Catalog

HYDRO ELECTRIC POWER PLANTS

In hydro electric power plants Kinetic Energy of water is converted into mechanical energy by a turbine and then electrical energy by a generator.

CLASSIFICATION

1. Classification according to the availability of load

   a. Low head power plant

   b. Medium head power plant

   b. High head power plant

   Classification according to the nature ofload

   c. Base load plant b. Peak load plant

2. Classification according to the quantity of water available

   a. Run-off river plant without pondage

   b. Run-off river plant with pondage

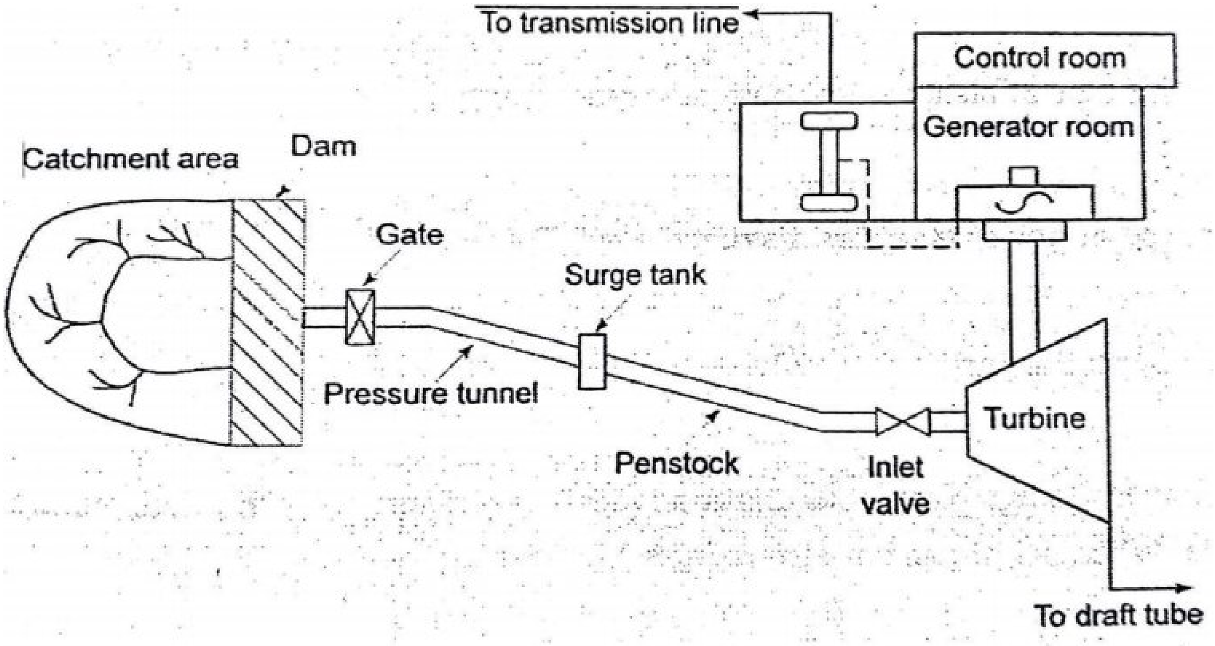
   c. Pumped storage plant

3. Classification based on the power developed by the plant

Large hydro	More than 100 MW
Medium hydro	15-100 MW
Small hydro	1-14 MW
Mini hydro	Above 100kW but below 1 MW
Micro hydro	From 5 kW upto 100 kW
Pico hydro	From few hundred watts upto 5 kW

LAYOUT OF HYDRO ELECTRIC POWER PLANT

Fig. shows the typical layout of a hydroelectric power plant and its basic components.



Layout of hydroelectric power plant

The different parts of a hydroelectric power plant are

(1) Dam

Dams are structures built over rivers to stop the water flow and form a reservoir. The reservoir stores the water flowing down the river. This water is diverted to turbines in power stations. The dams collect water during the rainy season and stores it, thus allowing for a steady flow through the turbines throughout the year. Dams are also used for controlling floods and irrigation. The dams should be water-tight and should be able to withstand the pressure exerted by the water on it. There are different types of dams such as arch dams, gravity dams and buttress dams. The height of water in the dam is called *head race*.

(2) Spillway

A spillway as the name suggests could be called as a way for spilling of water from dams. It is used to provide for the release of flood water from a dam. It is used to prevent over toping of the dams which could result in damage or failure of dams. Spillways could be controlled type or uncontrolled type. The uncontrolled types start releasing water upon water rising above a particular level. But in case of the controlled type, regulation of flow is possible.

(3) Penstock and Tunnel

Penstocks are pipes which carry water from the reservoir to the turbines inside power station. They are usually made of steel and are equipped with gate systems.Water under high pressure flows through the penstock. A tunnel serves the same purpose as a penstock. It is used when an obstruction is present between the dam and power station such as a mountain.

(4) Surge Tank

Surge tanks are tanks connected to the water conductor system. It serves the purpose of reducing water hammering in pipes which can cause damage to pipes. The sudden surges of water in penstock is taken by the surge tank, and when the water requirements increase, it supplies the collected water thereby regulating water flow and pressure inside the penstock.

(5) Power Station

Power station contains a turbine coupled to a generator (see the cross section of a power house on the left). The water brought to the power station rotates the vanes of the turbine producing torque and rotation of turbine shaft. This rotational torque is transferred to the generator and is converted into electricity. The used water is released through the *tail race*. The difference between head race and tail race is called gross head and by subtracting the frictional losses we get the net head available to the turbine for generation of electricity.

Advantages

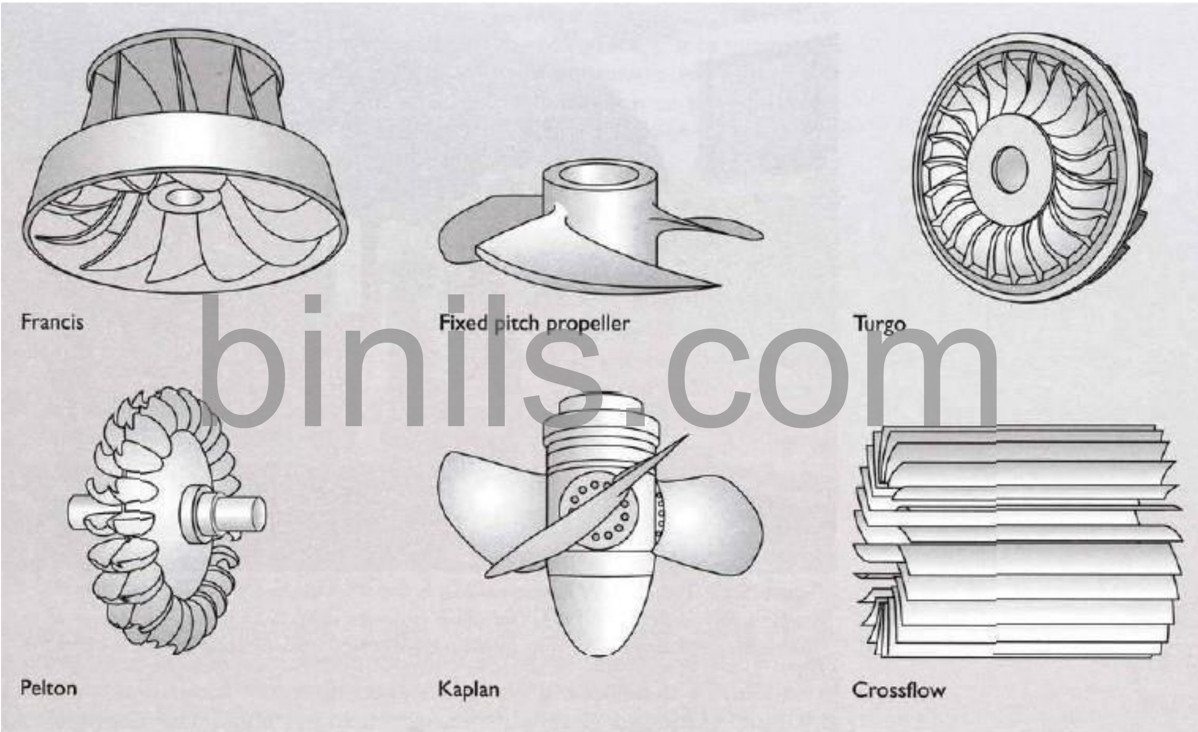
- No fuel is required as potential energy is stored water is used for electricity generation
- Neat and clean source of energy
- Very small running charges - as water is available free of cost
- Comparatively less maintenance is required and has longer life
- Serves other purposes too, such as irrigation

Disadvantages

- Very high capital cost due to construction of dam
- High cost of transmission – as hydro plants are located in hilly areas which are quite away from the consumers

WATER TURBINE

There are two main categories of hydro turbines: impulse and reaction, as described above. The type of hydropower turbine selected for a project is based on the height of standing water—referred to as "head"—and the flow, or volume of water, at the site. The most common type of impulse turbine is Pelton turbine. There are also Turgo turbine, Cross-flow turbine (also known as the Bánki-Michell turbine, or Ossberger turbine), Jonval turbine, Reverse overshot water-wheel,Screw turbine.On the other side,the most common reaction turbine is Francis turbine but there are also Kaplan turbine,Tyson turbine,Gorlov helical turbine.



1. PELTON TURBINE

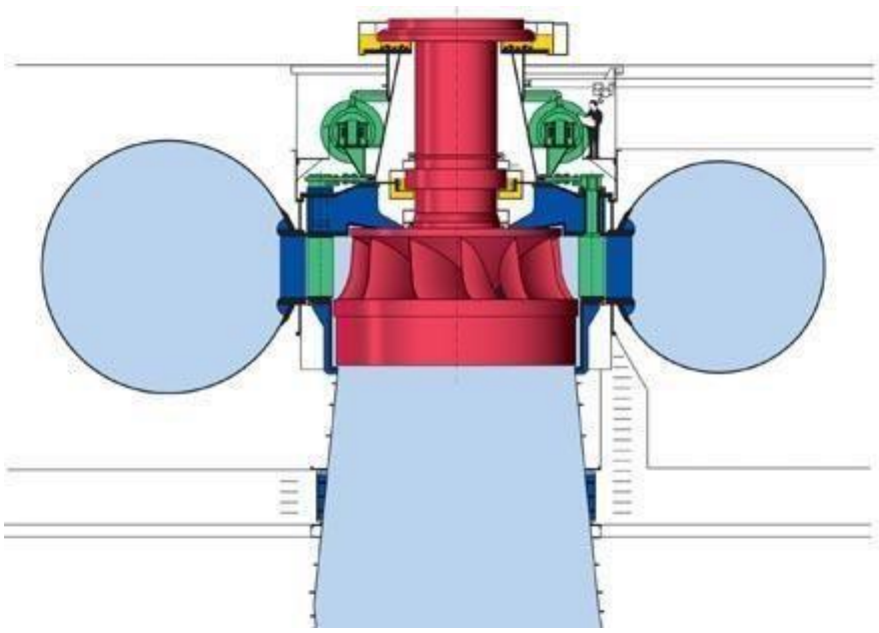
Pelton turbine or wheel is an impulsive turbine used mainly for high head hydroelectric schemes. The Pelton wheel is among the most efficient types of water turbines. The fluid power is converted into kinetic energy in the nozzles. The total pressure drop occurs in the nozzle. The resulting jet of water is directed tangentially at buckets on the wheel producing impulsive force on them.

Nozzles direct forceful, high-speed streams of water against a rotary series of spoon-shaped buckets, also known as impulse blades, which are mounted around the circumferential rim of a drive wheel. As the water jet impinges upon the contoured bucket-blades, the direction of water velocity is changed to follow the contours of the bucket. Water impulse energy exerts torque on the bucket and wheel system, spinning the wheel, the water stream itself does a "u-turn" and exits at the outer sides of the bucket, decelerated to a low velocity. In the process, the water jet's momentum is transferred to the wheel and thence to a turbine. Thus, "impulse" energy does work on the turbine. For maximum power and efficiency, the wheel and turbine system is designed such that the water jet velocity is twice the velocity of the rotating buckets. A very small percentage of the water jet's original kinetic energy will remain in the water, which causes the bucket to be emptied at the same rate it is filled and thereby allows the high-pressure input flow to continue uninterrupted and without waste of energy. Typically two buckets are mounted side-by-side on the wheel, which permits splitting the water jet into two equal streams. This balances the side-load forces on the wheel and helps to ensure smooth, efficient transfer of momentum of the fluid jet of water to the turbine wheel.

Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates, where the Pelton wheel is most efficient. Thus, more power can be extracted from a water source with high-pressure and low-flow than from a source with low-pressure and high-flow, even when the two flows theoretically contain the same power. Also a comparable amount of pipe material is required for each of the two sources, one requiring a long thin pipe, and the other a short wide pipe. Pelton wheels are made in all sizes. There exist multi-ton Pelton wheels mounted on vertical oil pad bearings in hydroelectric plants. The largest units can be up to 200 megawatts. The smallest Pelton wheels are only a few inches across, and can be used to tap power from mountain streams having flows of a few gallons per minute. Some of these systems use household plumbing fixtures for water delivery. These small units are recommended for use with 30 feet (9.1 m) or more of head, in order to generate significant power levels. Depending on water flow and design, Pelton wheels operate best with heads from 49–5,905 feet (14.9–1,799.8 m), although there is no theoretical limit.

2. FRANCIS TURBINE

The Francis turbine is a reaction turbine where water changes pressure as it moves through the turbine, transferring its energy. A watertight casement is needed to contain the water flow. Generally such turbines are suitable for sites such as dams where they are located between the high pressure water source and the low pressure water exit. Francis turbines are the most common water turbine in use today. They operate in a water head from 40 to 600 m (130 to 2,000 ft) and are primarily used for electrical power production.



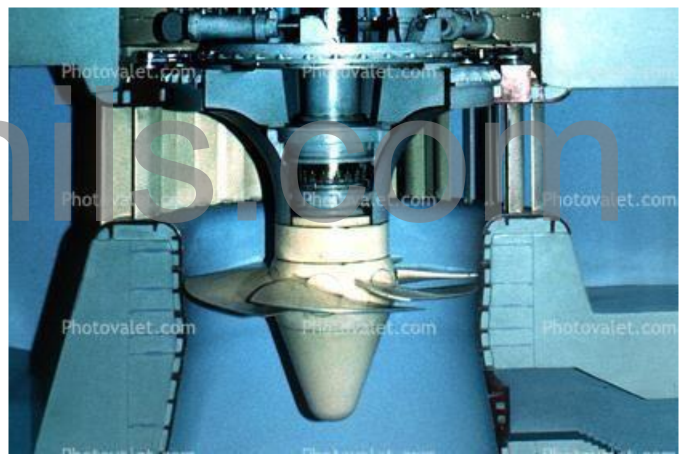
Water flows from the penstock into the spiral casing. In the spiral casing the water is distributed around the complete periphery. The water is then guided by the stay vanes and guide vanes in the correct angle towards the runner. The guide vanes are adjustable and can change the angle depending on the inlet and outlet conditions of the turbine, they are controlled by a governor servo motor. The runner transfers the energy from the pressure and velocity in the water to a rotational momentum. The water exits through a draft tube that extracts the remaining energy in the water. The torque produced in the runner is transferred to a power producing generator through a shaft.

Francis turbines may be designed for a wide range of heads and flows. This, along with their high efficiency, has made them the most widely used turbine in the world. Francis type units cover a head range from 40 to 600 m (130 to 2,000 ft), and their connected generator output power varies from just a few kilowatts up to 800 MW. Large Francis turbines are individually designed for each site to operate with the given water supply and water head at the highest possible efficiency, typically over 90%. In addition to electrical production, they may also be used for pumped storage, where a reservoir is filled by the turbine (acting as a pump) driven by the generator acting as a large electrical motor during periods of low power demand, and then reversed and used to generate power during peak demand. These pump storage reservoirs, etc. act as large energy storage sources to store "excess" electrical energy in the form of water in elevated reservoirs. This is one of only a few ways that temporary excess electrical capacity can be stored for later utilization.

3. KAPLAN TURBINES

The Kaplan turbine has adjustable blades and was developed on the basic platform (design principles) of the Francis turbine by the Viktor Kaplan in 1913. The main advantage of Kaplan turbines is its ability to work in low head sites which was not possible with Francis turbines. Kaplan turbines are widely used in high-flow, low-head power production. The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features. The inlet is a scroll-shaped tube that wraps around the turbine’s wicket gate. Water is directed tangentially through the wicket gate and spirals onto a propeller shaped runner, causing it to spin.

The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy. The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube that may lead to cavitations due to the pressure drop. Typically the efficiencies achieved for Kaplan turbine are over 90%, mainly due to the variable geometry of wicket gate and turbine blades. This efficiency however maybe lower for very low head applications. Since the propeller blades are rotated by high- pressure hydraulic oil, a critical design element of Kaplan turbine is to maintain a positive seal to prevent leakage of oil into the waterway. Kaplan turbines are widely used throughout the world for electrical power production. They are especially suited for the low head hydro and high flow conditions – mostly in canal based hydro power sites.



WIND POWER PLANT

Tower of Wind Turbine

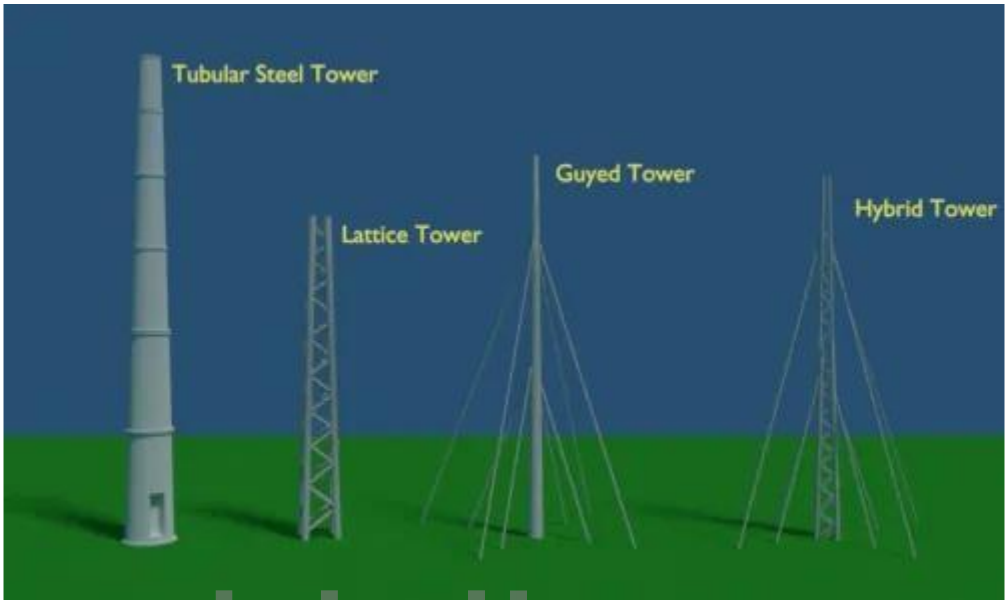
Tower is very crucial part of wind turbine that supports all the other parts. It not only supports the turbine but raises the turbine to sufficient height so that its blades tips would be at safe height during rotation. Not only that, we have to maintain the height of the tower, so that it can get sufficiently strong wind.

The height of tower ultimately depends on the power capacity of wind turbines. The tower of the turbines in commercial wind power plants usually ranges from 40 meters to 100 meters. These towers may be either tubular steel towers, lattice towers, or concrete towers. We use a tubular steel tower for a large wind turbine. These are normally manufactured in a section of 30 to 40 meters in length.

Each section has flanges with holes. Such sections are fitted together by nut bolts at the site to form a complete tower. The complete tower is slight conical shape to provide better mechanical stability. We assemble a lattice tower by different members of steel or GI angles or tubes. All members are bolted or welded together to form a complete tower of desired height. The cost of these towers are much less than that of steel tubular tower, but it aesthetically looks not as good as steel tubular tower.

Although, transportation, assembling, and maintenance are quite easy but still use of lattice tower is avoided in modern wind turbine plant due to its aesthetic look. There is another type of tower used for small wind turbines, and this is guyed pole tower. Guyed pole tower is a single vertical pole supported by guy wired from different sides. Because of numbers of guy wires, it is difficult to access the footing area of the tower. Because of that, we avoid this type of tower in the agricultural field.

There is another type of wind turbine tower used for small plant, and this is a hybrid type tower. Hybrid type tower is also a guyed type tower, but the only difference is that instead of using a single pole in the middle it uses a thin and tall lattice type tower. Hybrid type tower is hybrid of both lattice type and guyed type tower.



Nacelle of Wind Turbine

The nacelle is a big box or kiosk that sits on the tower and houses all the **components of a wind turbine**. It houses an electrical generator, power converter, gearbox, turbine controller, cables, a yaw drive.

Rotor Blades of Wind Turbine

Blades are the main mechanical parts of a wind turbine. The blades convert wind energy into usable mechanical energy. When the wind strikes on the blades, the blades rotate. This rotation transfers its mechanical energy to the shaft. We design the blades like airplane wings. The wind turbine blades can be 40 meters to 90 meters long. The blades should be mechanically strong enough to withstand strong wind even during the storm. At the same time, the wind turbine blades should be made as light as possible to facilitate smooth rotation of the blades. For that, we make the blades with fiberglass and carbon fiber layers on synthetic reinforce.

In a modern turbine, normally three identical blades are fitted to a central hub using nut bolts. Each identical blades are aligned at 120° to each other. The process makes a better distribution of mass and gives the system more smooth rotation.

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The shaft directly connected to the hub is a low-speed shaft. When the blades rotate, this shaft spins with the same rpm as the rotating hub. We couple this shaft directly to the electrical generator in case of a low-speed generator. But in most cases, the low-speed main shaft is geared with a high-speed shaft through a gearbox. In this way, the rotor blades transfer its mechanical energy to the shaft which ultimately enters into an electrical generator.

Gearbox

The wind turbine does not rotate at high speed rather it rotates gently at low speed. But most of the electrical generators require high-speed rotation, to generate electricity at a desired voltage level. So there must be some speed multiplication arrangement to achieve the high speed of the generator shaft. The gearbox of the wind turbine does this. Gearbox increases the speed to much higher value. For example, if the gearbox ratio is 1:80 and if the rpm of a low-speed main shaft is 15, the gearbox will increase the speed of generator shaft to 15 × 80 = 1200 rpm.

Generator

The generator is an electrical device that converts mechanical energy received from the shaft into electrical energy. Normally, we use induction generators in modern wind turbines. Previously, synchronous generators were popular for this purpose. Permanent Magnet DC generator also used in some wind turbines. The speed of the shaft can be made high by using gearbox assembly, but we can not make the shaft speed constant. There may be a fluctuation in shaft speed since it depends on wind speed. So, the speed of the rotor also varies. This variation affects the frequency, voltage of the generated electric power. To, overcome these issues, we normally use an induction generator for the purpose.

Because the induction generator always produces electric power synchronized to the connected grid irrespective of the speed of the rotor. If we use the three-phase synchronous generator, then we first rectify the output power to DC and then convert it to AC of desired voltage and frequency using inverter circuit. Because the alternating power generated by the synchronous generator is not constant in voltage and frequency, rather it varies with speed of the rotor. Because, for the same reason, in some cases, we use a DC generator for the purpose. In these cases, the output DC power from generator inverted to AC of desired voltage and frequency, before feeding it to the grid.

Power Converter

Because wind is not always constant, so electrical potential generated from a generator is not constant, but we need a very stable voltage to feed the grid. A power converter is an electrical device that stabilizes the alternating output voltage transferred to the grid.

Turbine Controller

Turbine controller is a computer (PLC) that controls the entire turbine. It starts and stops the turbine and runs self diagnostic in case of any error in the turbine.

Anemometer

It measures the wind speed and passes the speed information to PLC to control the turbine power.

Wind Vane

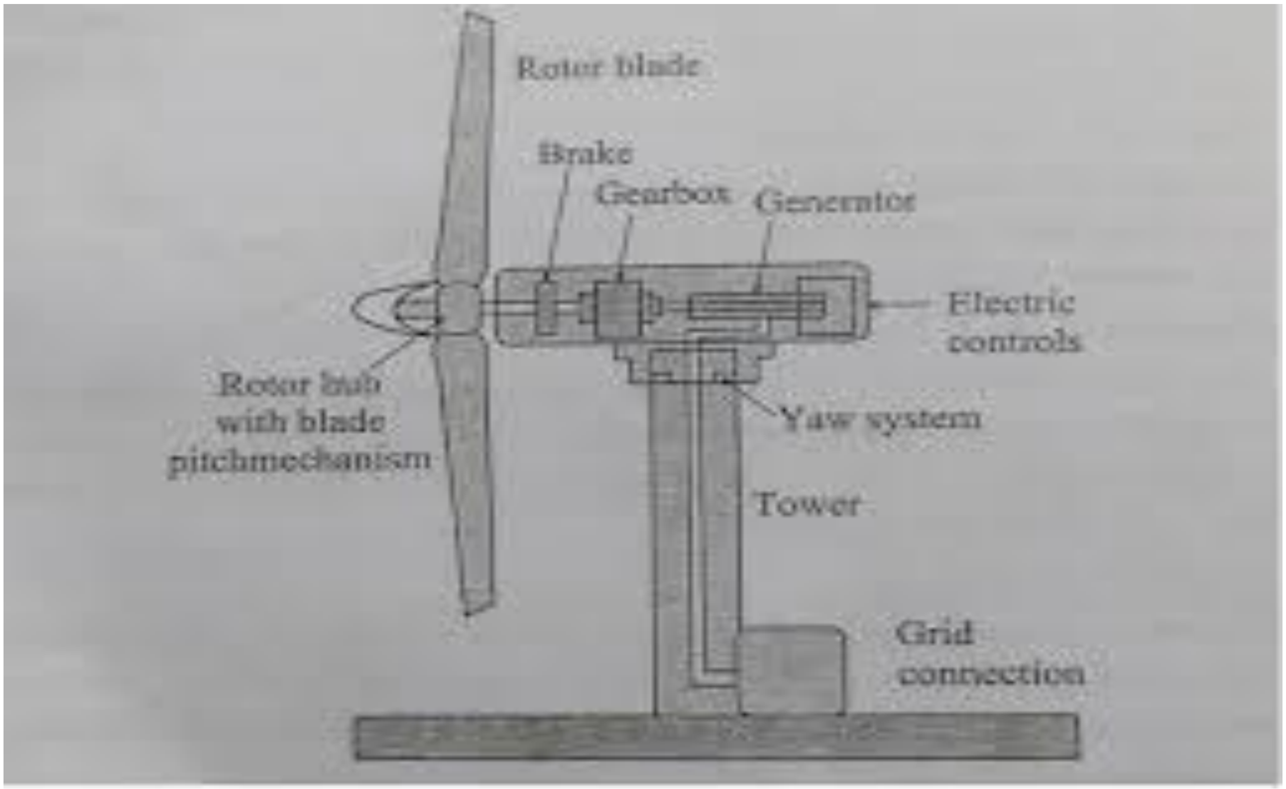
It senses the direction of the wind and passes the direction to PLC then PLC faces the blades in such a way that it cuts the maximum wind.

Pitch Drive

Pitch drive motors control the angle of blades whenever the wind changes it rotates the angle of blades to cut the maximum wind, which is called pitching of blades.

Yaw Drive

Blades and other components in wind turbine are housed in a nacelle, whenever any change in wind direction is there, the nacelle has to face in the direction of the wind to extract the maximum energy from wind. For this purpose yaw drive, a motor is used to rotate the nacelle. It is controlled by PLC that uses the wind vane information to sense the wind direction.


Rotor blade
Brake
Gearbox
Generator
Electric
controls
Rotor hub
with blade
pitchmechanism
Yaw system
Tower
Grid
connection

Working principle of Tidal power plants

Tide or wave is periodic rise and fall of water level of the sea. Tides occur due to the attraction of sea water by the moon. Tides contain large amount of potential energy which is used for power generation. When the water is above the mean sea level, it is called flood tide. When the water level is below the mean level it is called ebb tide.

Working

The arrangement of this system is shown in figure. The ocean tides rise and fall and water can be stored during the rise period and it can be discharged during fall. A dam is constructed separating the tidal basin from the sea and a difference in water level is obtained between the basin and sea.

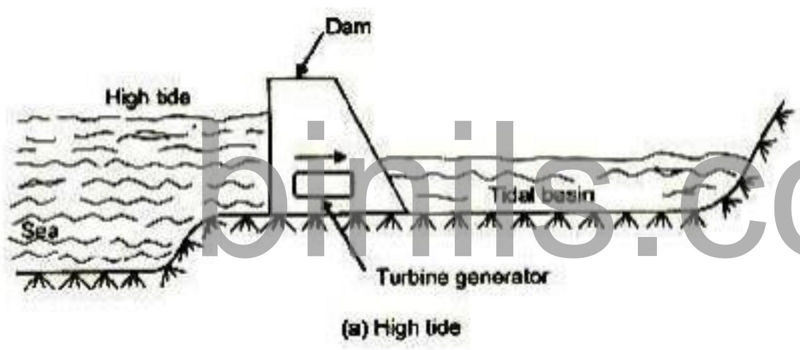


Figure: High tide

Figure: High tide

During high tide period, water flows from the sea into the tidal basin through the water turbine. The height of tide is above that of tidal basin. Hence the turbine unit operates and generates power, as it is directly coupled to a generator.

During low tide period, water flows from tidal basin to sea, as the water level in the basin is more than that of the tide in the sea. During this period also, the flowing water rotates the turbine and generator power.

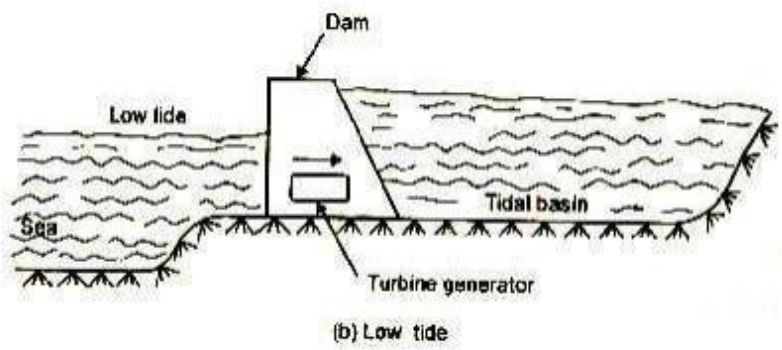


Figure : Low tide

The generation of power stops only when the sea level and the tidal basin level are equal. For the generation of power economically using this source of energy requires some minimum tide height and suitable site. Kislaya power plant of 250 MW capacity in Russia and Rance power plant in France are the only examples of this type of power plant.

Advantages of tidal power plants.

1. It is free from pollution as it does not use any fuel.
2. It is superior to hydro-power plant as it is totally independent of rain.
3. It improves the possibility of fish farming in the tidal basins and it can provide recreation to visitors and holiday makers.

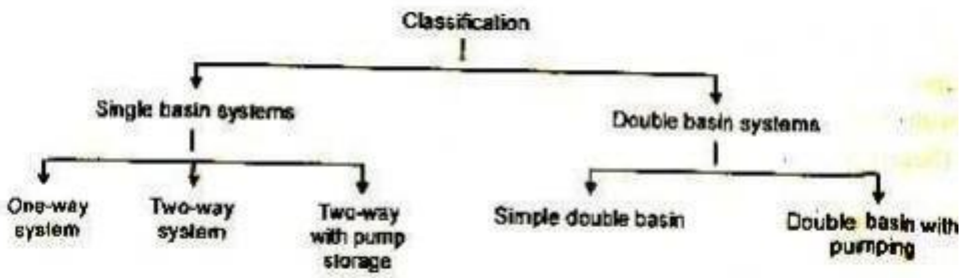
Disadvantages

1. Tidal power plants can be developed only if natural sites are available on the bay.
2. As the sites are available on the bays which are always far away from load centres, the power generated has to be transmitted to long distances. This increases the transmission cost and transmission losses.

Different tidal power plants

The tidal power plants are generally classified on the basis of the number of basins used for the power generation. They are further subdivided as one-way or two-way system as per the cycle of operation for power generation.

The classification is represented with the help of a line diagram as given below.



Working of different tidal power plants

1. Single basin-one-way cycle

This is the simplest form of tidal power plant. In this system a basin is allowed to get filled during flood tide and during the ebb tide, the water flows from the basin to the sea passing through the turbine and generates power. The power is available for a short duration ebb tide.

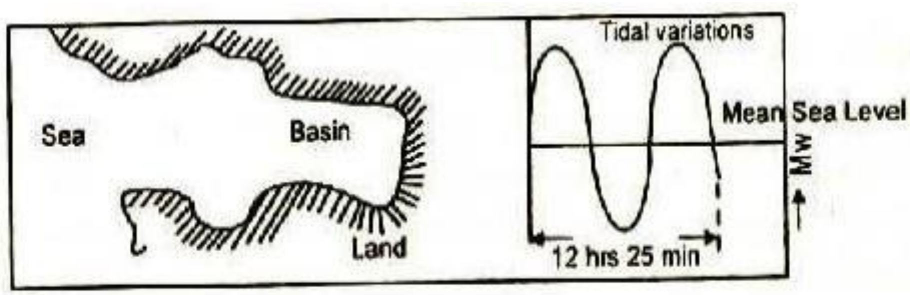


Figure: (a) Tidal region before construction of the power plant and tidal variation

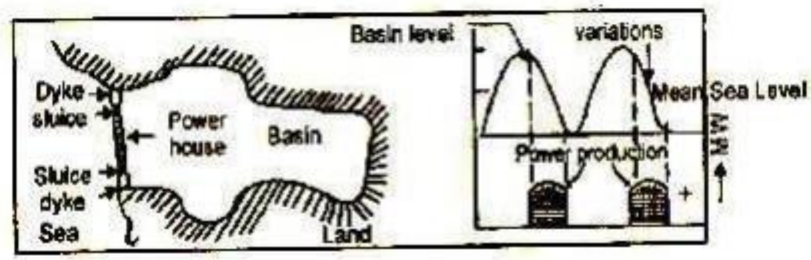


Figure: (b) Single basin, one –way tidal power plant

Figure: (b) Single basin, one –way tidal power plant

Figure (a) shows a single tide basin before the construction, of dam and figure (b) shows the diagrammatic representation of a dam at the mouth of the basin and power generating during the falling tide.

2. Single-basin two-way cycle

In this arrangement, power is generated both during flood tide as well as ebb tide also. The power generation is also intermittent but generation period is increased compared with one-way cycle. However, the peak obtained is less than the one-way cycle. The arrangement of the basin and the power cycle is shown in figure.

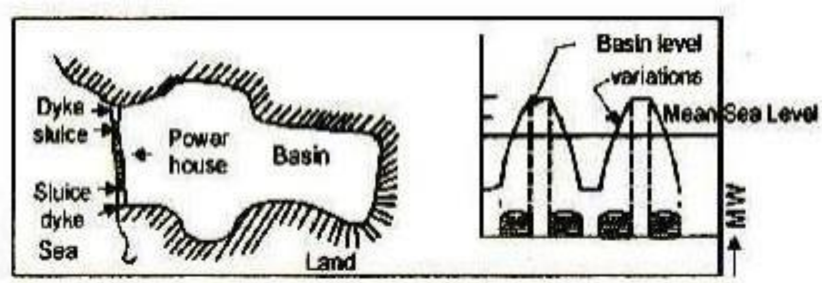


Figure: Single –basin two-way tidal power plant

Figure: Single –basin two-way tidal power plant

The main difficulty with this arrangement, the same turbine must be used as prime mover as ebb and tide flows pass through the turbine in opposite directions. Variable pitch turbine and dual rotation generator are used of such scheme.

3. Single –basin two-way cycle with pump storage

In this system, power is generated both during flood and ebb tides. Complex machines capable of generating power and pumping the water in either directions are used. A part of the energy produced is used for introducing the difference in the water levels between the basin and sea at any time of the tide and this is done by pumping water into the basin up or down. The period of power production with this system is much longer than the other two described earlier. The cycle of operation is shown in figure.

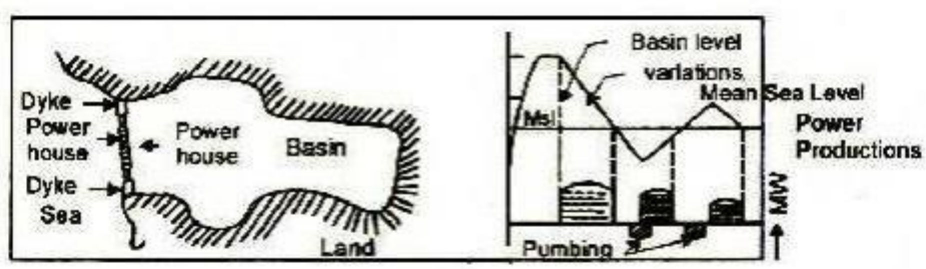


Figure: Single-basin, two-way tidal plant coupled with pump storage system.

4. Double basin type

In this arrangement, the turbine is set up between the basins as shown in figure. One basin is intermittently filled tide and other is intermittently drained by the ebb tide. Therefore, a small capacity but continuous power is made available with this system as shown in figure. The main disadvantages of this system are that 50% of the potential energy is sacrificed in introducing the variation in the water levels of the two basins.

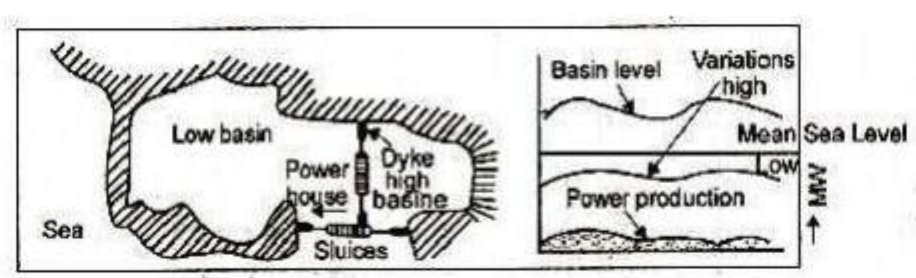


Figure: Double basin, one-way tidal plant.

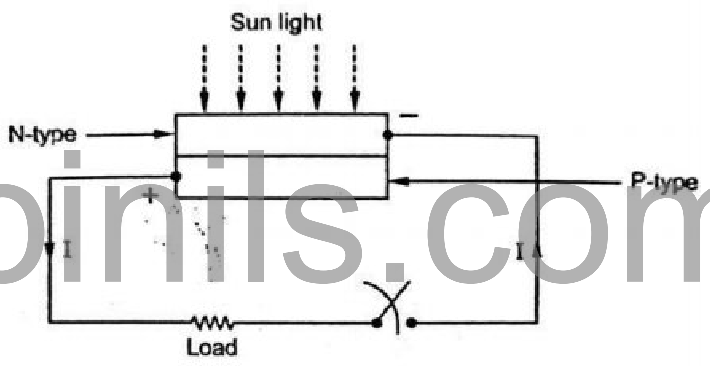
5. Double basin with pumping

In this case, off peak power from the base load plant in a interconnected transmission system is used either to pump the water up the high basin. Net energy gain is possible with such a system if the pumping head is lower than the basin-to-basin turbine generating head.

SOLAR PHOTOVOLTAIC POWER SYSTEM

Principle of photovoltaic or solar cell

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes a significant number of free electrons in the crystal. This is the basic reason for producing electricity due to photovoltaic effect. **Photovoltaic cell** is the basic unit of the system where the photovoltaic effect is utilised to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing the photovoltaic cell.

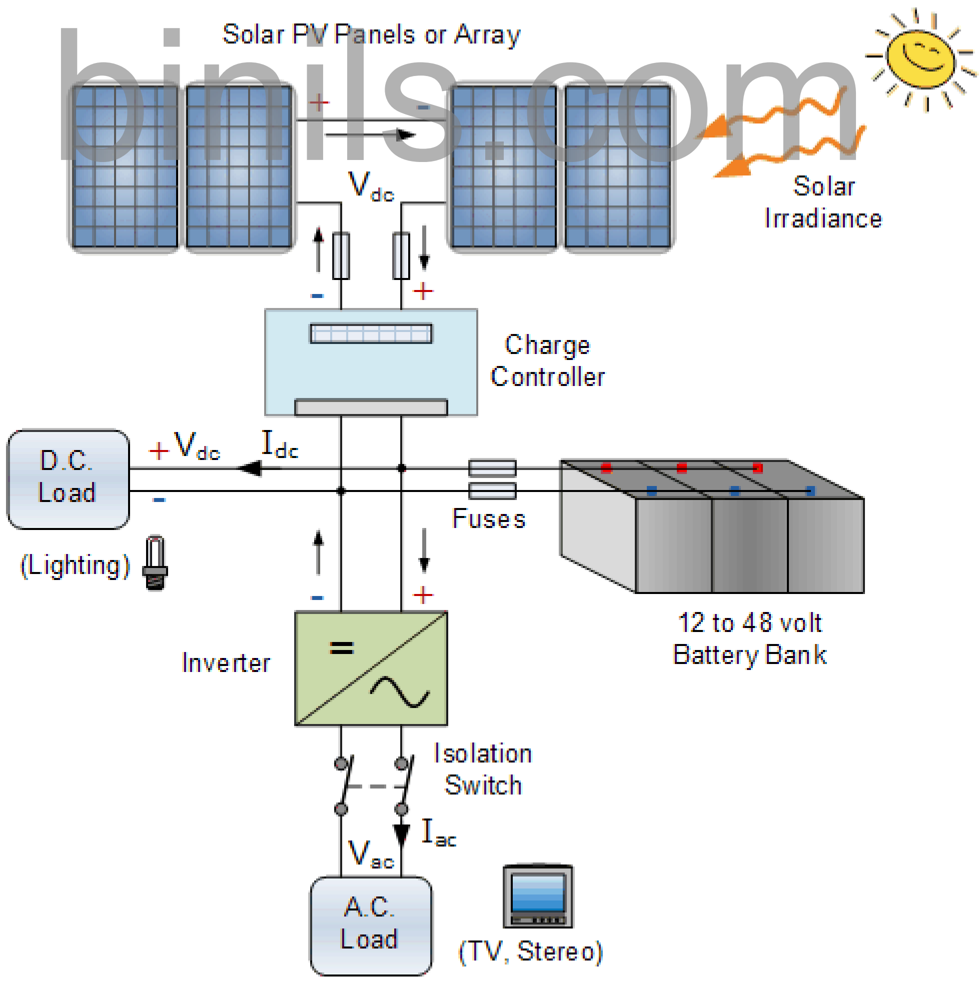


Principle of solar cell

Standalone PV power system

While a major component and cost of a standalone PV system is the solar array, several other components are typically needed. These include:

- Batteries: Batteries are an important element in any stand alone PV system but can be optional depending upon the design. Batteries are used to store the solar-produced electricity for night time or emergency use during the day. Depending upon the solar array configuration, battery banks can be of 12V, 24V or 48V and many hundreds of amperes in total.
- Charge Controller: A charge controller regulates and controls the output from the solar array to prevent the batteries from being over charged (or over discharged) by dissipating the excess power into a load resistance. Charge controllers within a standalone PV system are optional but it is a good idea to have one for safety reasons.



- Fuses and Isolation Switches: These allow PV installations to be protected from accidental shorting of wires allowing power from the PV modules and system to be turned "OFF" when not required saving energy and improving battery life.
- Inverter: The inverter can be another optional unit in a standalone system. Inverters are used to convert the 12V, 24V or 48 Volts direct current (DC) power from the solar array and batteries into an alternating current (AC) electricity and power of either 120 VAC or 240 VAC for use in the home to power AC mains appliances such as TV's, washing machines, freezers, etc.
- Wiring: The final component required in and PV solar system is the electrical wiring. The cables need to be correctly rated for the voltage and power requirements. Thin telephone wire will not work!.

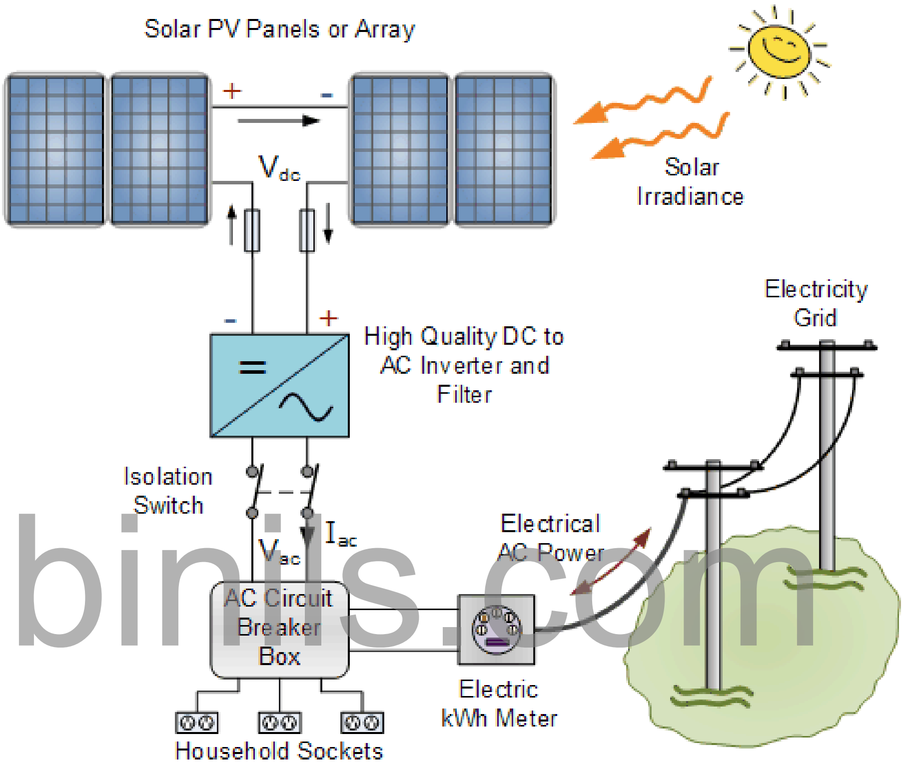
Batteries are an important element and the heart of any stand alone solar power system, whether that is one using a large array of panels to power a home or a small pico solar system used to power the garden, shed or fish pond.

Batteries are needed because of the fluctuating nature of the output being delivered by the PV panels or array. They also convert the electrical energy into stored chemical energy for use when the solar array is not producing power. During the hours of sunshine, the PV system is directly fed to the load, with excess electrical energy being stored in the batteries for later use. During the night, or during a period of low solar irradiance, such as a cloudy, rainy days, energy is supplied to the load from the battery.

So battery storage allows a standalone PV system to be run when the solar panels are not producing enough energy on their own with the battery storage size tied to the electrical usage.

Grid connected PV systems always have a connection to the public electricity grid via a suitable inverter because a photovoltaic panel or array (multiple PV panels) only deliver DC power. As well as the solar panels, the additional components that make up a grid connected PV system compared to a stand alone PV system are:

- Inverter: The inverter is the most important part of any grid connected system. The inverter extracts as much DC (direct current) electricity as possible from the PV array and converts it into clean mains AC (alternating current) electricity at the right voltage and frequency for feeding into the grid or for supplying domestic loads. It is important to choose the best quality inverter possible for the budget allowed as the main considerations in grid connected inverter choice are: *Power* – Maximum high and low voltage power the inverter can handle and *Efficiency* – How efficiently does the inverter convert solar power to AC power.



- Electricity Meter: The electricity meter also called a Kilowatt hour (kWh) meter is used to record the flow of electricity to and from the grid. Twin kWh meters can be used, one to indicate the electrical energy being consumed and the other to record the solar electricity being sent to the grid. A single bidirectional kWh meter can also be used to indicate the net amount of electricity taken from the grid. A grid connected PV system will slow down or halt the aluminium disc in the electric meter and may cause it to spin backwards. This is generally referred to as *net metering*.

- AC Breaker Panel and Fuses: The breaker panel or fuse box is the normal type of fuse box provided with a domestic electricity supply and installation with the exception of additional breakers for inverter and/or filter connections.

- Safety Switches and Cabling: A photovoltaic array will always produce a voltage output in sunlight so it must be possible to disconnect it from the inverter for maintenance or testing. Isolator switches rated for the maximum DC voltage and current of the array and inverter safety switches must be provided separately with easy access to disconnect the system. Other safety features demanded by the electrical company may include earthing and fuses. The electrical cables used to connect the various components must also be correctly rated and sized.
- The Electricity Grid: Finally the electricity grid itself to connect too, because without the utility grid it is not a Grid Connected PV System.

An grid connected system without batteries are the simplest and cheapest solar power setup available, and by not having to charge and maintain batteries they are also more efficient. It is important to note that a grid connected solar power system is not an independent power source unlike a stand alone system. Should the mains supply from the electrical grid be interrupted, the lights may go out, even if the sun is shining. One way to overcome this is to have some form of short term energy storage built into the design.

Advantages

1. Sun is essentially an infinite source of energy. Therefore solar energy is a very large inexhaustible and renewable source of energy and is freely available all over the world.
2. It is environmentally very clean and is hence pollution-free.
3. It is a dependable energy source without new requirements of a highly technical and specialized nature for its wide spread utilization.
4. It is the best alternative for the rapid depletion of fossil fuels.

Disadvantages

1. It is available in a dilute and is at low potential. The intensity of solar energy on a sunny day in India is about 1.1 kW/square meter area. Hence very large collecting areas are required.
2. Also the dilute and diffused nature of the solar energy needs large land area for the power plant for instance, about 30 square kilometers area is required for a solar power station to replace a nuclear plant on a 1 square kilometer site. Hence capital cost is more for the solar plant.

3. Solar energy is not available at night or during cloudy or rainy days.

Applications of Solar Energy:

Applications of solar energy enjoying most success today are:

1. Solar engines for pumping.
2. Solar water heaters.
3. Solar cookers.
4. Solar driers.
5. Solar furnaces.
6. Photo-voltaic conversion (solar cells)
7. Solar power generation.

SOLAR THERMAL POWER SYSTEM

SOLAR COLLECTOR

A **solar collector** is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. These collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions.

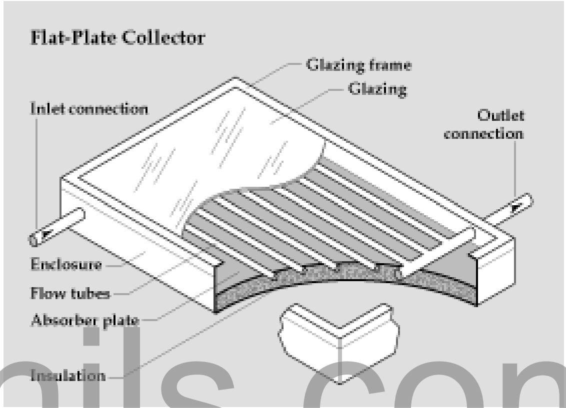
The use of these solar collectors provides an alternative for traditional domestic water heating using a water heater, potentially reducing energy costs over time. As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants.

TYPES OF SOLAR COLLECTORS

There are many different types of solar collectors, but all of them are constructed with the same basic premise in mind. In general, there is some material that is used to collect and focus energy from the Sun and use it to heat water. The simplest of these devices uses a black material surrounding pipes that water flows through. The black material absorbs the solar radiation very well, and as the material heats up the water it surrounds. This is a very simple design, but collectors can get very complex. Absorber plates can be used if a high temperature increase isn't necessary, but generally devices that use reflective materials to focus sunlight result in a greater temperature increase.

1. FLAT PLATE COLLECTOR

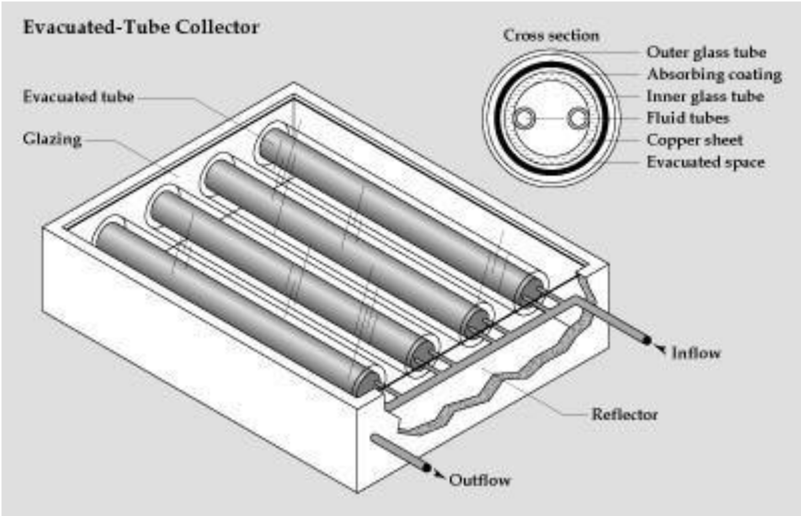
These collectors are simply metal boxes that have some sort of transparent glazing as a cover on top of a dark-coloured absorber plate. The sides and bottom of the collector are usually covered with insulation to minimize heat losses to other parts of the collector. Solar radiation passes through the transparent glazing material and hits the absorber plate.



This plate heats up, transferring the heat to either water or air that is held between the glazing and absorber plate. Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than traditional black paint. These plates are usually made out of metal that is a good conductor - usually copper or aluminum.

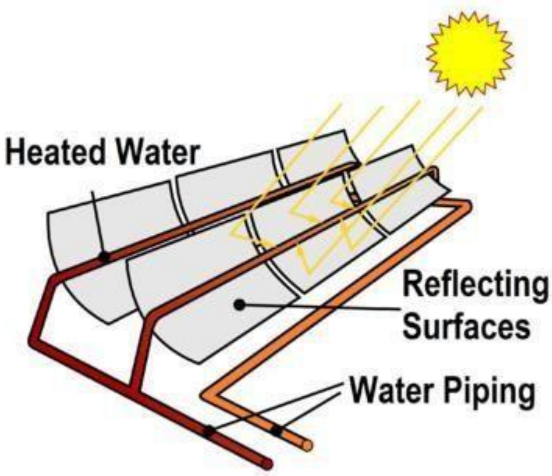
2. EVACUATED SOLAR COLLECTOR

This type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings. They have an inner metal tube which acts as the absorber plate, which is connected to a heat pipe to carry the heat collected from the Sun to the water. This heat pipe is essentially a pipe where the fluid contents are under a very particular pressure. At this pressure, the "hot" end of the pipe has boiling liquid in it while the "cold" end has condensing vapour. This allows for thermal energy to move more efficiently from one end of the pipe to the other. Once the heat from the Sun moves from the hot end of the heat pipe to the condensing end, the thermal energy is transported into the water being heated for use.



3. LINE FOCUS SOLAR COLLECTOR

These collectors, sometimes known as parabolic troughs, use highly reflective materials to collect and concentrate the heat energy from solar radiation. These collectors are composed of parabolically shaped reflective sections connected into a long trough. A pipe that carries water is placed in the center of this trough so that sunlight collected by the reflective material is focused onto the pipe, heating the contents. These are very high powered collectors and are thus generally used to generate steam for Solar thermal power plants and are not used in residential applications. These troughs can be extremely effective in generating heat from the Sun, particularly those that can pivot, tracking the Sun in the sky to ensure maximum sunlight collection.



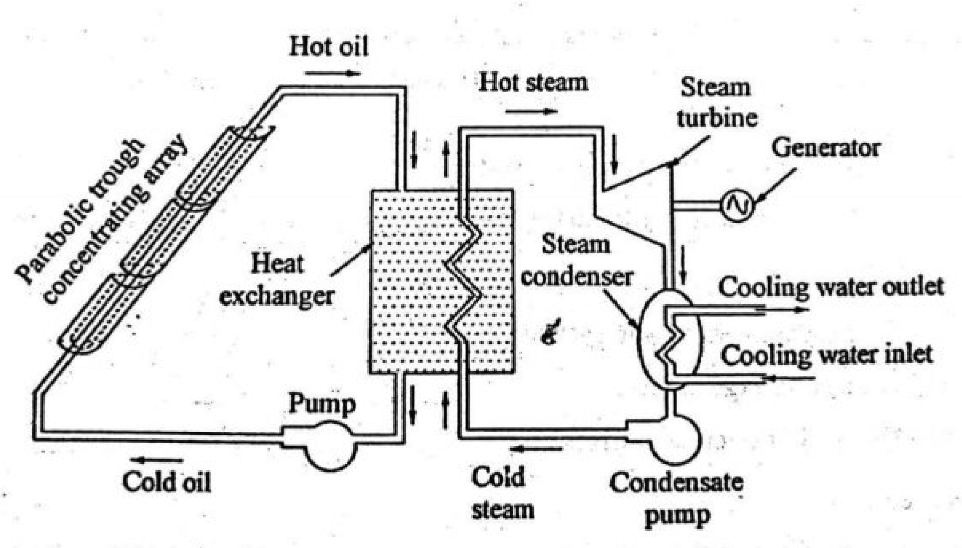
4. POINT FOCUS COLLECTOR

These collectors are large parabolic dishes composed of some reflective material that focus the Sun's energy onto a single point. The heat from these collectors is generally used for driving Stirling engines. Although very effective at collecting sunlight, they must actively track the Sun across the sky to be of any value. These dishes can work alone or be combined into an array to gather even more energy from the Sun.

Point focus collectors and similar apparatuses can also be utilized to concentrate solar energy for use with Concentrated photovoltaics. In this case, instead of producing heat, the Sun's energy is converted directly into electricity with high efficiency photovoltaic cells designed specifically to harness concentrated solar energy.

DISTRIBUTED COLLECTOR SOLAR THERMAL POWER PLANT

In parabolic trough collector, long, U-curved mirrors focus the rays of the sun into an absorber pipe. The mirrors track the sun on one linear axis from north to south during the day. The pipe is seated above the mirror in the center along the focal line and has a heat-absorbent medium (mineral oil, synthetic oil, molten salt etc.) running in it. The sun's energy heats up the oil, which carries the energy to the water in a boiler heat exchanger, reaching a temperature of about 400°C. The heat is transferred into the water, producing steam to drive turbine. Turbine is the prime mover for the generator and generator produce electrical power.



Distributed collector solar thermal power plant

GEOTHERMAL POWER PLANT

Geothermal power plant

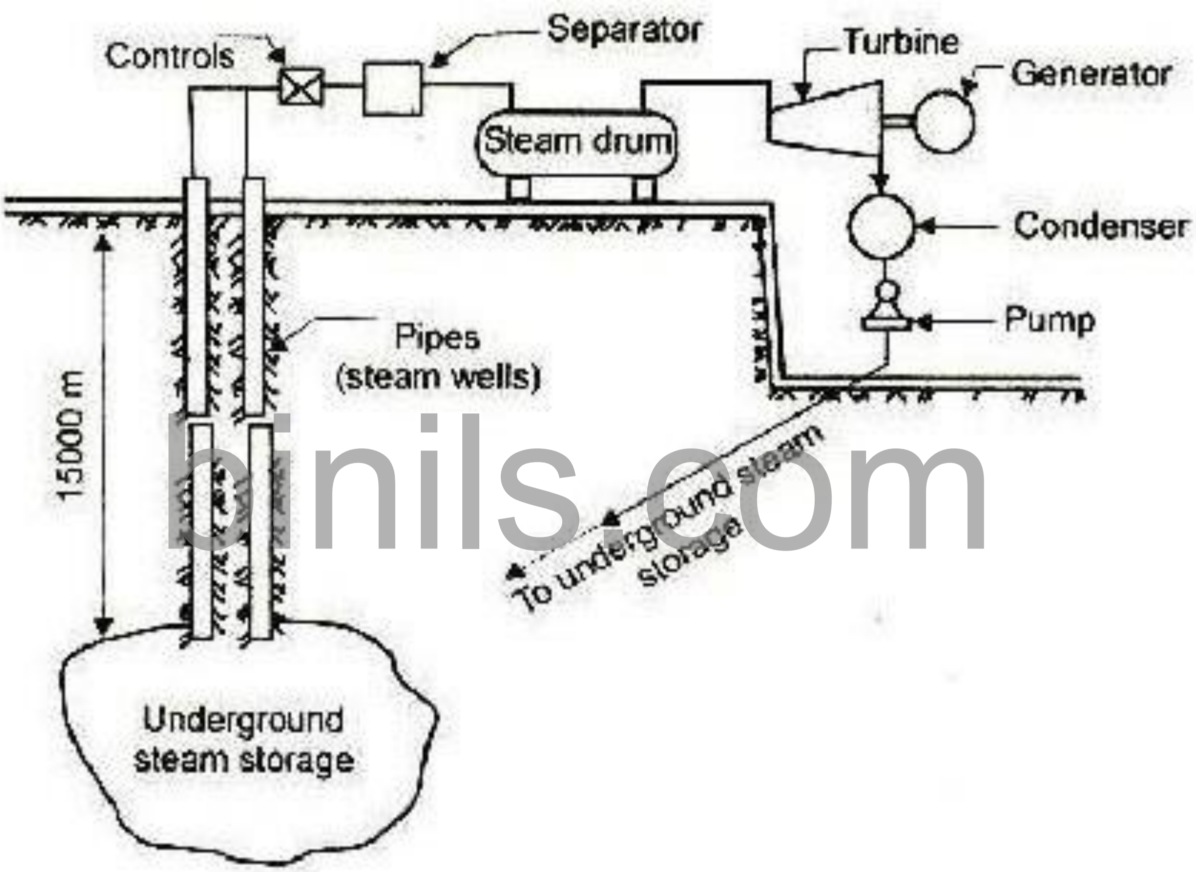


Figure: Geo-thermal power plant

It is also a thermal power plant, but the steam required for power generation is available naturally in some part of the earth below the earth surface. According to various theories earth has a molten core. The fact that volcanic action taken place in many places on the surface of earth supports these theories.

Steam well

Pipes are embedded at places of fresh volcanic action called steam wells, where the molten internal mass of earth vents to the atmospheric with very high temperatures. By sending water through embedded pipes, steam is raised from the underground steam storage wells to the ground level.

Separator

The steam is then passed through the separator where most of the dirt and sand carried by the steam are removed.

Turbine

The steam from the separator is passed through steam drum and is used to run the turbine which in turn drives the generator. The exhaust steam from the turbine is condensed. The condensate is pumped into the earth to absorb the ground heat again and to get converted into steam.

Location of the plant, installation of equipment like control unit etc., within the source of heat and the cost of drilling deep wells as deep as 15,000 metres are some of the difficulties commonly encountered.