# UNIT I

# Introduction of energy sources & its conversion

## Syllabus:-

**Energy sources: Thermal energy, Hydropower energy, Nuclear energy, Solar energy, Geothermal energy, Wind energy, Hydrogen energy, Biomass energy and Tidal energy.**

**Grades of Energy. (*Numerical on efficiency calculation of thermal power plant*)**

**Energy conversion devices: Introduction of pump, compressor, turbines, wind mills etc.**

**(*Simple numerical on power and efficiency calculations)***

## Introduction:-

The basic natural resources available for power generation are hydel, thermal & nuclear. These resources cannot be created newly but these should be used most economically so that they can be used for longer time.

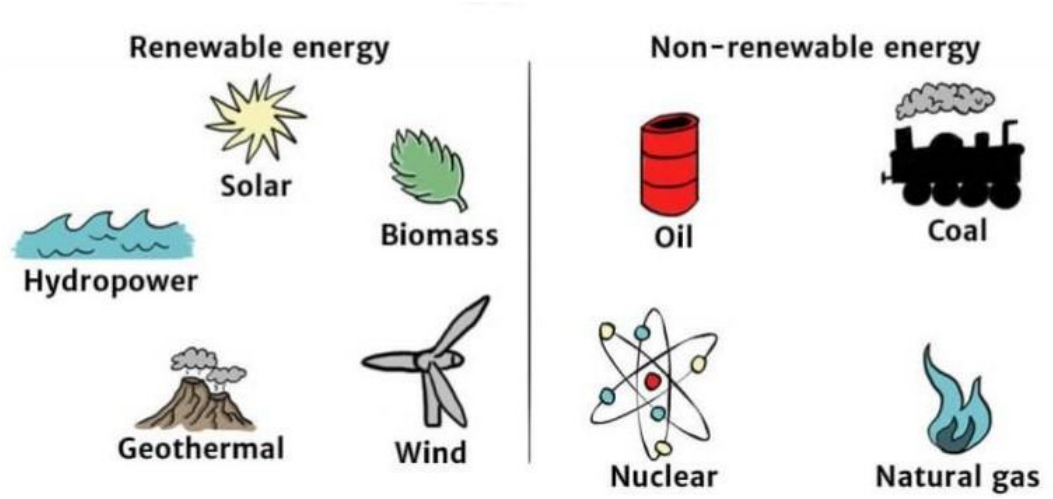
The cost of energy is increasing day by day due to increase in demand for better life, increase in population & depletion of the existing resources like coal and oil.

The purpose of this unit is to discuss different methods for developing power using available sources most economically and to study energy conversion devices.

The major energy sources we use today are classified into two broad groups

1. **Renewable / Non Conventional**
2. **Non renewable / Conventional**

**Renewable & Non Renewable Energy Sources**



Renewable energy resource is energy which is generated from natural sources i.e. sun, wind, rain, tides and can be generated again and again as and when required. They are available in plenty and by far most the cleanest sources of energy available on this planet.

Renewable technologies are suited to large-scale production small off grid applications. Main forms of renewable energy are Wind energy, Hydro energy, solar energy, Bio-fuel, geothermal energy, Tidal Energy.

A non renewable energy resource is a natural resource that cannot be re-made or re grown or used again & again at a scale comparable to its consumption. These energy sources are coal, nuclear, fossil fuels etc.

**Definition and unit of Energy and Power**

**Energy:** The capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms.
**Unit:** The SI unit of energy is joules (J), which is named in honor of James Prescott Joule.
**Power:** Power can be defined as the rate at which work is done i.e. energy converted. The formula for power is

$P = W/t$

**Unit:** The unit of power is watt (W).The watt unit is named after James Watt, the inventor of the steam engine.

## Units

- 1 W= 1 J/s
- 1055 Joule= 1 BTU
- 1 HP = 745.7 Watts
- 1 kW= 1000 W
- 1 MW= $10^6$ W
- 1 Calorie = 4.184 J

## Thermal Energy

Thermal energy is the internal energy of an object due to the kinetic energy of its molecules. The atoms molecules of a hotter object have greater kinetic energy than those of a colder one. A hot object has greater thermal energy than a cold object of the same type.

The energy that comes from the temperature of heated substance is called thermal energy.

Thermal or steam power plant uses **steam** as **a working fluid** for power generation. Generally thermal power plant consists of boiler, turbine, generator, and condenser.

Steam power plant:-

The block diagram of thermal power plant is given below,

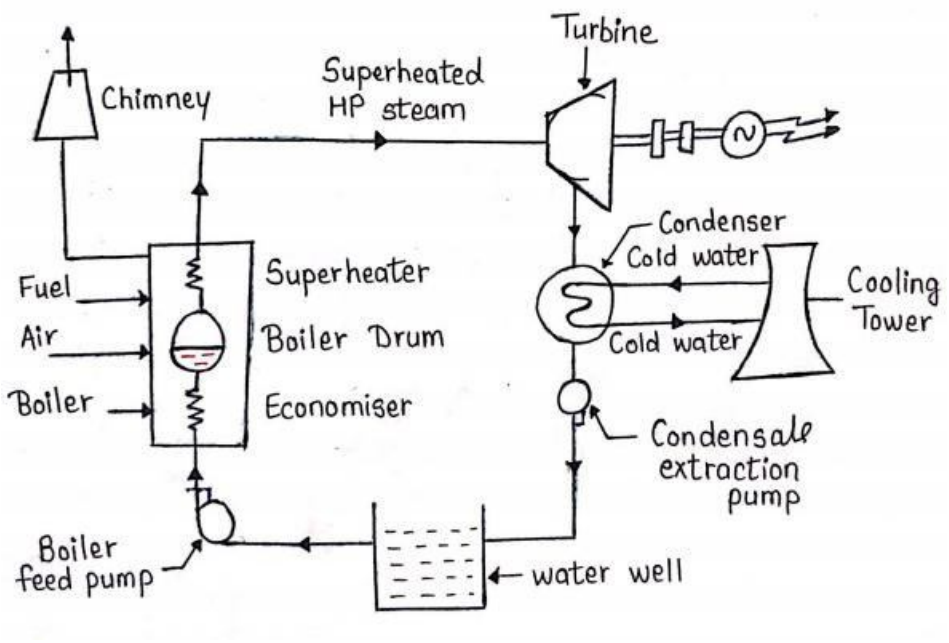



**Fig. Thermal Power Plant**

**It consists of,**

1. **Boiler: -** It is a closed vessel made up of steel whose main function is to convert water into steam by using heat energy obtained from combustion of fuel. In India coal is used as a fuel. The boiler gives dry superheated high pressurised steam at the required temperature through super heater. The input water to the boiler is supplied by boiler feed pump through economiser where water gets heated using hot flue gases generated during combustion of fuel which helps to increase efficiency of plant.
2. **Steam Turbine: -** In steam turbine the high pressurised steam is expanded on blades of turbine which drives the turbine shaft.
3. **Generator: -** The shaft of steam turbine is coupled to the shaft of generator & the mechanical energy of steam turbine is converted into electrical energy.
4. **Condenser: -** The exhaust steam from the turbine is allowed to condense into water in condenser. The condensate from the condenser is passed into water well through condensate extraction pump.
5. **Boiler feed pump: -** The collected water is again fed back to the boiler with the help of boiler feed pump through economiser.

**Advantages:**

1. Fuel used is cheaper
2. Respond quickly to changing load
3. Less space
4. Portion of steam can be used for various process industries
5. Cost of electric power generation and initial cost is less

**Disadvantages:**

1. Operation and maintenance cost is high
2. Time required for mounting plant is more
3. Large quantity of water is needed

4. Coal and ash handling is difficult
5. Low efficiency
6. Pollution causes health problems to workers and habitant near power plant.

# Hydropower energy

The energy obtained by potential energy of water is the hydropower energy.

## Hydroelectric power plant

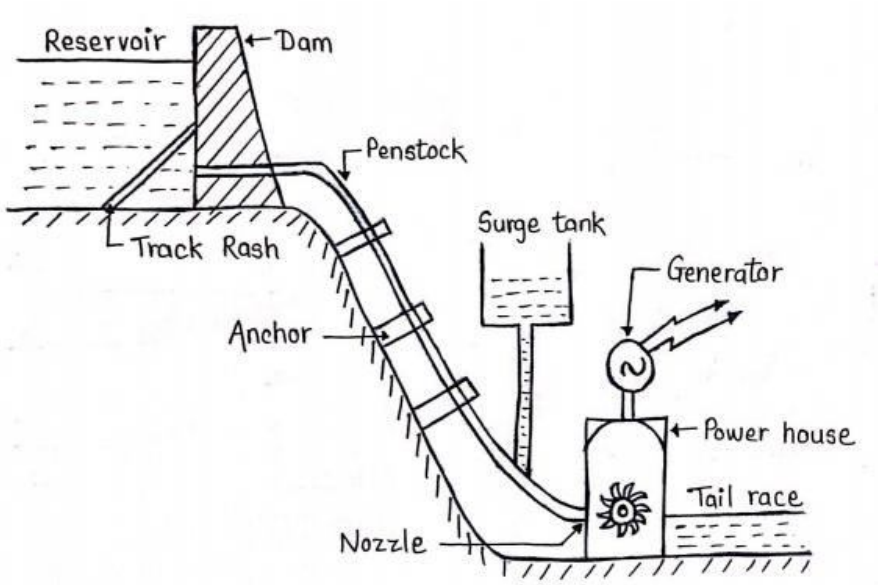



**Fig. Hydroelectric Power Plant**

It consists of,

1. **Reservoir: -** It is used to store large amount of water during rainy season & supply water during other seasons. The water stored is not only used for power generation but also for flood control, irrigation etc. The track rash is provided to filter the water before it flows through penstock.
2. **Dam: -** It is a structure with high height built across the reservoir. It provides a higher level & storage.
3. **Penstock: -** It is a pipe which carries water from reservoir to turbine. A nozzle is provided which converts potential energy of water into kinetic energy as it falls through the head of H. Supporting blocks are used to provide support to penstock.
4. **Power house: -** It consists of turbine & generator where the kinetic energy of water is utilised to run water turbine (mechanical energy) and this is further converted into electrical energy through generator.
5. **Tail race: -** It is a path to lead the water discharged from turbine to the river.

**Advantages:**

1. Operation cost is less compare to capital cost
2. Starting and stopping of plant takes place in very short time.
3. No ash disposal
4. Long life

5. Require less skilled operator
6. Plant can be used for irrigation and flood control.

**Disadvantages:**

1. Depends on availability of water
2. Requires long transmission lines (power loss n cost increases)
3. Time required is more for mounting

## Nuclear energy

During nuclear fission reaction tremendous amount of energy is generated. It is a continues process so if it is controlled then it can be used for power generation.

**Nuclear Chain Reaction:**

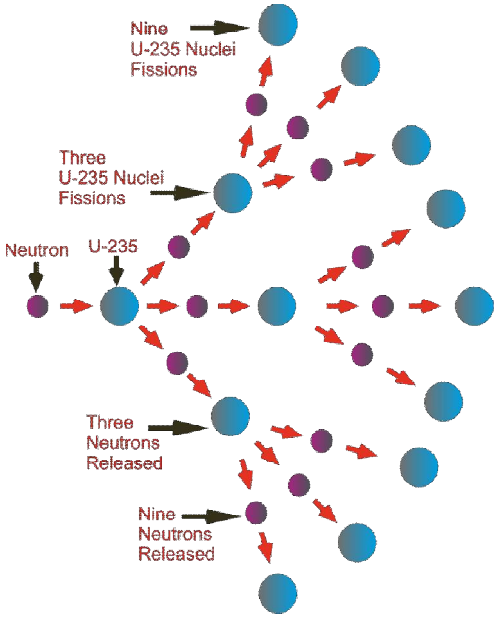



**Fig. Nuclear Chain Reaction**

In nuclear chain reaction process, a heavyweight isotope generally uranium-235 is used for a nuclear chain reaction. Because it produces comparatively higher amount of energy and heat from the other fissionable materials. One of the most common nuclear chain reaction process is:

$$^{235}_{92}U + {}^{1}_{0}n = {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\,{}^{1}_{0}n + \text{Energy}$$

In the above reaction, it is shown that a heavy nucleus uranium-235 strikes one neutron and it produce alternative three neutrons. These three neutrons again strike U-235 which produce nine neutrons and striking nine neutrons produce another twenty-seven neutrons and so on. A single fission reaction generates a large amount of energy, so the complete nuclear chain reaction process will generate many times greater energy. If this reaction is not controlled, it will produce explosive violence.

# Nuclear power plant

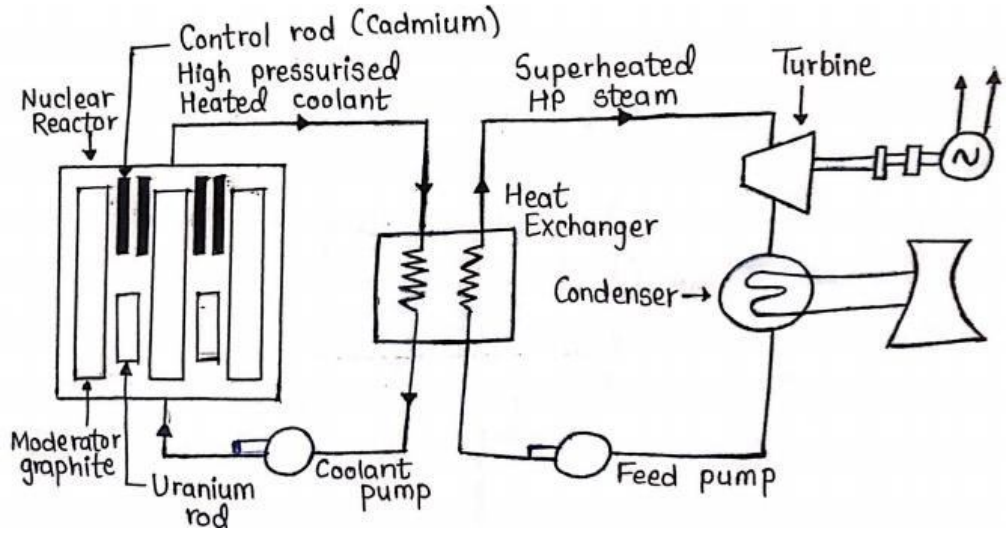



**Fig. Nuclear Power Plant**

It consist of,

1. **Nuclear reactor:** - In this nuclear energy is produces by the nuclear fission of unstable atoms like uranium. It is in the form of rods. The nuclear fission process id continues so it is controlled by moderators & control rods. Moderators are of graphite which reduces the production of neutrons & control rods of cadmium which absorbs the neutrons. This energy is transferred to circulating coolant having high boiling point.
2. **Heat exchanger: -** The heat exchanger acts as a boiler for this power plant. The heat absorbed by the coolant in the reactor is transferred to the water & steam is generated.
3. **Steam turbine:-** In steam turbine the high pressurised steam is expanded on blades of turbine which drives the turbine shaft.
4. **Generator: -** The shaft of steam turbine is coupled to the shaft of generator & the mechanical energy of steam turbine is converted into electrical energy.
5. **Condenser: -** The exhaust steam from the turbine is allowed to condense into water in condenser and it is fed back to heat exchanger with the help feed pump.
6. **Coolant pump:-** The coolant after transferring the heat in heat exchanger coolant is again fed back to nuclear reactor with the help of coolant pump.

**Advantages:**

1. Large quantity of energy is released with small amount of fuel.
2. Problem of fuel transportation and its storage is not needed
3. No air pollution
4. Less space
5. High performance

**Disadvantages:**

1. High capital cost
2. Skilled man power
3. Radioactive waste disposal

4. High degree of safety is required

## Solar energy

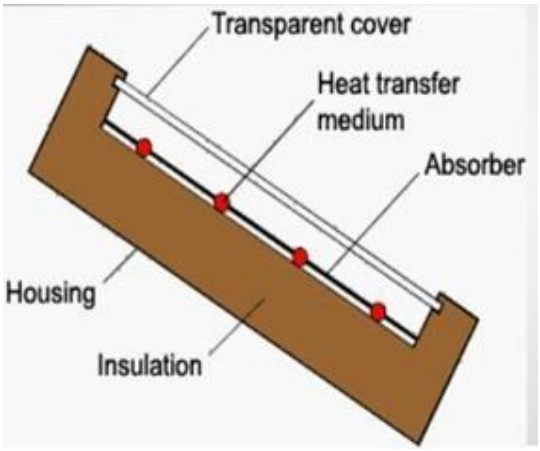
The earth surface receives energy from Sun in the form of electromagnetic radiations. It is about $10^{14}$ kW of solar energy which is 5 times greater than current used from all sources.

Solar energy which falls on the earth is at considerably low density and hence it cannot be used directly for power generation.

The energy has to be collected & converted so that it can be used to run turbine.

The device used to collect & concentrate the solar energy is called as **Solar Concentrating Collector**. The collectors are **flat plate collector & parabolic collector**.

a. Flat Plate Collector (Temp range 60 to 80 degree)




1) **A transparent cover –** one or more sheets of glass or radiation transmitting plastic film or sheet are used to avoid losses through radiation.

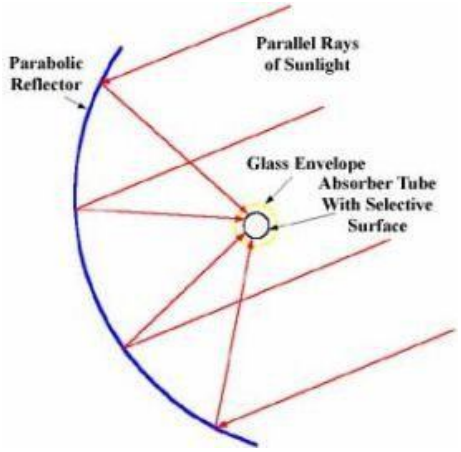
2) **Heat transfer medium:-** Tubes, fins, passages or channels- integral with or connected to the absorber plate & conduct the working fluid through the collector.

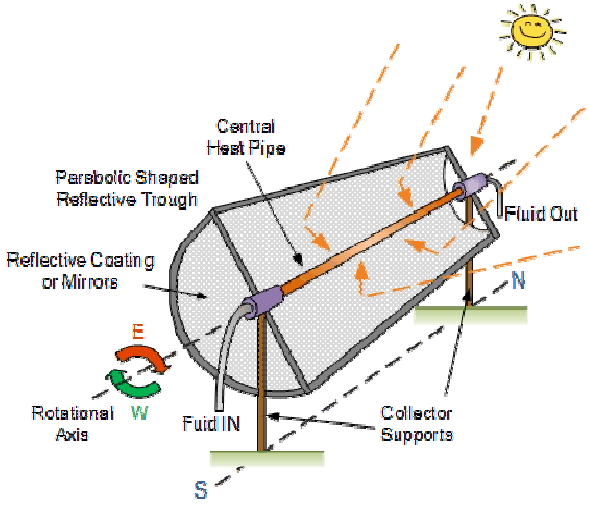
3) **The absorber plate-** normally metallic or with a black surface

4) **Insulation –** provided at the back & sides to minimize heat losses

5) **Housing -** encloses the other components & protects them from the weather.

b. Parabolic collector (Temp range above 100 degree)




Parabolic collectors have a pipe positioned along the focal line of the collector. A number of these collectors can be strung together to increase the energy output. The trough surface is generally silver or aluminium for high reflectivity. The tube running along the focal line is called a receiver and can be coated with anti-reflective coating to more efficiency capture light rays sent towards it. The fluid might simply be water, but more commonly it is oil because of oil's greater thermal density. After the oil is heated by passing through a series of troughs, it goes to a heat exchanger where the energy generates steam to drive turbines and produce electricity.

## Solar Power Plant:-

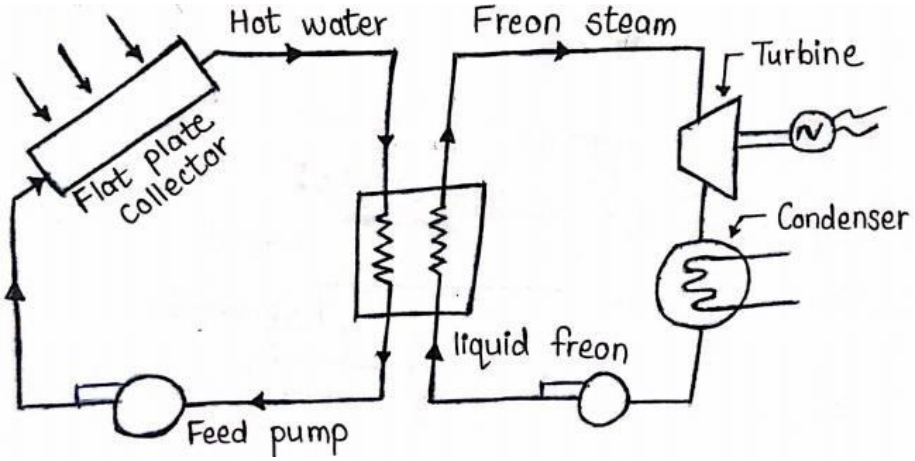



**Fig. Solar Power Plant**

It consists of,

1. **Flat plate collector: -** The sun rays coming from Sun fall on flat plate collector and the water in it is heated up to 80 degree.

2. **Heat exchanger: -** The heat exchanger acts as a boiler for this power plant. The heat absorbed by the water in the reactor is transferred to the Freon (Low B.P.) & produces Freon steam.
3. **Turbine:-** In steam turbine the high pressurised Freon steam is expanded on blades of turbine which drives the turbine shaft.
4. **Generator: -** The shaft of turbine is coupled to the shaft of generator & the mechanical energy of turbine is converted into electrical energy.
5. **Condenser: -** The exhaust Freon steam from the turbine is allowed to condense into liquid Freon in condenser and it is fed back to heat exchanger with the help feed pump.
6. **Water feed pump: -** The after transferring the heat in heat exchanger water is again fed back to nuclear reactor with the help of water pump.

**Advantages:**

1. Renewable Source
2. Less maintenance
3. Simple in design
4. Pollution free
5. High performance

**Disadvantages:**

1. High initial costs
2. No solar power at night so there is a need for a large battery bank
3. Cloudy days do not produce much energy

## Geothermal energy

It is known from many years that core of the earth is considerably hot (200 – 250$^0$C). It has also been found that the earth contains large reservoirs of steam. This naturally available steam can be directly used in the steam power plant.

## Binary cycle Geothermal power plant

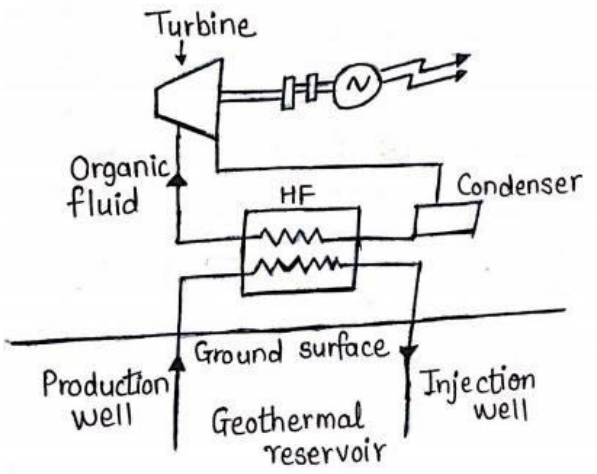



**Fig. Binary Cycle Geothermal Power Plant**

The ground storage contains large quantities of hot water at a considerably high temperature. In this system hot water is indirectly used for generating steam at medium pressure using thermal energy of hot water. The arrangement of the system is shown in figure.

In this system the hot water from production well is circulated through heat exchanger where heat gets exchanged between hot water & organic fluid having low boiling point basically propane, Isobutene . The organic fluid converts into steam and this steam is expanded on blades of turbine which rotates the generator shaft and produces electricity. The steam at exit of turbine is passed to condenser where it is converted in to liquid and is supplied to heat exchanger. The hot water at the exit of heat exchanger is pumped back in to core of earth through injection well.

**Advantages:**

1. Reliable source
2. No harmful emissions
3. High Efficiency
4. Low maintenance
5. No external source required to keep plant running
6. Power stations are smaller

**Disadvantages:**

1. Possibility of depletion of geothermal sources
2. High Investment Cost, difficult in transportation
3. Source is close to volcanic activity, may stop working suddenly

## Wind energy

Wind is air in motion. It is produced by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of various land and water formations, it absorbs the sun's radiation unevenly. Two factors are necessary to specify wind: speed and direction.

As the sun warms the Earth's surface, the atmosphere warms too. Some parts of the Earth receive direct rays from the sun all year and are always warm. Other places receive indirect rays, so the climate is colder. Warm air, which weighs less than cold air, rises. Then cool air moves in and replaces the rising warm air. This movement of air is what makes the wind blow.

# Wind Power plant

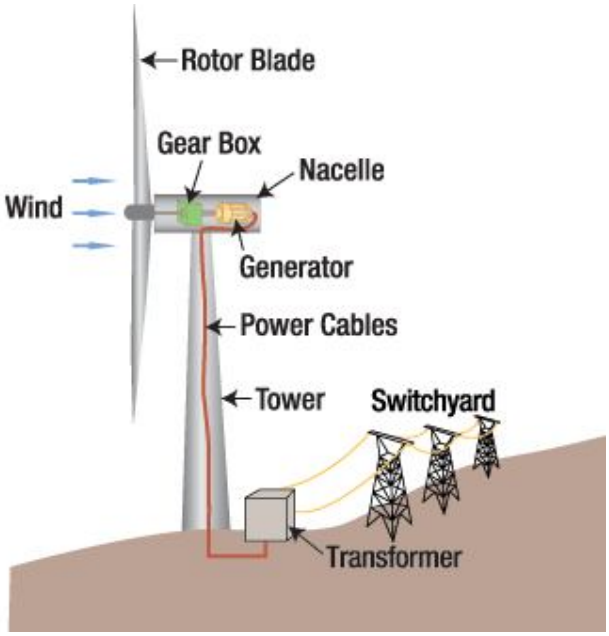



**Fig. Wind Turbine**

It consists of,

**Blades:** The main part of wind turbine is blades. It lifts and rotates when wind is blown over them, causing the rotor to spin. Most turbines have either two or three blades.

**Gear box:** Connects the low-speed shaft to the high-speed shaft and increases the rotational speeds from about 30-60 rotations per minute (rpm), to about 1,000-1,800 rpm; this is the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

**Generator:** Produces 60-cycle AC electricity; it is usually an off-the-shelf induction generator.

**Nacelle:** It Sits a top of the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake.

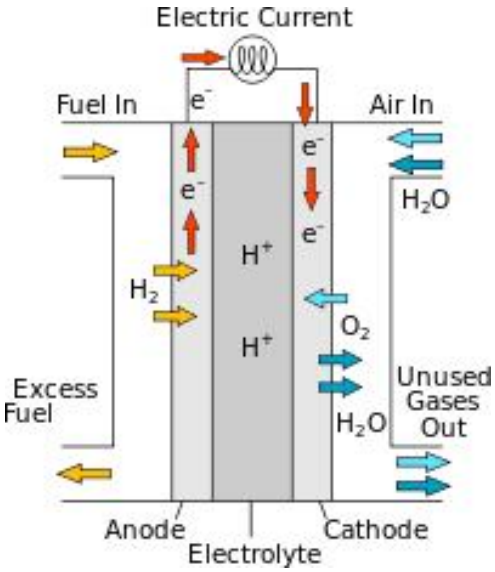
**Advantages:**

1. Wind is available at no cost.
2. It does not cause any pollution.
3. Low maintenance

**Disadvantages:**

1. Low energy density
2. Initial cost of plant set up is high.
3. It is favourable in locations which are away from cities.

## Hydrogen energy



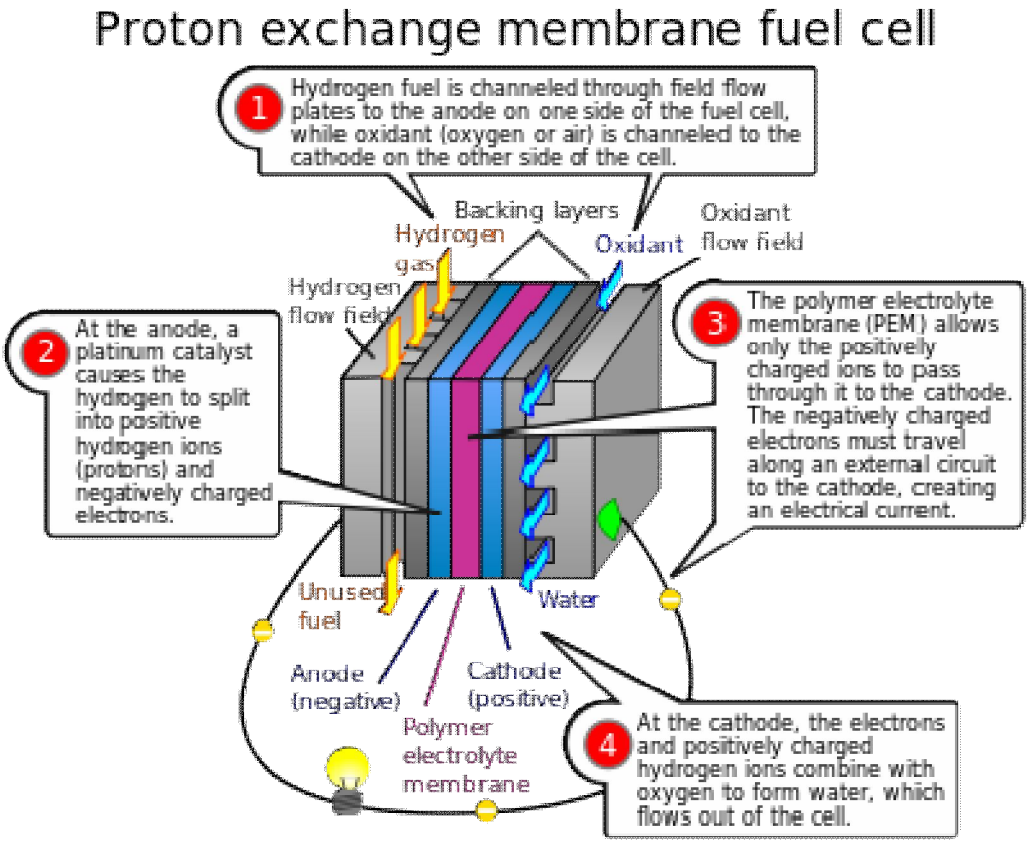




**Fig. Hydrogen Cell**

**Advantages:**

1. It is readily available
2. It doesn't produce harmful emissions.
3. It can be used as fuel in rockets.
4. It is fuel efficient.

5. It is renewable.

**Disadvantages:**

1. It is difficult to store.
2. It is highly flammable.

## Biomass energy

Biomass is organic material that comes from plants and animals, and it is a renewable source of energy. Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. When biomass is burned, the chemical energy in biomass is released as heat. Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels.

Examples of biomass and their uses for energy

1. Wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to generate electricity
2. Agricultural crops and waste materials—burned as a fuel or converted to liquid biofuels
3. Food, yard, and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills
4. Animal manure and human sewage—converted to biogas, which can be burned as a fuel

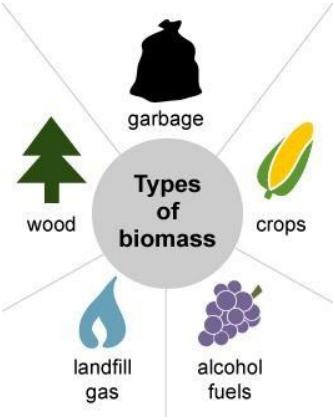



Fig. Sources of Biomass

### Different Ways of Extracting Energy From Biomass

#### 1. Combustion

The direct combustion of biomass in presence of oxygen to produce heat. This heat energy is used for various applications like space heating or cooling, power generation, process heating in industries etc. The moisture content in biomass produces low calorific value of fuel.

#### 2. Pyrolysis

It is the heating of biomass in a closed vessel at temperature range of $500^0$c to $900^0$c in the absence of oxygen with steam. It produces solid, liquid & gases. This process includes

all type of organic materials with plastic & rubber. The gases produced by this process include mixture of CO, $CH_4$, $N_2$, $H_2$, $CO_2$ & other hydrocarbons. The liquids produced are oil like materials & solids produced are similar to pure carbon charcoal.

### 3. Anaerobic-Digestion

Biogas is produced when wet sewage sludge, animal dung or green plants are allowed to decompose in a sealed tank under anaerobic (oxygen-free) conditions.

### 4. Fermentation

If the biomass used is (or can be converted into) mostly sugar, then yeast can be added. The fermentation that follows produces alcohol which is a very high energy fuel that makes it very practicle for use in cars. This has been tried successfully in Brazil.

**Applications of biomass Energy**

Biomass systems range from small stoves used in homes for heating or cooking to large power plants used by centralized utilities to produce electricity.

In residential applications, biomass can be used for space heating or for cooking. Wood is the most common source of fuel, although many different materials are used. New designs for woodstoves can improve the efficiency of the cooking or heating system, decreasing the amount of fuel that is needed.

Industry and businesses use biomass for several purposes including space heating, hot water heating, and electricity generation. Many industrial facilities, such as lumber mills, naturally produce organic waste.

## Photovoltaic cell

In this cell, the light energy coming from sun is directly converted into electrical energy. This conversion is due to quantum interaction between radiated photons & electronic structure of cell material. The photons have a quantum of energy & when it is lost falling on the cell, it comes out in the other form of energy that is electrical energy.

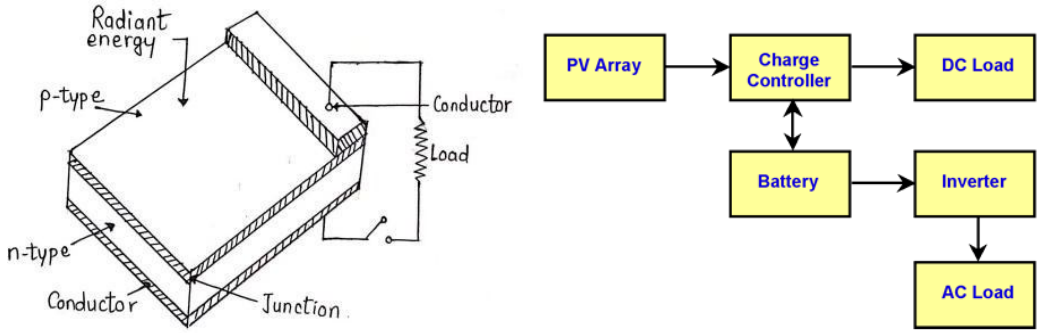



**Fig. Photovoltaic Cell**

Fig shows the schematic arrangement of this generator using p-n semiconductors. For the operation of the cell, it is essential that the solar rays strike the junction. To achieve this, a thin slice of n – type semiconductor is cut and coated with a very thin layer of p – type which is extremely thin (in microns). This is essential for the sun rays to penetrate & reach the junction. Whenever, the sunlight strikes the junction , it generates an excess free electrons & e.m.f.

The efficiency of this system lies between 8 to 15 % with the use of best material.

For appreciable power output, a large number of individual cells are connected electrically to produce desired power.

**Advantages:-**

1. It coverts solar energy directly into electrical energy without going through thermal mechanical link, it has no moving parts.
2. Solar PV systems are reliable, modular, durable & generally maintenance free.
3. These systems are quiet, compatible with almost all environments, expected life span of 20 years or more.
4. It can be located at the place of use and hence no distribution network is required.

**Disadvantages:**

1. For a continuous supply of electric power, especially for on-grid connections, Photovoltaic panels require not only Inverters but also storage batteries; thus increasing the investment cost for PV panels considerably.
2. Solar panels efficiency levels are relatively low (between 14%-25%) compared to the efficiency levels of other renewable energy systems.
3. The efficiency of solar panels is low compared to other renewable sources of energy.

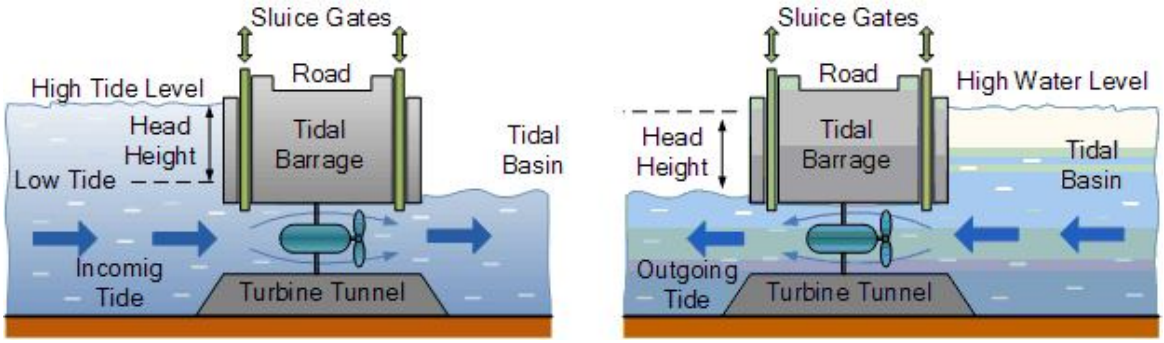
## Tidal energy

Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun, and the rotation of the Earth.

Tidal power or tidal energy is the form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity. Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun.

**Types of tide:-** High tide & Low tide

**Tidal Power Plant:-**




**1) Low Tide** **2) High Tide**

During high tide the water level in sea is higher than basin water level so water flows from sea to tidal basin through reversible water turbine & turbine rotates. The shaft of turbine & shaft of generator are coupled with each other produces electricity.

During low tide the basin water level is higher than sea water level so water flows from basin to sea through reversible turbine & turbine rotates. The shaft of turbine & shaft of generator are coupled with each other produces electricity.

**Advantages:-**

4. Running costs are very low.
5. No waste or pollution is produced. T
6. The technology is very reliable.
7. No fuel is required.

**Disadvantages:**

1. There are only a few suitable places for tidal energy projects.
2. Tidal stream technology is at a very early stage of development.
3. Very expensive to build.
4. Only generate electricity twice a day.
5. Affect wildlife habitats and farming areas.
6. Very limited choice of suitable sites.

# Grades of Energy: High and low grade energy

### High-Grade Energy

Electrical and chemical energy are high-grade energy, because the energy is concentrated in a small space. Even a small amount of electrical and chemical energy can do a great amount of work. The molecules or particles that store these forms of energy are highly ordered and compact and thus considered as high grade energy. High-grade energy like electricity is better used for high grade applications like melting of metals rather than simply heating of water.

### Low-Grade Energy

Heat is low-grade energy. Heat can still be used to do work (example of a heater boiling water), but it rapidly dissipates. The molecules, in which this kind of energy is stored (air and water molecules), are more randomly distributed than the molecules of carbon in a coal. This disordered state of the molecules and the dissipated energy are classified as low-grade energy.

## Energy conversion devices:

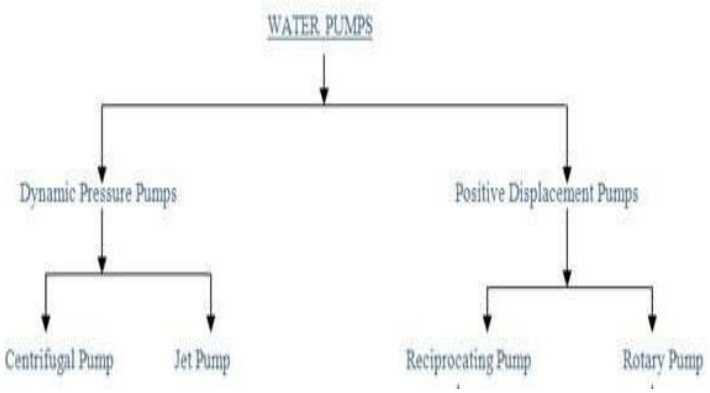
## Pumps

The function of pump is to lift a quantity of liquid from a low level to high level or to transfer it from one place to another place.

Pump is defined as a device which converts mechanical energy of a motor into kinetic energy of fluid.

In short pump is a device which converts the mechanical energy into hydraulic energy.

**Classification**




## Centrifugal Pump

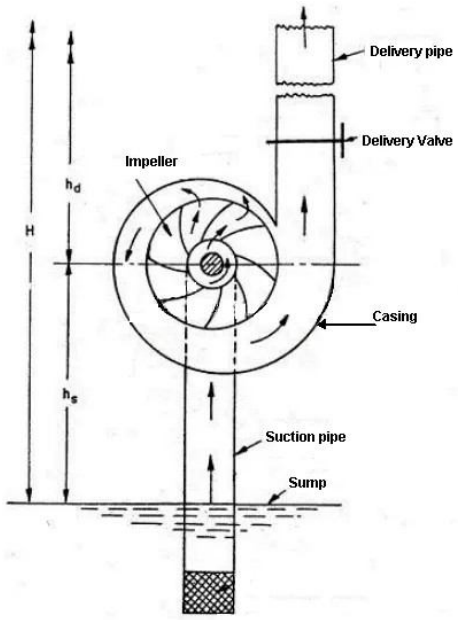



**Fig. Centrifugal Pump**

**Impeller**

It is a wheel or rotor which is provided with a series of backward curved blades or vanes. It is mounted on a shaft which is usually coupled to motor. The motor provides the required input energy to rotate the impeller.

**Casing**

The impeller is enclosed in watertight casing with delivery pipe on one side and suction pipe on suction side which are connect by eye of empeller.

It is designed in such a way that it helps in converting the K.E. of liquid into pressure energy.

**Suction pipe**

The pipe which connect sump to eye of impeller is called suction pipe. The sump carries liquid to be lifted by the pump. The suction pipe at its inlet is provided with strainer & foot valve. The function of strainer is to prevent the entry of any waste material like sand, leaves from water into suction pipe. The foot valve is non return valve which allows the flow of water only in upward direction.

**Delivery pipe**

The pipe which connects the outlet of pump to delivery point is called delivery pipe. A delivery valve is provided to regulate the supply of liquid from pump to delivery pipe.

## Working:-

Priming is the most basic and first step in the working of centrifugal pump. The process of filling the casing, suction pipe and delivery pipe up to the delivery valve before starting the pump is known as priming. In order to remove the air gap present in pump, it is filled by liquid.

After the pump is primed the delivery valve is still kept closed and electric motor is started to rotate the impeller. The delivery valve is kept closed in order to reduce valve is opened the liquid is made to flow in an outward radial direction there by vanes of impeller at the outer circumference with high velocity at outer circumference due to centrifugal action vacuum is created. This cause liquid from sump to rush through suction pipe to eye of impeller thereby replacing long discharge from center circumference of the impeller is utilized in lifting liquid to required height through delivery pipe.

## Advantages:

1. Centrifugal pumps don’t have any leakage issue.
2. They are able to pump hazardous as well as sensitive fluids.
3. There is also no problem of heat transfer as the space between the motor and chamber is sufficiently large.
4. There is no loss of power due to friction and they are very simple in structure and easy in handling.

## Disadvantages:

1. Magnetic resonance in centrifugal pump results in small loss of energy.
2. The risk of the clogging of pipe may arise due to particle attractive nature of magnetic drive.
3. Vibrations due to surrounding atmosphere can damage these pumps.
4. The risk of cavitations is always there.

## Applications:

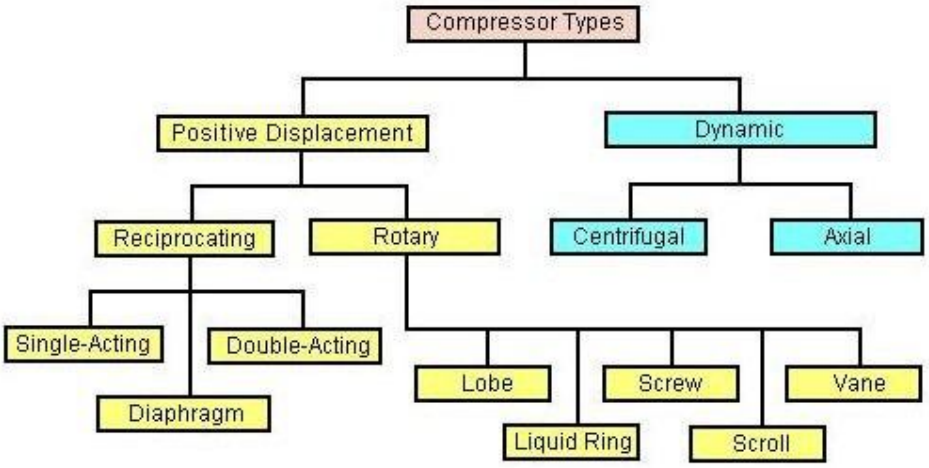
5. These pumps are used in buildings for pumping the regular water.
6. They are used in the fire protection related services.
7. Centrifugal pumps are used to transfer lactose and other drugs in pharmaceutical industry.
8. They are also used in coolant recirculation, refrigerants.
9. These pumps are used in sprinkling, irrigation, drainage.

## Compressor

It is a device that compresses the atmospheric air (any gas) to a higher pressure at the expense of external work supplied either by a prime mover.

Compressed air is supplied and stored in a closed vessel, from which it is further supplied to point of application.

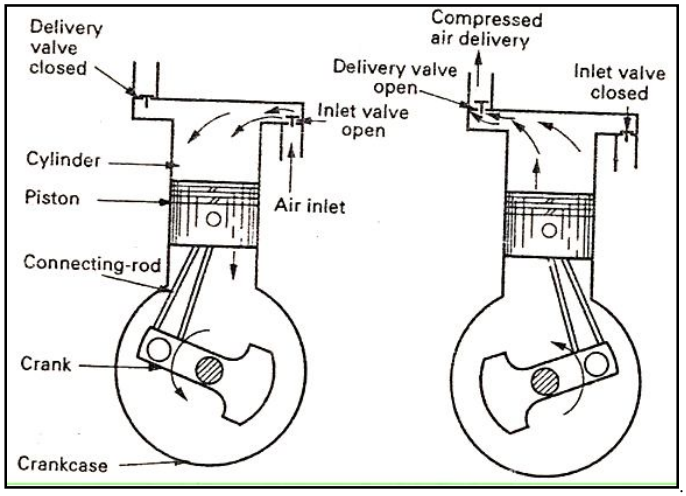
## Classification




## Reciprocating Compressor

The fig shows the cross section of single acting reciprocating air compressor.
It consists of piston which reciprocates in a cylinder. The piston is driven through connecting rod and crank. The crankshaft is driven by an electric motor.

The suction valve and delivery valve are mounted on the cylinder head. The valves are automatically opened and closed depending upon pressure difference across the valve.




**1)Suction stroke 2) Compression stroke**

**Fig. Reciprocating Compressor**

## Working

**Suction stroke:-**

When piston is moving downwards, the delivery valve is closed. When the pressure inside the cylinder falls below the atmosphere pressure and suction valve opens. The atmospheric air is sucked inside the cylinder up to the end of suction stroke.

**Compression & delivery stroke:-**

When the piston is moving upward, the air sucked inside the cylinder during suction stroke is compressed gradually. When the pressure become higher than atmospheric pressure , the inlet valve closes.

With the further movement of piston upward, air pressure increases. When the pressure reaches above the pressure on delivery side, the delivery valve opens. The compressed air is discharged to the receiver.

## Advantages:

1. It is used to produce high pressure gas.
2. High efficiency and flexibility

## Disadvantages:

1. The size of compressor is very large for given capacity.
2. High vibrations and noise.
3. Part of work input is lost due to frictional resistance between piston & cylinder.
4. The risk of cavitations is always there.

## Applications:-

1. It is used to produce high pressure gas output.
2. It is used in refrigeration cycle.
3. It is used in oil refineries, gas pipelines, natural gas processing units, chemical plants etc.
4. It is also used in blowing of the plastic bottles.

# Hydraulic Turbines

It is a machine which converts pressure & kinetic energy of water into mechanical energy. The mechanical energy is further converted into electrical energy through generator.

**Pelton Wheel**

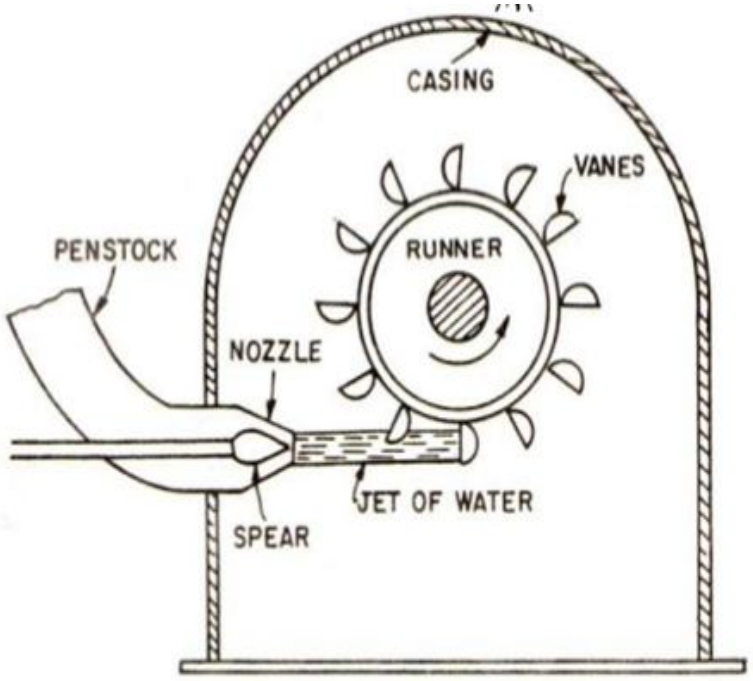



**Fig. Pelton wheel turbine**

1. The water stored at high head is made to flow through the penstock and reaches the nozzle of the Pelton turbine.
2. The nozzle increases the K.E. of the water and directs the water in the form of jet.
3. The jet of water from the nozzle strikes the buckets (vanes) of the runner. This made the runner to rotate at very high speed.
4. The quantity of water striking the vanes or buckets is controlled by the spear present inside the nozzle.
5. The generator is attached to the shaft of the runner which converts the mechanical energy ( i.e. rotational energy) of the runner into electrical energy.

# Numerical on Efficiency calculation of Thermal Power Plant

1. A Steam Power Plant has Coal Consumption of 165 Tons Per Hour. Calorific Value of Coal is 3500 kcal/kg. If the power generation is 250 MW, find overall efficiency of the plant. Use relation 1 kcal = 4.18 kJ.

2. A small generating plant of 100 KW capacity uses gas of a calorific value of 4000 $KJ/m^3$.The volume of gas required per hour when the plant is running at full load condition is 450 $m^3$ / hr. Find: (a) Input Power and (b) Overall Efficiency of the plant.

3. A Steam Power Plant has Coal Consumption of 16200 Kg/hr with Calorific Value of Coal as 17793.9 kJ/kg. If the speed of steam turbine is 1000 rpm and generated torque is 477464.8293 Nm. Find: (a) Input Power, (b) Output Power and (c) Efficiency.

4. A Steam Power Plant has Coal Consumption of 16300 Kg/hr with Calorific Value of Coal as 17793.9 kJ/kg. If the speed of steam turbine is 1100 rpm, radial distance is 1.5m and generated force is 318309.8862 N. Find: (a) Generated Torque, (b) Input Power , (c) Output Power and (d) Efficiency.

5. For a thermal power plant efficiency is 38 %. The workdone by turbine is 1 Kj/kg and amount of heat supplied by the boiler is 2.2 Kj/kg. Find work consumed by the pump .

6. In a steam power plant the heat supplied by boiler is 2900 J/kg. For this amount of heat supplied, the turbine work is 900 J/kg and pump work is 100 J/kg. Find effiieny of the plant. If it is required to increase efficiency by 3 % for the same amount of heat supplied and turbine work then what will be the pump work?

7. The coal consumption in a steam power plant is 100 tonnes per day having calorific value of 21000KJ/kg. Average power output per day from the plant is 5800 KW. Find overall efficiency of plant.

8. Determine the power in the wind if the wind speed is 20 m/s and blade length is 50 Air density $\rho = 1.23$ $kg/m^3$.