

### Advantages and Disadvantages of Thermal Power Station

**Advantages:**

1. Economical for low initial cost other than any generating plant.
2. Land required less than [hydro power plant](https://www.electrical4u.com/hydro-power-plant-construction-working-and-history-of-hydro-power-plant/).
3. Since coal is main fuel and its cost is quite cheap than petrol/diesel so generation cost is economical.
4. Maintenance is easier.
5. Thermal power plant can be installed in any location where transportation & bulk of water are available.

**Disadvantages:**

1. The running cost for a thermal power station is comparatively high due to fuel,maintenance etc.
2. Large amount of smoke causes air pollution.The thermal power station is responsible for Global warming.
3. The heated water that comes from thermal power plant has an adverse effect on the aquatic lives in the water and disturbs the ecology.
4. Overall efficiency of thermal power plant is low like less 30%.

**NUCLEAR POWER STATION**

Electric power can be generated by means of nuclear power. In **nuclear power station**, electrical power is generated by nuclear reaction.Here, heavy radioactive elements such as Uranium (U235) or Thorium (Th232) are subjected to nuclear fission. This fission is done in a special apparatus called as reactor. Before going to details of nuclear power station, let’s try to understand what is fission? In fission process, the nuclei of heavy radioactive atoms are broken into two nearly equal parts. During this breaking of nuclei, huge quantity of energy is released. This release of energy is due to mass defect. That means, the total mass of initial product would be reduced during fission. This loss of mass during fission is converted into heat energy as per famous equation E = mc2, established by Albert Einstein.

The basic principle of **nuclear power station** is same as [steam](https://www.electrical4u.com/steam/) power station. Only difference is that, instead of using heat generated due to [coal combustion](https://www.electrical4u.com/coal-combustion-theory/), here in nuclear power plant, heat generated due to nuclear fission is used to produce steam from water in the boiler. This steam is used to drive a steam turbine. This turbine is the prime mover of the alternator. This [alternator](https://www.electrical4u.com/alternator-or-synchronous-generator/) generates electrical energy. Although, the availability of nuclear fuel is not much but very less amount of nuclear fuel can generate huge amount of electrical energy. This is the unique feature of a nuclear power plant. One kg of uranium is equivalent to 4500 metric tons of high grade coal. That means complete fission of 1 kg uranium can produce as much heat as can be produced by complete combustion of 4500 metric tons high grade coal. This is why, although nuclear fuel is much costlier, but nuclear fuel cost per unit electrical energy is still lower than that cost of energy generated by means of other fuel like coal and diesel. To meet up conventional fuel crisis in present era, nuclear power station can be the most suitable alternatives.

### Advantages of Nuclear Power Station

1. As we said, the fuel consumption in this power station is quite low and hence, cost for generating single unit of energy is quite less than other conventional [power generation](https://www.electrical4u.com/electric-power-generation/) method. Amount of nuclear fuel required is also less.
2. A nuclear power station occupies much smaller space compared to other conventional power station of same capacity.
3. This station does not require plenty of water, hence it is not essential to construct plant near natural source of water. This also does not required huge quantity of fuel; hence it is also not essential to construct the plant near coal mine, or the place where good transport facilities are available. Because of this, the nuclear power station can be established very near to the load centre.
4. There are large deposits of nuclear fuel globally therefore such plants can ensure continued supply of electrical energy for coming thousands years.

### Disadvantages of Nuclear Power Plant

1. The fuel is not easily available and it is very costly.
2. Initial cost for constructing nuclear power station is quite high.
3. Erection and commissioning of this plant is much complicated and sophisticated than other conventional power station.
4. The fission by products is radioactive in nature, and it may cause high radioactive pollution.
5. The maintenance cost is higher and the man power required to run a **nuclear power plant** is quite higher since specialist trained people are required.
6. Sudden fluctuation of load cannot be met up efficiently by nuclear plant.
7. As the by products of nuclear reaction is high radioactive, it is very big problem for disposal of this by products. It can only be disposed deep inside ground or in a sea away from sea shore.

## Different Components of Nuclear Power Station

A nuclear power station has mainly four components.

1. Nuclear reactor,
2. Heat exchanger,
3. Steam turbine,
4. Alternator.

Let’s discuss these components one by one:

### Nuclear Reactor

In nuclear reactor, Uranium 235 is subjected to nuclear fission. It controls the chain reaction that starts when the fission is done. The chain reaction must be controlled otherwise rate of energy release will be fast, there may be a high chance of explosion. In nuclear fission, the nuclei of nuclear fuel, such as U235 are bombarded by slow flow of neutrons. Due to this bombarding, the nuclei of Uranium is broken, which causes release of huge heat energy and during breaking of nuclei, number of neutrons are also emitted.

These emitted neutrons are called fission neutrons. These fission neutrons cause further fission. Further fission creates more fission neutrons which again accelerate the speed of fission. This is cumulative process. If the process is not controlled, in very short time the rate of fission becomes so high, it will release so huge amount of energy, there may be dangerous explosion. This cumulative reaction is called chain reaction. This chain reaction can only be controlled by removing fission neutrons from nuclear reactor. The speed of the fission can be controlled by changing the rate of removing fission neutrons from reactors.

A [nuclear reactor](https://www.electrical4u.com/nuclear-reactor/) is a cylindrical shaped stunt pressure vessel. The fuel rods are made of nuclear fuel i.e. Uranium moderates, which is generally made of graphite cover the fuel rods. The moderates slow down the neutrons before collision with uranium nuclei. The controls rods are made of cadmium because cadmium is a strong absorber of neutrons.

The control rods are inserted in the fission chamber. These cadmium controls rods can be pushed down and pull up as per requirement. When these rods are pushed down enough, most of the fission neutrons are absorbed by these rods, hence the chain reaction stops. Again, while the controls rods are pulled up, the availability of fission neutrons becomes more which increases the rates of chain reaction. Hence, it is clear that by adjusting the position of the control rods, the rate of nuclear reaction can be controlled and consequently the [generation of electrical power](https://www.electrical4u.com/electric-power-generation/)can be controlled as per load demand. In actual practice, the pushing and pulling of control rods are controlled by automatic feedback system as per requirement of the load. It is not controlled manually. The heat released during nuclear reaction, are carried to the heat exchanger by means of coolant consist of sodium metal.

### Heat Exchanger

In heat exchanger, the heat carried by sodium metal, is dissipated in water and water is converted to high pressure steam here. After releasing heat in water the sodium metal coolant comes back to the reactor by means of coolant circulating pump.

### Steam Turbine

In nuclear power plant, the steam turbine plays the same role as coal power plant. The steam drives the turbine in same way. After doing its job, the exhaust steam comes into steam condenser where it is condensed to provide space to the steam behind it.

### Alternator

An alternator, coupled with turbine, rotates and generates electrical power, for utilization. The output from alternator is delivered to the bus-bars through transformer, circuit breakers and isolators.

### Site Selection of Nuclear Power Station

1. **Availability of Water :** Although very large quantity of water is not regulated as hydro-electric power plant, but still sufficient supply of neutral water is obvious for cooling purposes in nuclear power station. That is why it is always preferable to locate this plant near a river or sea side.
2. **Disposal of Water :** The by products or wastes of nuclear power station are radioactive and may cause severe health hazards. Because of this, special care to be taken during disposal of wastes of nuclear power plant. The wastes must be buried in sufficient deep from earth level or these must be disposed off in sea quite away from the sea share. Hence, during selecting the location of nuclear plant, these factors must be taken into consideration.
3. **Distance from Populated Area :** As there is always a probability of radioactivity, it is always preferable to locate a nuclear station sufficiently away from populated area.
4. **Transportation Facilities :** During commissioning period, heavy equipments to be erected, which to be transported from manufacturer site. So good railways and road ways availabilities are required. For availability of skilled manpower good public transport should also be present at the site.