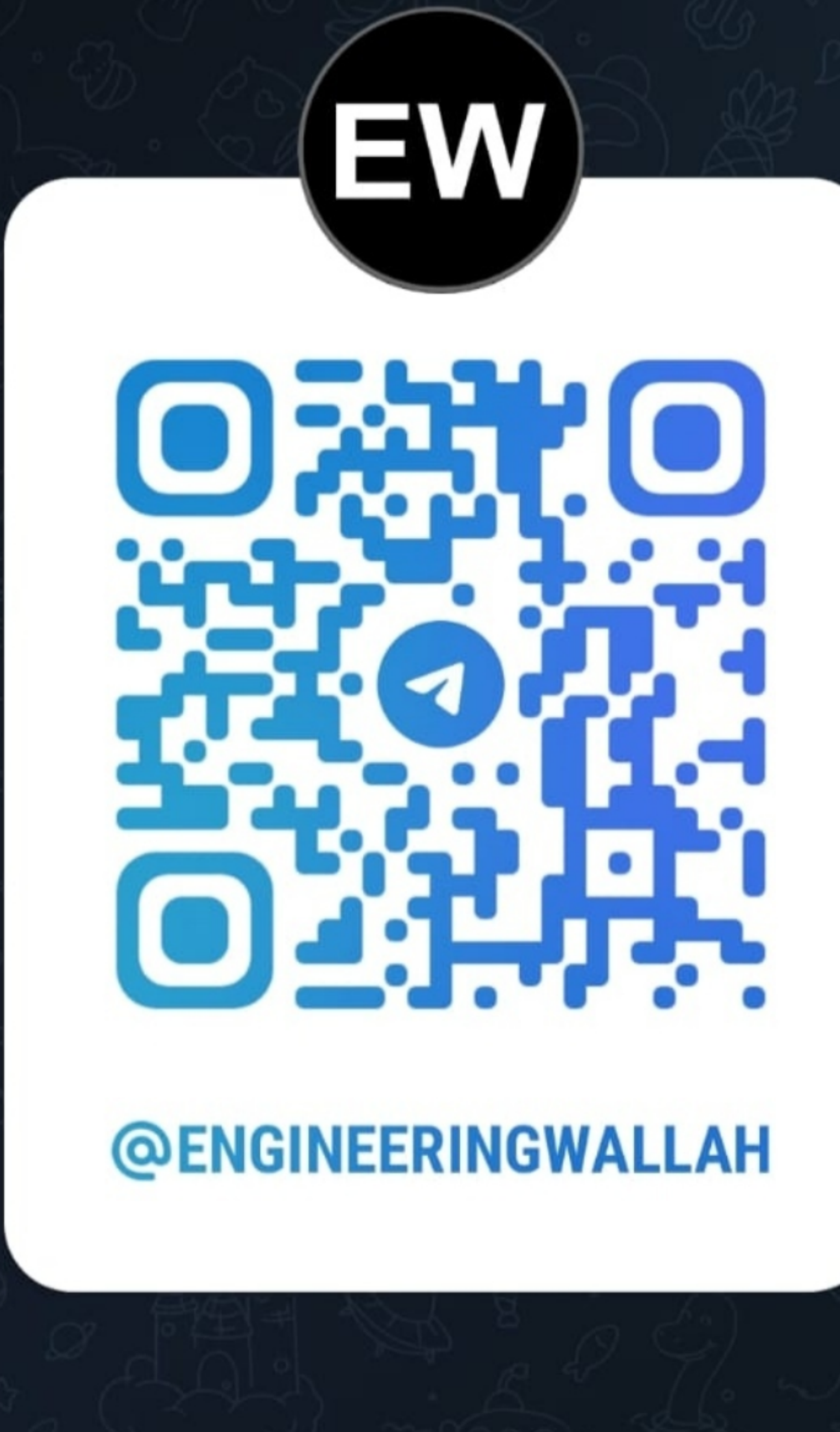
EW
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# UNIT I
# Introduction of energy sources & conversion

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## Renewable Energy Sources

i. Renewable Energy Sources are those which are available in nature and are used again and again

ii. These are also known as non conventional energy sources

iii. The different energy sources are

a) solar energy b) wind energy

c) tidal energy

Advantages

i. They are widely available

ii. Non polluting

iii. No maintenance cost

Disadvantages

i. Their collection is very expensive

ii. Availability is periodic and uncertain

iii. Power plant using these energies have low efficiency

## non Renewable Energy Sources

i. non renewable energy sources are those which cant used again and again and cant recovered
ii. These are also known as conventional energy sources
iii. The different energy sources are
   a) thermal energy ( energy obtained from coal, oil )
   b) nuclear energy ( energy obtained from nuclear fuels )

**Advantages**

i. Less initial cost
ii. High efficiency

**Disadvantages**

i. high running cost
ii. High maintenance cost
i. Polluting

| Sr no | parameter | Renewable | non renewable |
|---|---|---|---|
| 1 | Efficiency | Less | High |
| 2 | Running cost | Less | High |
| 3 | Initial cost | High | Less |
| 4 | Air pollution | Non Polluting | Polluting |

# Energy

i. Energy is the capacity to do work

ii. Energy is measured in Nm or J (joule).

Energy can be classified into two types

Internal Energy

External Energy

**grades of energy**

1. **High grade energy**

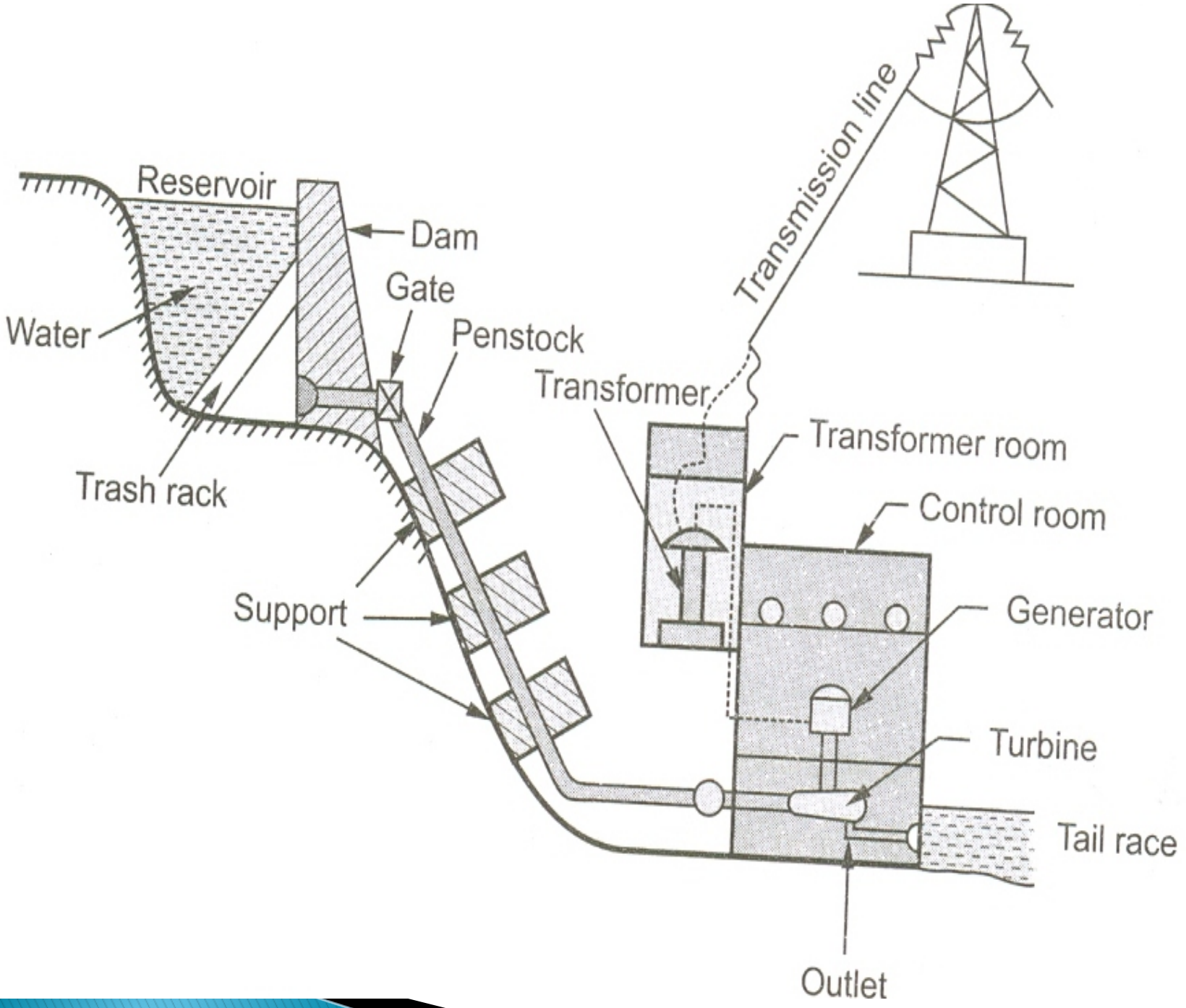
High grade is that form of energy which completely converts into some other forms like electrical energy which can be converted into thermal energy

2. **Low grade energy**

Low grade energy will not be able to convert into other forms completely like thermal energy used in thermal power plants to convert into electricity.

| Sr no | Parameter | High grade energy | Low grade energy |
|---|---|---|---|
| 1 | Conversion into other form | completely converts into some other forms | Not Completely converts into some other forms |
| 2 | Cost | More expensive | Less expensive |
| 3 | Process of conversion | Easy to convert into other form | difficult to convert into other form |
| 4 | Pollution | Less polluting | More polluting |
| 5 | Efficiency | High | Less |
| 6 | Examples | electrical energy, wind energy, work | heat produces because of combustion, fusion and fission reactions |

# Hydroelectric power plant



## Introduction

i. Hydroelectric power plant utilies the P.E. of water to move hydraulic turbine

ii. hydraulic turbines are coupled to the electric generators

## Principle of operation

In Hydroelectric power plant the P.E. of water is used to move the hydraulic turbine which in turn runs an electric generator to convert the mech energy of turbine into electric energy

## Construction

1. **Reservoir**
   i. A reservoir is provided to store water during rainy season and supplies the same throughout.
   ii. The water from the reservoir is used run the hydraulic turbine

2. **Dam**
   i. A dam is constructed at a considerable height across the river
   ii. Its function is to provide working head of water for power plant
   iii. It also used to increase the storage capacity of reservoir

3. **Trash Rack**
   i. It is made of steel bars
   ii. It is provided to prevent entry of any debris into the dam
   iii. Any debris into the penstock block the penstock or damage the turbine rotor

4. **Gate**

   Gate is provided for controlling the flow of water from reservoir to hydraulic turbine through penstock

5. **Surge tank**
   i. The function of surge tank is to protect the penstock because of variation of flow or the velosity of water
   ii. It located near the power

6. **Penstock**
   i. It carries the water from reservoir to the turbine house
   ii. It is made of concrete to withstand high pressure having 1m to 2m diameter

8. **Power house**
   i. It consist of hydraulic and electric equipments
   ii. In this KE of water is converted into electrical energy
   iii. Usually Power house is located under ground

9. **Hydraulic turbine**

These are used to convert KE of water into mech energy

**Working**

i. Water from reservoir flows through penstock to Hydraulic turbine
ii. This high velocity jet of water strikes on the Hydraulic turbine
iii. Hence KE of water is converted into mech energy
iv. Hydraulic turbine is connected to the electric generator which converts mech energy into electrical energy

**Advantages**

i. Power generation cost per unit is less
ii. More reliable
iii. starting and stopping of these plant takes short time as compared to steam and nuclear plants
iv. High life

v. Water is easily and readily available
vi. Less running cost
vii. No fuel is to burnt to generate power
viii. There is no problem of disposal of ash emission of polluting gases

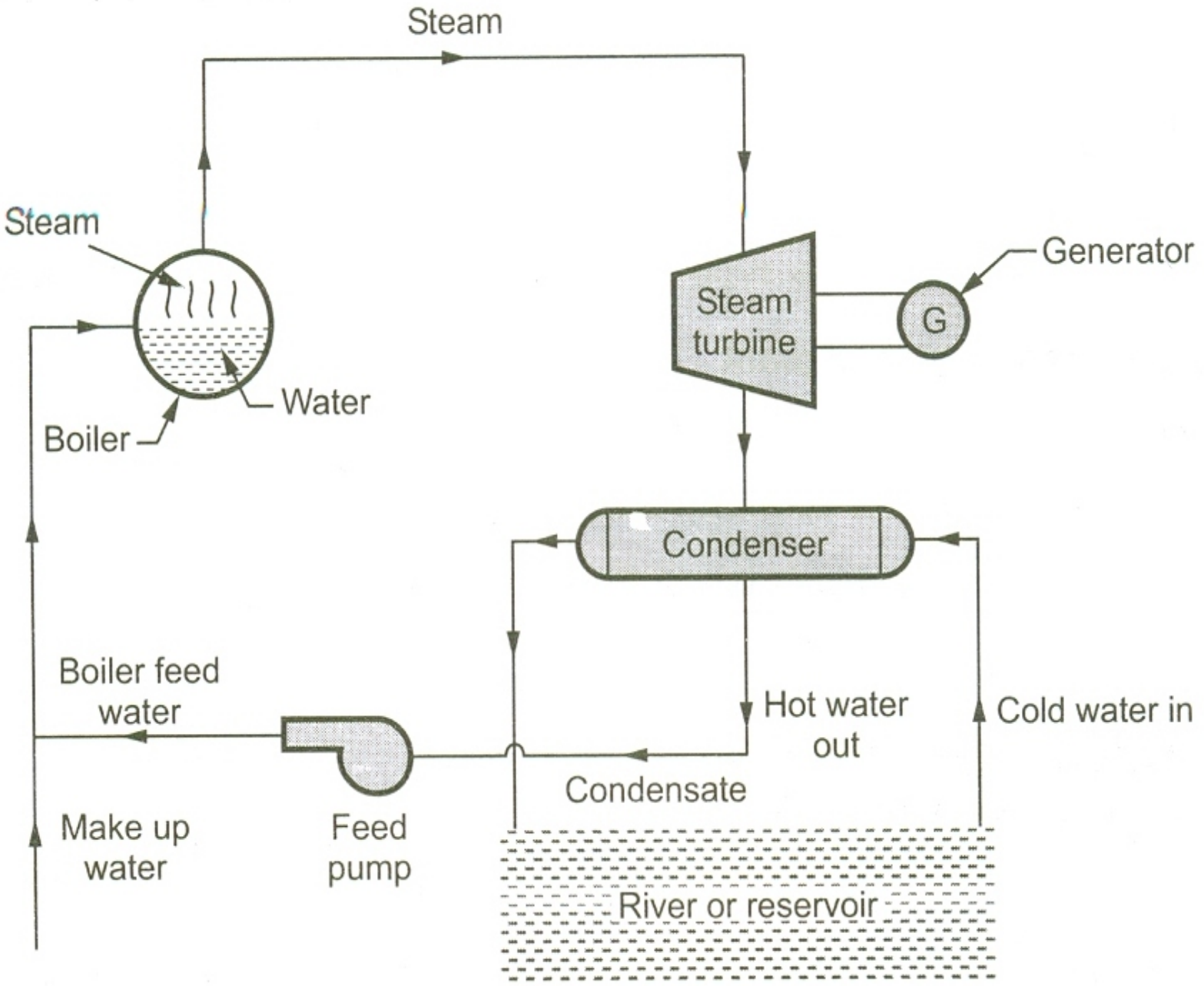
## Disadvantages

i. Initial cost of plant is very high
ii. Tim required for set up of plant is more
iii. power generation is depend on the quantity of water available
iv. These are located far away from load centre which requires long transmission lines.
v. The cost of these transmission lines are high

## Hydroelectric power plant in India

i. Mulshi Dam in Maharashtra
ii. Koyna in Maharashtra
iii. Srisailam Dam in Andhra Pradesh
iv. Sardar Sarovar in Gujarat

# Thermal or steam power plant



## Principle of operation

i. Thermal or steam power plant uses steam to produce electrical power

ii. in this chemical energy of fuel is used to convert water into steam in the high pressure boilers

## Construction

1. **Boiler**
   i. Boiler is used to convert water into high pressure and high temp steam
   ii. For this conversion the water is supplied to the boiler by feed pump
   iii. For better efficiency of plant boiler consist of superheater, economiser

2. **Steam turbine**
    i. High pressure and temp steam from the boiler is passed into the steam turbine
    ii. Because of High pressure and temp steam shaft of the turbine rotates
    iii. After this the steam is exhausted to the condenser

3. **generator**
    i. The shaft of steam turbine is coupled to the shaft of the generator
    ii. The mech energy of the steam turbine is converted into electrical energy

4. **Condenser**
    i. Steam exhausted from the steam turbine is collected in the condenser
    ii. In condenser steam is condensed using cooling water
    iii. The condensed amt of water is known as condensate

5. **Feed pump**
    i. Feed pump is used to supply the condensate from the condenser to the boiler
    ii. This condensate is already slightly hot hence there is less amt of heat required to convert condensate into steam

**Working**

i. In the boiler, high amount of heat is generated because of burning of coal
ii. The water from the reservoir enters into the boiler
iii. Because of high heat inside the boiler, water is converted into steam
iv. This high pressure and high temp steam enters into the steam turbine and used to rotate turbine
v. The shaft of the turbine is coupled with the shaft of the generator
vi. Hence The mech energy of the steam turbine is converted into electrical energy

## Advantages

i. Fuel used in the boiler is coal which is cheaper
ii. Less initial cost
iii. It requires less space
iv. These plants can be located near the load centre which reduces the cost of transmission

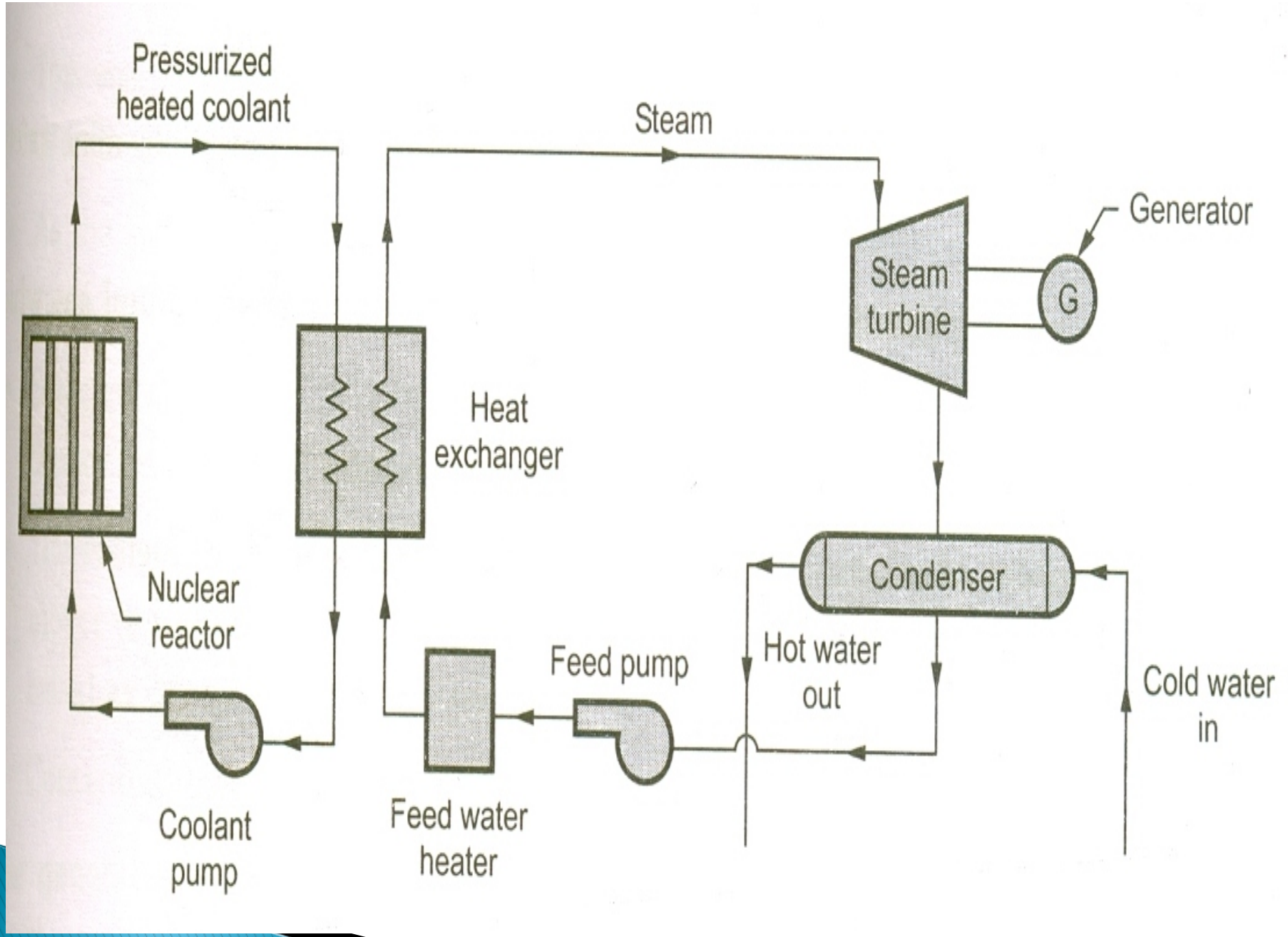
## Disadvantages

i. High maintenance cost
ii. Tim required for set up of plant is more
iii. Handling of coal and ash is major problem
iv. Large amt of water is required
v. burning of coal pollutes the atm
vi. Low efficiency

## Thermal Power plants in India

i. Panipat Thermal Power Station in Haryana
ii. Guru Gobind Singh Super Thermal Power Plant in Punjab
iii. Ekalahare Thermal Power Station in Nashik, Maharastra

# Nuclear power plant



## Principle of operation

i. Uranium 235 is used as a fuel in Nuclear power plant
ii. The heat generated in the reactor core because of fission reaction of uranium is used to produce steam
iii. This steam is used to rotate the steam turbine

## Construction

1. **Nuclear Reactor**

i. A nuclear reactor is an apparatus in which heat is produced because of nuclear fission chain reaction
ii. Nuclear Reactor consists of following parts

A. Moderator
   i. In the chain reaction neutrons produce are fast moving
   ii. These fast moving electrons affects the fission of U235
   iii. Hence moderator is used to reduce the speed of the electrons
   iv. Heavy water, graphite are used as moderator

B. Control Rod

i. The energy produced in the reactor because of fission of U235 during chain reaction is very high
ii. If this high energy is not controlled then entire structure can be melt
iii. Hence control rods are used to controlled the chain reaction and reduce the energy inside the reactor
iv. Cadmium, boron are commonly used as control rods

C. Concrete Shielding

i. During fission reaction, alpha particles, beta particles, gamma rays ans neutrons are produced
ii. When these particles are come in contact with atm air =, it produces harmful effects
iii. Hence to protect from such harmfull effects, concrete shielding is provided around the reactor

2. **Coolant**

i. Coolants flows around the reactor core

ii. It is used to absorb large amount of heat produced in the reactor

3. **Heat Exchanger**

i. Heat exchanger is used to exchange the heat

ii. In HX heat absorb by coolant from the reactor is transferred to the water

iii. Because of high temp of coolant, water is converted into steam

4. **Steam turbine**

   i. High pressure and temp steam from the HX is passed into the steam turbine

   ii. Because of High pressure and temp steam shaft of the turbine rotates

   iii. After this the steam is exhausted to the condenser

5. **generator**
   i. The shaft of steam turbine is coupled to the shaft of the generator
   ii. The mech energy of the steam turbine is converted into electrical energy

6. **Condenser**
   i. Steam exhausted from the steam turbine is collected in the condenser
   ii. In condenser steam is condensed using cooling water
   iii. The condensed amt of water is known as condensate

**Working**

i. because of fission reaction of U235, High amount of heat generated in the reactor
ii. The coolent from the coolant pump enters into the reactor
iii. Because of this the temp of coolant icreases and it becomes hot
iv. The hot coolant then enters into the HX
v. At the same tim the feed water is also enters into the HX
vi. IN THE HX, the hot coolant transfers its heat to the feed water
 As a result of this water is converted into steam

viii. This steam enters into the steam turbine and used to rotate turbine
ix. The shaft of the turbine is coupled with the shaft of the generator

## Advantages

i. Less space requirement
ii. High amount of heat generated
iii. Fuel require is less as compare to coal in steam plant
iv. Water required is very less
v. Fuel transport cost is very less
vi. Reliable in opern

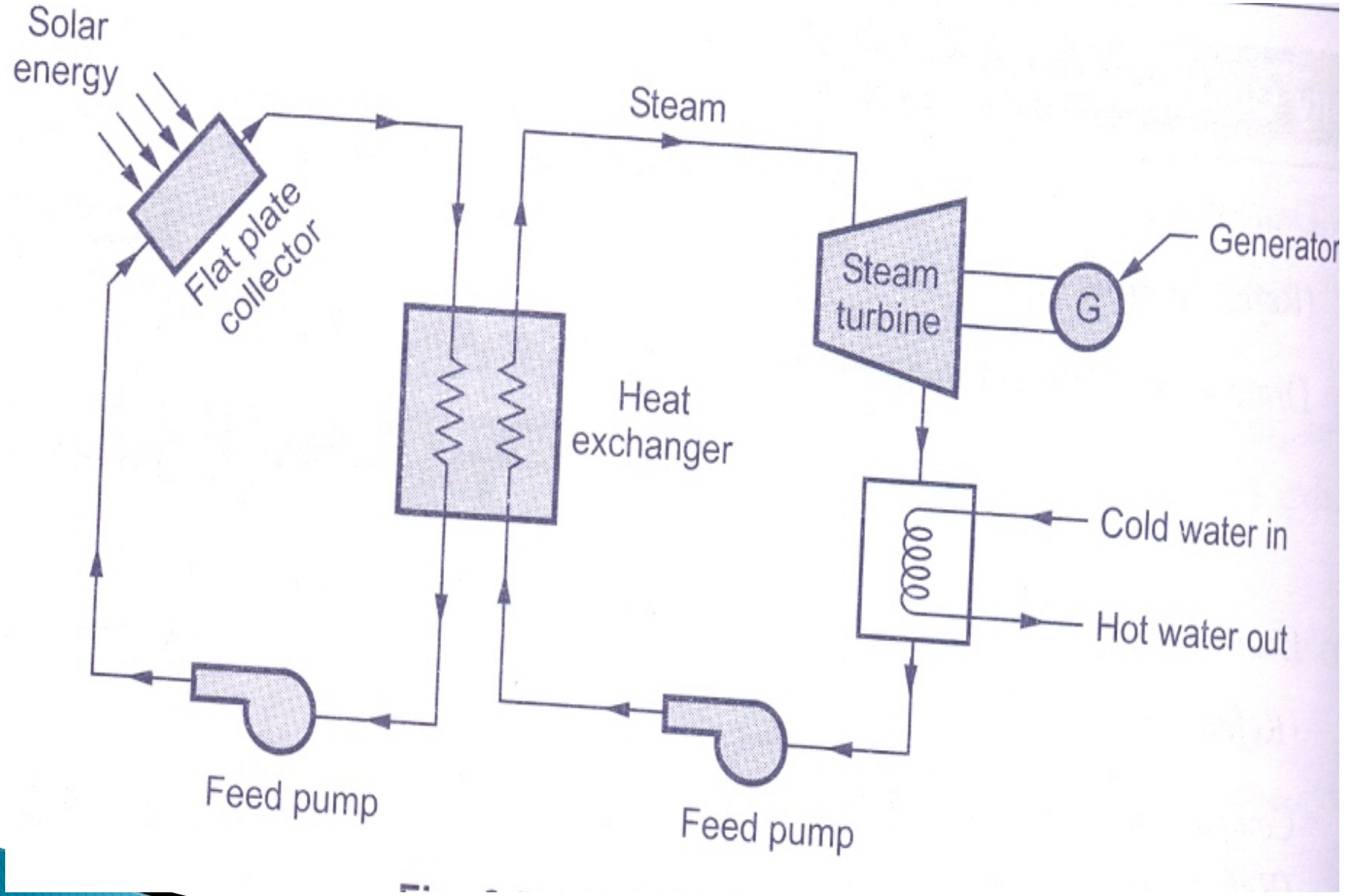
## Disadvantages

i. High initial cost
ii. High maintainance cost
iii. Skilled operator is required
iv. High risk is there

## Nuclear power plant in India

i. Rana Pratp Sagar in Rajasthan
ii. Kalpakam in Uttar Pradesh
iii. Narora in Uttar Pradesh
iv. Kaiga in Karnataka

# Solar power plant



## Introduction

i. Solar energy has greatest potential of all the sources of renewable energy
ii. The solar energy is largely available in our country
iii. The main difficulty in using this energy is its collection and storage

## Construction

1. **Flat Plate Collectors**

i. Flat plate collectors are used for collecting the solar energy
ii. These are made in rectangular panels
iii. These are simple to construct
iv. It consist of transparent cover and absorbing surface

2. **Insulation**

i. The insulation is used to prevent the loss of heat
ii. The commonly used insulating material is fiber glass

3. **Heat Exchanger**

i. Heat exchanger is used to exchange the heat

ii. In HX heat absorb by coolant from the Flat Plate Collectors

iii. is transferred to the water

iv. Because of high temp of coolant, water is converted into steam

4. **Steam turbine**

   i. High pressure and temp steam from the HX is passed into the steam turbine

   ii. Because of High pressure and temp steam shaft of the turbine rotates

   iii. After this the steam is exhausted to the condenser

5. **generator**

   i. The shaft of steam turbine is coupled to the shaft of the generator

   ii. The mech energy of the steam turbine is converted into electrical energy

6. **Condenser**
   i. Steam exhausted from the steam turbine is collected in the condenser
   ii. In condenser steam is condensed using cooling water
   iii. The condensed amt of water is known as condensate

**Working**

i. The solar rays falls on the absorbing surface of the flat plate collector
ii. The absorbing surface absorbs the solar radiation energy
iii. This energy is converted into heat and water flowing through the tube gets heated
iv. The coolant from the coolant pump enters into the reactor
v. Because of this the temp of coolant increases and it becomes hot
vi. The hot coolant then enters into the HX
vii. At the same time the feed water is also enters into the HX
viii. IN THE HX, the hot coolant transfers its heat to the feed water
ix. As a result of this water is converted into steam
x. This steam enters into the steam turbine and used to rotate turbine
xi. The shaft of the turbine is coupled with the shaft of the generator

## Advantages

i. Solar energy is renewable energy source
ii. Available free of cost
iii. Clean and pollution free
iv. The source doesn’t deplete with use
v. solar energy avoid fuel provision
vi. solar energy avoid transportation cost

## Disadvantaged

i. Varies with climatic conditions
ii. Because of irregularity , it requires storage device
iii. High cost of conversion of energy
iv. It is not available at night

## Applications

i. Solar water heating
ii. Solar pumping
iii. Solar cells
iv. Solar furnace
v. Solar cells
vi. Solar cooking

# Photovoltaics (PV)

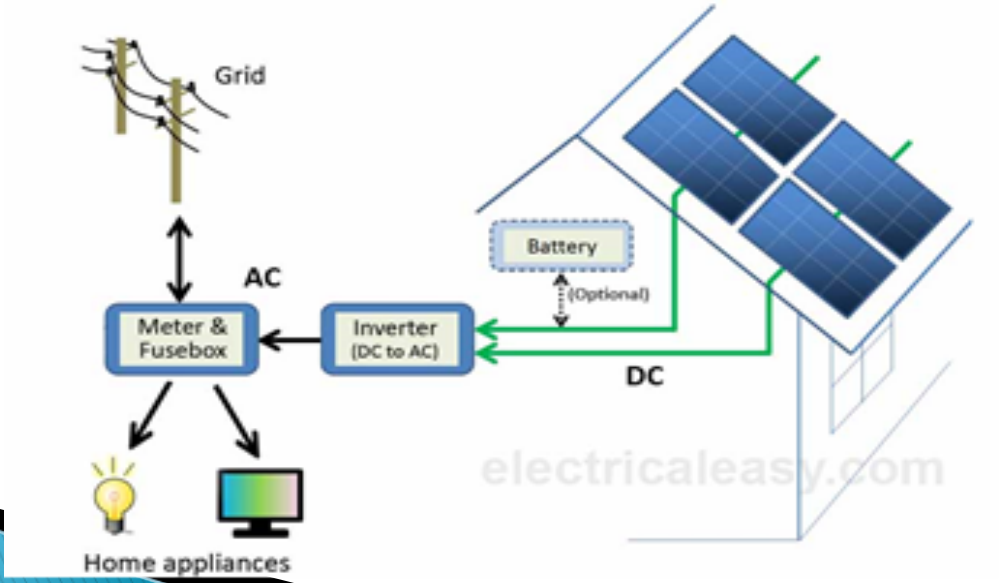
## Introduction

i. Photovoltaics directly convert solar energy into electricity.

ii. They work on the principle of the photovoltaic effect.

iii. When certain materials are exposed to light, they absorb photons and release free electrons.

iv. This phenomenon is called as the photoelectric effect. Photovoltaic effect is a method of producing direct current electricity based on the principle of the photoelectric effect.



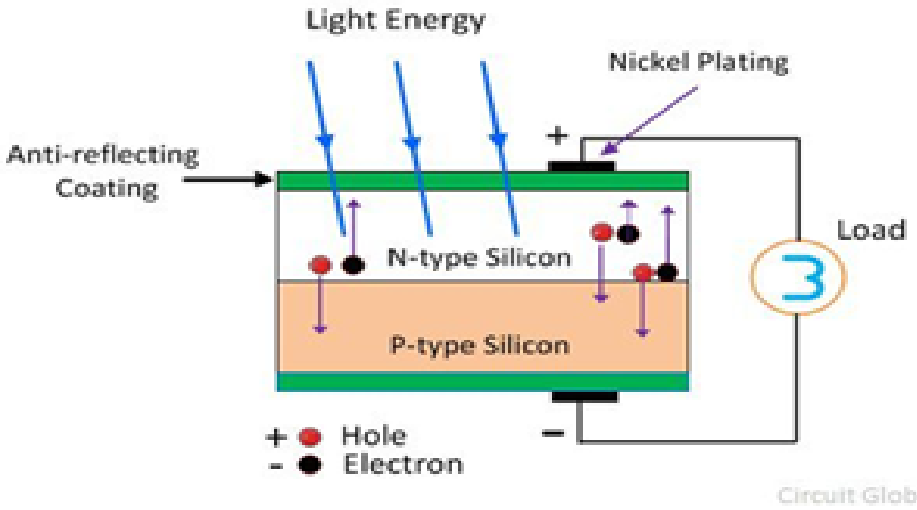
## Construction

i. The semiconductor materials like arsenide, indium, cadmium, silicon, selenium and gallium are used for making the PV cells. mostly silicon and selenium are used for making the cell.

ii. Consider the figure below shows the constructions of the silicon photovoltaic cell.

iii. The upper surface of the cell is made of the thin layer of the p-type material so that the light can easily enter into the material.

iv. The metal rings are placed around p-type and n-type material which acts as their positive and negative output terminals respectively.



## Working

i. The light incident on the semiconductor material may be pass or reflected through it.

ii. The PV cell is made of the semiconductor material which is neither a complete conductor nor an insulator.

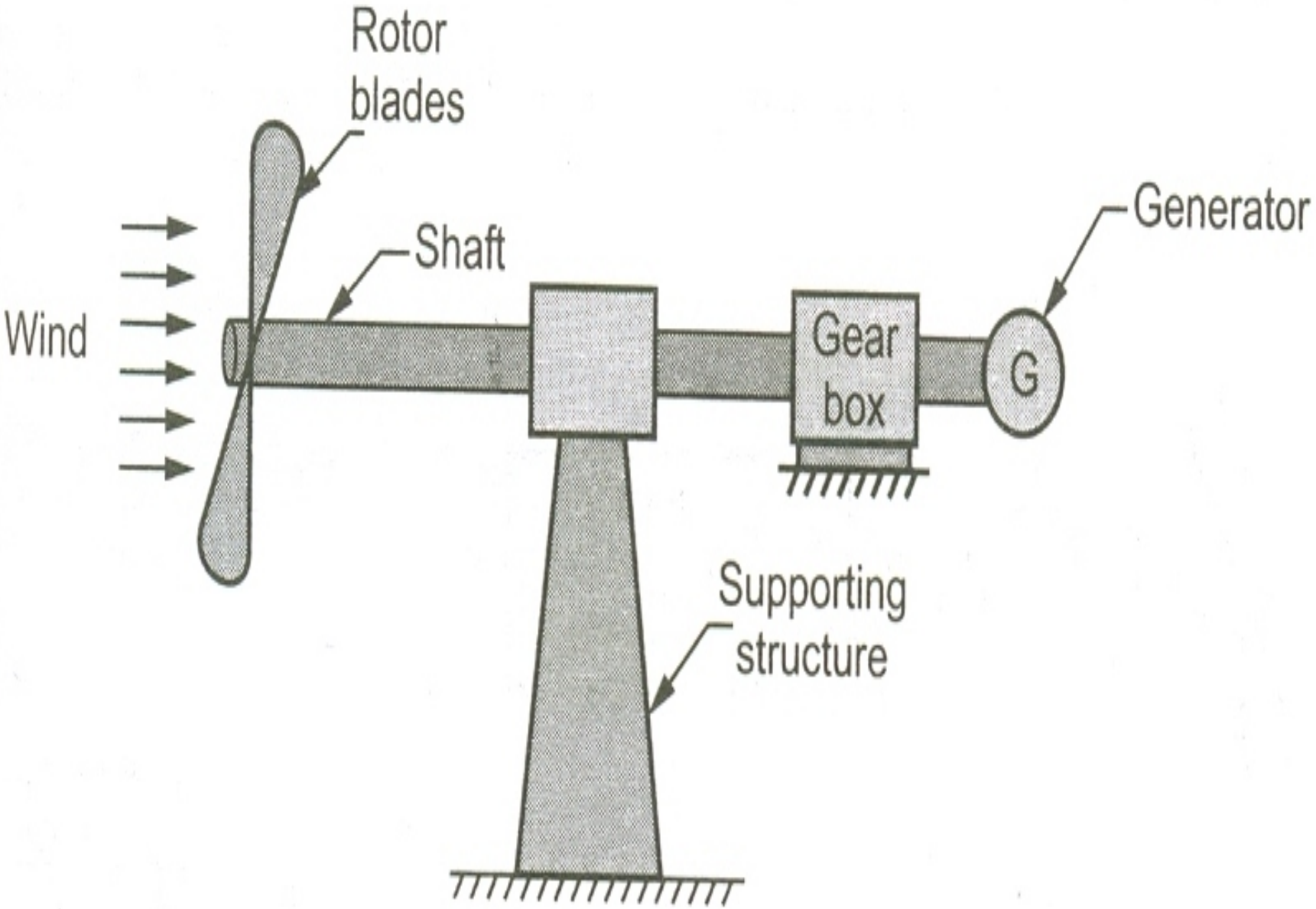
iii. This property of semiconductor material makes it more efficient for converting the light energy into electric energy.

iv. When the semiconductor material absorbs light, the electrons of the material starts emitting. This happens because the light consists small energise particles called photons.

v. When the electrons absorb the photons, they become energised and starts moving into the material. because of the effect of an electric field, the particles move only in the one direction and develops current.

vi. The semiconductor materials have the metallic electrodes through which the current goes out of it.

# Wind Energy


Rotor
blades
Shaft
Generator
Wind
Gear
box
G
Supporting
structure

## Introduction

i. Wind energy can be used for generation of electrical energy
ii. It is a renewable energy source
iii. The wind power can generated where wind velocities are more than 8 kmph

## Construction

It consists of

1. **Blades**

**Types of Windmill**

Horizontal axis

Vertical axis

2. **NacelleIt**
   i. It is a fibre glass tube that contains the gearbox, brakes and a generator.
   ii. Also it has got direction and speed sensors mounted as back as possible on nacelle to prevent them from the dirt coming from blades.

3. **Gearbox**
   i. Shaft connected to hub directly goes into gearbox and it increase its rpm to required level .
   ii. it is the most heavy part in the nacelle.

4. **Brakes**
   i. Brakes are used when wind is blowing above critical level to same turbine from damage .
   ii. Brakes is mounted just behind the gearbox.

5. **Generator**
   i. It converts the energy of fast rotating shaft into electrical energy,
   ii. the high voltage transformer converts it to high voltage to be ready to go in transmission lines.

6. **Yaw Platform**
   i. It is a steel platform at the top of the tower and helps the nacelle to yaw in the direction of the wind.
   ii. It has also got brakes in some high end wind turbines to maintain the direction of the nacelle.

## Advantages

i. Wind energy is renewable energy source
ii. Available free of cost
iii. Clean and pollution free
iv. The source doesn’t deplete with use
v. Wind energy avoid fuel provision
vi. Wind energy avoid transportation cost

## Disadvantages

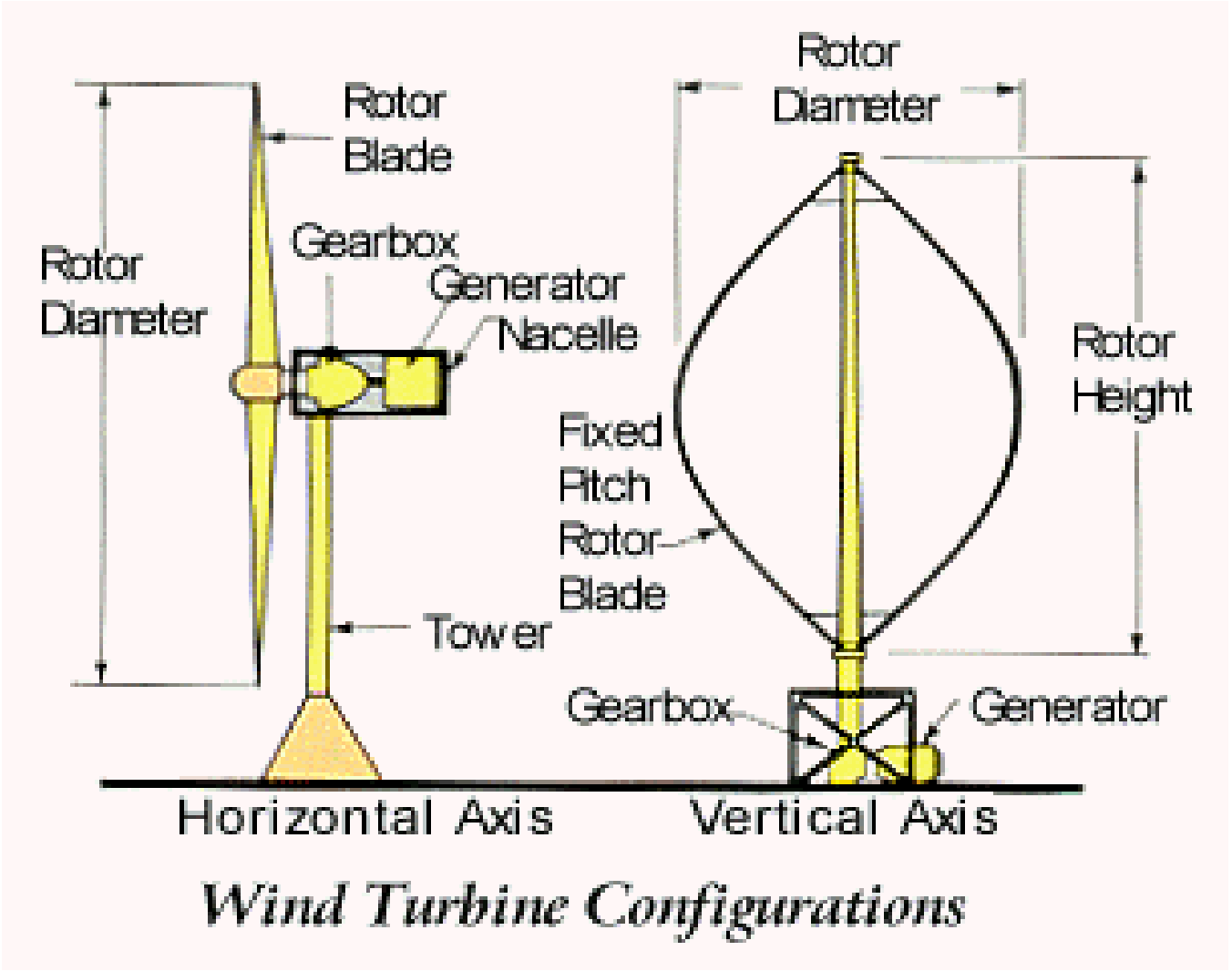
i. wind energy is fluctuating in nature
ii. Because of irregularity , it requires storage device
iii. This system has high weight
iv. Wind energy system is noisy

# Windmill

i. Windmills are those machines that uses wind energy to produce electricity.
ii. Windmills convert the kinetic energy of wind to electricity
iii. The main parts of windmills are its blades, also called vanes.
iv. These blades are connected to a shaft, which is straddled on a tower.
v. Blades rotate due to wind and thereby turning the shaft.

## Types of Windmill

- Horizontal axis
- Vertical axis




*Wind Turbine Configurations*

## 1. Horizontal axis

i. Horizontal axis wind turbines are the most common type used

ii. All of the components (blades, shaft, generator) are on top of a tall tower, and the blades face into the wind.

iii. The shaft is horizontal to the ground. The wind hits the blades of the turbine that are connected to a shaft causing rotation.

iv. The shaft has a gear on the end which turns a generator.

v. The generator produces electricity and sends the electricity into the power grid.

vi. The wind turbine also has some key elements that adds to efficiency. Inside the Nacelle (or head) is an anemometer, wind vane, and controller that read the speed and direction of the wind.

vii. As the wind changes direction, a motor (yaw motor) turns the nacelle so the blades are always facing the wind.

viii. The power source also comes with a safety feature. In case of extreme winds the turbine has a break that can slow the shaft speed. This is to inhibit any damage to the turbine in extreme conditions.

## 2. Vertical axis

i. In vertical axis turbines the shaft the blades are connected to is vertical to the ground.

ii. All of the main components are close to the ground.

iii. Also, the wind turbine itself is near the ground, unlike horizontal where everything is on a tower.

iv. There are two types of vertical axis wind turbines; lift based and drag based

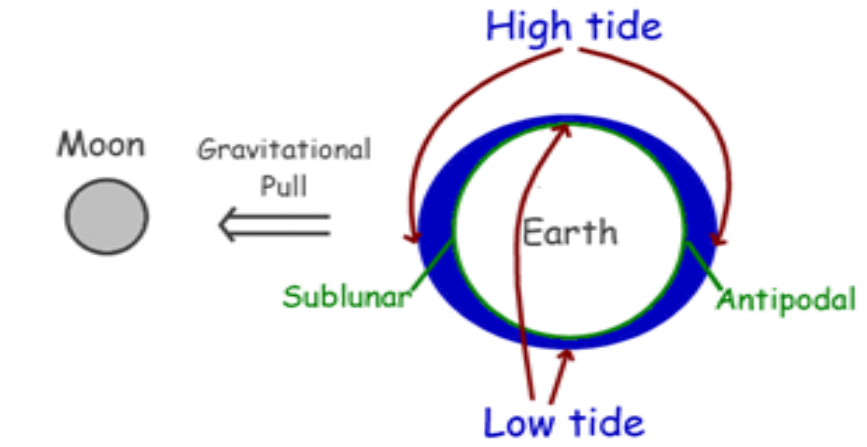
| Sr. | Particulars | Horizontal Axis | Vertical Axis |
|---|---|---|---|
| 1 | Rotor orientation | About Horizontal Axis | About Vertical Axis |
| 2 | structure | Require tall structure | doesn’t Require tall structure |
| | | **Advantages** | **Disadvantages** |
| 3 | Power generation | more | less |
| 4 | Efficiency | more | less |
| 5 | Blades manufacturing | Easy | difficult |
| 6 | suitability | For large power generation | For small power generation |
| | | **Disadvantages** | **Advantages** |
| 7 | Yaw mechanism | Required | not required |
| 8 | Support | Required | not required |
| 9 | Overall cost | large | less |
| 10 | maintenance | Large and difficult | Less and easy |

# Tidal Energy

## Introduction

i. Tidal energy, also known as tidal power is a renewable form of hydropower where the kinetic or potential energy of the tides are used for the generation of electricity.

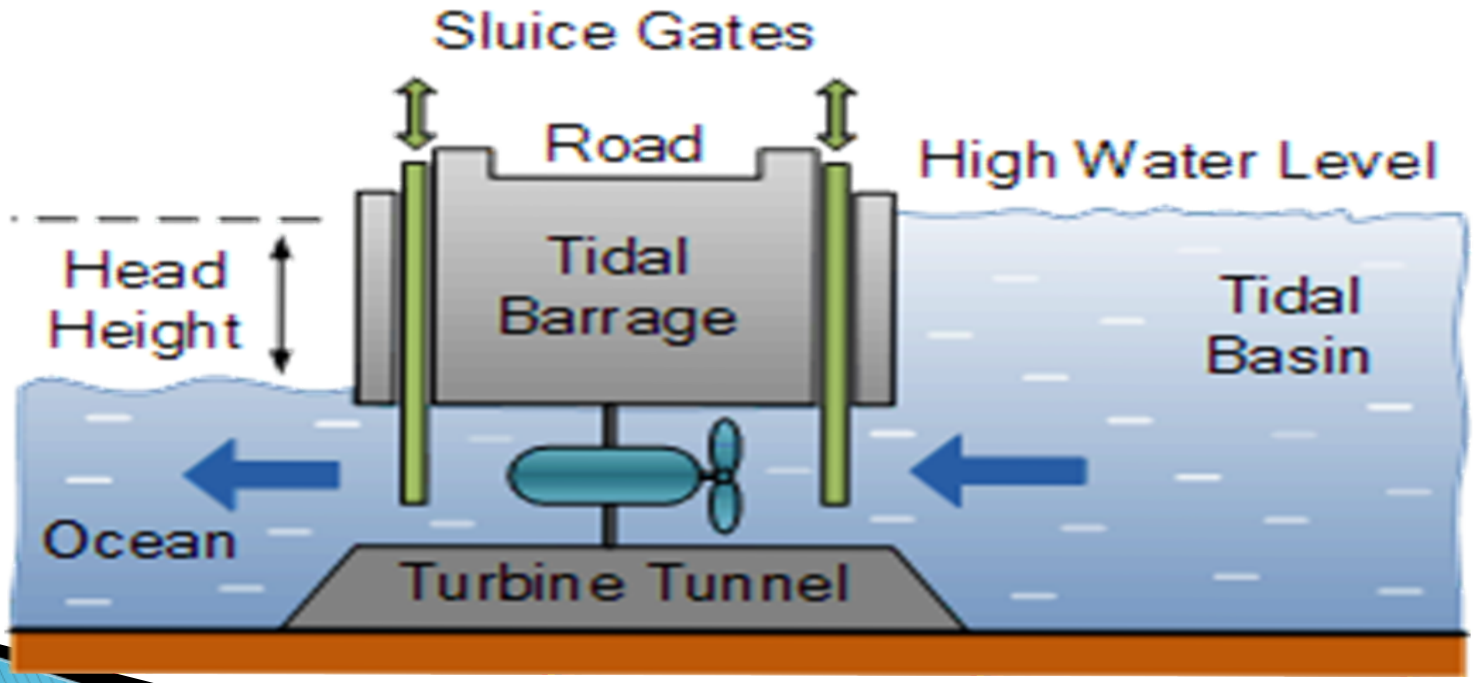
ii. A tide is created by the gravitational effect of the sun and the moon on earth, thereby causing cyclical movement of the seas, leading to the tides



iv. the Sun and the rotation of the Earth both have some tidal impact, the location of the Moon has the biggest affect on the tide.

v. The gravity of the Moon causes a high tide both on the side of the Earth directly below the Moon (sublunar tide) and the opposite side of the Earth (antipodal).

vi. Low tides are on the sides of the Earth 90 degrees away from the Moon.



## Construction

This consists of following parts.

1. **Tidal barrage**
   i. A tidal barrage is used to hold the water back during high tide.
   ii. The function of barrage is to form barrier between sea and the basin.

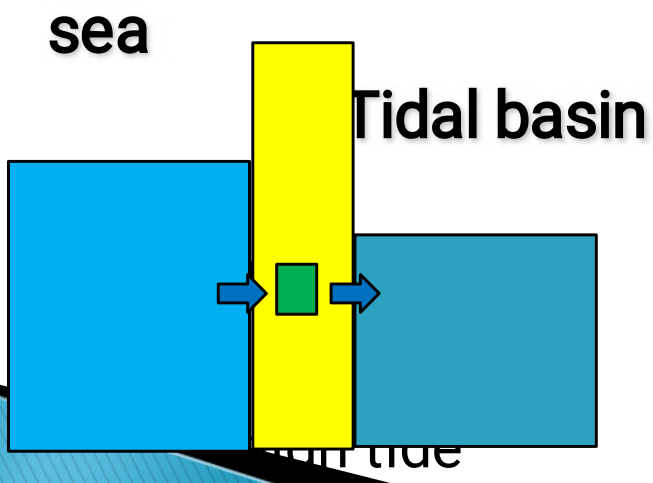
2. **Sluice gate**
   i. The sluice gate opens during high tide and closed during low tide.
   ii. This creates the water level difference.

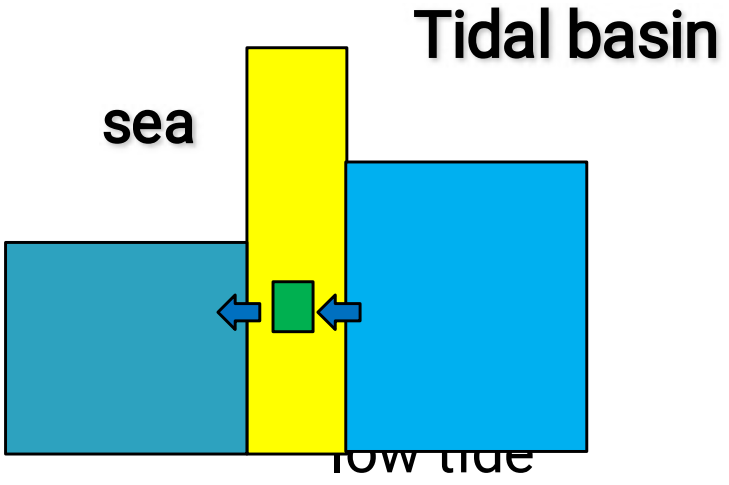
3. **Turbine**
   i. High pressure water strikes on the turbine.
   ii. Because of this shaft of the turbine rotates

4. **generator**
   i. The shaft of turbine is coupled to the shaft of the generator
   ii. The mech energy of the steam turbine is converted into electrical energy

## Working

i. During the high tide period, the level of the tide is more than the level of the water in the tidal basin.
ii. As a result of this water flows from sea to a tidal basin.
iii. This operates the turbine and ultimately generator.
iv. Hence electricity is produced.
v. During the low tide period, the level of tide is lower than the level of water in the tidal basin.
vi. As a result of this water flows from tidal basin to sea.
vii. This operates the turbine and ultimately generator.
viii. Hence electricity is produced.



# Advantages

i. Tidal energy is a renewable energy resource
ii. process is free and clean as no fuel is needed and no waste bi-products are produced.
iii. Tidal energy has the potential to produce a great deal of free and green energy.
iv. Tidal energy is not expensive to operate and maintain compared to other forms of renewable energies
v. Low noise pollution as any sound generated is transmitted through the water.
vi. High predictability as high and low tides can be predicted years in advance, unlike wind.

## Disadvantages

i. Tidal energy is not always a constant energy source as it depends on the strength and flow of the tides which themselves are effected by the gravitational effects of the moon and the sun.
ii. Tidal Energy requires a suitable site, where the tides and tidal streams are consistently strong.
iii. high capital, construction and maintenance costs.
iv. High power distribution costs to send the generated power from the submerged devices to the land using long underwater cables.
v. Intermittent power generation, only generates power ten hours a day during the ebb and flow of the tides
vi. Danger to fish and other sea-life as they get stuck in the barrage or sucked through the tidal turbine blades.

# Hydrogen energy

## Hydrogen

i. Hydrogen is a very light gas.
ii. Its density is eight times less than that of natural gas.
iii. There are no significant problems with regard to storage, transportation

**Advantages of Hydrogen**

(i) Easy storage

A large volume of hydrogen can be easily stored in a number of different ways.

(ii) High efficiency

Hydrogen is considered as a highly efficient fuel.

(iii) Pollution free

Hydrogen is a pollution free fuel.

(iv) Various applications

It can used for transportation, heating and power . generations in places where it is difficult to use electricity.

(v) Economical

It is less costly to ship hydrogen by pipeline than sending electricity over long distances by wire in some instances.

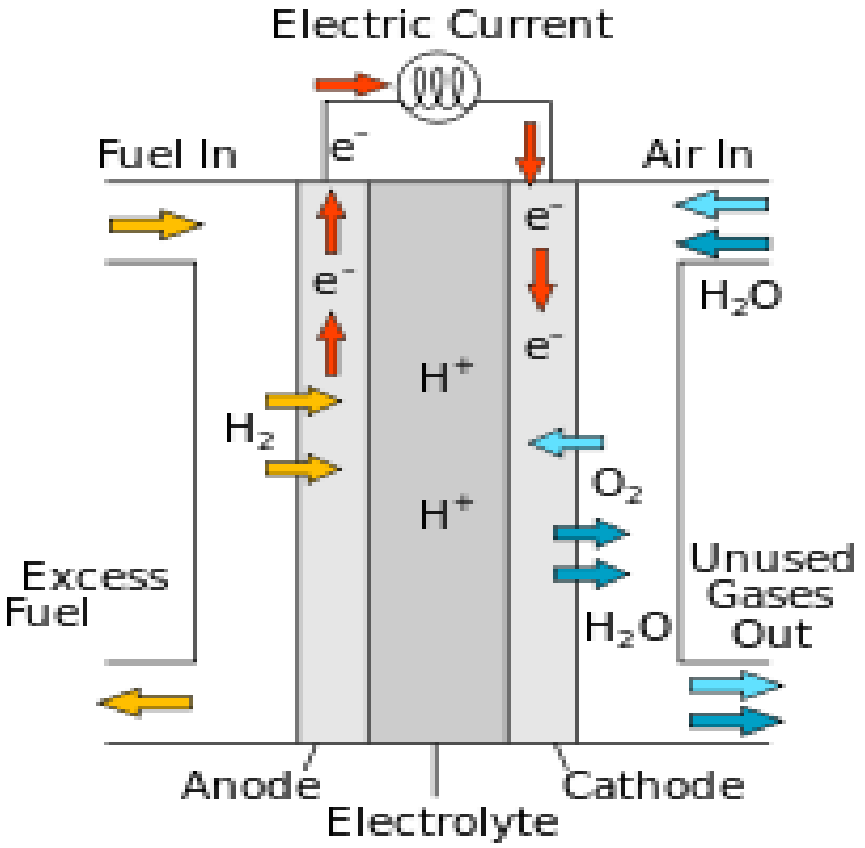
**Disadvantages of Hydrogen**

i. It is expensive. While widely available, hydrogen is expensive.
ii. It is difficult to store.
iii. Hydrogen is very hard to move around.
iv. It is not easy to replace exiting infrastructure.
v. It is dependent on fossil fuels

# Hydrogen Fuel Cell

i. A fuel cell is an electrochemical cell that converts the chemical energy of a fuel and an oxidizing agent into electricity.

ii. Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.



## Construction

1. **Anode**
   i. It is the positive post of the fuel cell.
   ii. Through Aathode Hydrogen enters in a fuel cell.
2. **Cathod**
   i. It is the negative post of the fuel cell.
   ii. Through Cathode oxygen enters in a fuel cell.
3. **Electrolyte**
   i. This is the proton exchange membrane.
   ii. This only conducts positively charged ions.
4. **Catalyst**
   i. This is a special material that facilitates the reaction of oxygen and hydrogen.
   ii. It is usually made of platinum nanoparticles very thinly coated onto carbon paper or cloth.

iii. The catalyst is rough and porous so that the maximum surface area o the platinum can be exposed to the hydrogen or oxygen.

iv. The platinum-coated side of the catalyst faces the PEM.

## Working

i. A fuel cell is composed of an anode, a cathode, and an electrolyte membrane.

ii. A fuel cell works by passing hydrogen through the anode of a fuel cell and oxygen through the cathode.

iii. At the anode site, the hydrogen molecules are split into electrons and protons.

iv. The protons pass through the electrolyte membrane, while the electrons are forced through a circuit, generating an electric current and excess heat.

At the cathode, the protons, electrons, and oxygen combine to produce water molecules.

**Reactions**

Cathode:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

Anode:

$$2H_2 \rightarrow 4H^+ + 4e^-$$

Overall:

$$2H_2 + O_2 \rightarrow 2H_2O$$

## Advantages of Hydrogen Fuel Cells

i. Hydrogen fuel cells are pollution-free
ii. Have greater efficiency than traditional combustion technology.
iii. These fuel cells offer a better overall fuel economy.
iv. It does not release emissions when being used.
v. Hydrogen fuel cells are much safer than other types of fuel.
vi. It is able to perform consistently at any size.

## Disadvantages of Hydrogen Fuel Cells

i. Hydrogen fuel cell vehicles are currently very expensive than conventional vehicles or any hybrids
ii. It is not an affordable technology for the average person.
iii. Hydrogen fuel cells are available in limited quantities.
iv. It requires a huge capital investment

v. The costs of transporting hydrogen are extremely high.
vi. It requires a specific temperature zone for consistent operation.

## Applications

i. power devices like hearing aids, video recorders, cellular phones and laptop computers.
ii. source of power to cities, towns and buildings.
iii. used for back-up
iv. remote power applications including remote weather stations and rural locations

# Geothermal Power Plant

## Introduction

i. The magma heats the water present inside the earth and increases its temperature greater than 182 degree Celsius.

ii. This hot water from the earth is piping to the surface of the earth through hot water wells.

iii. The steam from the hot water is separated and made it to strike on the turbine blade and it starts rotating.

iv. A Generator is coupled to the turbine also starts rotating and produces electricity.

The Geothermal power plant which is in working is of three types

- Dry steam power plant
- Flash steam power plant
- Binary cycle power plant

# Binary cycle power plant

## Introduction

i. In binary cycle power plant, the heat of hot water is transferred to another liquid (called as secondary liquid).

ii. The heat of hot water causes another liquid to change into steam and then this steam is used to rotate turbine.

iii. It is the most recent developed power plant which may be operated at lowest temperature of atleast 58 degree Celsius.

iv. The secondary fluid (i.e. another liquid) used in this binary cycle geothermal power plant has much lower boiling point than water.

v. The thermal efficiency of this power station is expected to be lie in between 10-13%.

vi. This power plant is called as binary, since here we are using two liquids (hot water and secondary liquid) for its working.

## Construction

1. **Hydrothermal resources**
   i. It is a source which has both heat and water.
   ii. In the earth crust we have both water and heat (magma).
2. **Dry or hot water wells**
   i. These are the wells through which the dry steam and hot water from the earth is taken out.
   ii. If dry steam is taken out than it is called as dry steam well and if hot water is taken out through it than it is called as hot water well
3. **Turbine & Generator**

**Turbine** is rotating device which converts the kinetic energy of the fast moving steam into rotational energy (i.e. Mechanical energy).

**Generator** is coupled to the turbine shaft and converts mechanical energy of the turbine into electrical energy.

4. **Heat Exchanger**

i. Heat exchanger is used to exchange the heat

ii. In the HX there is a exchange of heat between hot water and isobutene takes place and isobutene steam is produced.

5. **Secondary or binary liquid**

i. The secondary fluid (i.e. another liquid) used in power plant has much lower boiling point than water

ii. Isobutane is use as secondary fluid in this power plant

6. **Injection Well**

It is the well which is drilled in the earth to inject the condensed water again into the earth crust

## Working

i. The hot magma present inside the earth heats the water present in the earth.

ii. The temperature of the water increases upto 58 to 80 degree Celsius

iii. The hot high pressure water, due to its own pressure moves upward in the hot water well.

iv. As the water reaches to the surface of the earth, its temperature increases but its not converted into steam.

v. So that high temp water is enters inside the HX.

vi. Similarly at the same time another liquid isobutene which has very low boiling point is also enters in the HX

vii. So in the HX there is a exchange of heat between hot water and isobutene takes place and isobutene steam is produced.

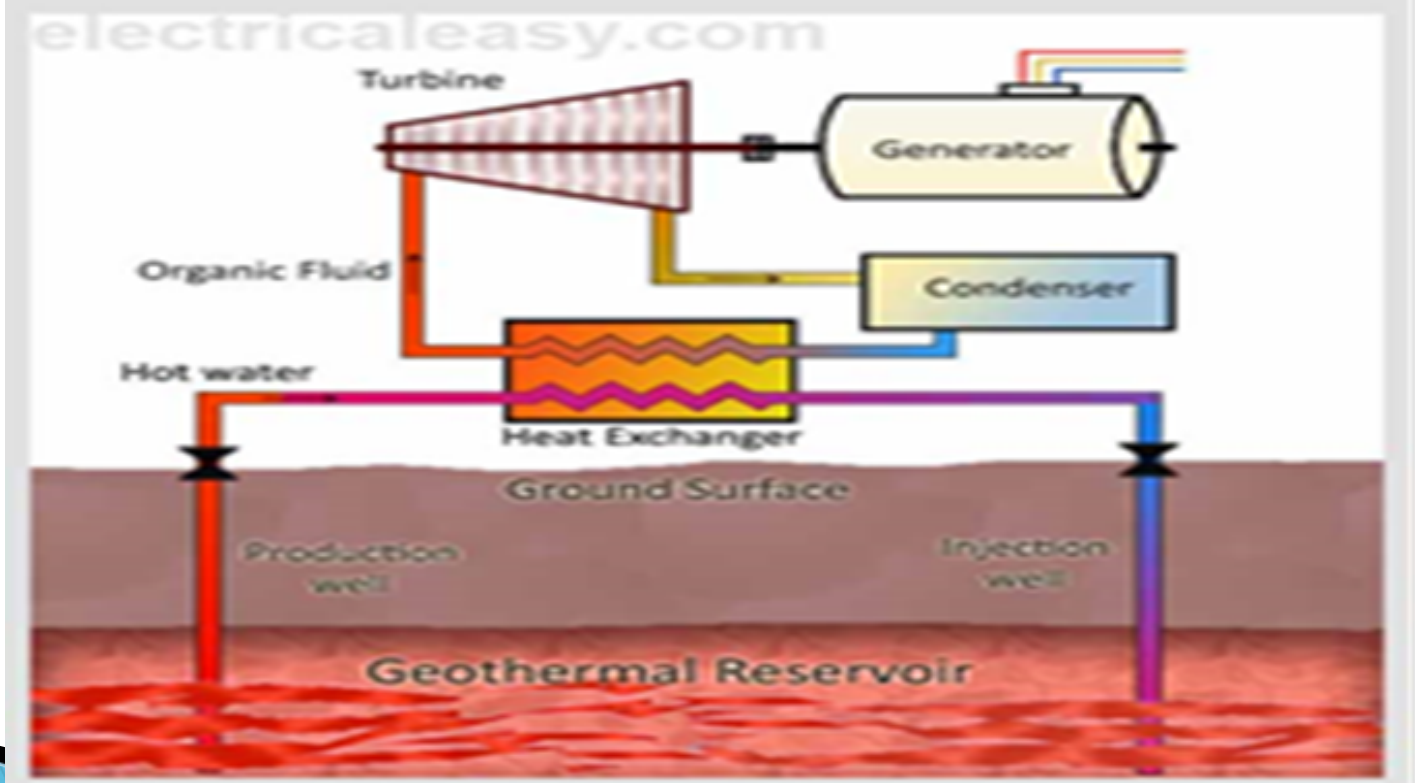
viii. The steam produced in HX is allowed to strike on the blades of the turbine.

ix. As this high pressures steam strikes the blades of the turbine, it starts rotating. The generator coupled with the turbine also rotates and electricity is produced.

ix. The exhaust steam from the turbine which has low pressure sent to the low pressure turbine where it is further used to produce electricity.

x. The exhaust steam is than enters into the condenser where it gets converted into liquid isobutene.

xi. Finally the liquid isobutene from the condenser is collected in the HX.



Binary Cycle Plant

## Advantages

i. It requires no fuel for its working.
ii. It requires minimal land and fresh water.
iii. Renewable energy source
iv. Harmful gases are nt emitted
v. Capital cost is 40-60% less than thermal and Nuclear plants
vi. Short construction period

## Disadvantages

i. The fluid taken out from deep earth contains mixtures of gases such as Hydrogen sulphide, Carbon dioxide, Ammonia, and Radon. If these gases are released, it will contribute to global warming, acid rain, Radiation and noxious smell.

ii. The hot water taken out from the geothermal sources is hold in a solution which may contain traces of toxic chemicals like mercury, boron, antimon and salt. when water cools these toxic chemicals comes out of the soln and responsible for the environment pollution if released.

iii. Geothermal power plant constructed at the site may adversely affect land stability.

iv. Low efficiency (10-12%)

v. Availability at certain regions only (Where magma is nearer to the surface

vi. It requires emission control system to reduce the exhaust acids and volatile chemicals.

# Biomass Energy

## Introduction

Biomass is fuel that is developed from organic materials, a renewable and sustainable source of Energy used to create electricity or other forms of power.

## Sources of Biomass Energy

1. Leaves of the plants
   i. In the densely planted places lots of leaves fall from the trees.
   ii. These can be dried, powdered and converted into small pieces, whic can used as the biomass fuel to generate heat used usually for cooking food.

2. Agricultural waste
   i. Lots of waste materials obtained from the farms are a great source of biomass materials.
   ii. Livestock waste can also be used to generate methane gas.

3. Wood and waste wood

i. Wood is the most commonly used type of biomass. earliest the fuel being used for cooking and heating is the wood.
ii. Even at present wood as the biomass material is major source of energy in a number of developing countries.
iii. Wood as a biomass can be used in various forms like large wooden blocks obtained from the trees, wooden chips, and saw dust.
iv. The wasted wood and wooden scrap are also the source of biomass

4. Waste paper

i. Tons of waste paper is produced dailly. These can be burnt to produce lots of heat.
ii. The paper is manufactured from the plants, so it is considered as biomass material.

5. garbage

i. The garbage, also called as municipal solid waste is another source of biomass.

ii. The garbage can be in the form of food scrap, lawn clippings, waste paper, fallen leaves etc all mixed together or collected individually.

6. Human waste

i. The human wastes are also considered to the source of biomass.

ii. These can used to generate methane gas which is the major component of natural gas.

# The methods of generating energy

The methods of generating energy can be split in two different groups. There are the dry processes and the wet processes.

The dry processes are: Combustion and Pyrolysis

The wet processes are: Anaerobic Digestion, Gasification and Fermentation

1. **Combustion**
   i. The most obvious way of extracting energy from biomass, the technology of direct combustion is well understood, straightforward and commercially available.
   ii. Combustion systems come in a wide range of shapes and sizes burning virtually any kind of fuel, from chicken manure and straw bales to tree trunks, municipal refuse and scrap tyres.
   iii. Some of the ways in which heat from burning wastes is currently used include space and water heating, industrial processing and electricity generation
   iv. One problem with this method is its very low efficiency.

v. With an open fire most of the heat is wasted and is not used to cook or whatever.

vi. One method of improving this in developing countries is to build stoves out of mud and scrap iron.

2. **Pyrolysis**

i. A wide range of energy-rich fuels can be produced by roasting dry woody matter like straw and woodchips. The process has been used for centuries to produce charcoal.

ii. The material is pulverised or shredded then fed into a reactor vessel and heated in the absence of air.

iii. Pyrolysis can also be carried out in the presence of a small quantity of oxygen ('gasification'), water ('steam gasification') or hydrogen ('hydrogenation').

iv. One of the most useful products is methane, which is a suitable fuel for electricity generation using high-efficiency gas turbines.

3. **Anaerobic Digestion**
   i. 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.
   ii. Feedstocks like wood shavings, straw and refuse may be used, but digestion takes much longer. Each kilogram of organic material (dry weight) can be expected to yield 450-500 litres of biogas.
   iii. The residue left after digestion is a potentially valuable fertilizer or compost.

4. **Gasification**
   i. This process, usually using wood produces a flammable gas mixture of hydrogen, carbon monoxide, methane and other non flammable by products.
   ii. This is done by partially burning and partially heating the biomass (using the heat from the limited burning) in the presence of charcoal (a natural by-product of burning biomass).

i. The gas can be used instead of petrol and reduces the power output of the car by 40%.
ii. It is also possible that in the future this fuel could be a major source of energy for power stations.

5. **Fermentation**
   i. If the biomass used is (or can be converted into) mostly sugar, then yeast can be added.
   ii. The fermentation that follows produces alcohol which is a very high energy fuel that makes it very practical for use in cars.

## Appl

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

ii. In residential applications, biomass can be used for space heating or for cooking.

iii. Wood is the most common source of fuel, although many different materials are used.

iv. New designs for woodstoves can improve the efficiency of the cooking heating system, decreasing the amount of fuel that is needed.

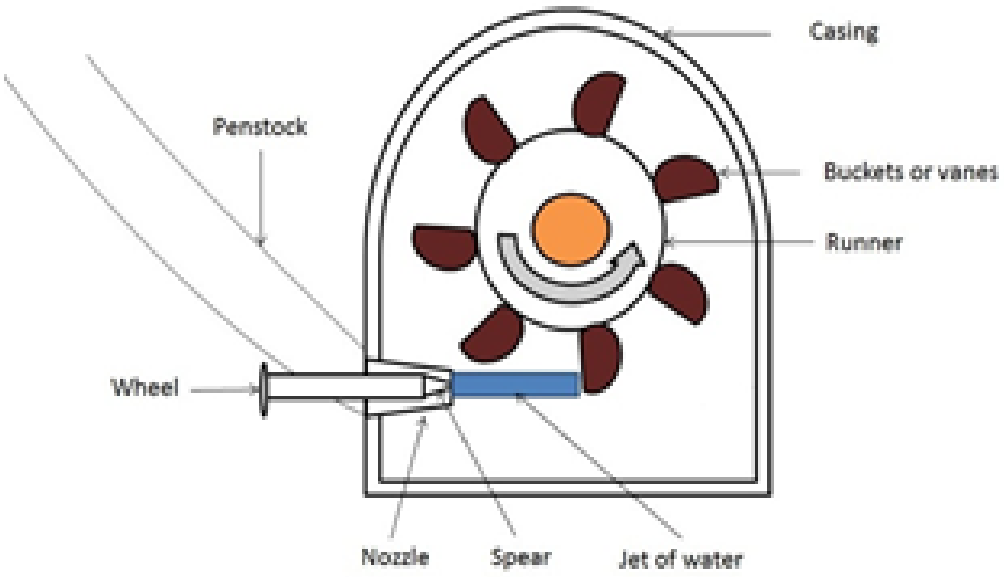
# Pelton Turbine

## Introduction

i. It is a type of tangential flow impulse turbine used to generate electricity in the hydroelectric power plant.

ii. The energy available at the inlet of the Pelton turbine is only kinetic energ

iii. The pressure at the inlet and outlet of the turbine is atmospheric pressur



## Construction

1. **Nozzle and Flow Regulating Arrangement (Spear)**

i. Nozzle is used to increase the kinetic energy of the water that is going to strike the buckets or vanes attached to the runner.

ii. The quantity of water that strikes the buckets is controlled by spear The spear is installed inside the nozzle and regulates the flow of water that is going to strike on the vanes of the runner

iii. It is operated by a hand wheel or automatically in an axial direction.

iv. When the spear is move backward the rate of flow of water increases an when it is pushed forward the rate of flow of water decreases.

2. **Runner and Buckets**

i. Runner is a rotating part of the turbine.

ii. It is a circular disc on the periphery of which a number of buckets evenly spaced are fixed.

iii. The buckets are designed in such a way that the jet of water strike the buckets, deflected through 160 degree to 180 degree.

iv. The buckets are made up of cast iron, cast steel bronze or stainless stee

3. **Casing**

i. The outer covering of the this turbine is called casing.

ii. It prevents the splashing of the water

iii. helps to discharge the water to the trail race.

iv. Cast iron or fabricated steel plates are used to make the casing of the Pelton Turbine.

4. **breaking jet**

i. When the jet of water is completely closed by pushing the spear in forwar direction than the amount of water striking the runner becomes zero.

ii. but still the runner keeps moving due to the inertia of the runner.

iii. In order to stop the runner in the shortest possible time a small nozzle is provided which directs the jet of water at the back of the vanes.

iv. This jet of water used to stop the runner of the turbine is called breaking jet.

## Working

i. The water stored  is made to flow through the penstock and reaches the nozzle of the Pelton turbine.

ii. The nozzle increases the K.E. of the water and directs the water in the form of jet.

iii. The jet of water from the nozzle strikes the buckets (vanes) of the runne

iv. This made the runner to rotate at very high speed.

v. The quantity of water striking the vanes or buckets is controlled through spear present inside the nozzle.

vi. 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.

Advantages

- Less Space requirement
- blade manufacturing is simple
- Steam velocity is higher
- Less Pressure drop

- Disadvantages
- Less Efficiency
- Suitaible for Small power requirement

# Pumps

i. Pump increases the energy of flowing fluid

ii. The main difference between turbine and pump is that, in case of turbine flow of fluid takes place from high pressure to low pressure

iii. In case of pump the floe of fluid takes place from low pressure to high pressure

## Types of pump

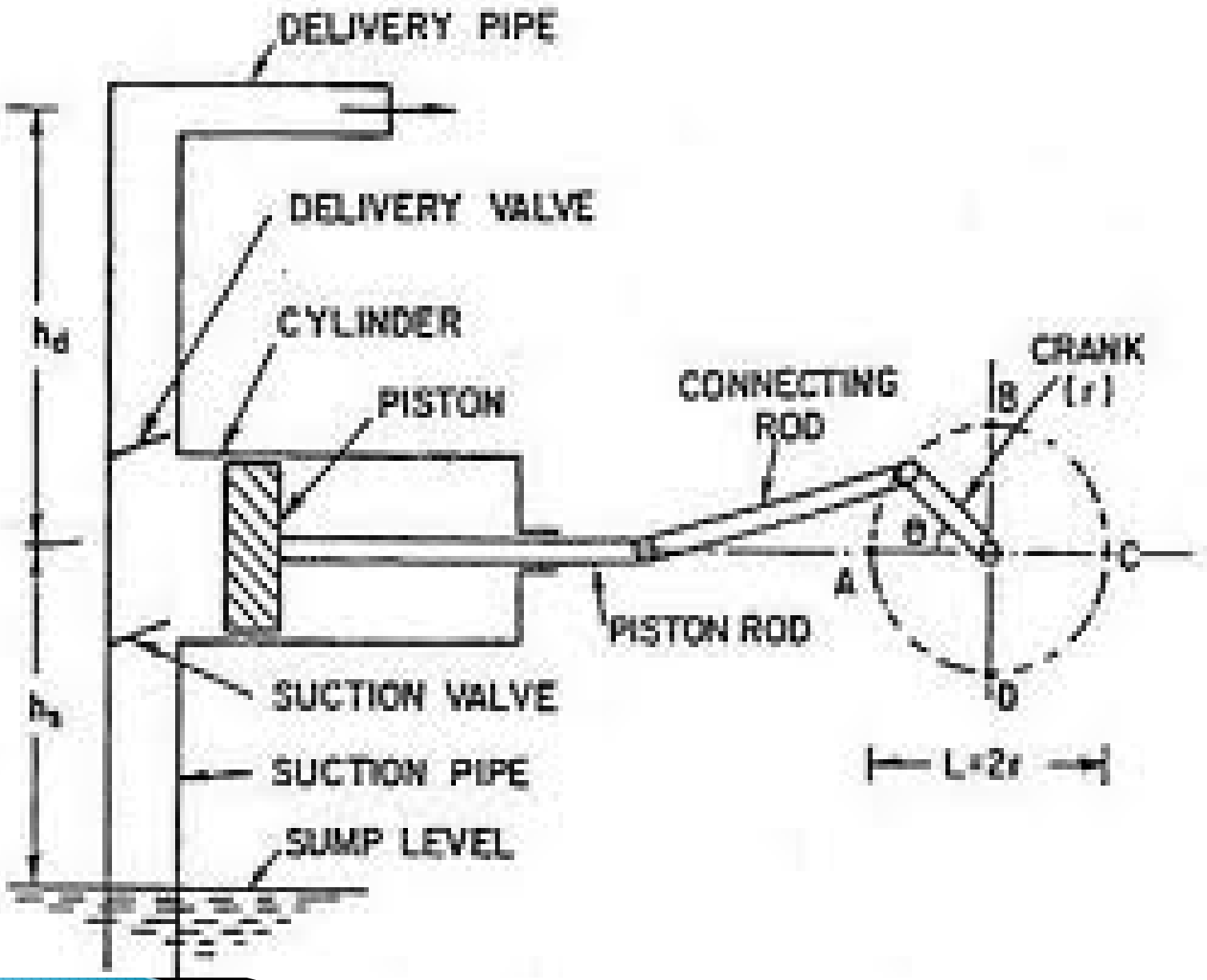
1. **Positive diplacement pump**

   Example : reciprocating pump

2. **Rotodynamic pump**

   Example : centrifugal pump

# Reciprocating Pump



## Introduction

i. Reciprocating pump is positive displacement type pump

ii. In this liquid is displaced using piston cylinder arrangement which is driven using crank and connecting rod

## Construction

1. **Suction pipe**
   i. Suction pipe is connected to the sump and through this pipe liquid is sucked into the pump
   ii. Delivery pipe is connected to the discharge end of the suction pipe

2. **Piston and cylinder**
   i. The piston reciprocates inside the cylinder

3. **Crank and connecting rod**

   i. The crank is mounted on the crankshaft

   ii. It is driven either by IC engine or electric motor

4. **Sump**

   It is the reservoir through which the liquid is pumped into the system

**Working**

1. **Suction stroke**

i. The crank is connected to the piston by connecting rod hence the rotary motion of crank is connected into reciprocating motion of the piston

ii. Initially the crank is at IDC

iii. When the crank rotates in CW direction, piston moves towards right side

iv. Hence at the left side of the piston, vacuum or space is created

v. This vacuum opens the suction valve and the water from sump will forced to the left side of the piston

vi. At the end of the suction stroke the cylinder is full of water

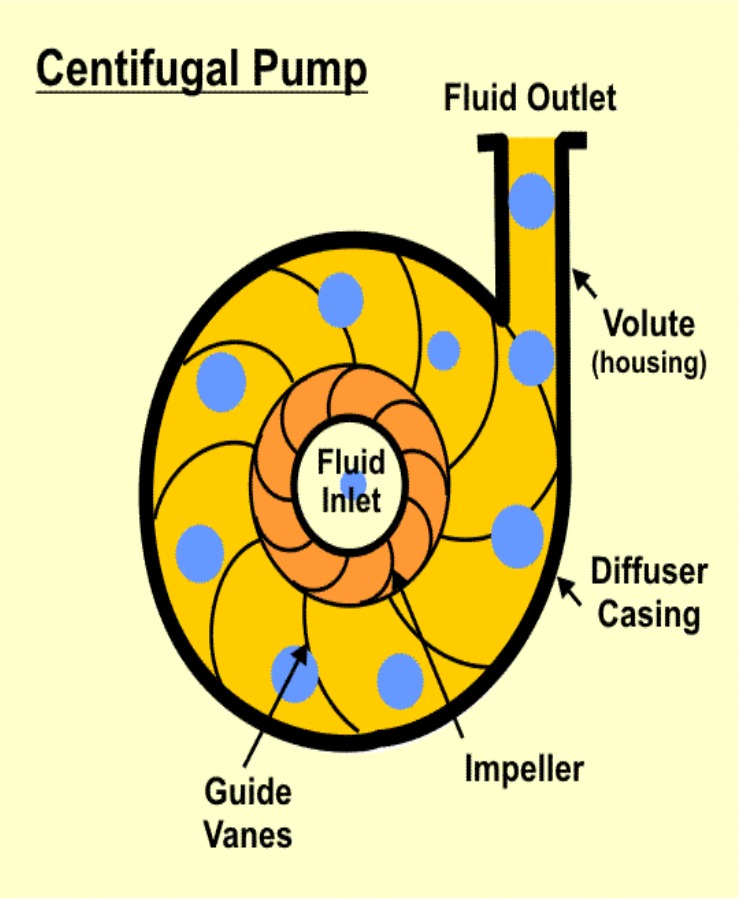
2. **Delivery stroke**

i. When the crank rotates from ODC to IDC the volume inside the cylinder will reduced and water will be compressed

ii. because of this high pressure will de developed inside the cylinder

iii. because of high pressure, delivery valve opens and water is delivered through the delivery pipe

# Centrifugal Pump




## Introduction

Centrifugal pump is the hydraulic m/c in which mechanical energy is converted into pressure

## Construction

1. **Impeller**

i. It is the rotating part of centrifugal

ii. It consist of curved vanes

2. **Casing**

i. It is an air tight passage surrounding the impeller

ii. The casing is of spiral type in which the area of flow increases gradually

iii. This increases the area and increase the pressure of the water flowing through the casing

3. **Suction pipe**

i. Its one end is connected to the inlet of the pump and other end dips into the water sump

ii. At the lower end of the suction pipe, strainer is fitted to remove dust and dirt

4. **Delivery pipe**

i. Its one end is connected to the outlet of the pump and other end delivers the water at desired height

ii. To control the flow of water delivery valve is connected to this pipe

**Working**

i. The water from the sump is forced on the shaft

ii. Water falls on the impeller which consist of curved vanes

iii. Because of rotating curved vanes water is discharged with high pressure

iv. guide vanes are used to guide water to delivery pipe

# Comparison between Centrifugal pump and Reciprocating pump

| Sr no | particulars | Centrifugal pump | Reciprocating pump |
|---|---|---|---|
| advantages disadvantages | | | |
| 1 | Initial cost | Low | High |
| 2 | Maintenance cost | Low | High |
| 3 | Space requirement | Less | More |
| 4 | Flow rate | Continuous and smooth | Fluctuating |
| 5 | Quantity of liquid supplied | Large | Small |
| 6 | Speed | Run at high speed | Run at low speed |
| 7 | Torque | Uniform | Non uniform |
| 8 | noise | Produce less noise | Produce more noise |

| Sr no | particulars | Centrifugal pump | Reciprocating pump |
|---|---|---|---|
| | | **disadvantages** | **advantages** |
| 1 | pressure | not suitable for high pressure | suitable for high pressure |
| | | | |
| | | | |
| | Applications | domestic water supply<br><br>power plant fire protection sprinkler<br><br>Air conditioners<br><br>Chemical industries<br>Irrigation | Boilers<br><br>Hand operated pumps<br><br>Agriculture field<br><br>Pressure washing |

# Air compressors

## Introduction

i. A device or machine providing air at high pressure is called air compressor

ii. An air compressor atm air is compressed and delivers high pressure air to storage vessel known as receiver

## Applications of compressed air

i. Machine tools

ii. Cleaning of workshops and automobiles

iii. Super charging of IC engines

iv. Spray painting

v. Refrigeration

vi. Air-conditioning

vii. Diesel engine

viii. Air braking

## Classification

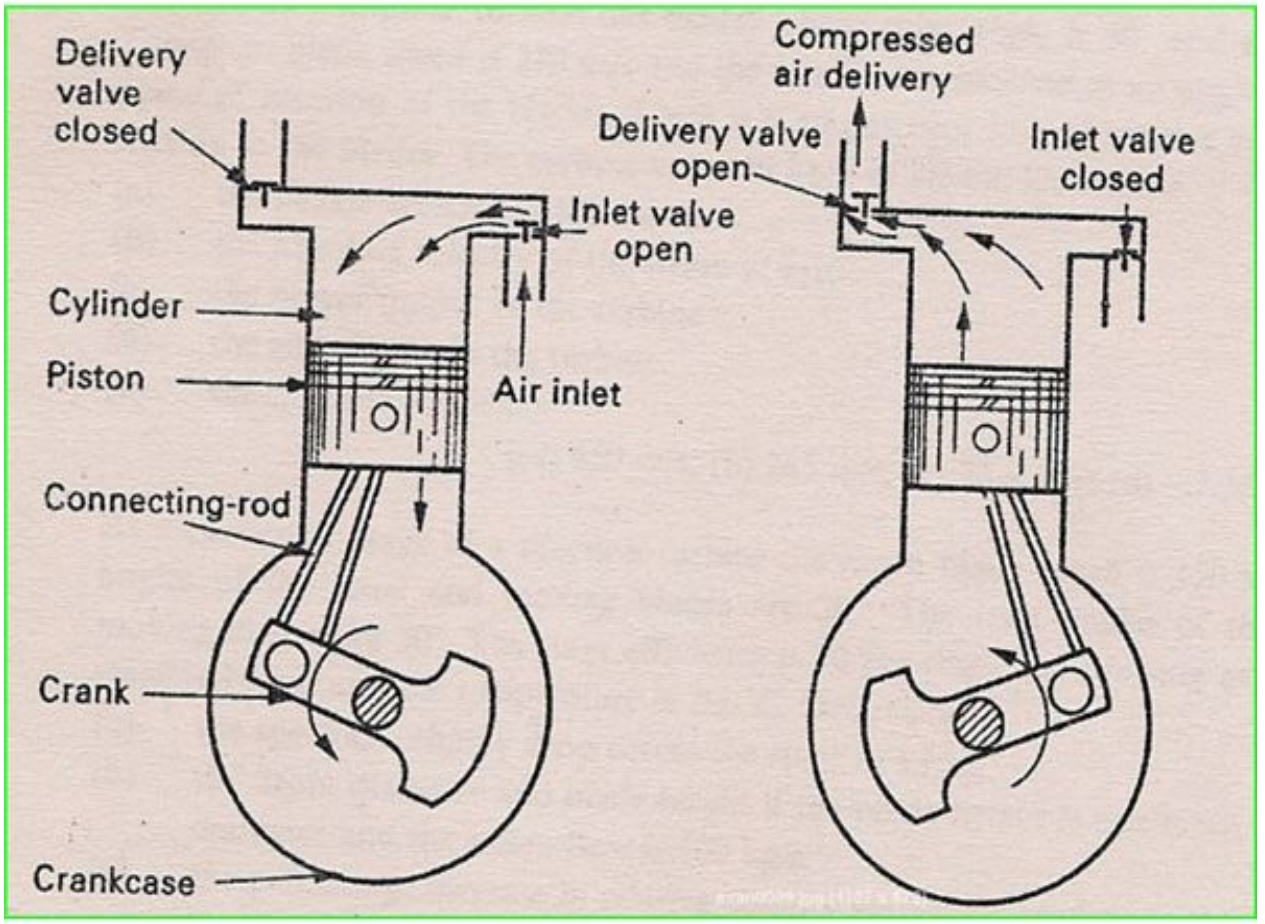
1. **Type of motions**
   i. Reciprocating
   ii. Rotary

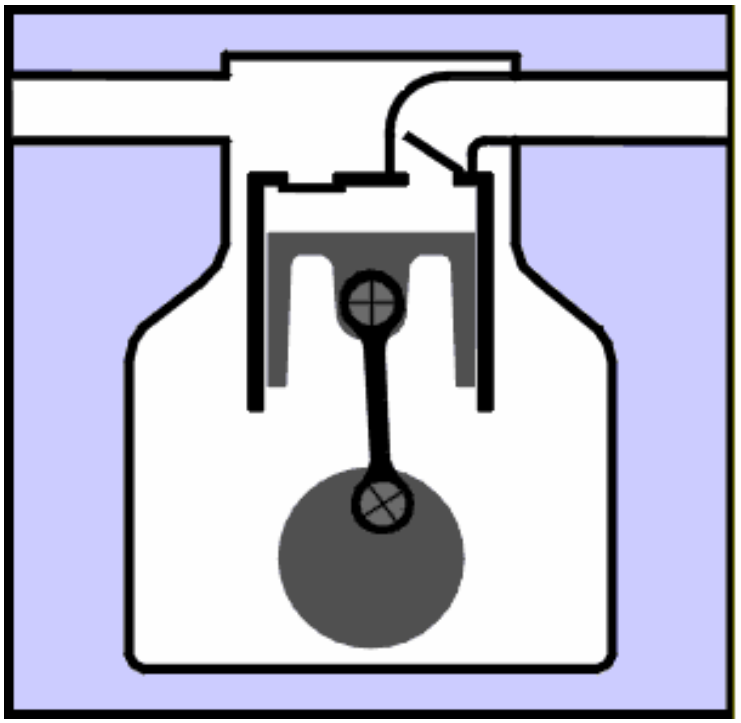
2. **According to number of stages**
   i. Single stage
   ii. Multi-stage

3. **According to working position of piston**
   i. Single acting
   ii. Double acting

4. **According to discharge pressure**
   i. Low
   ii. Medium
   High

# Reciprocating Compressor



## Introduction

This is the single stage single acting reciprocating compressor

## Construction

1. **Crank and connecting rod**
   i. The crank is mounted on the crankshaft
   ii. It is driven either by IC engine or electric motor

2. **Inlet and exhaust valve**

   Inlet and exhaust valves are closed by the pressure difference on both side of valves

## Working

The working of reciprocating compressor is divided into two stroke

1. **Suction stroke**

i. During suction stroke, piston moves downward.

ii. because of this the pressure inside the cylinder falls below atm pressure

iii. Hence the inlet valve is open and air is sucked inside the cylinder

iv. At the end of inlet valve is closed

2. **delivery stroke**

i. In this stroke piston moves from bottom side to top

ii. because of this movement volume inside the cylinder reduces and air is compressed

As the air is compressed its pressure increases When the pressure increases above the receiver pressure delivery valve opens and air is discharged to the receiver