UNIT - 01 (SUB - KOE 074)

RENEWABLE ENERGY RESOURCES

ONE - SHOT @MULTIATOMS

Topics:

- Various non-conventional energy resources
- Classification
- Merits and demerits
- Solar cells
- Theory of solar cells
- Solar cells materials
- Solar cell array
- Solar cell power plant
- limitation

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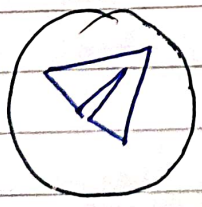
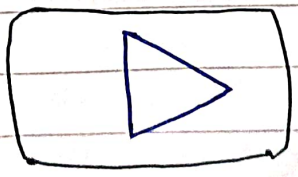




CONVENTIONAL ENERGY RESOURCES

- Conventional energy resources are traditional sources of energy that have been used for many years.
- It is also known as non-renewable energy resources
- It cannot be replaced, if once they are used

NON CONVENTIONAL ENERGY RESOURCES

- It is also known as renewable energy resources
- It can be used to produce energy again and again.
- Non-conventional energy resources are ways to make energy that are different from the usual fossil fuels like coal and oil.

features	Conventional Energy	Non-Conventional Energy
Examples	Fossil fuels, nuclear energy	solar, wind, geothermal, biomass
Reliability	Very reliable and consistent	can be variable (eg depend on weather)
Environmental Impact	Higher pollution and greenhouse gas emission	Lower impact, generally cleaner and more sustainable

Q Discuss the main features of various types of renewable and non-renewable energy resources. Also explain the importance of non-conventional energy sources in the context of global warming.
[AKTU 2021-22]

OR

Q Discuss about various conventional energy resources with renewable energy
[AKTU 2022-23]

OR

Q Discuss the main features of various types of renewable energy and non-renewable energy resources. [AKTU 2023-2024]

Sol Non-Renewable Energy :- Non-renewable energy comes from sources that cannot be easily replenished in a short time.

⊙ The two main types are fossil fuels and nuclear fuels

⇒ Fossil Fuels

⊙ Fossil fuels come from the remains of ancient plant and animals that decomposed over millions of years.

1. Natural Gas:-

- Natural gas is a fossil fuel in gas form, most made of methane.
- It is found with oil and is used for heating, cooking, and making electricity
- It can also be used as vehicle fuel.

2. Coal:-

- Coal is a solid fossil fuel that comes from plants that were burried and heated over millions of years.
- It is mainly used in power plants to produce electricity
- Coal contains a lot of carbon, which make it a major contributor to pollution.

3. Oil:-

- Oil is a liquid fossil fuel that forms tiny sea
- Organism like zooplankton and algae under great pressure.
- It is crucial for transportation (like gasoline for cars), manufacturing, and making petrochemical product like plastics

Environmental Impact of Fossil Fuels:

- Climate Change: All fossil fuels release CO2 when burned, a major contributor to the greenhouse effect and global warming.

- Pollution :- They also emit harmful pollutants that affect air quality and human health.
- Non- renewable :- These are finite resources

Nuclear Fuels :-

- Nuclear fuels are used in nuclear power plants to make energy.
- The most common nuclear fuel is uranium, found in small amounts in the Earth's crust.
- In nuclear power plants, uranium goes through fission (splitting atoms), which release a lot of energy used to generate electricity.
- Nuclear submarine and some spaceships also use nuclear fuel for power.

Environmental Impact :-

① Low air pollution
② Accidents : If a nuclear power plant has an accident (like the ones in Fukushima), it can release harmful radiation into the environment, which can cause serious health and environmental problems.
③ Mining impact

Renewable Energy Resources :- Renewable energy source is energy that is sustainable - something that can't run out or is endless

1. Solar energy :-

- Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation.
- This energy can be used to generate electricity or be stored in batteries or thermal storage.
- There are two main types of solar energy technology - photovoltaics (PV) and concentrating solar-thermal power (CSP)
- The sun sends out the energy in the form of radiation at the rate of 3.7×10^{20} MW.

Merits :- ① Noiseless operation
② cheaper ~~initial~~ cost maintenance
③ produces little pollution

Demerits :- Solar equipments fail to work in nights, cloudy days or rainy seasons.

2. Wind Energy :-

① Wind is used to produce electricity by converting the kinetic energy of air in motion into electricity.

① In modern wind turbines, wind rotates the rotor blades, which convert kinetic energy into rotational energy, this energy is transferred by a shaft which connect to the generator, thereby producing electrical energy.

① Wind power is a clean and renewable energy source.

Merits : ① Produces minimal pollution
① Creates jobs for maintenance and operations

Demerits : ① Some find wind turbines unattractive or noisy.

3. Biomass Energy :-

① It is renewable energy source.

① Biomass energy comes from organic materials like plant, wood and waste.

① It can be generated by burning these materials to produce heat or by allowing them to decompose, which creates gases like methane that can be captured for fuel.

② The materials used for biomass are known as feedstocks.

Merits:- ① can be carbon neutral if managed properly through reforestation.

②

DeMerits:- ① Growing plants make longer than burning them

4. Geothermal Energy:-

① Geothermal energy is heat energy from the earth — geo (earth) + thermal (heat).

② Geothermal energy is produced from the Earth's internal heat, which is continually replenished.

③ Hot molten rocks called 'magma' are present in the core of the earth. This causes sometimes volcanic action.

Merits:- ① cheap and clean source of energy
② Geothermal plants require little land area

Demerits : ① Air pollution results in case of release of gases like H_2S, NH_3, present in the steam waste.

5. Tidal Energy :-

① Tides are caused by the gravitational pull of the Sun and the Moon, resulting in the rise and fall of sea levels.

① This movement can be harnessed through a tidal barrage, which functions like a dam to capture tidal energy.

① During high tide, seawater flows into the barrage reservior, turning turbines to generate electricity.

Merits : ① Low Greenhouse Gas Emissions
① Energy from Both High and Low tides

Demerits : ① High Initial cost.
① limited location

6. Hydrogen Energy :-

① Hydrogen is considered as an alternative future source of energy.
① It is a non conventional energy resources.
① Hydrogen can be separated from water by means of electricity

Merits :- ① Hydrogen energy has very high energy content.
② It's burning is non-polluting

Demerits :- ① It is more expensive
② Highly flammable.

Importance of Renewable Energy Resource w.r.t Global warming.

① Renewable.
② Environmentally friendly.
③ Reduce global warming
④ Conserve natural resources
⑤ Gaining importance

⇒ MNRE :-

① MNRE stands for Ministry of New and Renewable Energy is India's nodal ministry for new and renewable energy matters.

② Aims to develop and deploy new and renewable energy to supplement the country's energy needs.

③ New and renewable energy's role gains significance for India's energy security.

- Energy self-sufficiency became a priority post the oil shocks in the 1970's
- The commission for Additional Source of Energy was established in 1981 to formulate policies, implement programs, and coordinate R and D in new and renewable energy.

MISSION :-

- Jawaharlal Nehru National Solar Mission launched on January 11, 2010 by the Prime Minister.
- Deploy 20,000 MW of grid-connected solar power by 2022.
- Aims to reduce solar power generation costs through :-
  - long term policy
  - large scale deployment goals
  - Aggressive R&D, and
  - Domestic production of critical raw materials
- Mission focuses on creating an enabling policy framework to establish India as a global leader in solar energy

CLASSIFICATION OF ENERGY RESOURCES

① Primary Energy Resources :-

-> These resources are obtained from the environment
Ex :- Fossil fuels, solar energy, hydro energy and tidal energy.

∴ These resources can further be classified as :-

(a) Conventional Energy Sources :-
Example : Thermal powers

(b) Non Conventional Energy Sources :-
Example : Wind energy, geothermal, ocean energy, solar energy and tidal energy.

(c) Renewable : These sources are being continuously produced in nature and are inexhaustible.
Ex :- Wind Energy, Biomass, solar energy etc

(d) Non Renewable :- These are finite and exhaustible
Ex : Coal, petroleum etc.

② Secondary Energy Resources :- These resources do not occur in nature but are derived from primary energy resources.
Ex :- H_2 obtained from hydrolysis of H_2O

⇒ MERITS OF Renewable Energy Resources :-

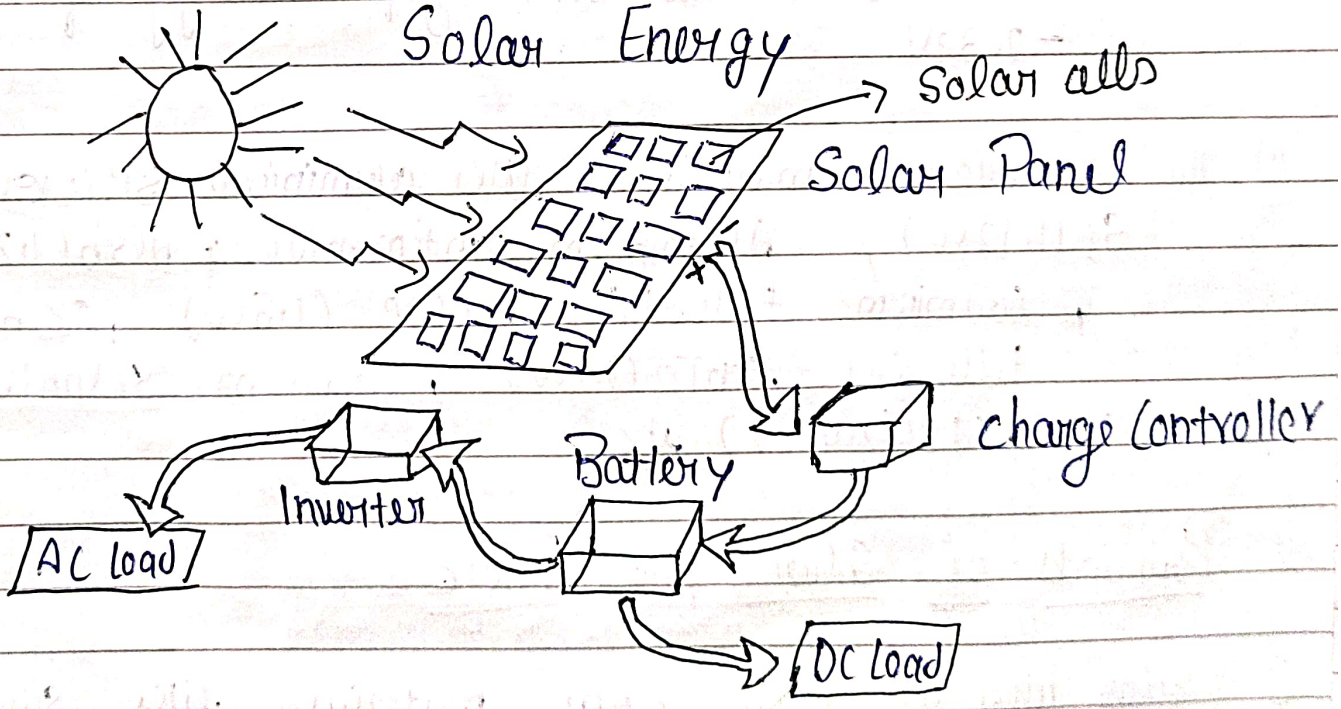
- **Sustainable :-** They can be replenished naturally and won't run out.
- **Environmentally Friendly :-** no greenhouse gas emission, reducing pollution
- Reduced Dependence on Fossil Fuels
- **Job Creation :-** Growing renewable energy sectors create new jobs in various fields.
- Low Operating Costs.
- Technological Advancements

DEMERITS OF Renewable Energy Resources :-

- **Intermittent Supply :-** Energy production can be inconsistent.
- High Initial Costs
- Land and Space Requirements
- **Resource Location :-** Availability of renewable sources can be location dependent.
- **Environmental Impact :-** Some renewable projects can disrupt local ecosystems. (e.g hydropower dams)
- Limited Energy Density

SOLAR CELLS

- Solar cells are the small units that make up solar panels.
- Solar cells is used to convert sunlight into electricity.
- Each solar cell is like a mini power generator
- When sunlight hits the cell, it creates an electric current that can be used to power lights, gadgets, or even a house.



- Solar cells contain a material as silicon that absorbs light energy.
- The energy knocks electrons loose so they can flow freely and produce a difference in electric potential energy, or voltage.

① The flow of electrons or negative charge creates electric current.

② Solar cells have positive and negative contacts, like the terminals in a Battery.

Solar Cell Materials:-

① The solar cell is made of different materials and silicon, silicon is one used for nearly 90% applications.

② The maximum efficiency of solar cell is achieved with the band gap energy of 1.12eV - 2.3eV

③ The various materials like aluminium silicon, Si (1.12eV), Aluminium antimonide, AlSb (1.27eV), cadmium telluride, CdTe (1.5eV), Zinc telluride, ZnTe (2.1eV), Cadmium Sulphide, CdS (2.42eV) etc.

Principle of Solar photovoltaic

① Solar cells are made from materials like silicon (Si) or gallium arsenide (GaAs), known as semiconductors

② In Semiconductor, each atom has four electrons in its outer orbit, which can be freed if they receive extra energy (like sunlight)

① When sunlight hits the solar cell, it gives energy to the electrons, freeing them and allowing them to move.

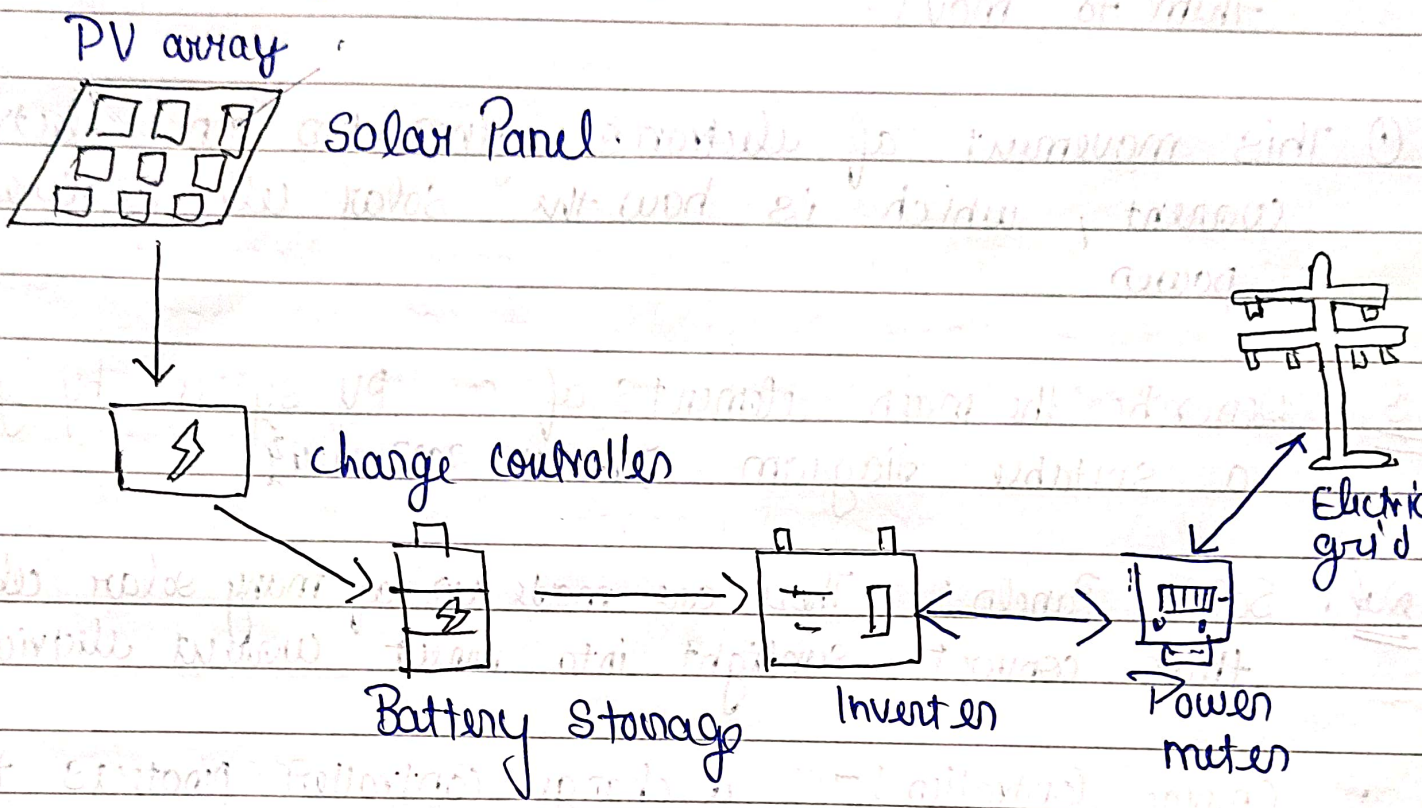
② This movement of electrons generates an electric current, which is how the solar cell produces power

Q Describe the main elements of a PV system by giving a suitable diagram. {AKTU 2023-2024}

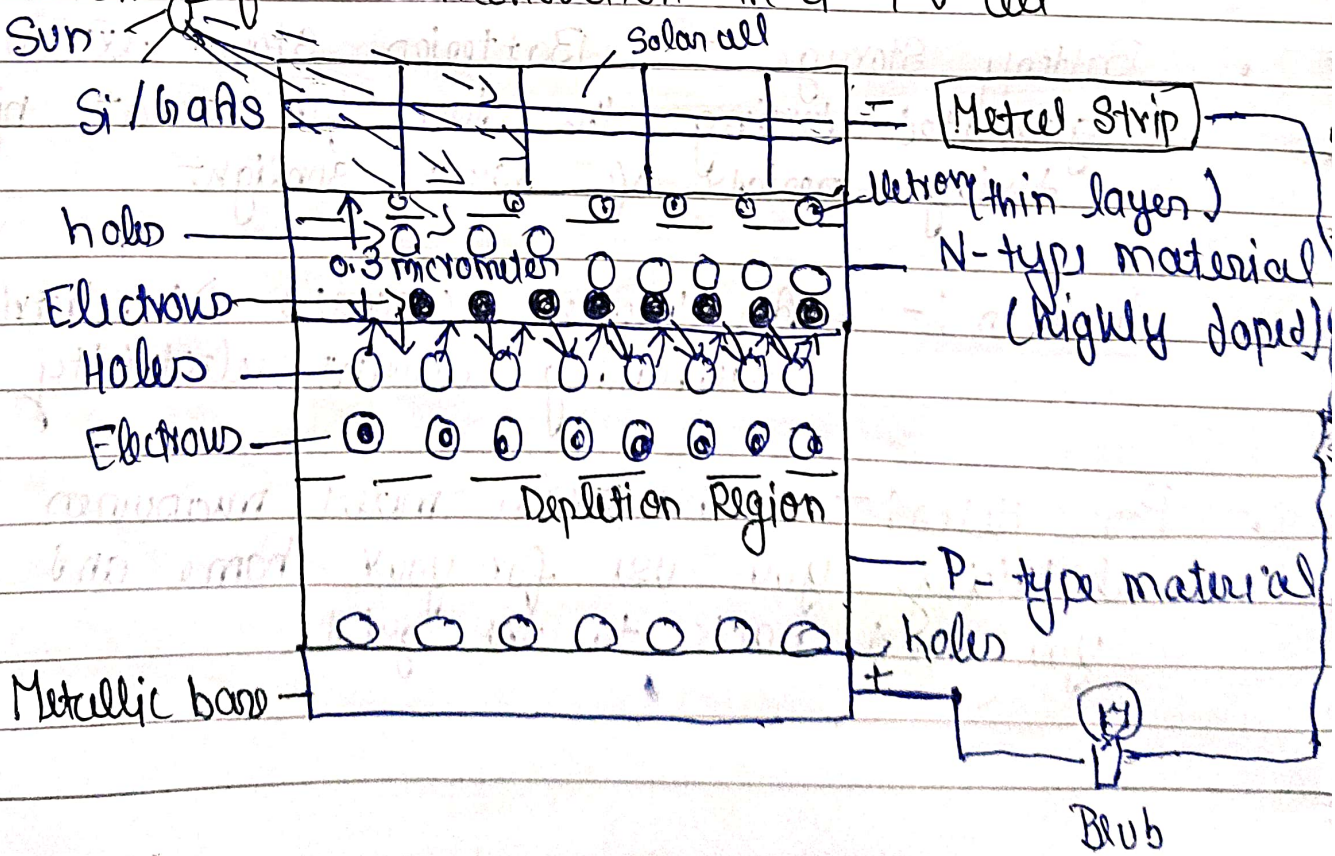
Sol. Solar Panels: There are made up of many solar cells that convert sunlight into direct current electricity (DC)

- Charge Controller :- A charge controller protects the battery from overcharging
- Battery Storage :- Batteries store excess energy generated during the day for use at night or during periods of low sunlight
- Inverter :- An Inverter converts DC electricity into Alternating current electricity.
- Power Meter :- A power meter measures how much electricity you use for your home and how much you send back to the grid:

- Electric grid :- During peak periods and at night, electricity imported from the electric grid



⇒ Mechanism of Photonduction in a PV cell



① In P-n junction, of the photons (sun light particles) are absorbed, the free e^- of n side will tend to flow to the p-side and the holes of the p-side will tend to flow to n-side.

② This depletion layer will create Electric Field from n-region to P-region

③ This Field will increase until it reaches equilibrium of VC, sum of diffusion potential for holes and electrons

④ if electrical contacts are made with two semi-conductor materials & the contacts are connected through external Metallic strip, the free electrons will flow from n-types material through conductor to p-type material

⑤ The flow of e^- through external conductor constitutes an electric current which will continue as long as more free e^- and holes are being formed by solar radiation.

⑥ This is the basis of photovoltic conversion that is, conversion of solar energy to electrical energy

CLASSIFICATION OF SOLAR CELL

① Monocrystalline Solar cells :- (1.1 ev)

-> There are made from a single crystal of silicon
-> They are the most efficient type because they have high purity and can convert more sunlight into electricity.
-> They are usually more expensive.

② Polycrystalline Solar cells :- (1.1 ev)

-> Made from many silicon crystals melted together
-> there are less expensive to produce but also slightly less efficient than monocrystalline cells.

③ Thin-film Solar cells :- (1.5 ev)
-> There are made by layering thin sheets of photovoltic material like cadmium telluride or amorphous silicion.
-> They are flexible and cheaper.
-> They are usually less efficient than silicon-based cells

⑥ Perovskite Solar cells :- (1.5W) A newer type, these use materials called perovskites.

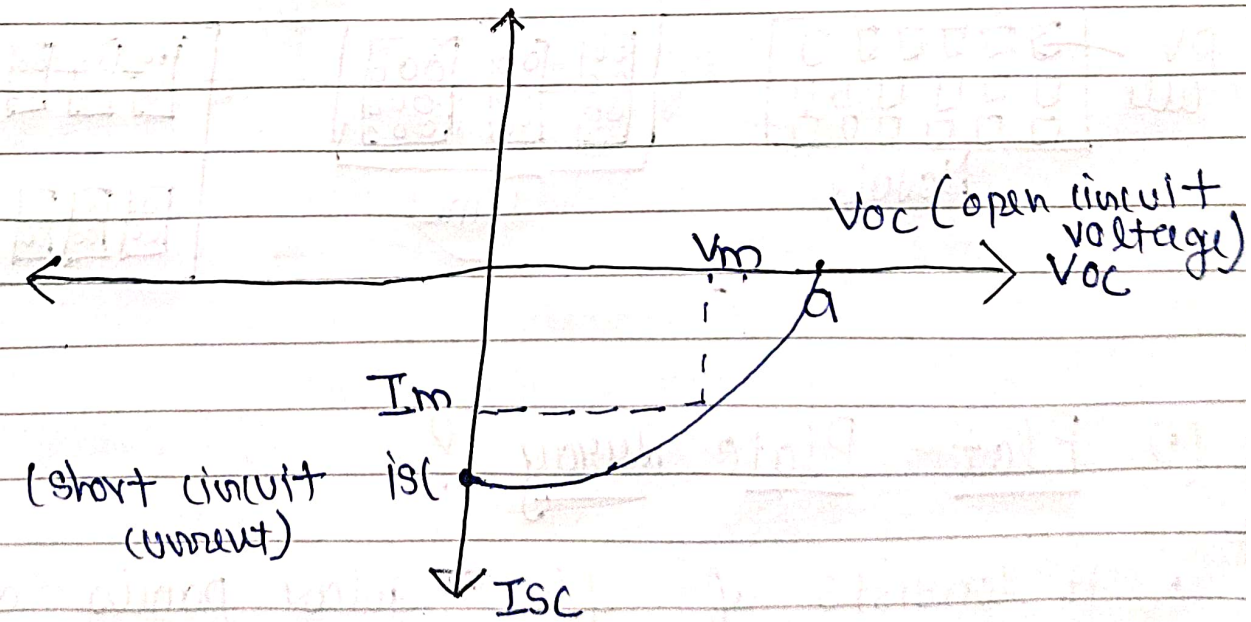
→ They are still being developed but show great potential because they can be cheaper and more efficient than traditional cells.

⇒ V - I characteristics :-

① V-i characteristics of solar cell lies in 4th quadrant.

② V-i characteristics of normal p-n junction diode lies in 1st and 3rd quadrant.

③ In p-n junction diode we provide voltage source using battery while solar cell produces voltage itself.



Maximum Power output $P_{max} = V_{maxp} \times I_{maxp}$

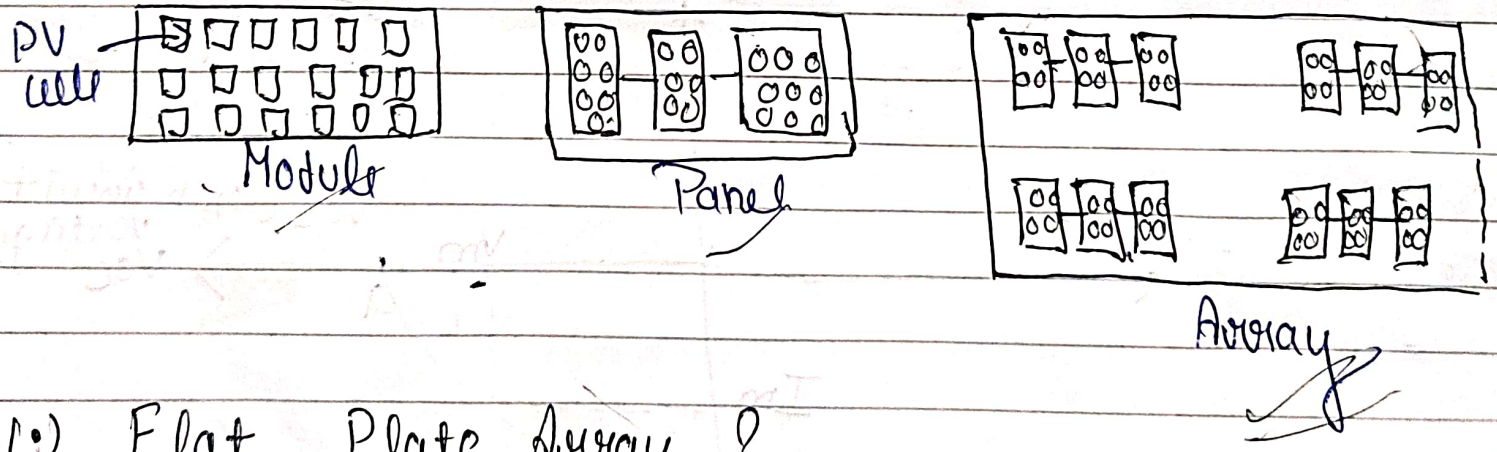
SOLAR CELL ARRAY :-

① A solar cell Array is a large group of solar cells connected together to produce more electricity.

② A collection of individual solar cells linked to work together

③ It main function to captures sunlight and convert it into a significant amount of electrical power.

④ Solar cells are arranged in panel and many panels make up an array.



⑤ Flat Plate Array :

- It consists of flat solar panels arranged in a fixed position to capture sunlight.

⊙ It doesn't use mirrors or lenses to concentrate sunlight, just relies on the direct and diffuse light hitting the panels.

⊙ This is the most common and widely used type of solar array for homes and business

Adv:- ⊙ Simple to install
⊙ No moving parts

Disadv:- ⊙ less efficient
⊙ large Area Needed.

(*) Concentrated Solar Array?

⊙ It's an array that uses optical devices (like mirrors or lens) to focus sunlight onto a small area of solar cells.

⊙ Concentrated Photovoltaics (CPV) and Concentrated Solar Power (CSP) are the type of Concentrated solar array.

Adv:- ⊙ Higher Efficiency
⊙ Suitable for Large-scale Projects

Disadv:- ⊙ Requires Direct Sunlight
⊙ Expensive

Q write short note on PV arrays and System charge controller. What are the advantage and disadvantage of photovoltaic solar energy:
{AKTU 2021-2022}

Sol

Advantage of Photovoltaic Solar energy Conversion

1. Renewable Energy Source
2. Environmentally Friendly
3. Low operating costs
4. Energy Independence
5. Scalability

Disadvantage of Photovoltaic Solar energy Conversion

1. High initial cost
2. Weather Dependent
3. Energy storage Requirement
4. Large Space requirement

Q Describe various direct and indirect application of solar energy. [AKTU 2021-2022]

Sol Direct Application :-

- Solar Photovoltaic (PV) system :- Directly converts sunlight into electricity using solar panels.
- Solar thermal system :- Converts sunlight into heat energy, which can be used for various heating purposes.
- Concentrated Solar Power :- Uses mirror or lenses to focus sunlight onto a small area to generate heat.
- Solar lightining :- Uses solar panels to capture sunlight and store it in batteries, which is used to power light during the night.
- Solar Desalination :- Uses solar heat to evaporate and then condense water, removing salt and other impurities to produce clean drinking water.

Indirect Application :-

- Biomass Energy :- Plants absorb sunlight.
- Wind Energy :- Solar energy heats the Earth unevenly and create wind

① Hydropower :- Solar energy drives the water cycle
② Fossil Fuels :- such as coal, oil and natural gas are ancient forms of solar energy

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UNIT - 02

(SUB - KOE074)

RENEWABLE ENERGY RESOURCES

ONE - SHOT

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Topics :-

1. Solar Radiation
2. Solar Collector & Classification
3. Solar Flat Plate Collector
4. Materials for Flat Plate Collector
5. Application and advantage & disadvantage
6. Performance of Flat Plate Collector
7. Focusing of Collector
8. Material of Collector
9. Application of Collector
10. Performance of Collector
11. Solar thermal Power plant
12. Thermal Energy Storage for Heating & Cooling
13. Limitation

Solar Radiation :-

⊙ Solar Radiation, often called the solar resources or just sunlight, is a general form, or term for the electromagnetic radiation emitted by the sun.

⊙ Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies

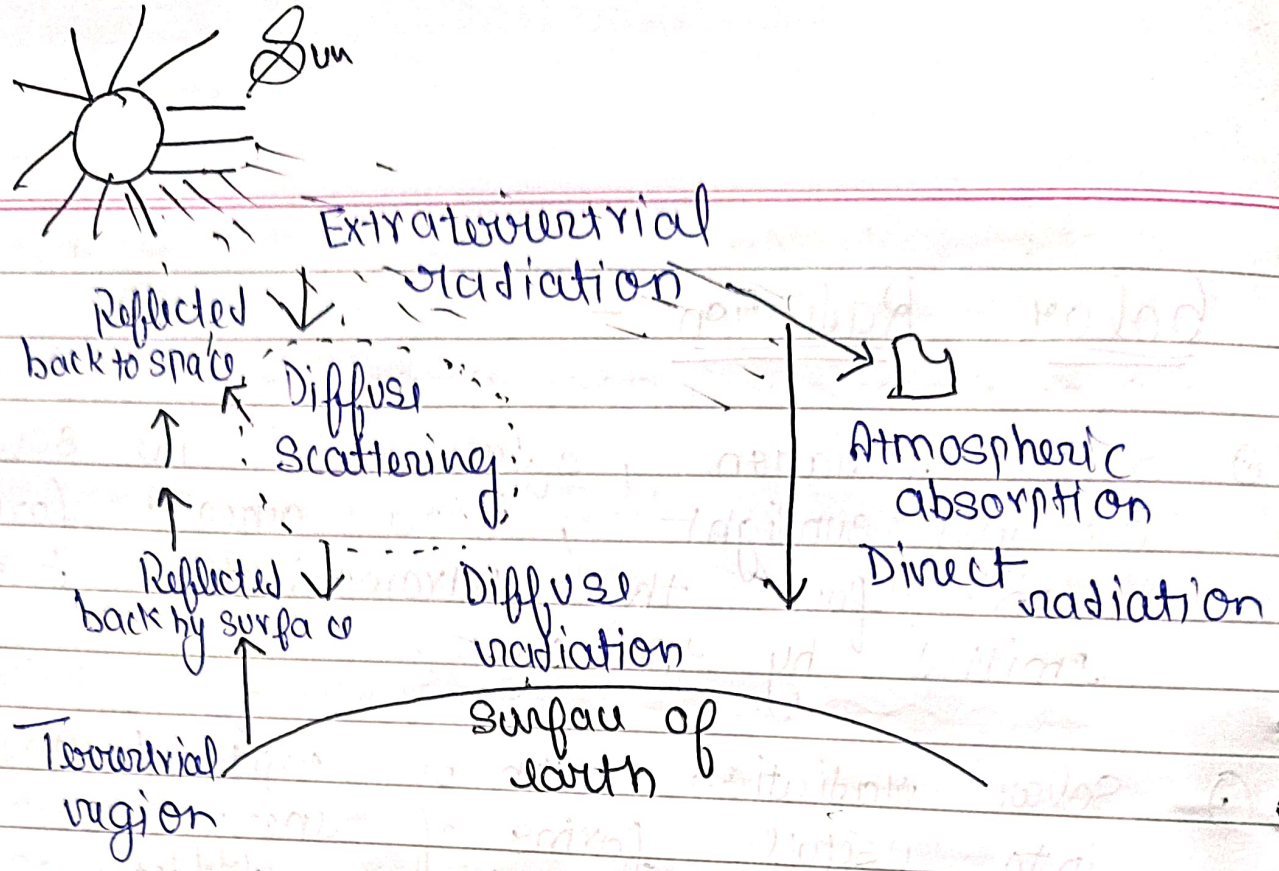
Types :-

a) Extraterrestrial Solar Radiation :-

→ The intensity of the sun's radiation outside the earth's atmosphere is called extra terrestrial and has no diffuse components

b) Terrestrial Solar Radiation :-

→ The radiation we receive on the earth surface is called terrestrial radiation and is nearly 70% of extra terrestrial radiation.



① Beam Radiation (I_b): Solar radiation received on the earth's surface without change in direction

② Diffuse Radiation (I_d):- The radiation received on a terrestrial surface (scattered by aerosols and dust) from all parts of the sky dome

③ Total Radiation (I_T):- The sum of beam and diffusion radiation ($I_b + I_d$).

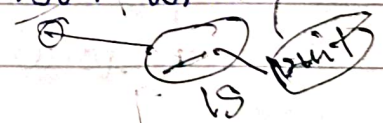
④ Air mass (m_a):- The path length that solar radiation travels through the Earth's atmosphere.

Direct Radiation	Diffuse Radiation
⊙ Travels straight from the sun to the surface.	⊙ Scattered in multiple direction by the atmosphere
⊙ More intense and concentrated	⊙ Weaker and spread out
⊙ Creates sharp, well-defined shadows	⊙ Produces soft, less-defined shadows
⊙ Dominant on clear, sunny days	⊙ Dominant on cloudy, hazy or polluted days

Solar constant :-

⊙ Solar constant is the amount of solar energy hitting a 1 square meter area at the top of Earth's atmosphere when Earth is at an average distance from the sun.

⊙ The standard value of the solar constant based on experimental measurements is 1367 W/m^2 with an accuracy of ±1.5%.



$$I_0 = I_{sc}\left[1 + 0.033\cos\frac{360n}{365}\right]$$

n = no. of days

* Day length :- The time of sunrise, sunset and the duration of the day length depends upon lattitude of location & month in a year

* LAT :- LAT stands for local apparent time.
⊙ The time used for calculating Hour Angle.

LAT = Standard time + Equation of time correction + 4 (Standard time longitude - longitude local)

* Altitude Angle :- The angle between the sun and the observer's horizon.

* Incident Angle :- The angle at which solar radiation strikes a surface.

* Lattitude Angle :- The angle formed between the sun's rays and line perpendicular to the Earth surface at a specific location, measured from the equator

* Hour Angle :- The angle that describes the position of the sun relative to the observer's local solar time

Hour angle = 15° x (local Solar Time - 12)

* Zenith Angle :- The zenith angle is the angle b/w the sun and the point directly overhead of an observer.

SOLAR COLLECTOR :- [AKTU 2023-2024]

⊙ Solar collector are used to collect the solar energy and convert this energy into the thermal energy by absorbing them

⊙ This thermal energy is further used for heating a collector fluid such as water, oil or air.

⊙ It is designed for high absorption and low emission

⇒ Classified into two types :-

1] Non-Concentrated Collectors :- These collectors captures sunlight without focusing it.
→ They are designed to absorb solar energy directly.

(a) Flat-Plate Collectors :-
→ A flat panel with a glass cover absorbs sunlight. The heat is transferred to a fluid (like water) circulating through the panel.
→ Best for heating water, pool heating

(b) Evacuated tube collectors :-
→ Glass tubes with a vacuum inside help to keep the heat trapped inside. Sunlight heats up the absorber within each tube, and a fluid inside absorb heat
→ Ideal for high-efficiency water heating.

2] Concentrated Collector :- There collectors focus sunlight using mirrors or lenses to generate higher temperatures.

(a) Parabolic Trough Collectors :- Long, curved mirror focus sunlight onto a receiver tube, which collect the concentrated solar energy.
-> Typically used for large-scale industrial application.

(b) Fresnel Collectors :- There use flat mirrors arranged in a pattern to focus sunlight onto a receiver tube.
-> They are also used for industrial application for generating high temp. heat or electricity.

SOLAIR FLAT PLATE COLLECTORS [AKTU 2022-23] [AKTU 2023-24]

① Flat plate collector is simplest in design and it is most important part of any solar thermal energy system.

② In this collector both direct and diffuse radiations are absorbed and converted into useful heat.

③ Flat plate collector is a type of device that is used to capture heat from solar radiation / it is used to convert solar energy into heat energy.

⇒ Components :-

i) Absorber Plate :

-> Absorber plate is used to grasp and absorb solar radiation

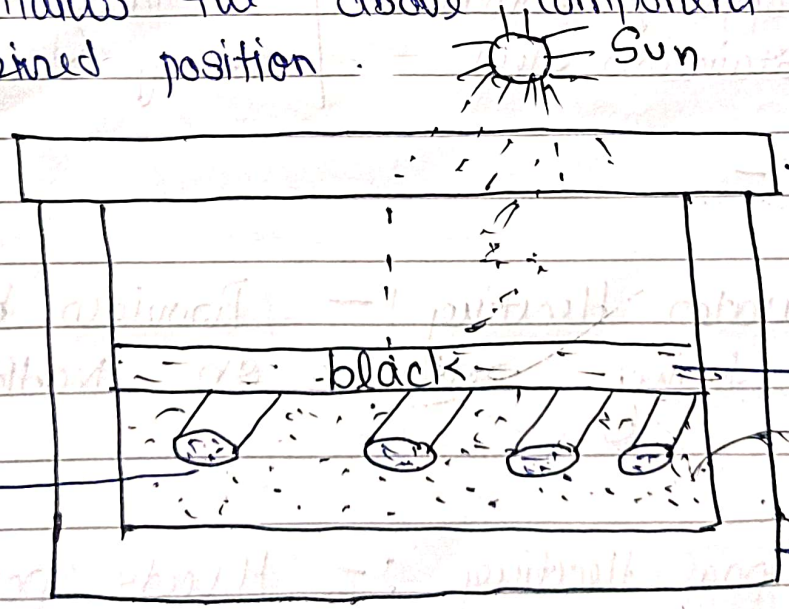
-> The plate is usually metallic (copper, Al or Steel), sometimes plastics have been used in some low temp. Application.

ii) Transparent Covers :-

-> There are one or more sheets made of glass for trapping the heat received by the absorber plate.

iii) Insulation :- It minimizes the heat losses by conduction

iv) Box :- It contains the above component and keep them into desired position.



Flat Plate Collector

Q Materials used in flat Plate Collector.

Component	Common Materials	Purpose
Absorber Plate	Copper, Aluminium, Steel	To absorb solar energy and convert into heat
Glazing (cover)	Tempered Glass, Acrylic Polycarbonate	To let sunlight in while trapping heat inside
Insulation	Mineral wool, Fiberglass, Foam	To prevent heat loss from the back and sides
Frame	Aluminum, Steel, plastic	To support and hold all the component together
Tubes	Copper, Aluminium Stainless Steel	To carry the heat transfer fluid

Application :-

① Domestic water Heating :- Provides hot water for homes, reducing reliance on traditional heating methods

② Swimming pool Heating :- Heats pool water

③ Space Heating :- Heats indoor spaces in homes

① Industrial process heat.
② Desalination
③ Agriculture Heating
④ Solar Air Heating.

⇒ Advantage and Disadvantage

Advantages :-

① low cost
② Easy to manufacture
③ less maintenance
④ Permanently fixed
⑤ Collect both beam and diffuse radiation

Disadvantage :-

① Limited Efficiency in cold climates
② low - Temperature Application
③ Space - Requirements
④ Seasonal performance

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Performance Analysis of Flat Plate Collector :-

a) Fin Efficiency Factor (Fe) :- Fin efficiency is a measure of how well a fin transfer heat and is calculated as the ratio of the actual heat transfer to the maximum possible heat transfer

$$\{\eta = Q_{actual} / Q_{max}\}$$

b) Collector Efficiency Factor (F_c) :- It is defined as the ratio how much useful heat goes to fluid versus how much heat escapes to the environment.

$$F_c = Q_u / A_c [\alpha_o \tau_o I_t - U_L (T_f - T_a)]$$

c) Collector Heat Removal Factor (F_H) :-
The collector heat Removal factor (F_R) is the ratio of the actual heat transfer to the maximum possible heat transfer through a collector plate.

$$\{F_c = \frac{Q_u}{A_c [\alpha_o \tau_o I_t - U_L (T_{fi} - T_a)]}\}$$

d) Collector Efficiency(η) :- Collector efficiency is a measure of how much sunlight a solar collector turns into useful heat for the fluid flowing through it.

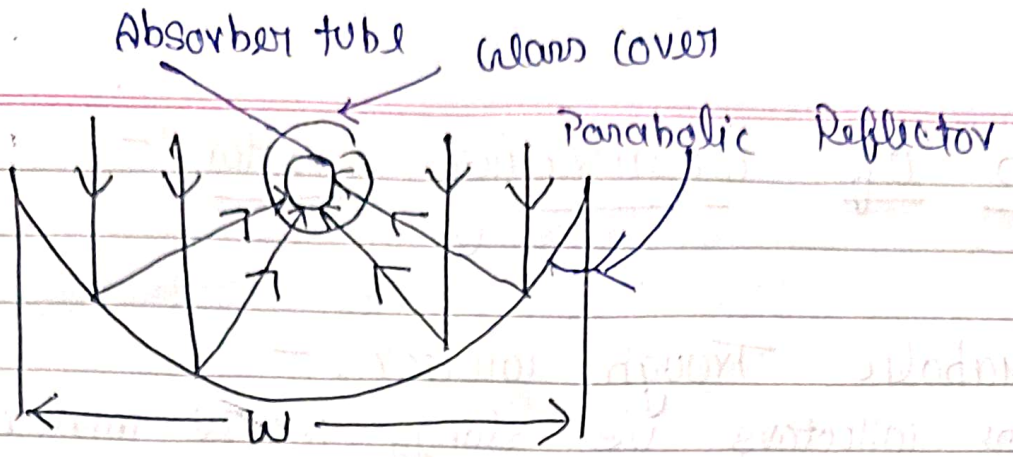
$$\{\eta_c = \frac{Q_u}{A_c I_t}\}$$

=> Factors which affect the performance of flat plate collector.

- Solar Radiation :- More Sunlight means better performance.
- Tilt and Orientation :- Correct positioning maximizes sunlight absorption.
- Ambient temperature :- Higher outside temperature cause more heat loss
- Material : High-quality absorber and cover materials improve heat capture
- Insulation :- Good insulation reduces heat loss
- Flow Rate : Optimal fluid flow balances heat transfer and temperature
- Cover Plate Quality :- Clear, thermal-resistant covers enhance efficiency.
- Wind Speed :- High winds speed increase heat loss
- Maintenance :- Regular cleaning prevents dust buildup and preserves performance

FOCUSING OF COLLECTER:

- Concentrating solar collector is a device to collect solar energy with high itensity of solar radiation on the absorbing surface by the help of reflector or refractor



Principle :-

① Concentrating solar collector uses reflective surface to concentrate sunlight to a small area, where it absorbed and converted to heat

Working of Concentrating Solar collector :-

① A concentrating solar collector consist of two main parts : a concentrator and an absorber.

① The concentrator gathers sunlight from a large area and focuses it onto the absorber which is much smaller in size.

① This way, the energy from the sun is concentrated on a smaller surface.

① By concentrating the sunlight, the system can heat a fluid to very high temp, up to 500°C or more.

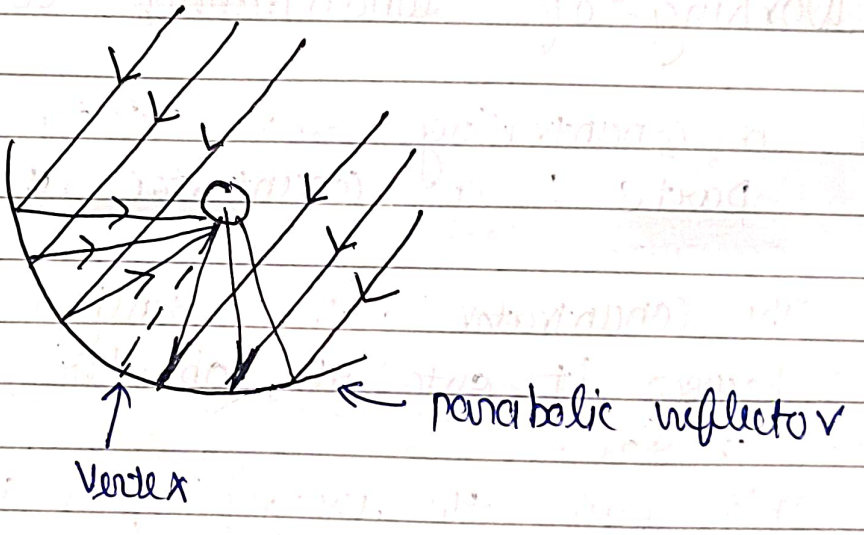
① These collector are very efficient because they loss less energy compared to non-concentrating collector.

Types Of Concentrating collector :-

1] Parabolic Trough Collector :-

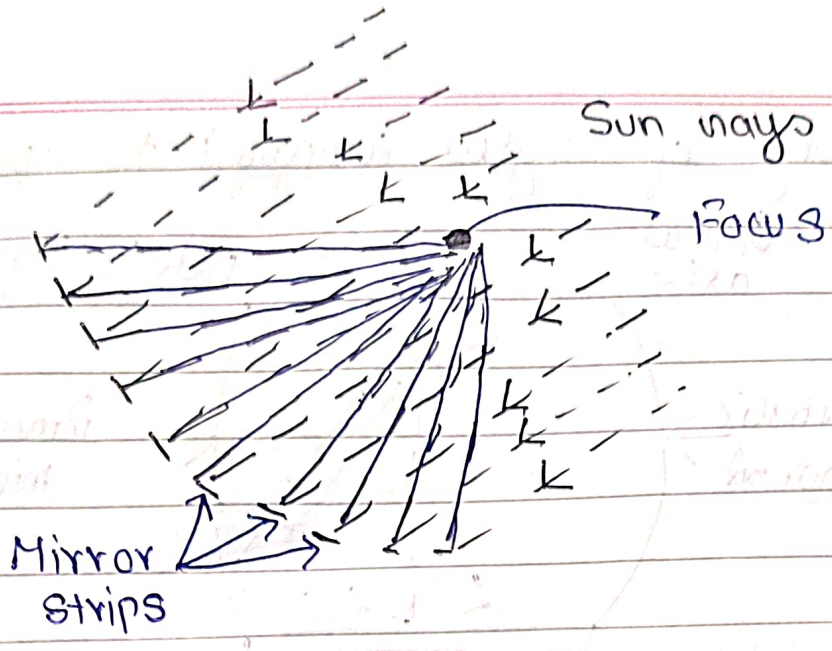
→ These collectors use long, curved mirrors shaped like a parabola to focus sunlight onto a receiver tube positioned along the focal line of the trough.

→ The receiver absorbs the concentrated heat and transfer it to a fluid running through the tube, which is then used to generate steam or power turbines



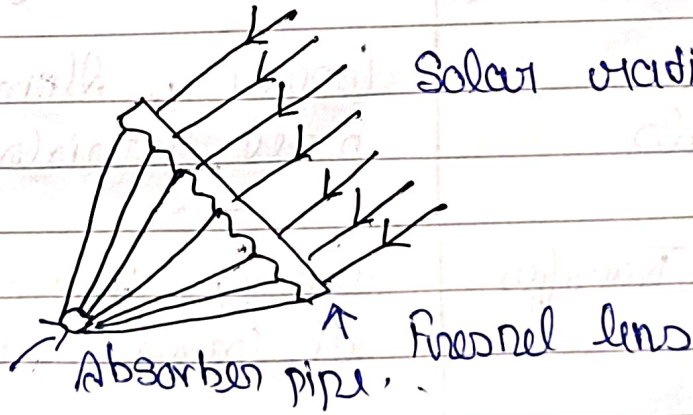
2] Mirror strip reflector :- A mirror strip reflector is a type of solar concentrator that uses flat, linear strips of reflective material to focus sunlight onto a receiver.

→ The strips are typically arranged in a way that focuses sunlight along a line, rather than single point, as in some other concentrating solar collector



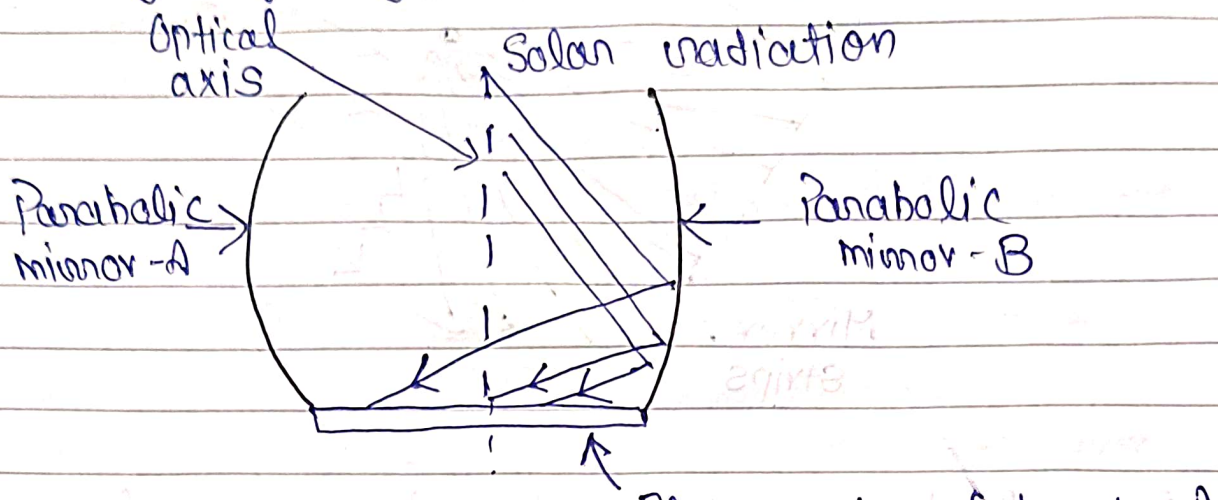
3] Fresnel lens collector :- A Fresnel lens collector is a type of concentrating solar collector that uses a Fresnel lens to focus sunlight onto a receiver.

→ The Fresnel lens is a flat, lightweight lens with a series of concentric, grooved sections designed to bend and focus light more efficiently than a conventional lens.



4] Compound parabolic concentrated :- It is a type of solar concentrator that uses a parabolic shape to collect and focus sunlight, but with a design it allows it to capture sunlight from a

wider range of angles compared to traditional concentrator



Material used for concentrating collector :-

Component	Material
① Reflective Surfaces	Aluminium, Silver, Gold, Stainless Steel Glass or Acrylic
② Absorber Materials	Copper, Aluminium, Steel, Carbon based Materials, Selective Coatings
③ Heat Transfer fluids	Water, Oil, Molten Salts, Air or Gases
④ Structural Materials	Concrete, Steel, Aluminium Alloys
⑤ Thermal Storage materials	Molten Salt

Application of Concentrating Collector :-

- They are used for which need high amount of heat such as power generation.
- They are used in solar power plant.
- They used to collected large solar energy which is used to convert water into steam.

Advantage of Concentrating Collector :-

- Higher Efficiency
- Less material use
- Cost-Effectiveness for Large-Scale Application.
- Use of High-Efficiency Cells
- Reduced land Area

Disadvantage of Concentrating Collector :-

- High Initial cost
- Requires Direct Sunlight
- Environmental Impact

Performance Analysis :-

→ Concentration Ratio (C) :- It is defined as the ratio of the effective aperture ratio to the absorber tube area.

$$C = \frac{\text{Effective aperture ratio}}{\text{Absorber tube area}}$$

→ Intercept factor (γ) :- It is defined as the ratio of radiation intercepted by absorber tube to the total reflected radiation.

$$\gamma = \frac{\text{Radiation intercepted by absorber tube}}{\text{Total reflected radiation}}$$

→ Collector Efficiency Factor (F_c) :- Collector efficiency factor is given by the relation :

$$F_c = \frac{1}{U_l \left[\frac{1}{U_l} + \frac{D_o}{D_i h_f} \right]}$$

→ Instantaneous Collector Efficiency (η_i) : Instantaneous collector efficiency is given by the relation

$$\eta_i = \frac{q_u}{(I_b r_b + I_d r_d) W L}$$

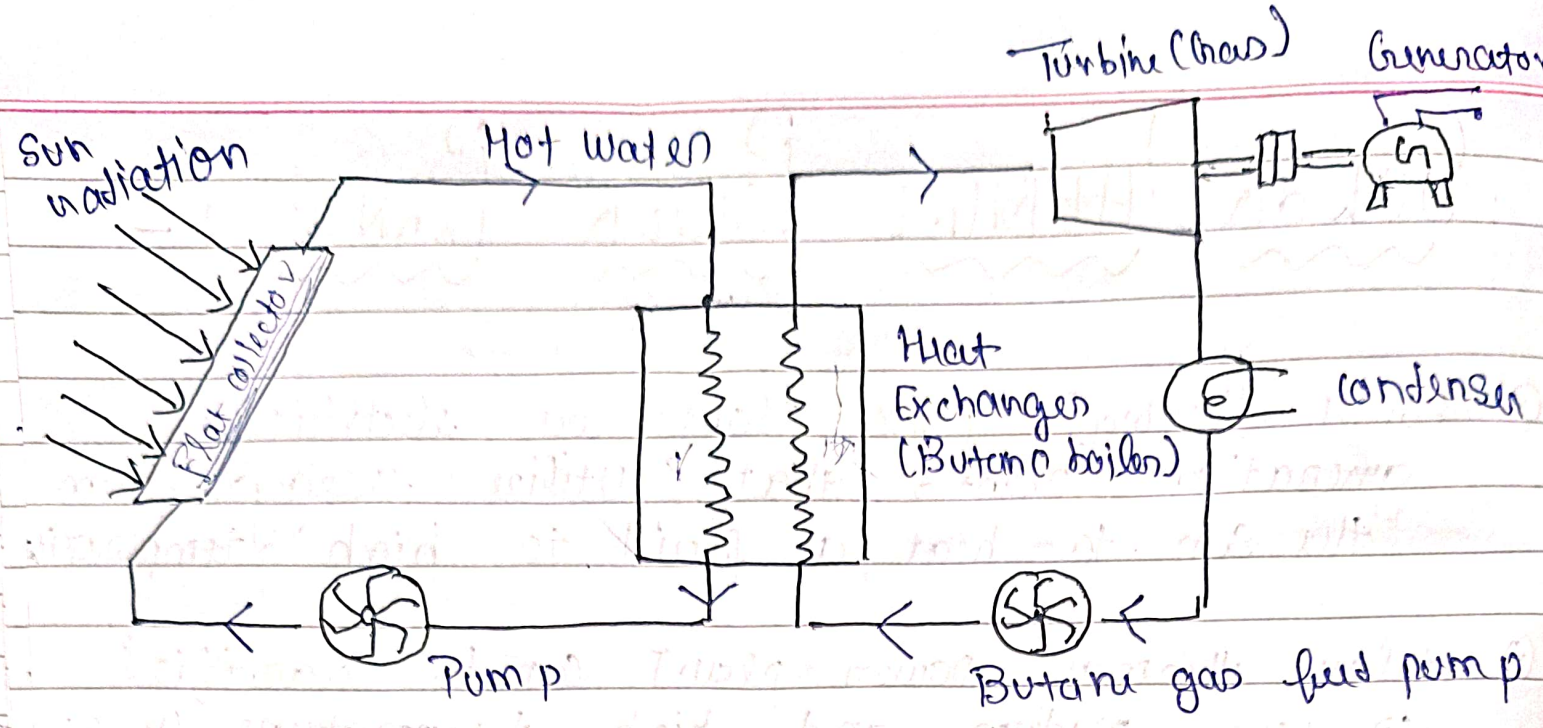
q_u = useful heat gain
$I_b r_b$ = Beam radiation normally incident on aperture
$I_d r_d$ = Diffuse radiation
L = length of concentrator

SOLAR THERMAL POWER PLANTS :-

- Solar thermal power plants are electricity generation plants that utilize energy from the sun to heat a fluid to high temperature
- Solar thermal power plant can be classified as low, midium and high temperature cycle.
  - Low temperature cycle operate at about 300°C
  - Medium temperature cycle operate at about 400°C
  - High temperature cycle operate at above 500°C

Low Temperature Solar Power Plant :-

- A low temperature solar power plant uses flate-plate collector array
- These collectors use a dark, heat-absorbing plate covered with transparent glass to trap sunlight.
- As sunlight hits the plate, it heats the fluid running through tubes attached to the plate.
- This heated fluid can be used to generate electricity.

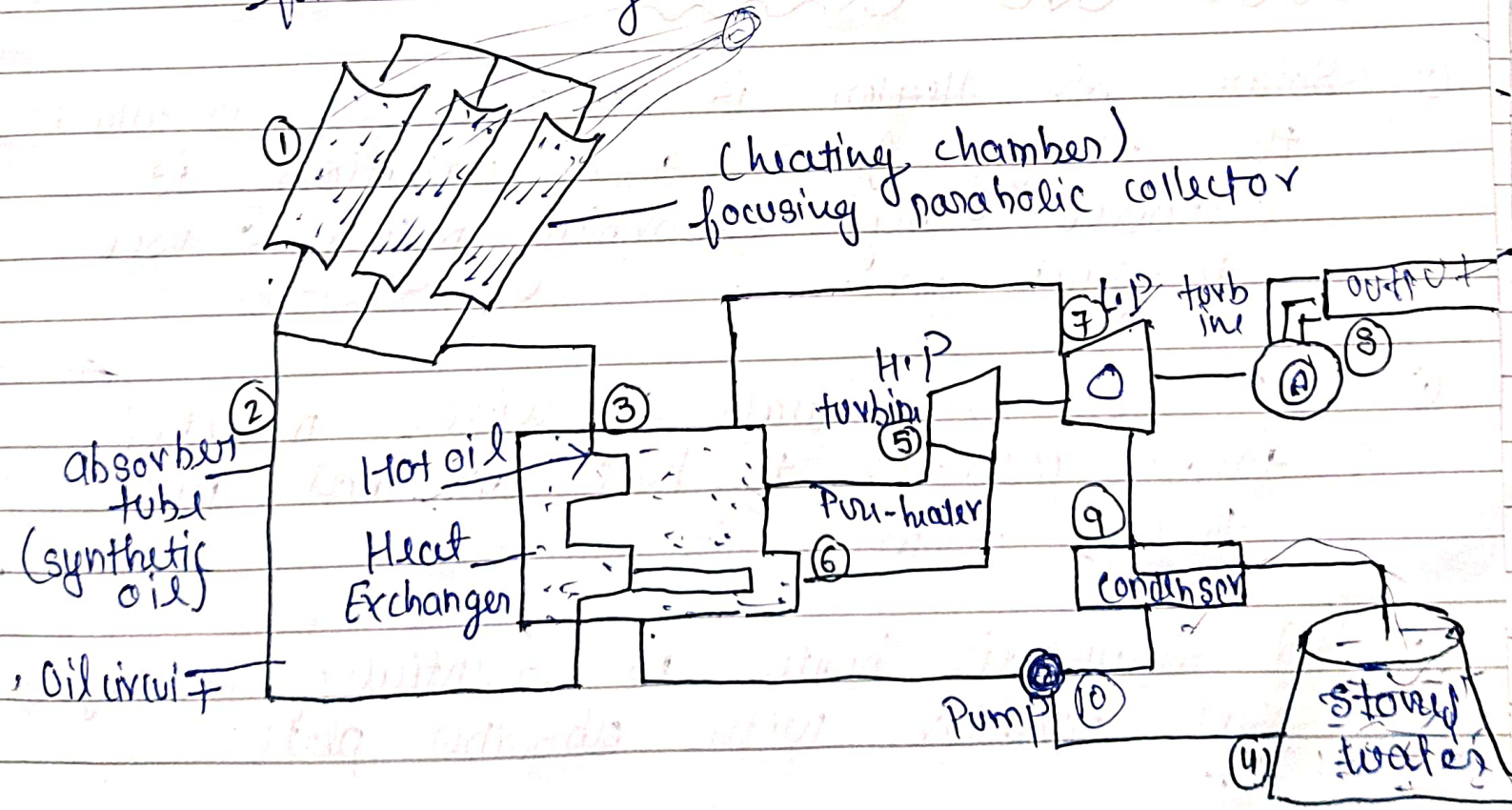


- A flat-plate solar collector captures energy from sunlight.
- This collected energy is converted into heat.
- The heat water that flow through pipe in the solar collector.
- The heated water flows to a heat exchanger which is also called the "butane boiler".
- In the heat exchanger, the hot water transfer its heat to butane, a gas that heats up and turns into high pressure gas.
- The high pressure butane gas flow into a turbine causing it to rotate.
- The rotating turbine create mechanical power, which drives a generator to produce electricity.
- After passing through the turbine, the butane gas loses pressure, that gas move to condenser than move to Butane boiler with the help of pump.

2] Medium temperature Solar Power Plant

① Medium temperature collector use concentrators to reach temperature between 100°C to 400°C.

① So, Array is used concentrated parabolic trough type, collects solar radiations
① Heat carried to storage tanks.
① Further in the steam generator.
① Steam goes to drive steam-turbine
① Mechanical energy of turbine drives the generator
① It convert it into electrical energy.
① Exhaust steam comes to condenser
① where it is condensed by cooled water from cooling tower and pumped



3] High pressure solar power plant

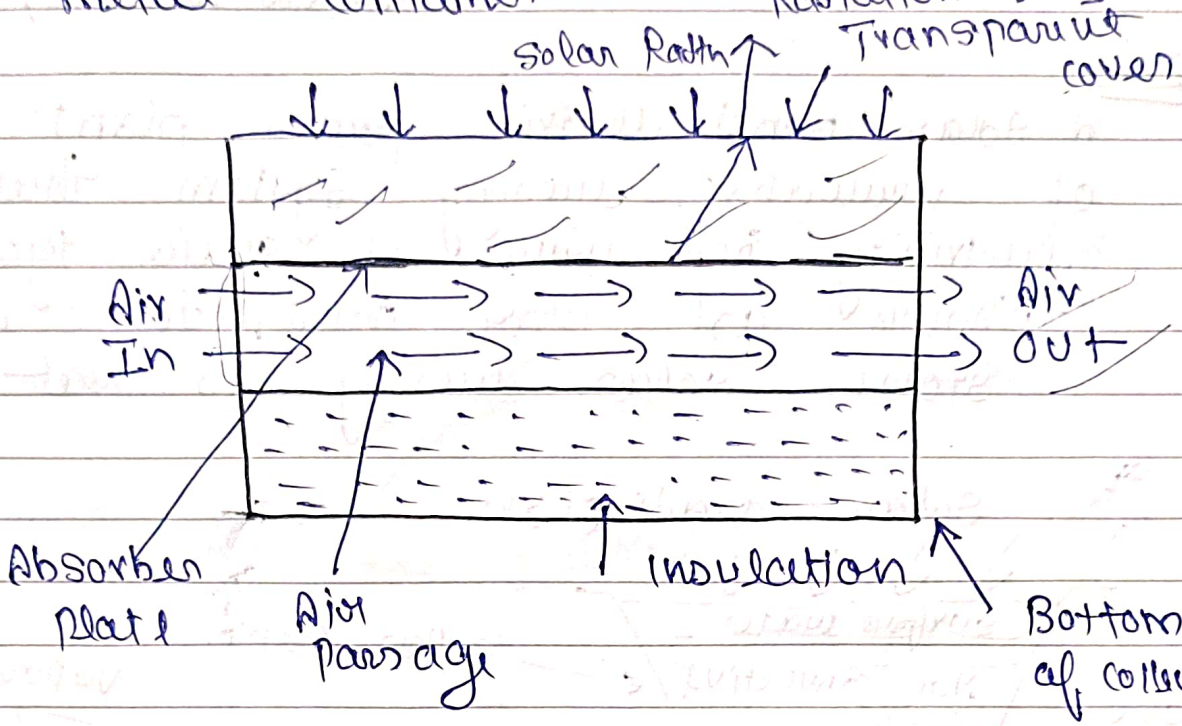
- In high temperature solar thermal power plant we can obtain temperature up to 1500°C.
- In this type of solar thermal power plant we use parabolic dish type collector or central receiver.
- By parabolic dish very high intensity solar arrays incident on common point.
- that's why fluid get heated and it convert water in to steam rotates the prime mover

SOLAR AIR HEATERS

- Solar Air Heater is a technology in which the energy from solar radiation is captured by absorbing medium & used to heat air.
- It use roof, wall or window mounted solar collector to heat air that passes through them
- A solar air heater is essentially a flat plate collector with absorber plate

① It is a transparent cover system at top & insulation at the bottom.

② The whole assembly is enclosed in a sheet metal container



Application :-

① Solar air heater provides ventilation and process air heating

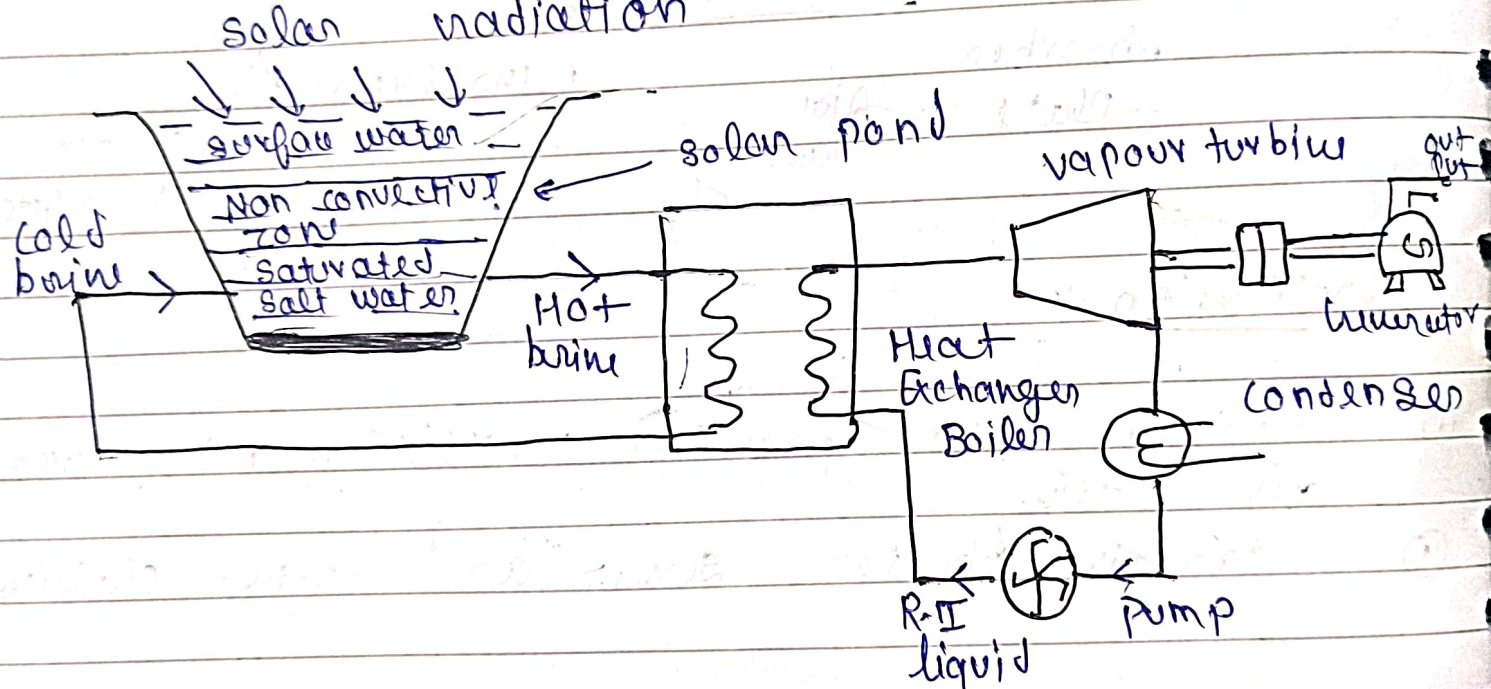
② Solar air heater serves as weather cladding

Q With the help of diagram explain the working of solar pond based electric power plant with diagram ?

[AKTU 2023-24, AKTU 2022-23]

Sol

-> A solar pond electric power plant is a type of renewable energy system that generates electricity by using a special type of pond, known as solar pond, to collect and store solar energy as heat



① A solar pond has layers of water with increasing salt concentration toward the bottom

② Sunlight heat the bottom layer, where the salinity traps and stores the heat

③ The heat from the bottom is transferred to a working fluid via a heat exchanger

⊙ The heated working fluid vaporizes, creating high-pressure gas that drives a turbines

⊙ The turbine powers a generator to produce electricity.

⊙ The gas cools, condenses, and is cycled back to the heat exchanger.

Thermal Energy Storage for Cooling :-

(a) Solar Power Refrigeration System

⊙ Solar energy can be used for cooling the buildings and preserving food by refrigeration

⊙ The cycle used for cooling with utilization of solar energy is vapour absorption cycle

=> Working :-

⊙ The basic function of solar collector is to collect more rays from sun and then converted to heat energy

⊙ The function of generator is to collect

heat energy from solar collector through pump and boil aqua ammonia solution to convert it in vapour form

⑥ The main function of rectifier is to separate water and ammonia vapour.

⑤ The main function of condenser is to change the phase of vapour refrigerant means convert it vapour to liquid.

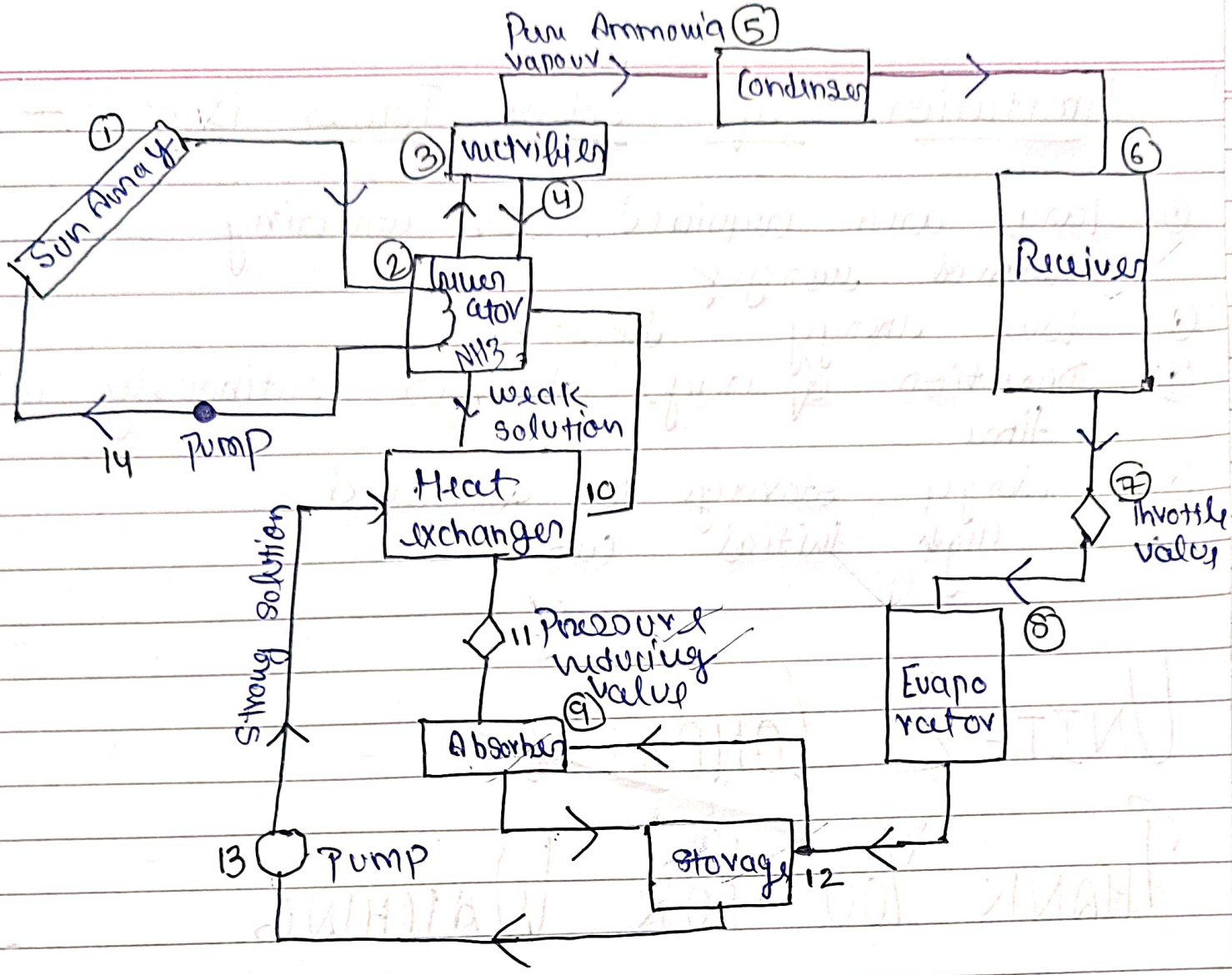
④ The receiver collect liquid refrigerant

③ The throttle vale helps in cooling effect

② The basic function of evaporator is to produce cooling effect by absorbing the space heat

① The main function of absorber is to absorb weak and strong solution.

⑦ The function of pump is to help the solution in circulation



B) Solar Air Conditioning system

-> A solar air conditioning system is simply a system of cooling and heating that utilizes solar power, rather than electricity.

-> This can be done through passive solar, solar thermal energy conversion and photovoltaic conversion

-> It is eco friendly as well as energy efficient

Limitation of Solar Power Plants :-

- Large area required for collecting solar thermal energy
- Low energy density
- Direction of rays changes continously with time
- Energy storage is essential
- High initial cost

UNIT-2 COMPLETE

THANK YOU FOR WATCHING

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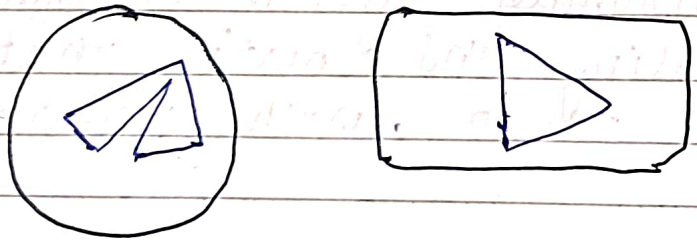

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UNIT-03

RENEWABLE ENERGY RESOURCES

ONE SHOT VIDEO

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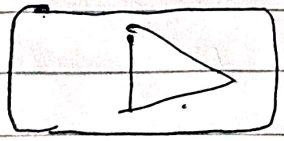
Topics :-

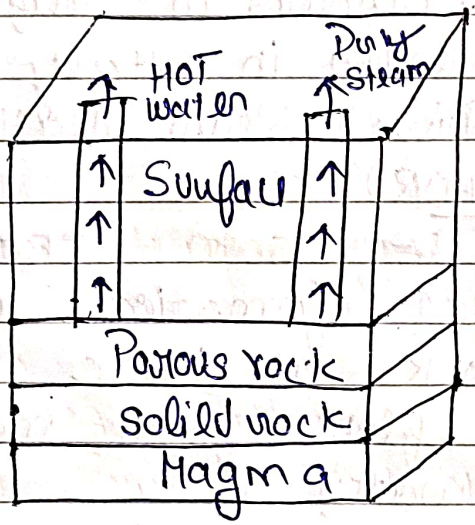
- Geothermal Energy
- Classification of Geothermal Energy
- System used for generating the power using G.E
- MHD Generating system and its type
- Fuel cells and its types and reaction
- Application
- Fuel cells vs Battery
- Geothermal Power plant vs thermal Power plant



GEOTHERMAL ENERGY

- Geothermal energy is the heat that comes from inside the Earth
- This heat is natural energy resource that can be use for thing like making electricity and heating building.

=> The word "geothermal" is made up of "geo", which means Earth and "thermal", which means heat



=> Classification of Geothermal Energy Resources

1. Hydrothermal Systems
-> Temperature Range :- 90°C – 300°C (194°F – 572°F)
-> These are reservoirs of hot water and or steam stored underground in porous rocks or fractures
=> They are the most common type of gothermal

resource and are used for both electricity generation and direct heating
→ Example :- Geothermal power plants in Iceland and California.
→ Direct uses :- Heating, Agriculture, Industrial
2. Vapor-Dominant Resources
→ Temperature Range :- Typically 240°C - 320°C (464°F - 608°F)
→ These resources contains mostly steam under high pressure, making efficient for electricity production.
→ Steam is brought directly to the surface to drive turbine for power generation
→ Example :- The Geysers in California, USA
Larderello in Italy
→ Direct uses :- Direct Steam Heating, Industrial heating
3. Hot Dry Rock (HDR)
→ Temperature Range :- 150°C - 350°C (302°F - 662°F)
→ This is a geological formation with high temperature rock at 650°C heated by conductive heat flow from magma but contains no water
→ To trap its energy the impermeable rock is fractured and water is injected to create an artificial reservior
→ Water circulates and hot fluids returns to the surface through the other drilled well as steam and hot water, which are used to generate electricity
→ Direct use :- District Heating, Industrial Process

4. Geopressured Systems

→ Temperature range :- 90°C – 200°C (194°F – 392°F)

→ These systems contain hot water and dissolved natural gas trapped under high pressure. Both the hot water and gas can be used as energy sources

→ Example :- Geopressured resources in the Gulf Coast of the United States

→ Direct use :- Industrial Heat Applications

5. Magma - Based Systems

→ Temperature range :- can exceed 600°C (1112°F) and even reach up to 1200°C (2192°F)

→ Found near magma or molten rock, these resources have extremely high temperatures.

→ They are mostly in the research stage due to the technical challenges involved

→ Example :- Volcanic area like Hawaii and Iceland

→ Direct use :- Future Industrial Heat

Q Explain detail about different geothermal energy resources and mention its direct uses

[AKTU – 2023-2024]

Ans Done ! (Above Part)

Q Explain the working of geothermal power plants. Discuss the various technical development [AKTU – 2021-2022]

Sol Geothermal power plants generate electricity by tapping into the Earth's natural heat, which is stored in hot water and rocks beneath the surface.

Working :-

- Drilling and Accessing the Heat :- Wells are drilled into the Earth to reach geothermal reservior that contain hot water or steam

- Steam production :- The hot water or steam from the geothermal reservoir is extract through there wells.

→ The type of steam production system used depend on the temperature and pressure condition of the reservoir.

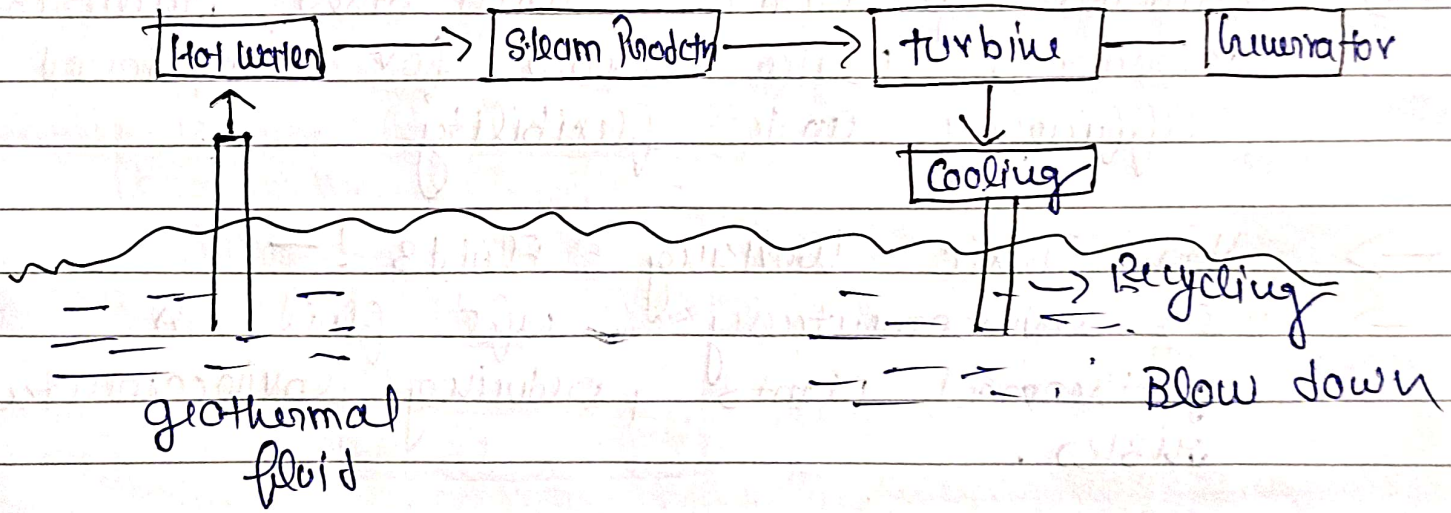
- Power Generation :- The steam, or in some cases hot water is directed towards turbines that spin when the steam hits them

• The spinning turbines are connected to generators which convert this mechanical energy into electricity.

① Cooling and Recycling

→ After passing through the turbine, the steam or water is cooled down, often in a cooling tower

→ The cooled water is then re-injected back into the ground to sustain the geothermal reservoir.



⇒ The various technical development are :-

→ Enhanced Geothermal Systems (EGS) :- (creates geo thermal energy by injecting water into hot dry rock to generate steam.

→ It expands geothermal use to areas without reservoirs (natural)

→ Advanced Drilling Technologies :-
→ New drilling techniques, like directional drilling, make it possible to access deeper, hotter geothermal resource more efficiently and at lower cost.

→ Supercritical Geothermal fluid :-
→ Harnessed superheated fluid (above 374°C) that carry more energy, increasing power generation efficiency.

→ Hybrid Geothermal system :-
→ Combines geothermal with other renewable resources (like Solar) for improved efficiency and flexibility.

→ Non-Toxic Working Fluids :-
→ Uses environmentally safe fluids in geothermal plants, reducing environmental risks.

→ Geothermal from low-Temperature Resources
→ Extract energy from low-temperature geothermal sources.

Q dry steam, wet steam and hot water geothermal system ?

=> Dry steam Geothermal System :-
-> In a dry steam system, steam directly comes from the Earths geothermal reservoir.
-> The steam is extracted from the ground and sent directly to from the ground and sent to turbines to generate electricity
Example :- The Geysers in California.

=> Wet steam Geothermal System :-
-> In a wet steam system, hot water is extracted from the geothermal reservoir, and when the pressure is lowered (flashed), some of it turns into steam.
-> The high-pressure hot water from the Earth is "flashed" (rapidly depressurized), causing part of it to turn into steam. The steam is then used to drive turbines
Example :- Flash steam plants are common and can operate in moderate to high temperature geothermal resources

=> Hot Water Geothermal System :-
-> These fields are similar to wet, steam fields but heat transfer from the dpth in much higher
-> These reservoirs produce superheated steam at pressure above atmosphere

-> The permeability of these fields is lower than wet fields.
-> The degree of superheating may reach up to 100°C

⇒ DIFFERENT SYSTEM USED FOR GENERATING THE POWER USING GEOTHERMAL PLANT

1. Vapour Dominated power plant

-> A vapour - dominant power plant uses steam (vapor) directly from the geothermal reservoir to generate electricity

components :-

1. Production Wells :- These wells bring steam from the underground reservoir to the surface.
2. Steam Turbine :- The steam from the reservoir spins this turbine to generate electricity
3. Generator :- Convert the mechanical energy from the turbine into electrical energy.
4. Condenser :- Cools the steam back into water, which is then re-injected into the geothermal reservoir
5. Re-injection Wells :- After condensation, the water is pumped back into the ground to maintain the pressure and supply

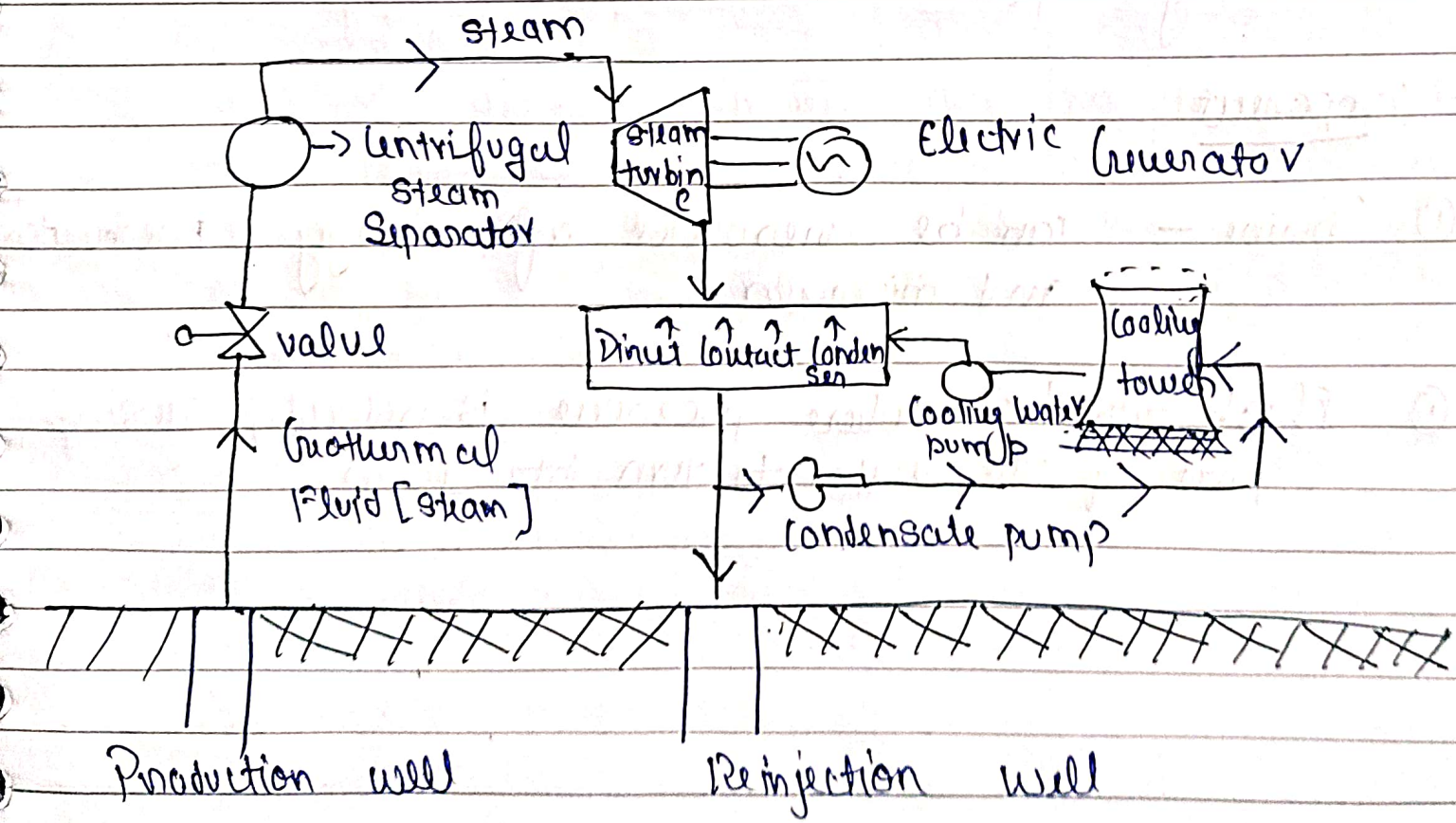
6. Valve :- Manage flow of water & steam. like start / stop, reduce / increase flow control the direction of flow.

7. Centrifugal steam separator :- Device from separating water droplets from steam & other impurities

8. Direct contact condenser :- One in which coolant is brought into contact with the vapour

9. Condensate pump :- Used in condensers to pump out the condensed steam as water

10 - Cooling water Pump :- Provide the fresh water to cool the exhaust steam in the condenser



2. Liquid - dominant Geothermal power plants

-> The liquid - dominant geothermal power plant can be classified based on how they handle and utilize hot water from the geothermal reservoir to generate electricity

a. Flashed Steam System :-

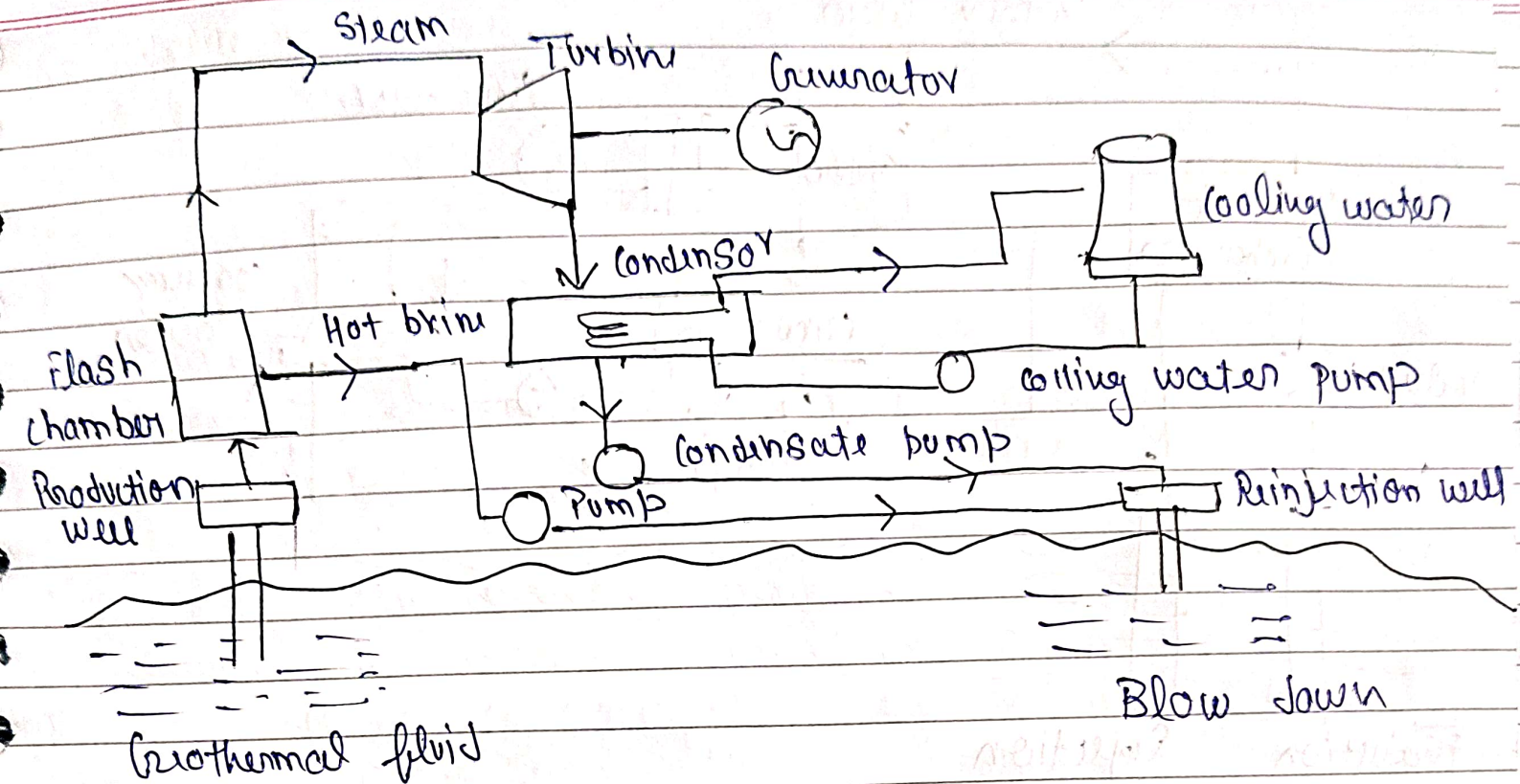
-> Flashed steam is preferred for high temperature mixture of geothermal brine and steam with low dissolved impurities

-> In this type hot water from the geothermal reservoir is brought to the surface under high pressure

Component

① Brine - can be resource of energy, Freshwater and minerals

① Flash tank :- Where pressure is reduced, causing part of the water to turn into steam



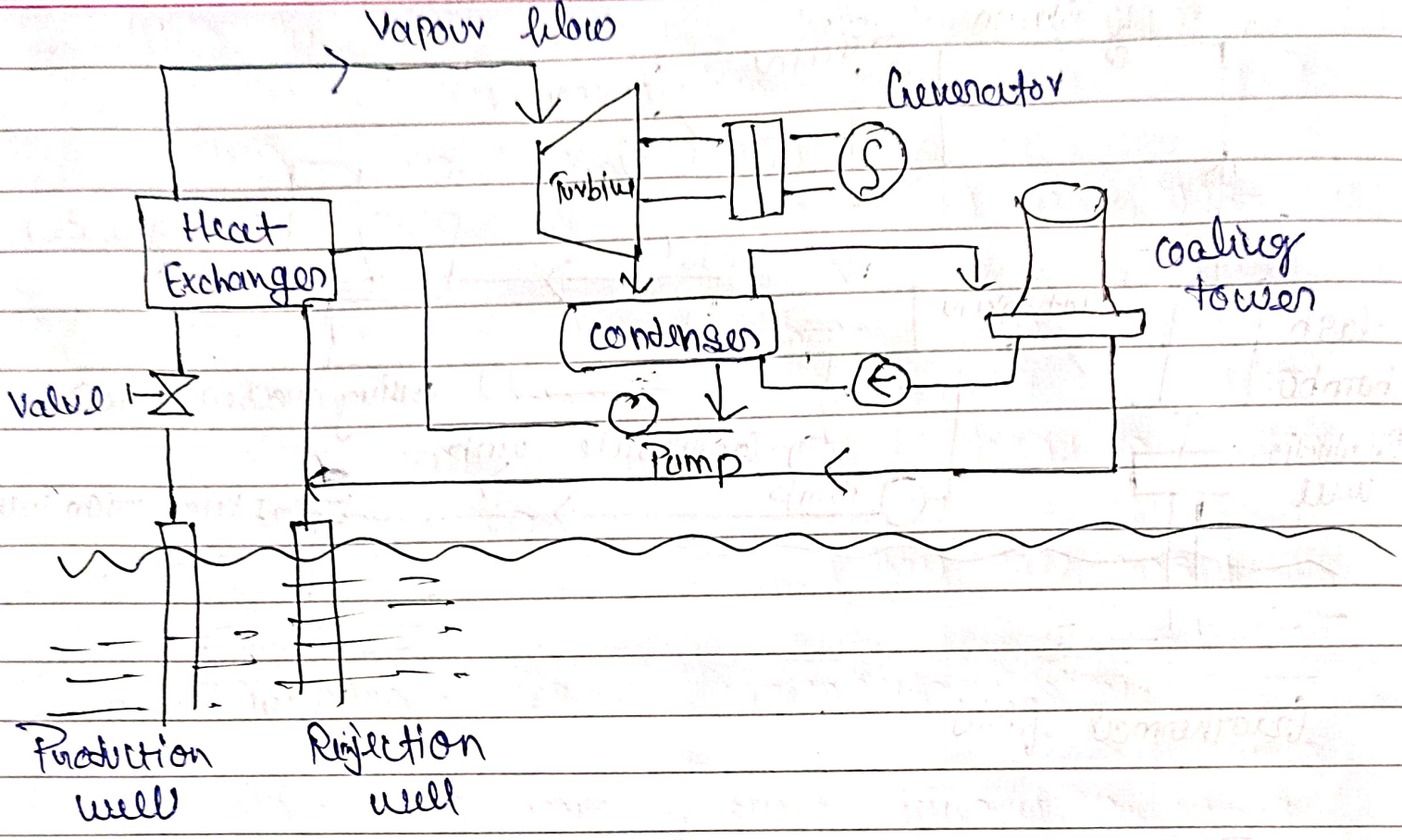
b. Binary cycle system :-

⊙ A binary cycle is used where geothermal fluid is hot water with temperature less than 100°C

⊙ This plant operates with a low boiling point working fluid (Isobutene or Freon) in a thermodynamic closed Rankine cycle.

Component :-

⊙ Heat Exchanger :- Transfer heat from the geothermal water to a secondary fluid with a lower boiling point



Application of Geothermal Energy

- Generation of electric power
- Space heating for building
- Production of salt from sea
- Textile industry

Geothermal Power Plant	Thermal Power plant
• It used inexhaustible sourc of energy	• It used exhaustible source of energy
• It is more environment friendly	• It is less environment friendly
• There power plants in some dangerous cases can caused earthquake	• There is no such problem
• It is mainly used for power generation process	• It can be used for various industrial processes
• Set up cost is high	• Setup cost is low
• Byproduct of there plants are not used	• Byproducts of there plant can be used
• There plant are less flexible	• There plants are more flexible
• Specified area is required	• There have no such restriction

Q With the help of a schematic diagram, explain the operation of closed cycle MHD generating system?

{AKTU 2021-2022, 2023-2024}

Q Illustrate in detail about MHD power generation system. Classify its system with clear flow chart diagram, application and it uses

{AKTU 2022-2023}

Sol MHD stands for Magnetohydrodynamic.

-> Magneto hydro dynamic power generation is a method of producing electricity by using a hot, electrically conductive gas (called plasma) that flows through a magnetic field.

-> This system does not have any moving part like turbines or piston. Instead the movement of the plasma within a magnetic field generates electricity.

-> MHD power generation is based on the Faraday's law of electromagnetic induction

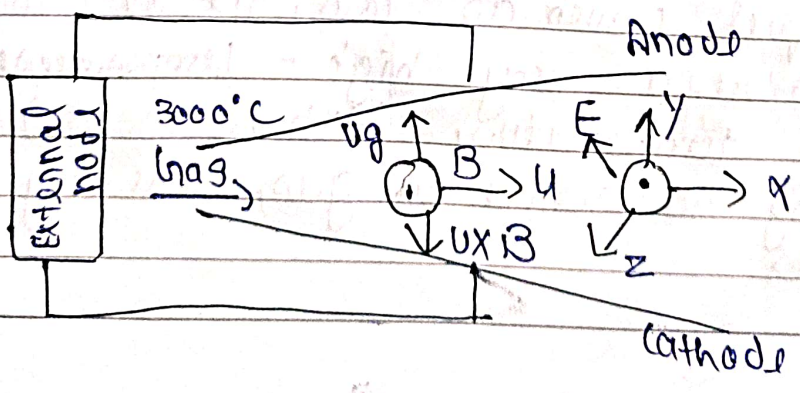
-> MHD system converts the kinetic energy of fast-moving ionized gases into electricity without using moving part

→ The MHD generator should meet the following requirements :-

- The magnet material should have high melting point
- The electrodes are made of SiC or ZrC material to withstand high temperature for preventing the chemical erosion
- To prevent the chemical erosion from hot gases the ceramics are chosen to construct the duct
- The insulation and conduction materials should be able to withstand high temperature around 2500°C

⇒ Working Principle :-

- In MHD power generation conversion process depends upon Faraday's law of electromagnetic induction, which state when a conductor and a magnetic field move relative to each other, a voltage is induced in the conductor.
- This induced voltage produces an electric current



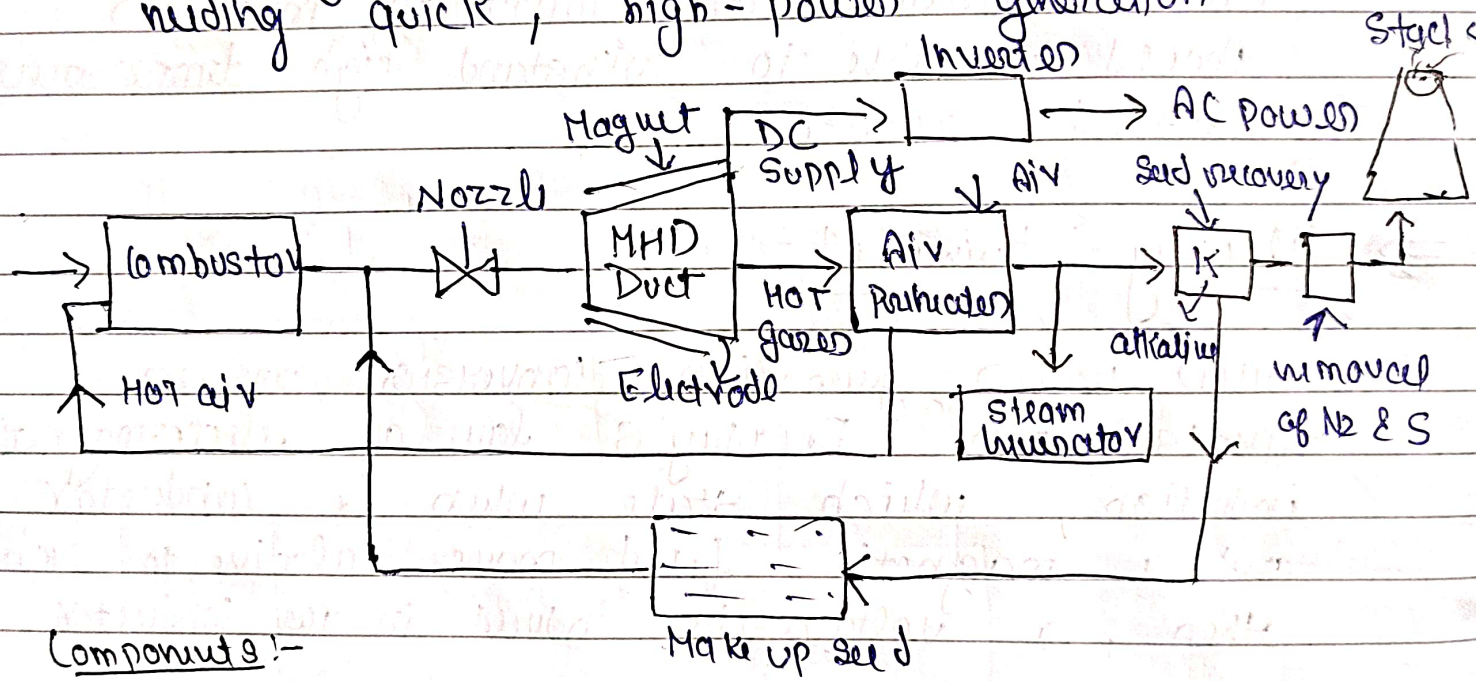
⇒ Classification of Hydrodynamic System :-

a). Open Cycle MHD System :-

Sol In Open-cycle systems, air or combustion gases are used as the working fluid

→ The gas flows through the MHD generator once is then released.

→ These systems are ideal for applications needing quick, high-power generation



Components :-

⊙ Combustion (Fuel Burner) :-

→ Burns fuel (such as coal, oil or natural gas) to produce a very high-temperature gas

→ The high temperature (above 2000°C) are necessary to ionize the gas, creating a conductive plasma

① Seeding Material Injector :-
→ Inject seeding material (usually potassium or cesium salts) into the gas
→ Enhances the electrical conductivity of the gas

② MHD Duct (channel) :-
→ A specially designed duct where the plasma (ionized gas) flow through
→ The duct is positioned b/w magnetic poles allowing the plasma to pass through the magnetic field, where it generates electricity according to Faraday's law

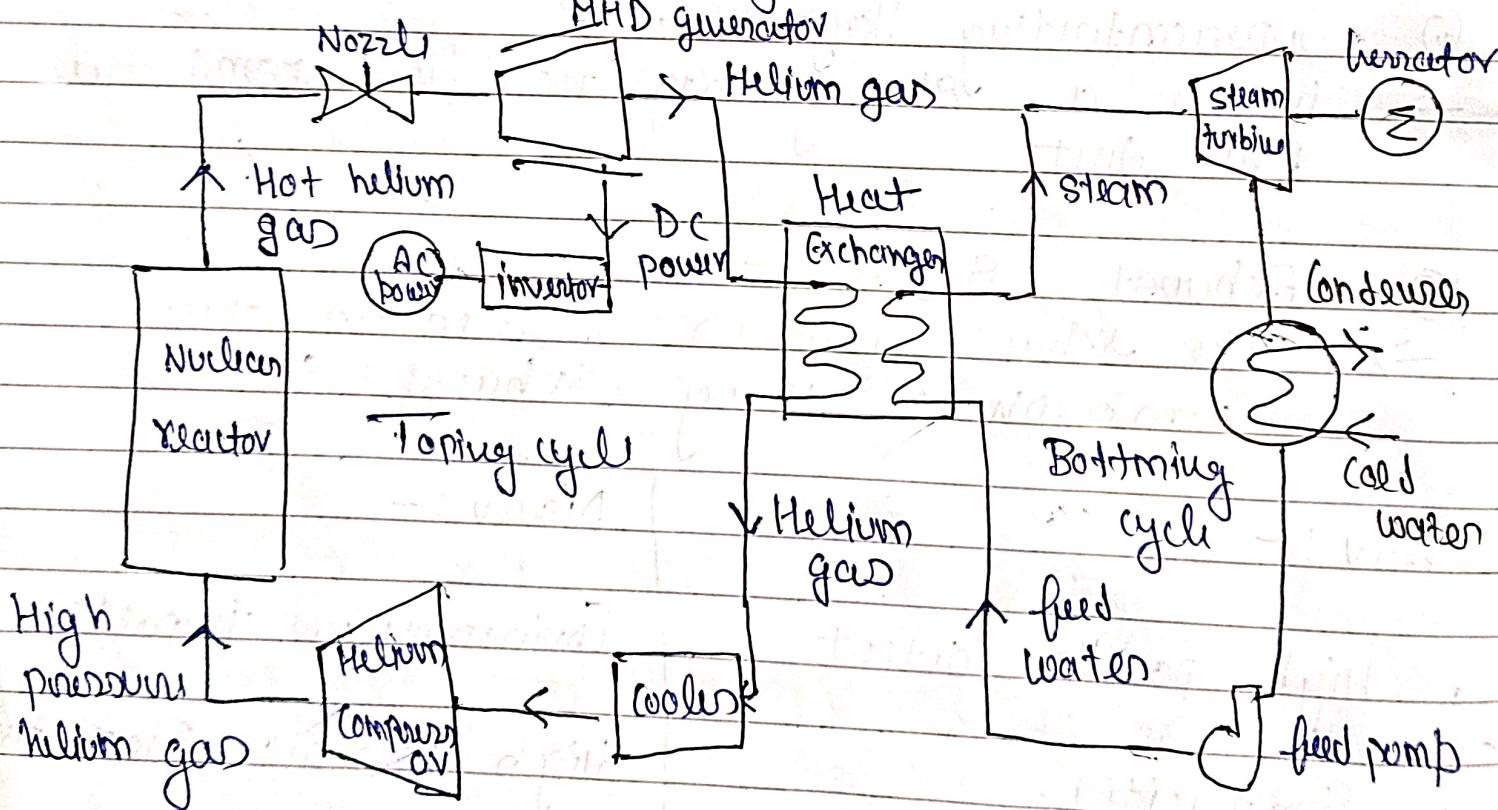
③ Superconducting Magnet :-
→ Create a strong magnetic field around the MHD duct

④ Exhaust System :-
→ The exhausted gas released to the atmosphere using exhaust system

Adv :-	Disadv :-
• High power output	Environmental impact
• Simplicity	High operation Temperature
• Ideal for temporary use	short - Term use

Closed cycle MHD system :-

- A closed cycle MHD can either operate on seeded inert gas (helium or argon) or liquid metal.
- In closed-cycle MHD systems, noble gases like argon are used as the working fluid, and the gas is continously recirculate.
- This make it more eco-friendly and suitable for continous power generation



Working :-

① The hot helium gas is passed through a nozzle to increase its velocity and then supplied to MHD duct to produce DC power. Here some part of the internal energy of the gas is directly converted into DC power.

② In next step, the gas is passed through the heat exchanger (i.e steam generator) to convert feed water into steam. Now this steam is used in a conventional steam power plant to generate electricity.

③ The exhausted helium gas from steam generator is cooled in the cooler and compressed in the compressor. Thereafter it is supplied back to the nuclear reactor and complete cycle is repeated again.

Advantage	Disadvantage
① Environmentally friendly	① Complex setup
② Continous operation	② High initial cost
③ lower maintenance	③ limited fuel options
④ Moderate Temperature	

FUEL CELLS

{AKTU 2022-2023}

① A fuel cell is an electro-chemical device that coverts chemical energy into electricity and heat without combustion.

② The conversion of chemical energy into electrical power in case of fuel cell is an isothermal process

Main Component

1. Anode (Fuel electrode)
2. Cathode (Oxident electrode)
3. Electrolyte.
4. Container
5. Separator
6. Sealing
7. Fuel Supply
8. Oxidant Supply

Working of a Fuel cell

1] Fuel Supply :- Hydrogen gas is supplied to the anode. (+ve side of the fuel cell)

2] Oxygen Supply :- Oxygen from the air is supplied to the cathode (-ve side of the fuel cell)

Chemical reaction :-

- At the anode, hydrogen molecules split into protons (H^+) and electrons (e^-).
- The protons travel through an electrolyte to reach the cathode
- The electrons creates an electrical current as they flow through an external circuit from the anode to the cathode, powering devices or machinery

Water formation :- At the cathode, the protons and electrons recombine oxygen to form water, remove from the container

At Anod

$$2H_2(g) \longrightarrow 4e^- + 4H^+$$
$$4H^+ + 4OH^- = 4H_2O$$
$$2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$$

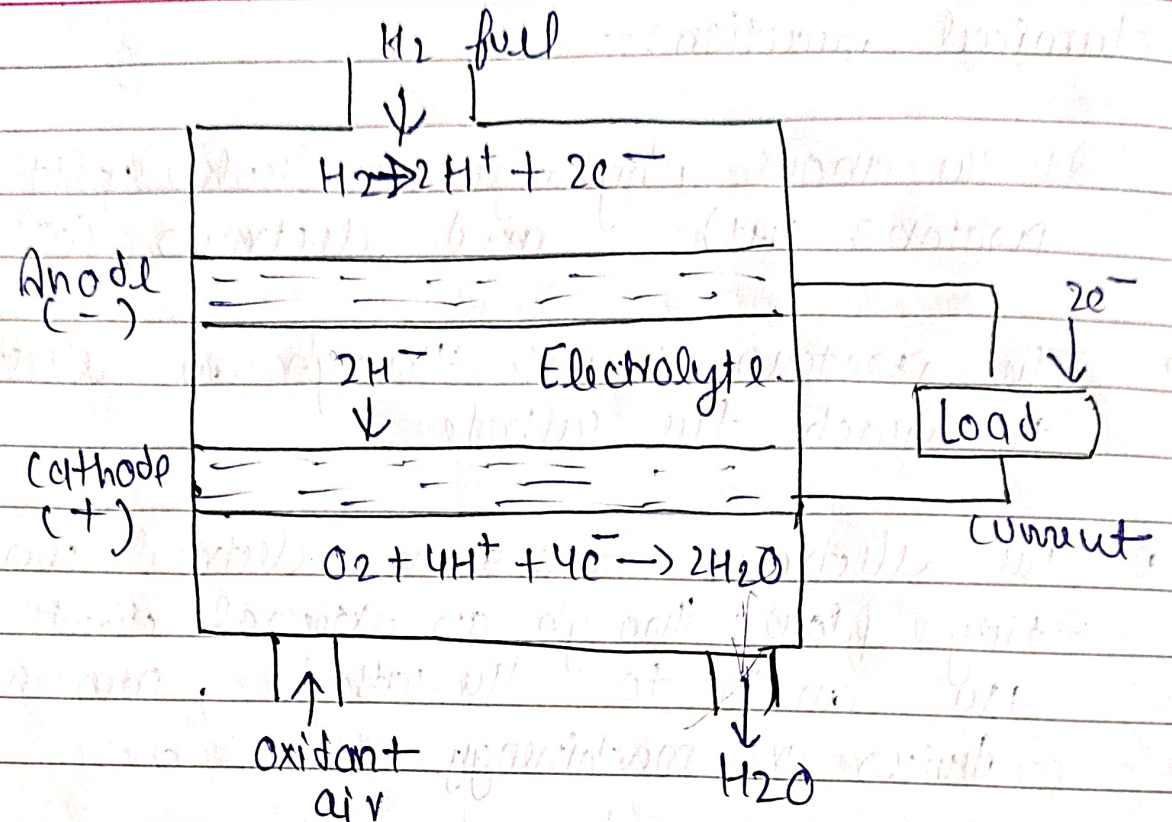
At Cathode

~~$O_2 + 4e^- + H_2O \rightarrow 4OH^-$~~

$$O_2 + 4e^- + 2H_2O \longrightarrow 4OH^-$$

Overall reaction

$$2H_2 + O_2 \longrightarrow 2H_2O$$



Types :-

1. PEM (The Polymer Electrolyte Membrane) Fuel cell
→ Also known as proton exchange membrane fuel cells, these cells are (PEMFCs).
→ The temperature range → 50°C to 100°C
→ Pure hydrogen fuel is used
→ Efficiency → 40 — 60%.
→ Application used in vehicles, backup power system

2. AFC (Alkaline Fuel cell)
→ Alkaline solution, typically potassium hydroxide.
→ The temperature → 70°C - 100°C
→ Hydrogen or other hydrocarbon fuels
→ Efficiency → 60 - 70%
→ Application used in spacecrafts

3 PAFC (Phosphoric Acid fuel cells)
→ Liquid phosphoric Acid
→ Temperature → 150°C – 200°C
→ Hydrogen fuel is used
→ Efficiency → 40 – 50%
→ Application :- used in stationary power generation

4. Molten Carbonate Fuel cell (MCFC)
→ Molten Carbonate Salt mixture
→ Temperature — 600 – 700°C
→ Hydrogen, methane and Natural gas, fuel is use
→ Efficiency 45 – 60%
→ Application :- used for large-scale power generation

5. Solid Oxide Fuel cell (SOFC)
→ ceramic material, usually zirconium oxide.
→ Temperature — 700 – 1000°C
→ Hydrogen, Carbon-monoxide, natural gas
→ Efficiency Around 50 – 60%
→ Applications :- large power generation plan

Adv :-
- Clean Energy Production
- High Efficiency
- Quiet Operation
- Scalability

Disadv :-
- High cost
- Hydrogen storage and safety
- Limited operating temperature

Application :-

→ It is used in automotive vehicles
→ It is used in domestic power unit
→ It is used in Untral power station
→ It is used in military and aerospace.

Fuel cell	Battery
• The fuel cell is a primary cell and cannot be recharged but can be refueled	• The battery is rechargeable
• The fuel and oxidizer do not mix together	• Fuel and oxidizer are not used seperately
• Fuel and oxidizer need continous replacement as per requirment	• Battery stores fixed charges of chemical, used up during reaction
• It produces electricity continously as long as fuel oxidizer is supplied	• Battery stores energy

UNIT-3 COMPLETED

THANK YOU FOR WATCHING

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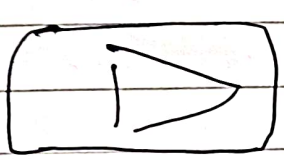

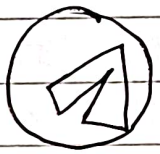

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UNIT-4 (SUB - KOE 074)

RENEWABLE ENERGY RESOURCES

ONE - SHOT

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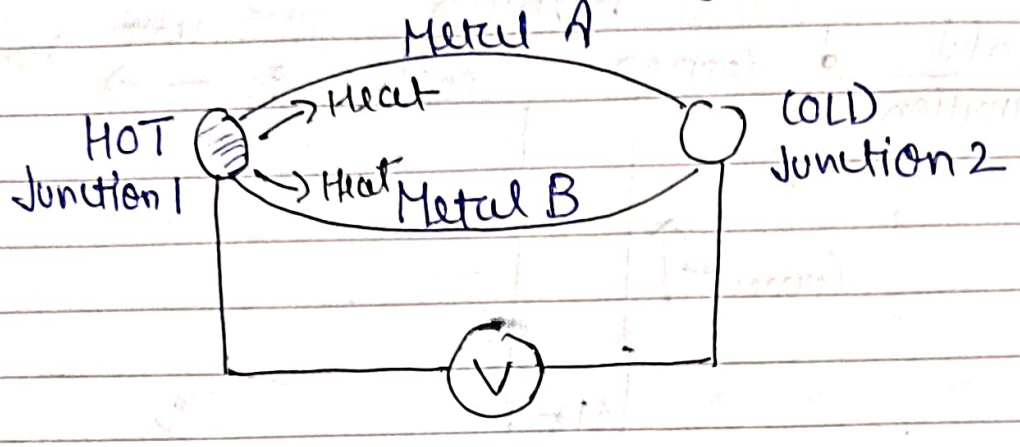
=> Topics :-

- Types of Effect
- ThermoElectric Generator
- Thermionic Generator
- Wind & caused of wind
- Wind Energy Conversion System
- Types of WECS
- limitation of WECs

⇒ SEEBECK EFFECT:-

⇒ The Seebeck effect is all about turning heat into electricity using the temperature difference between two points.

⇒ When two different types of metals or semiconductor are connected at two different points, and these points are kept at difference temperature, an electric current is generated.



$$E = \alpha_S \Delta T$$

ΔT = Difference between hot and cold Jnctn

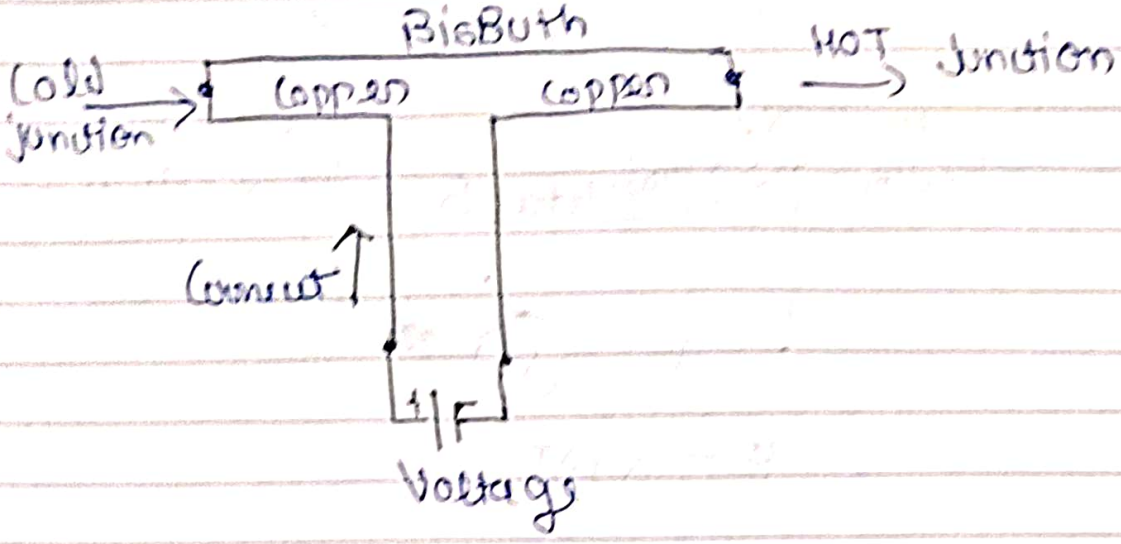
α_S = Seebeck coefficient

⇒ PELTIER EFFECT

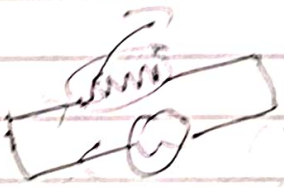
- The Peltier effect cooling or heating by simply passing an electric current

→ It is opposite of the Seebeck effect. Instead of generating electricity from heat, the peltier effect uses electricity to create a temperature difference.

→ When an electric current passed through a circuit made of two different materials (metals or semiconductors), heat is either absorbed or released at the junction where the two materials meet

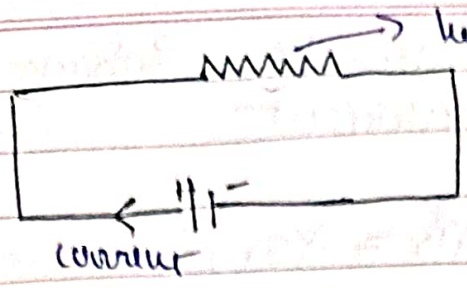


JOULE EFFECT :-



When electricity flow through a conductor (like a wire), the electrons collide with the atoms in the material.

→ These collision generate heat



$Q = I^2Rt$

The heat generated can be calculated using

$$\boxed{Q = I^2Rt}$$

THOMSON EFFECT :-

① It state that any current carrying conductor with a temperature difference between two points will either absorb or emit heat, depending upon the material.

Mathematically :-

$$\sigma = I \frac{dq_T/dx}{dT/dx}.$$

where σ = Thomson coefficient

$\frac{dq_T/dx}{dT/dx}$ = Heat interchange per unit time/length / Temperature gradient

I = current

⇒ Relationships between the Seebeck coefficient and Peltier coefficient

$$\alpha_p = \alpha_s \cdot T$$

or

$$\alpha_{p1,2} = \alpha_{1,2} T$$

⇒ Relationships between the Seebeck coefficient and Thomson coefficient

$$\sigma = T \frac{d\alpha_s}{dT}$$

or

$$\sigma_{1,2} = T \frac{d\alpha_{s1,2}}{dT}$$

THERMOELECTRICAL GENERATOR

⊙ A Thermoelectric Generator is a device that convert heat energy into electricity using the Seebeck effect

Principle:-

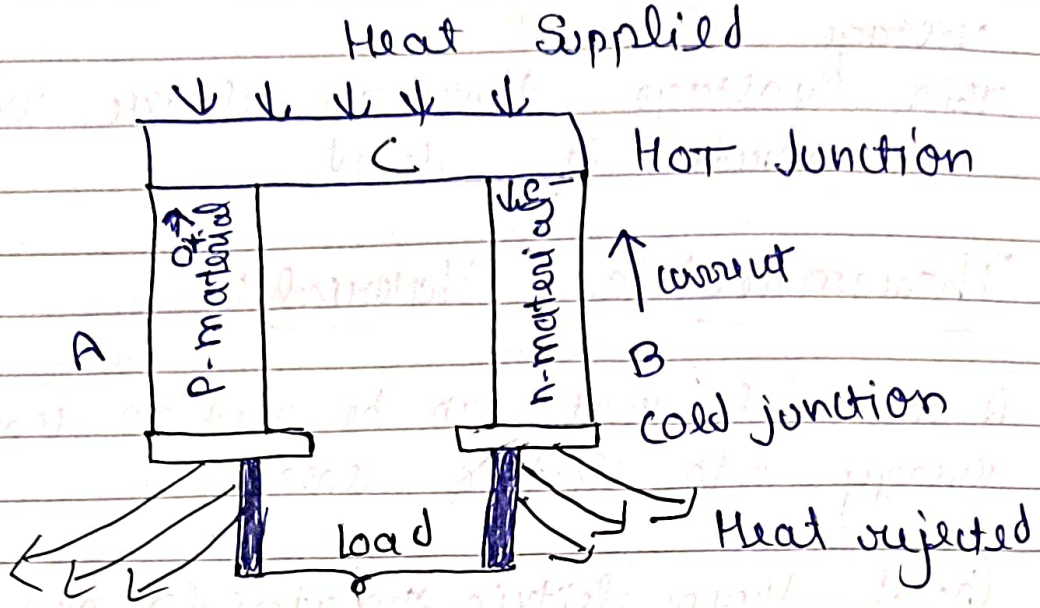
→ The Seebeck effect is the principle behind TEGs

→ The heat at the hot side gives energy

to electrons (or charge carriers), making them flow toward the cooler side.

- The movement of electrons generate a voltage, which can power devices

Construction



-> It consist of two different semiconductors (usually one n-type and one p-type material)

-> A potentiometer to measure the induced voltage.

Working :—

-> The temperature difference between the hot and cold sides create a temperature gradient.

-> Electrons in the n-type material and holes in the p-type material get energized by the heat

- Energized electrons in the n-type material move toward the cold side.
- Energized holes in the p-type material move in the opposite direction toward the cold side.
- The movement of electrons and holes creates a voltage difference.
- This voltage drives an electric current when the circuit is closed.

⇒ Thermoelectric Material :-

→ A material that can be used to convert thermal energy into electric energy.

→ Good thermoelectric materials possess :-

1. large Seabeck coefficient
2. High electrical conductivity
3. low thermal conductivity

Example :- lead telluride (PbTe)
Silicon germanium (SiGe)
Bismuth antimony (BiSb)

Advantages :-

1. No moving parts
2. Durable and long-lasting
3. Environmentaly friendly
4. Compact and lightweight
5. Scalable
6. Operates in extreme conditions

Disadvantages

1 low Efficiency
2 Expensive materials
3 limited power output
4 Dependence on temperature difference
5 Heat dissipation issues

Applications :-

1. Waste heat recovery
2. Space exploration
3. Remote power supply
4. Consumer electronics
5. Automobiles
6. Military and defenses

THERMIONIC GENERATOR

-> A Thermionic Generator is a device that convert heat directly into electricity using the flow of electrons between two electrodes

=> Principle :-

- A thermionic converter (or generator) converts heat energy directly into electrical energy by utilizing thermionic emission effect

=> When a metal or material is heated to a very high temperature, it emits electrons. This happens because the heat gives the electrons enough energy to escape the value or surface of the material.

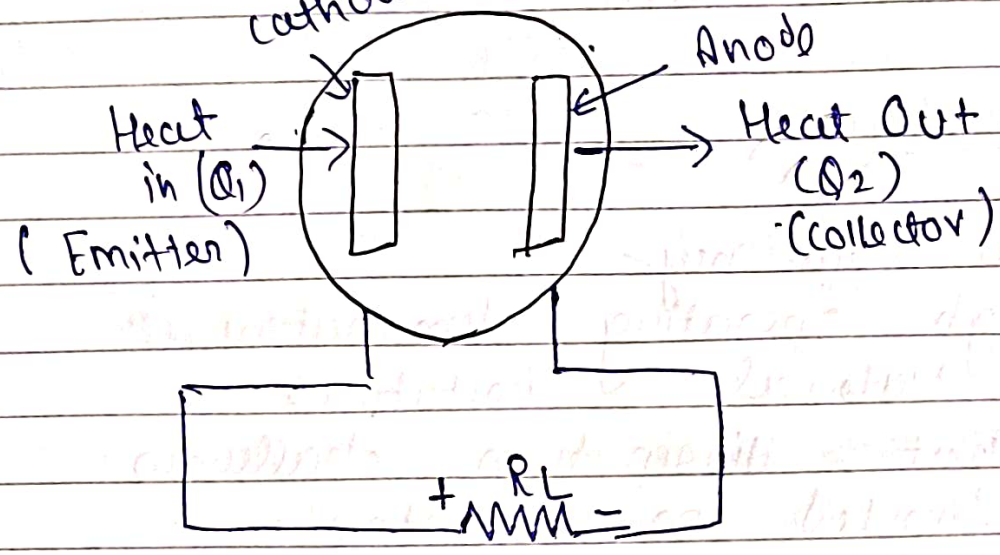
=> Work function :-

-> It is defined as the energy required to extract an electron from the metal.

-> The value of work function varies with the nature of metal and surface conditions

Construction

- The emitter and collector are placed parallel to each other with a small gap.
- A vaccum chamber or low-pressure gas surrounds the emitter and collector to reduce resistance.
- Heat is supplied to the emitter, and the collector is connected to a cooling system.
- The electrical circuit is connected across the emitter and collector to extract the generated electricity.



Working :-

- Heat is applied to the emitter (hot electrode), causing it to emit electrons.
- These electrons travel through a vaccum or low-pressure gas toward the collector (cold electrode)

- The collector absorb the electrons, creating a potential difference (voltage) between the two electrode.

- This voltage drives a current through an external circuit, generating electricity.

Advantage :-

1. Direct Energy conversion
2. Durable and reliable
3. Compact design
4. High temperature Operation
5. Environment Friendly

Disadvantage :-

1. low efficiency
2. High operating temperature
3. Material limitations
4. Heat dissipation challenges
5. Limited power output

Application of Thermionic Generator

1 Space Technology
2 Nuclear power plant
3 Waste heat recovery
4 Remote power systems

Feature	Thermionic Generator	Thermoelectric Generator
Working Principle	Uses thermionic emission	Uses the Seebeck Effect
Temperature Requirement	Requires very high temperature (above 1000°C)	Work with moderate temperature (200°C or more)
Efficiency	Higher Efficiency (10-20%)	lower Efficiency (5-8%)
Material Used	Metal like tungsten and coatings like cesium	Semiconductor like bismuth telluride.
Complexity	Requires a vaccum chamber or low-pressure gas system	Simple, solid-state design with no-special condition used
Cost	Expensive	cheaper
Application	Spacecraft, nuclear power plant, Industrial.	Waste heat recovery, automobile, wearable devices
Durability	less Durable	Extreme Durable
Power output	High Power Output	low Power Output

Q What is the basic difference between thermoelectric and thermionic conversion system & also explain its working (thermoelectric generator) {AKTU 2021-2022}

Sol Done Already (Previous Section)

Q Start Thermo-electrical conversion towards field. Discuss in detail about performance and limitations of thermoelectric power generator. {AKTU 2022-2023}

Sol This technology has promising application across various fields due to its ability to harness wasted heat and provide sustainable power in various settings

-> Industrial Waste Heat Recovery
-> Automative Industry
-> Space Exploration
-> Wearable devices and Consumer Electronics
-> Remote and Off-Grid Power Supply
-> Military and Defense

Performance of Thermoelectric Power Generation (TEGs) :-

1. Efficiency :- TEG's convert heat to electricity, but their efficiency is relatively low, usually between 5-8%.

2. Power Output :- TEG's generally produces small (low power), suitable for small applications like sensors

3. Materials :- The performance is determined by the choice of thermoelectric material like bismuth telluride

4. Temperature Gradient :- A large temperature differences (ideally 500-600°C) between the hot and cold sides of the TEG is needed for better performance

5. Durability :- TEG's are long-lasting

6. Cost :- The cost of materials and system integration can be high.

WIND

① Wind is moving air in the atmosphere.
① It happens because air moves from high-pressure areas to low-pressure areas.
① Wind helps in shaping weather, carrying moisture and even generating electricity.

Causes Of Wind

1. Uneven Heating by the Sun :-
→ The sun heats the Earth unevenly (land and water heat at different rates).
→ This causes temperature differences.

2. Pressure Differences :-
→ Warm air rises, creating a low-pressure area
→ Cool air sinks, creating a high-pressure area
→ Air moves between these areas, forming wind.

3. Earth's Rotation :-
→ The Earth's rotation makes wind change direction
→ Wind curve right —— Northern hemisphere
→ Wind curve left —— Southern hemisphere.

4. Seasons :-
→ Seasonal changes like monsoons, create big wind Pattern due to temperature differences

Q. Explain the factor take for site selection in the wind farm. What are the advantage of wind energy conversion system ?
[AKTU 2023-24]

Sol Factors for Wind Farm Site Selection :-

⊙ Open Area :- choose an open area because wind flow faster and more freely without obstacles like buildings or trees.

⊙ Average wind Speed :- Select the location by checking average wind speed data for consistent performance.

⊙ Year-Round Wind :- Ensure the site has minimum winds speed available throughout the year for steady energy generation

⊙ Stable Ground :- The ground should be stable with strong soil to support heavy wind turbines and towers

⊙ Near Consumers :- Place the wind farm close to power consumer to reduce energy transmission losses

⊙ Away from cities :- Keep the site at least 5km away from cities to minimize noise pollution affecting people

⊙ Low land cost :- Select land with low cost to make the project economically viable.

⊙ Approach Roads :- Ensure there are roads leading to the site for easy transportation of material and maintenance equipment

⊙ Height of Towers :- If trees are present, use taller towers to capture higher wind speed above tree height

Advantages :-

① Renewable Energy Source.
② Low Operating costs.
③ Reduces Greenhouse Gas Emissions.
④ Scalable Technology
⑤ Energy Independence
⑥ Job creation
⑦ Dual land use
⑧ long lifespan

Disadvantage :-

① Intermittent Nature
② High hitial cost
③ Noise pollution
④ Impact on Wildlife
⑤ Space Requirement
⑥ Transmission loss

Application :-

- Electricity Generation
- Remote Power Supply
- Water Pumping
- Desalination
- Battery charging
- Industrial application

Principle of Power Generation in Wind Mills :-

① The basic principle of wind energy is to convert the kinetic energy of wind into rotational motion to operate an electric generator

Q What is the principle of Energy Conversion (wind)? What methods are used to overcome the fluctuating power generation of windmills? [AKTU 2021-2022]

Sol Principle of Wind Energy Conversion

1. The principle of wind Energy conversion is based on aerodynamic and energy transformation.

→ Kinetic Energy of wind:- Wind contains kinetic energy due to its motion

→ Mechanical Energy :- The wind's kinetic energy rotates the turbines blades, converting it into mechanical energy

→ Electrical Energy :- The mechanical energy is then converted into electrical energy using a generator

The conversion follow Betz's law, which state that no wind turbine can capture more than 59.3% of the wind

Method to overcome Fluctuating Power Generation

1. Wind Energy is variable because wind speed and direction are not constant. To address this following methods are used :-

→ Batteries :- Store excess power during high winds for use during low wind periods

→ Pumped Hydro Storage :- Pump water to higher elevation using excess energy, generate electricity when the water flows back down

→ Fly Wheels :- Store kinetic energy to stabilize short-term power fluctuations

→ Grid Integration :- Connect wind farms to the grid to balance fluctuation by pooling energy from multiple sources

→ Advanced Control System :- Use real-time monitoring and algorithm to optimize turbine performance and power output.

→ Backup Generators :- Use conventional power sources (like gas or diesel) as backups during low wind periods

→ The various mechanical controls provided with the wind machine are as follows :-

⊙ Yaw Control :- Adjusts turbine orientation to face the wind.

→ This ensures that the turbines captures maximum wind energy

⊙ Pitch Control :- Changes blade angles to regulate wind capture and prevent damage in high winds

→ light wind → higher angle, high wind → lower angle

⊙ Braking Systems :-

. Stops or slows down the turbine in case of extreme weather conditions or maintenance needs

⊙ Overspeed Protection :- Prevents the turbine from rotating too fast and getting damaged.
→ By adjusting the pitch of the blade.

⊙ Gearbox Protection :- The gearbox in wind turbines helps convert the slow rotational speed of the blades into a higher speed suitable for the generator

---

⇒ Types Of Wind Energy Conversion System

⇒ There are two main types of Wind Energy conversion systems (WECS) based on the design of the turbine.

1. Horizontal Axis Wind Turbines (HAWT)
→ The axis of rotation is horizontal, meaning the blades spin around a horizontal shaft
→ HAWT are the most widely used type of wind turbine around the world.
→ They are highly efficient and perform best in areas with high and consistent wind speeds.
→ Used in large-scale wind farms both onshore and offshore.

Component of the HAWT

① Rotor Blades
→ Large, aerodynamic blade that catch the wind
→ convert wind's kinetic energy into mechanical energy by causing the rotor to spin

② Hub
→ Central part where the blades are attached
→ Connects the beads to the main shaft and allow the rotor to rotate

③ Naculle
→ Enclosed casing at the top of the tower containing mechanical and electrical components
→ Houses the gearbox, generator, yaw mechanism, and brake system, to convert M.E to E.E

④ Gearbox
→ Converts mechanical energy from the rotating rotor into electrical energy.

⑤ Tower
→ The tall structure that support the naculle and rotor.
→ Elevates the turbines to a height where winds speed are stronger and more consistent.

⑤ Yaw Mechanism :-

→ Allows the nacelle and rotor to rotate to face the wind direction
→ Ensures the turbine to a height where wind speeds are stronger and more consistent.
→ Ensures the turbine is always aligned with the wind for maximum energy capture

⑥ Control System :-

→ Monitors and adjusts the turbine's performance
→ Manage setting like blade pitch and rotor speed to optimize energy generation

⑦ Break System :-

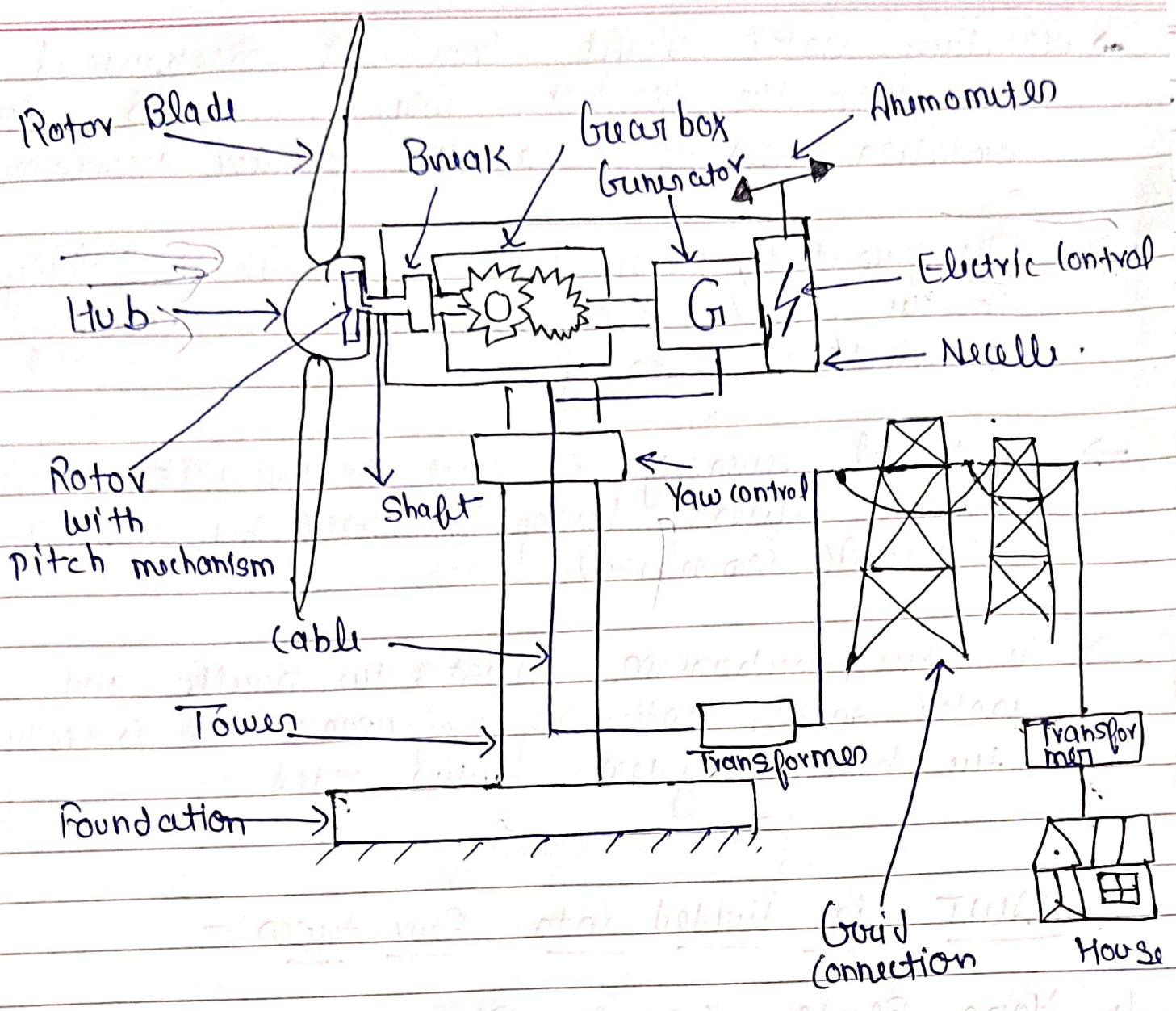
→ It is used to slow or stop the rotor when needed
→ Stops the turbine during high winds or maintenance.

⑧ Electrical System :-

→ Included component like transformer and inverter

⑨ Anemometer :-

→ Device that measures winds speed and direction



⇒ Working :-

⊙ Winds blows across the rotor blades, which are aerodynamically designed to efficiently capture the wind and convert its kinetic energy into mechanical energy.

⊙ The hub connects the blades to the main rotor shaft, causing the entire rotor to spin as the blades, rotate

→ rotating rotor shaft transmits mechanical energy to the gearbox, which increases the rotation speed to match the generator requirements

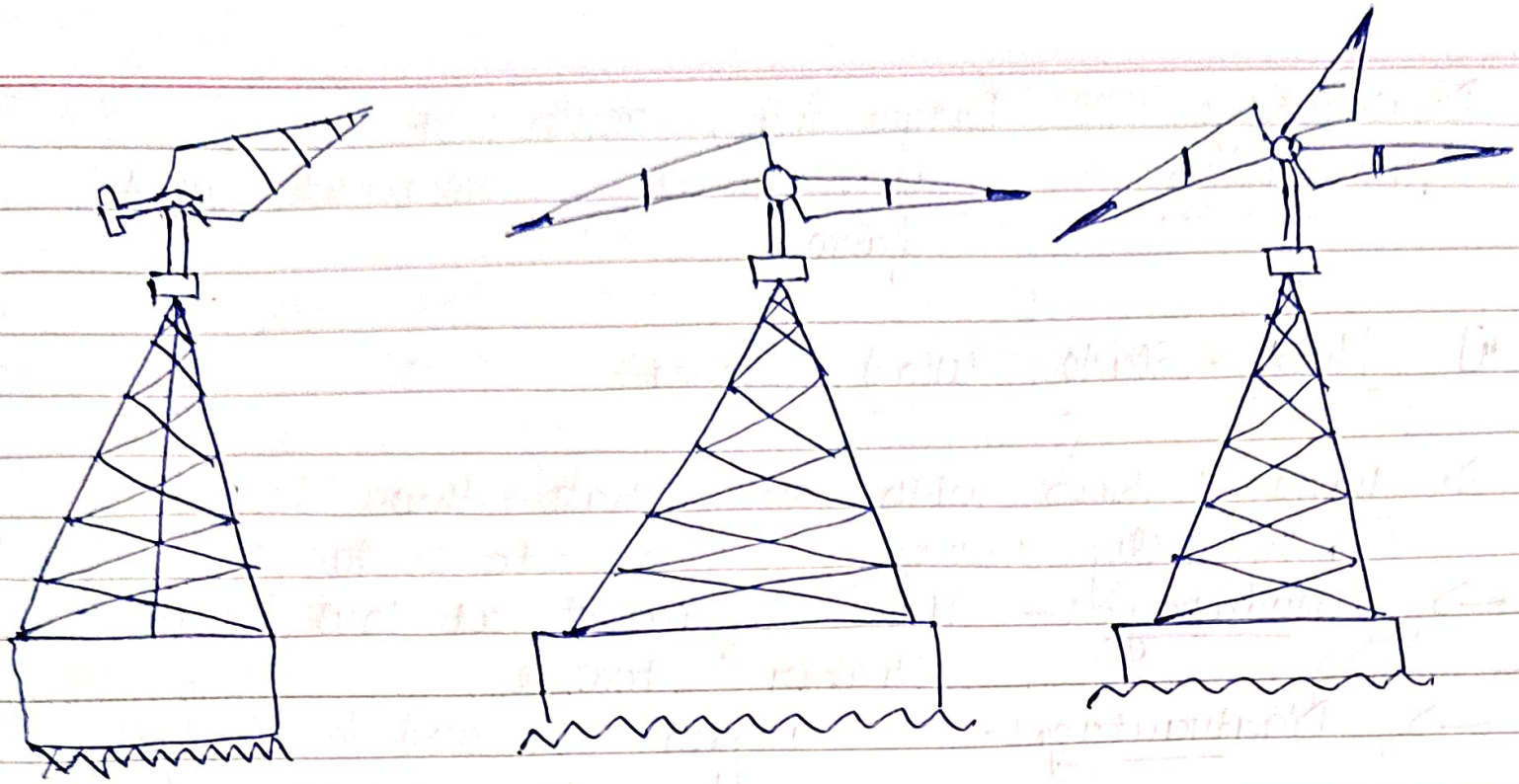
→ The generator, connected to the gearbox or directly to the rotor, converts mechanical energy to electrical energy

→ Electrical energy is sent to the grid or stored after being processed by inverters (DC to AC conversion).

→ The Yaw mechanism adjusts the nacelle and rotor speed, optimizing performance and controlling the brake system when needed

⇒ HAWT is divided into Four types!-

1. Mono Blade (Single Blade Wind Turbine)
→ A wind Turbine with only one blade attached to the rotor
→ Adv!- Simple Design, cost-Effective.
→ Disadvantage!- Stability issues, less Efficiency
→ Applications!- Used in small, experimental turbines
→ Power ⟶ 15KW to 50KW



Mono-blade Twin-blade Three-blade

ii] Twin-Blade :-

→ A wind turbine with two blades attached to the rotor

→ Power — 1 to 3MW

→ Advantage :- Compact Design, More Efficiency. Lowest cost,

→ Disadvantage :- less Stability, Noise and Vibration

→ Applications — Smaller wind turbines

iii] Three-Blade :-

→ A wind turbine with three blades attached to the rotor

→ Power — 15KW → 3MW units

→ Advantage :- Balanced and Stable, High Efficiency, less Vibration Widely used

Disadvantage!- Larger size, Higher cost

Application!- large-scale commercial wind farms

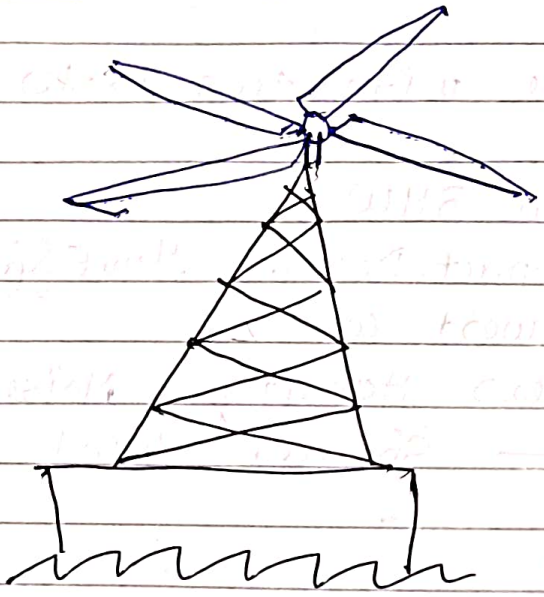
4] Multi-Blade Wind Turbine

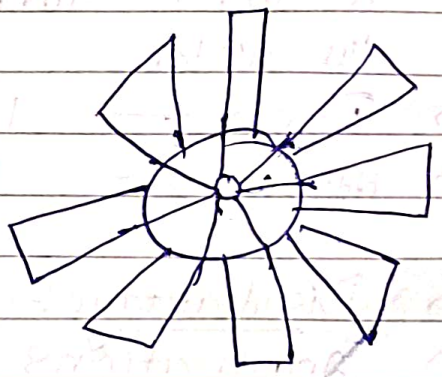
-> Wind turbines with more than three blades, typically ranging from 4 to 12 blades

-> Advantage!- More efficient at low winds
Higher torque.

-> Disadvantage!- Higher cost and complexity
Increased weight
More Mechanical wear

-> Application!- Small scale or older turbines





Multi blade

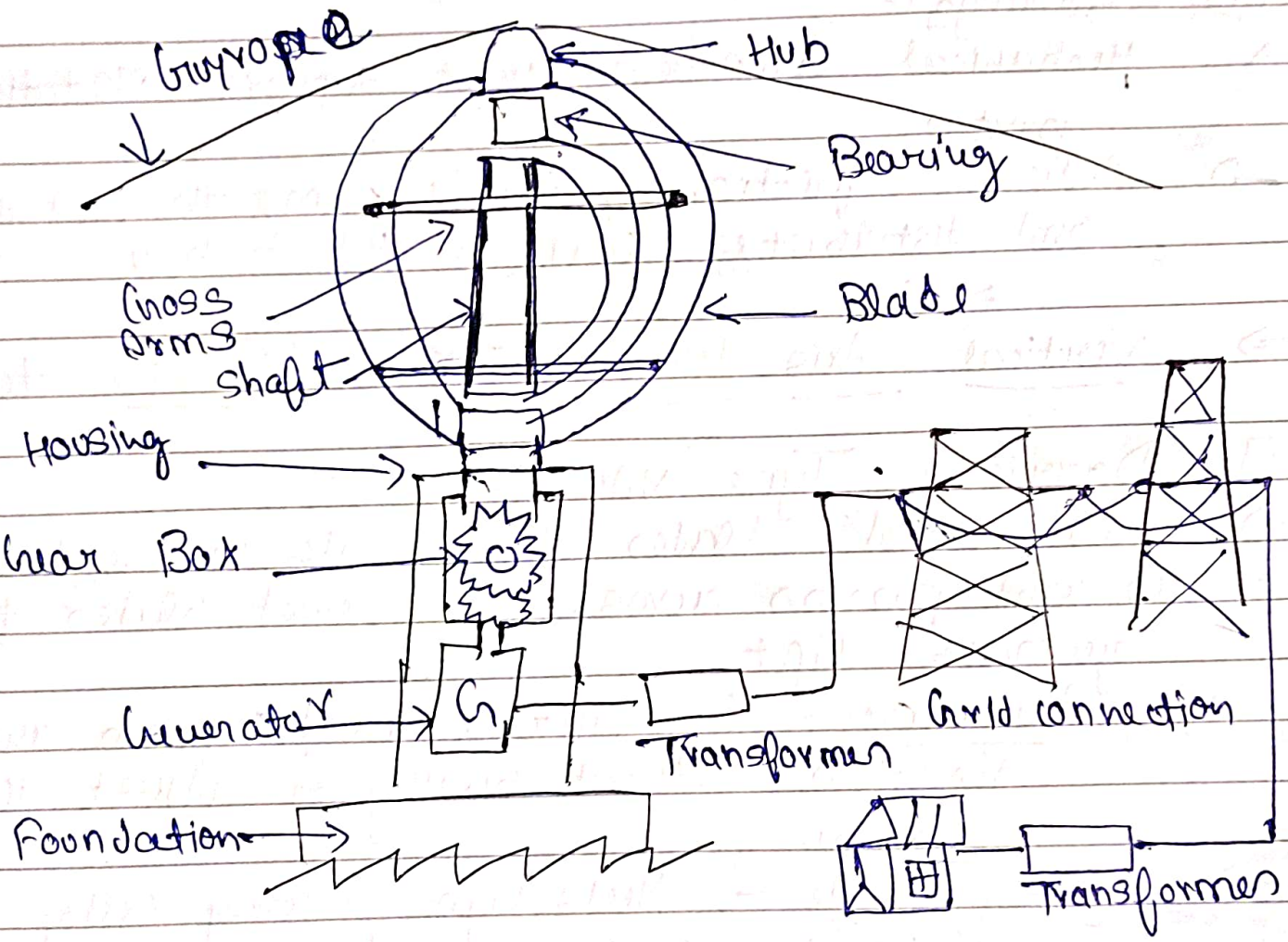
2] Vertical Axis Wind Turbines (VAWT)

-> The axis of rotation is vertical, so the blades spin around a vertical shaft.

-> VAWT do not require a yaw mechanism to face the wind, making them simpler to design and maintain

-> VAWT are generally less efficient than HAWT's

=> Components :-



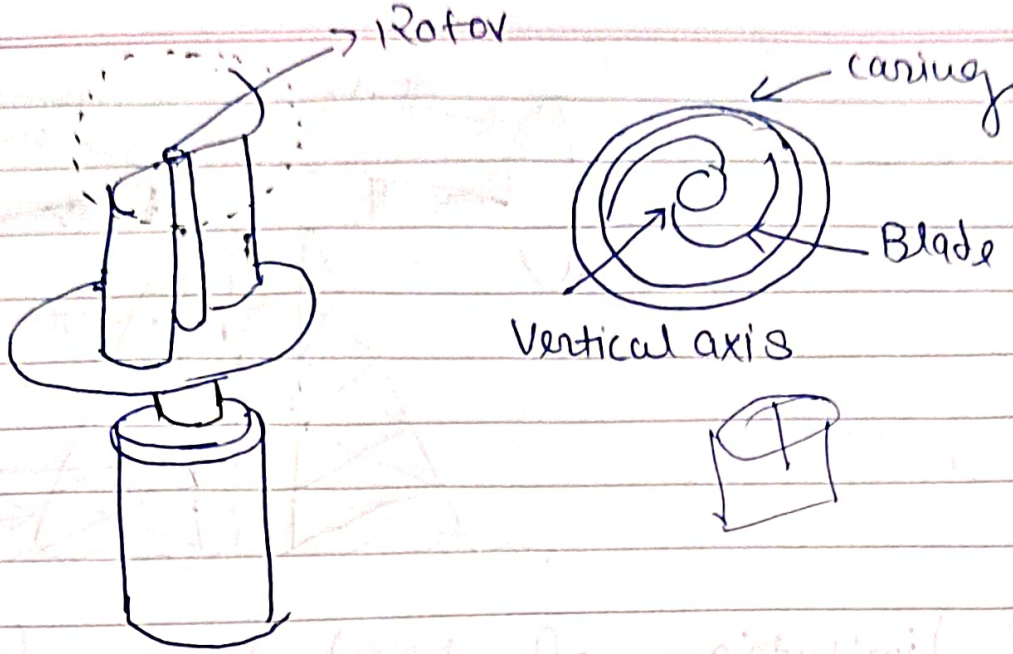
⑥ Cross Arms :-
→ Structural component that hold the rotor blades
→ provide stability, support blades, and distribute fore from the rotor blades

⑦ Gyroscope :-
→ A device that measures or maintains orientation
→ Helps stablize the turbine, assist with yaw control and detect shift in rotation

⑧ Bearings :-
→ Mechanical component that support rotating parts.
→ Reduce friction, enable smooth rotation and distribute loads in the turbine

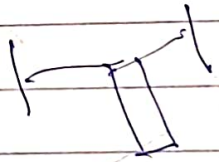
⇒ Vertical Axis Wind Turbines (VAWT) types

1] Darrieus Type VAWT :-
→ Has curved blades shaped like an eggbeater
→ The wind passes across the curved blades to generate lift
→ Advantage :- Can capture wind from any direction without needing to adjust the turbine.
→ Disadvantage :- Needs high starting speeds, less efficient at low winds

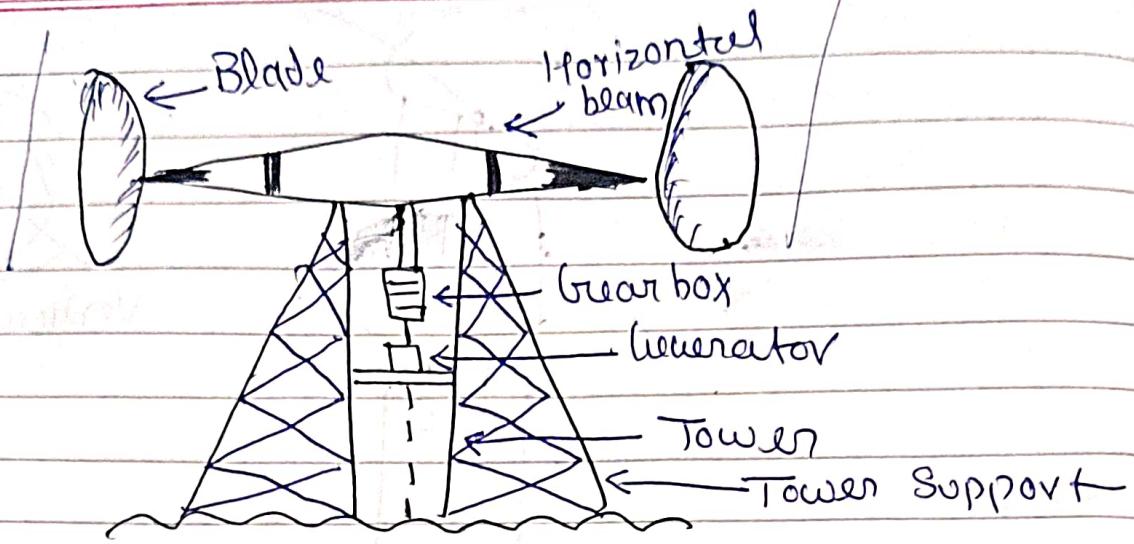


Savonius Wind turbine

2] Savonius Type VAWT
→ uses scooped blades to catch wind, similar to a waterwheel
→ The scooped blades create drag to generate power
→ Advantage!- Simple design, works well in low wind conditions and self-starting
→ Disadvantage!- less Efficient



3] H- Darrieus Type
→ A hybrid of the Darrieus with straight blades, resembling the letter 'H'.
→ Uses vertical straight blades that can better withstand high winds.
→ Advantage!- Improved stability
→ Disadvantage!- require high starting speed



Limitation of Wind Energy Conversion

1. Intermittent Nature
2. High Initial cost
3. Land and Space Requirement
4. Noise Pollution
5. Visual Impact
6. Impact on wildlife
7. Transmission losses
8. Dependency on wind speed
9. Grid Integration issues

UNIT-4 COMPLETED

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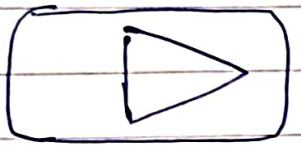
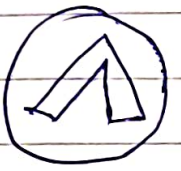




UNIT - 5 (SUB-CODE - KOE-074)

RENEWABLE ENERGY RESOURCES

ONE-SHOT @MULTIATOMS

Topics :-

- Biomass
- Availability, Energy Conversion from biomass. {AKTU 2021-2022}
- DESHBANDHU Biogas Plant
- Classification, Composition {AKTU 2021-2022}
- OTEC {AKTU 2021-2022, 2022-2023, 2023-2024}
- Tidal Power Plant

BIOMASS

⇒ Biomass is any organic material that comes from plant and animal, or their waste, which can be used as a source of energy.

⇒ It includes thing like wood, crops, food scraps, and animal manure

⇒ Biomass can be burned directly for heat or converted to liquid and gaseous fuel through various process

$$6CO_2 + 6H_2O \xrightarrow[\text{photosynthesis}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

⇒ Biomass does not add CO_2 to the atmosphere as it absorbs the same amount of carbon in growing the plant as it releases when consumed as fuel

Q Explain availability, conversion theory of biogas plant and energy conversion from biomass.

Sol Availability of Biomass for Biogas Production :-

- Biomass is widely available from various sources such as:
- Agricultural waste :- Crop residues, husk and straw
- Animal waste :- Manure from cattle, poultry and pigs
- Organic household waste :- Food scraps and kitchen waste
- Industrial Waste :- Waste from food processing industries

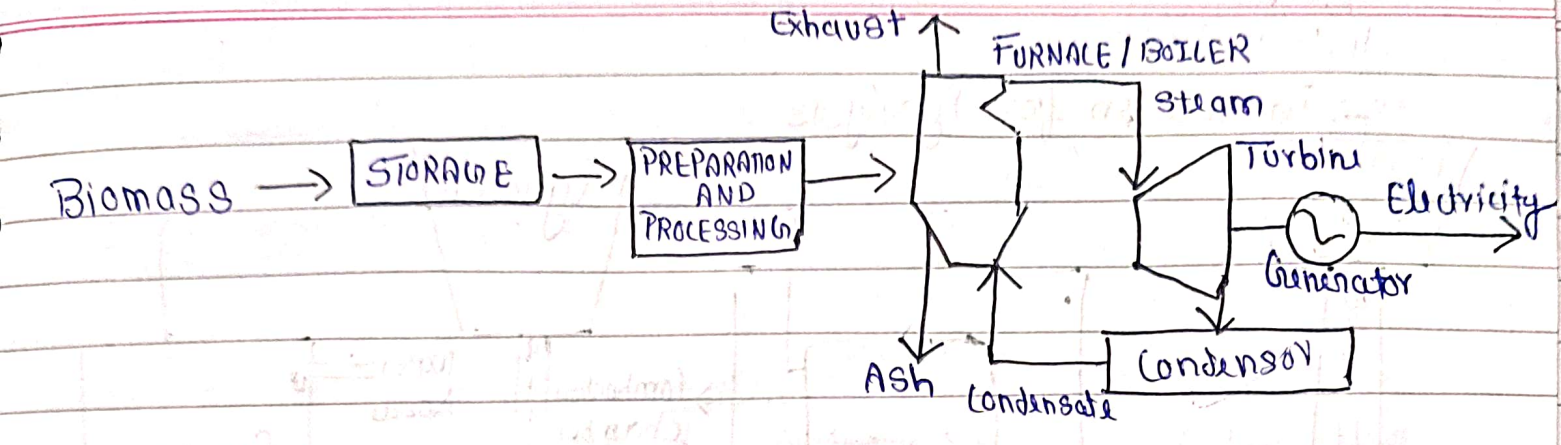
- Availability depends on factor like :—
- Location :- Rural area often have better access to agricultural and animal waste
- Seasonality :- Agricultural residues are more abundant after harvest seasons.
- Population density :- Urban areas produce more organic waste.

Biomass Conversion :—

The following processes are used for the biomass conversion to energy or to biofuels :

a). Direct Combustion :-

- Direct combustion is the simplest and most common method of converting biomass into energy.
- It involves burning organic materials like wood, crop residues, or animal waste to produce heat, which can be used for various purpose.
- In the pyrolysis process, the organic material is converted to gases, solids and liquids by heating to 500°C to 900°C in the absence of oxygen



Direct Combustion

b) Thermochemical Conversion :-

- Thermochemical conversion refers to the process of using heat to convert biomass to energy rich product like syngas, bio-oil or charcoal.

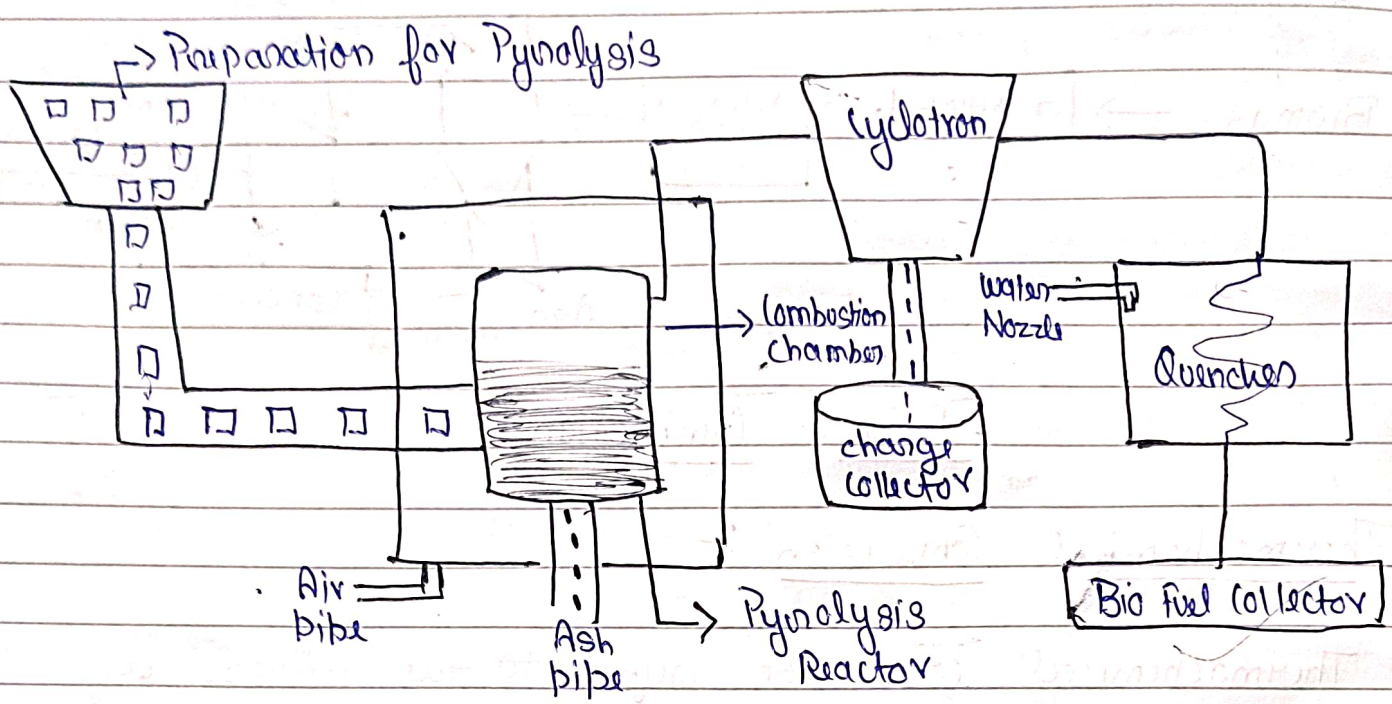
- Thermochemical conversion takes two forms :
  - -> Gasification.
  - -> Liquefaction.

- Gassification :-

-> Biomass is heated in a controlled, low-oxygen environment to produce syngas (a mixture of carbon monoxide, hydrogen and methane)

- Liquefaction :-

-> Biomass is processed at moderate temperature and high pressure in a liquid medium to produce liquid fuel (bio-crude)



③ Biochemical Conversion

In biochemical conversion there are two principal conversion processes:

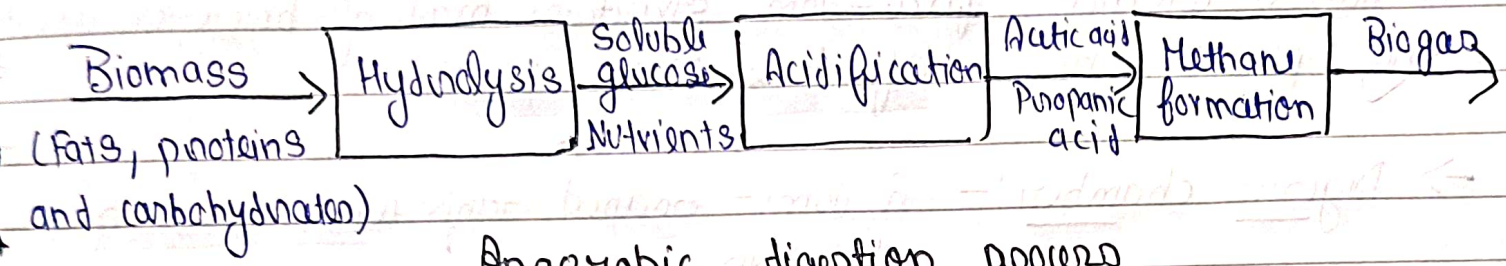
1) Anaerobic digestion
2) Fermentation

⇒ **Anaerobic Digestion:-** [AKTU 2022-2023]

① **Process:-** Microorganisms break down organic material in the absence of oxygen to produce biogas (a mixture of methane and (O_2).

① **Products:-** **Biogas:** Used for cooking, heating, or electricity generation.

- Digestate: A nutrient-rich by-product used as fertilizer
- Applications:- Biogas plants for rural and urban waste management



Anaerobic digestion process

⇒ Fermentation:-

- Process: Microorganism (e.g yeast) convert sugar and starches in biomass into ethanol or other alcohols
- Products: Bioethanol:- used as a fuel or fuel additive
- Application:- Production of transportation biofuels

DEENBANDHU BIOGAS PLANT

⇒ The Deenbandhu Biogas Plant is a low-cost and efficient biogas system designed for rural households in India

⇒ It was developed in 1984 by the Action for food

Production (AFPRO) organization to provide an affordable and sustainable solution for energy generation from organic waste.

⇒ Design :-

- It has a compact, fixed-dome structure made of brick and cement
- The plant consist of three main parts:

→ Digester chamber :- A dome-shaped tank where anaerobic digestion occurs

→ Inlet tank :- where biomass (dung and water mixture) is fed into the plant.

→ Outlet tank :- where the slurry (used as fertilizer) is discharged.

⇒ Materials Used :-

- Constructed with locally available materials like bricks, sand and cement
- This make it cost-effective and easy to maintain

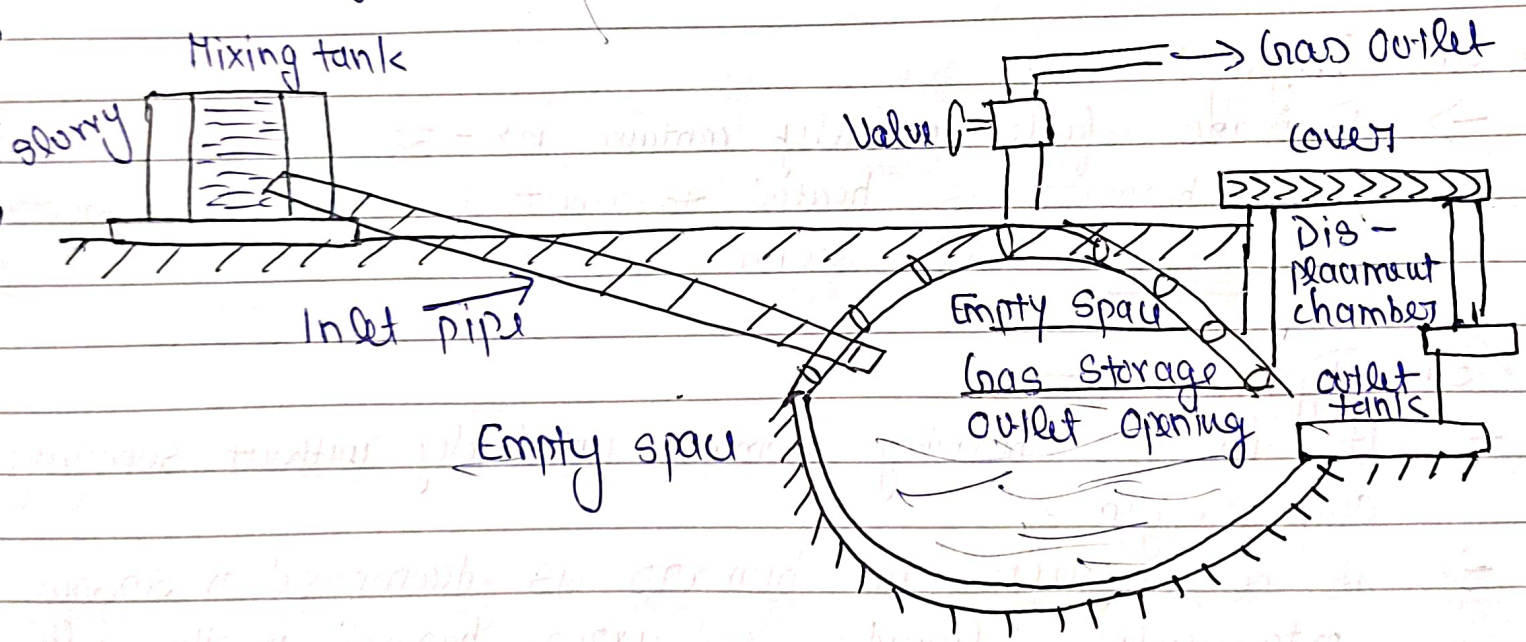
Working Principle :-

- Organic waste (e.g animal dung) is mixed with water to form a slurry and fed into the digester.
- Anaerobic digestion by microbes produces biogas (primarily methane) and digested slurry.

- Biogas collects in the dome and is piped out for use
- The leftover slurry exist through the outlet and is used as manure

Advantage:-

1] Cost - Effective
2] Efficient design
3] Environmental Benefits
4] Ease of Maintenance.



Q Explain the process of gasification of solid biomass. What is the general composition of the gas produced and what is the heating value. What are its application ? [AKTU 2021-2022]

Sol Gasification is a thermochemical process that converts solid biomass into a gaseous fuel (known as syngas) by heating the biomass in a controlled, oxygen-limited environment

⇒ The process of gasification involves the following four processes :-

a. Drying :-
→ Biomass fuels usually contain 10% - 35% moisture.
→ When biomass is heated to about 100°C, the moisture is converted into steam.

b. Pyrolysis :-
→ It involves burning biomass completely without supplying any oxygen
→ As a result, the biomass is decomposed or separated into solids, liquids, and gases, charcoal is the solid part, tar is the liquid part, fuel gases make up the gaseous part

c. Oxidation :-
→ Air is introduced into the gasifier after the decomposition process.

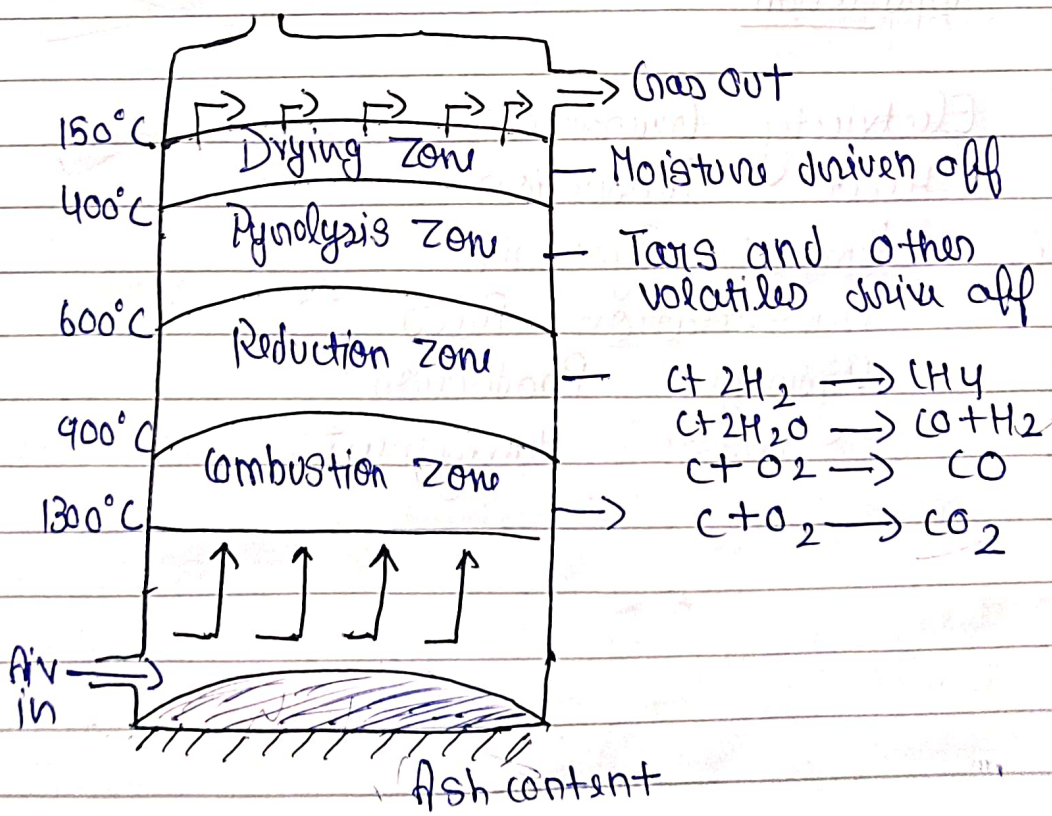
→ During oxidation which takes place at about 700-1400°C
→ charcoal or the solid carbonized fuel reacts with the oxygen in the air to produce carbon dioxide and heat

$$C + O_2 \longrightarrow CO_2 + \text{heat}\uparrow$$

d. Reduction :-

→ At higher temperature and under reducing conditions that is when not enough oxygen is available, the following reactions takes place forming carbon dioxide, hydrogen and methane.

$$C + CO_2 \longrightarrow 2CO$$
$$C + H_2O \longrightarrow CO + H_2$$
$$CO + H_2O \longrightarrow CO_2 + H_2$$
$$C + 2H_2 \longrightarrow CH_4$$



Composition :-

Carbon Monoxide	- 18 - 22%.
Hydrogen	- 13 - 19%.
Methane	- 1 - 5 %.
Heavier Hydrocarbons	- 0.2 - 0.4%.
Carbon - dioxide	- 9 - 12%.
Nitrogen	- 45 - 55%.
Water - vapour	- 4%.

Heating Value :-

The gas produced in the gasifier is a clean burning fuel having heating value of about 950 - 1200 Kcal/m^3.

Application :-

1. Electricity Generation
2. Heat Production
3. Chemical Synthesis
4. Transportation Fuels
5. Hydrogen Production
6. Waste Management

Q Explain the principle, working and efficiency of ocean thermal energy conversion (OTEC) power plant. What are the environmental effects of OTEC? {AKTU 2023-2024} {AKTU 2021-2022}

Q Explain in detail about OTEC and its types? {AKTU 2022-2023}

Principle :-

Sol. Ocean Thmal Energy Conversion is a process that can produce electricity by using the temperature difference between deep cold ocean waters.

- OTEC plants pump large amount of deep cold sea water and surface sea water to run a power cycle and produce electricity
- It is a renewable pollution free sources of energy

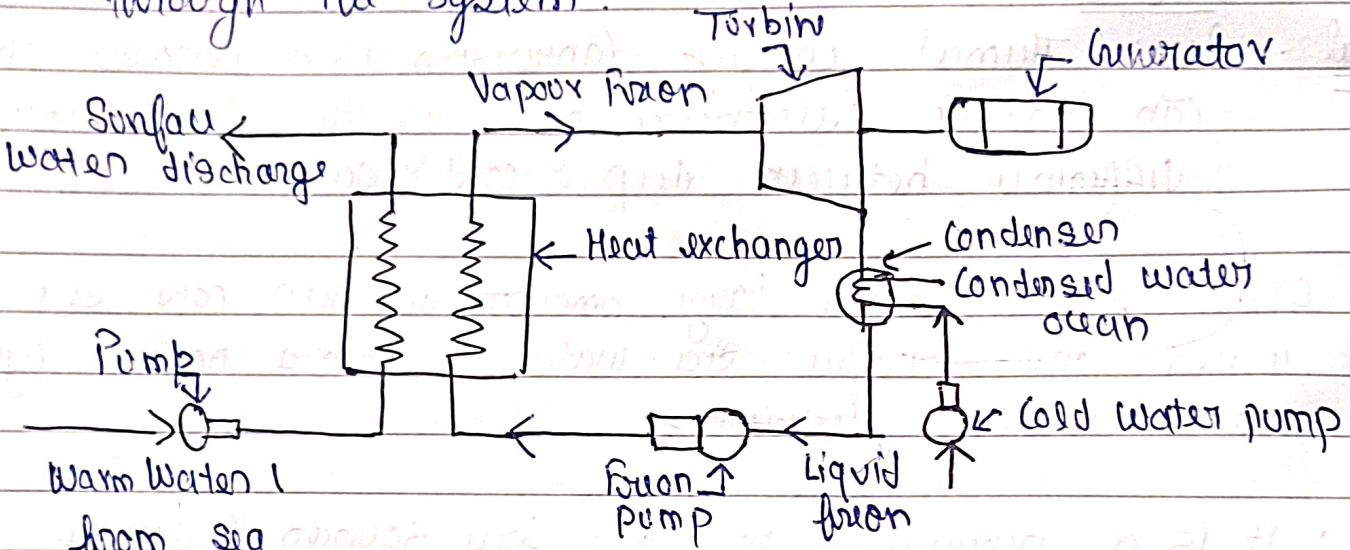
⇒ Types of OTEC System :-

a) Closed cycle system or Anderson cycle system
b) Open cycle system or Claude cycle system

⇒ Closed cycle System :-

→ In closed-cycle ocean thermal energy conversion, a working fluid with a low-boiling point, such as ammonia or propane, is circulated.

- Warm, surface seawater is pumped through a heat exchanger where the working fluid is vaporized through a turbine, which then generates electricity.
- Cold, deep seawater is then pumped through a second heat exchanger where the working fluid vapour condenses back into a liquid and is recycle through the system.



closed cycle system

Key Components of Closed-Cycle OTEC

1. Evaporator :-

-> A heat exchanger where warm seawater transfer its heat to the working fluid, causing it to vaporize.

2. Turbine :-

-> Convert the high-pressure vapour into mechanical energy which is then used to generate electricity

3. Condenser :→
→ A heat exchanger where cold deep seawater cools and condenses the working fluid back into liquid form

4. Pump :-
→ Moves the working fluid throughout the system and maintains its pressure.

5. Heat Exchangers :-
→ Used to transfer heat between seawater and the working fluid efficiently.

⇒ Advantage :-

1. Continuous Energy Production
2. Reliability
3. Low Environmental Impact
4. Flexibility in Location

⇒ Open cycle system or Claude cycle system :-

⇒ An open-cycle system in OTEC uses warm seawater directly as the working fluid to generate electricity.

⇒ This process involves evaporating warm surface seawater at low pressure to produce steam, which drives a turbine connected to an electricity generator

=> Unlike the closed cycle, the open cycle does not use an intermediate working fluid.

Key Component of Open-Cycle OTEC

1. Low-Pressure Chamber :-
   Maintains the low-pressure environment necessary for seawater to boil at low temperature

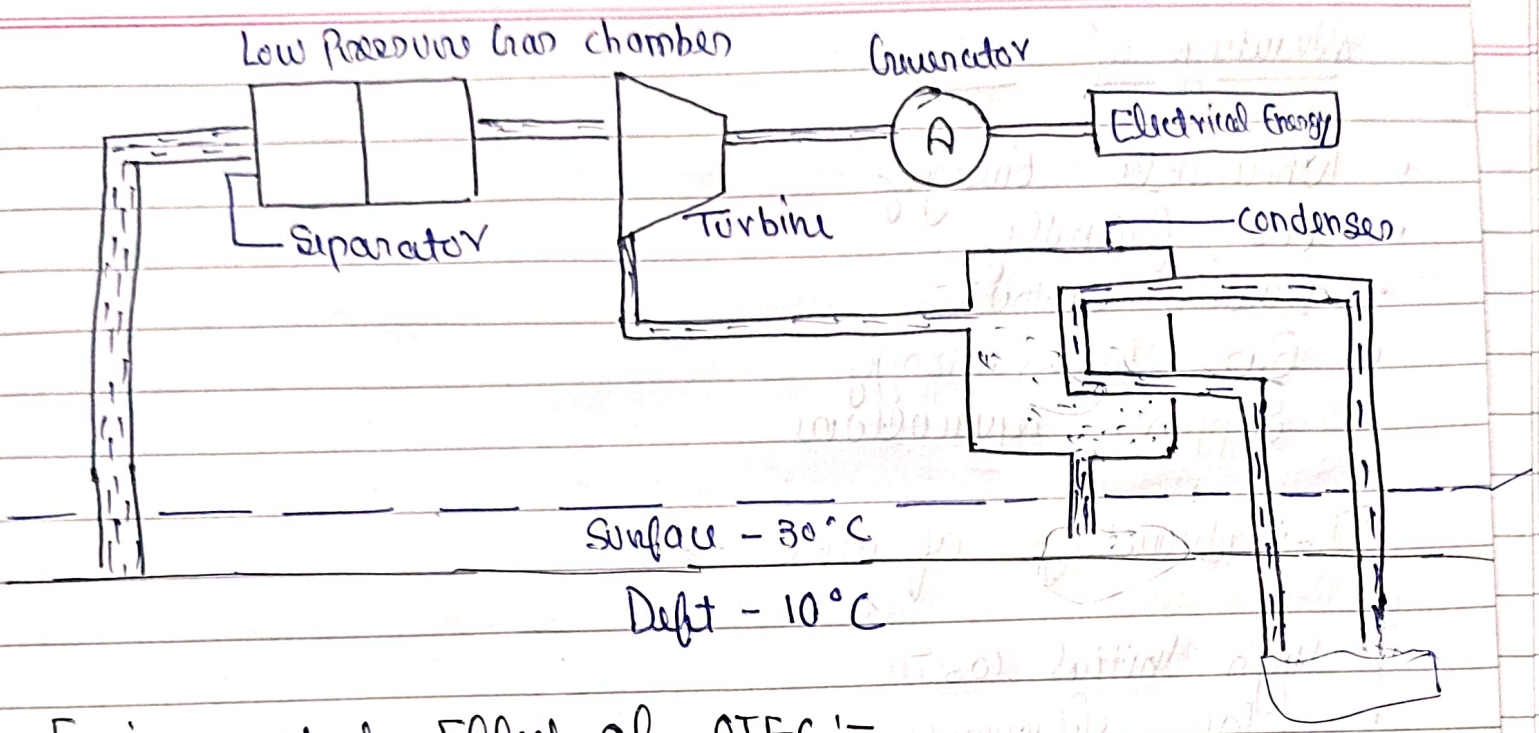
2. Turbine :-
   Convert the kinetic energy of the low-pressure steam into mechanical energy to generate electricity.

3. Condenser :-
   Uses cold deep seawater to condense the steam back into liquid form

4. Seawater Pumps :-
   Pumps warm surface seawater and cold deep seawater into the system

Advantage

1. Dual Benefits
2. No working fluid Needed
3. Environmentally friendly
4. Renewable energy source



Environmental Effect of OTEC :-

1. Minimal Emission : OTEC produced negligible greenhouse gases, making it eco-friendly.

2. Impact on Marine Life :- Pumps may disturb marine organisms and habitats if not managed carefully.

3. Seawater Movement :- large-scale pumping can slightly alter local ocean currents and ecosystems

4. Thermal Pollution :- Discharged water may cause localized temperature change in the ocean, affecting marine ecosystem

Advantage of OTEC :-

- Renewable Energy
- Eco - friendly
- Dual output
- Base load Energy
- Support Aquaculture

Disadvantage of OTEC :-

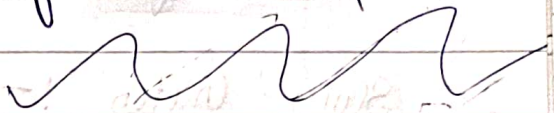
- High initial cost
- Low efficiency
- Geographical limitation
- Environmental concerns

Application :-

1. Electricity Generation.
2. Desalinated Water
3. Aquaculture
4. Cooling System
5. Hydrogen Production

WAVE ENERGY

Wave Energy is the power generated by capturing the movement of ocean waves. It uses the up and down or back and forth motion of waves to produce electricity.



TIDAL WAVE ENERGY

Tidal wave energy is the power created by using the rise and fall of sea level caused by the gravitational pull of the moon and sun.

→ It works by capturing the flow of water during high and low tides to generate electricity.

TIDAL POWER PLANT

Principle:- To utilize tidal energy, water must be trapped at high tide behind a dam or barrage and then made to drive turbine as it returns to sea during low tides.

→ Available energy is proportional to the square of Amplitude

Components :-

1. Tidal Barrage or Dam :-

→ A structure built across an tidal basin to control water flow and store tidal.

2. Sluice Gates :-

→ Gates that regulate the flow of water in and out of the tidal basin.

3. Turbines :-

→ Converts the kinetic and potential energy of moving water into mechanical energy

4. Tidal Basin :-

→ An area where water is stored during high tide and released during low tide to generate energy

Working :-

→ The working is described according to the following type of basins :-

1. One - Basin System :-

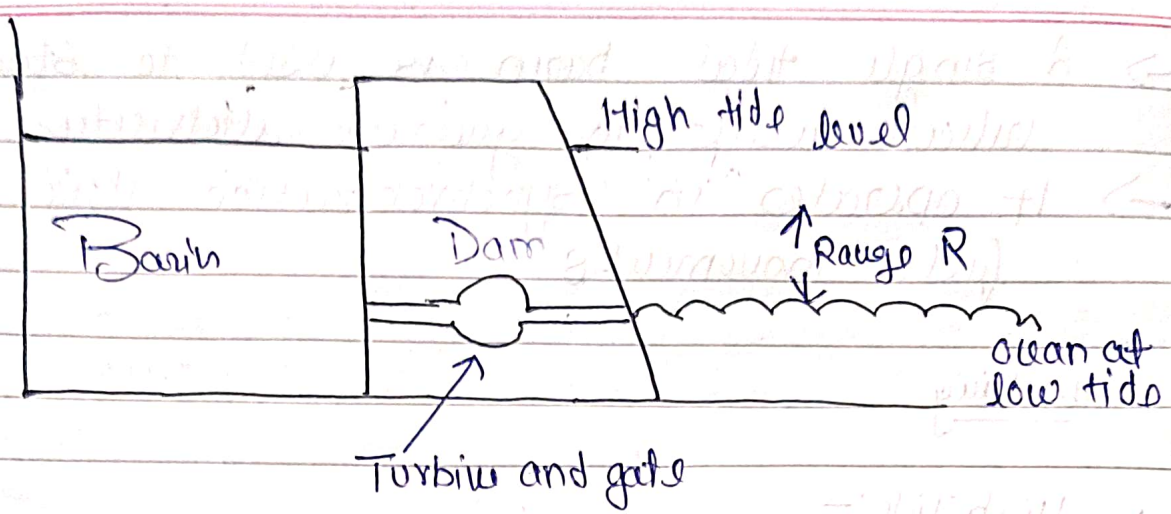
-> A single tidal basin is used to store and release water to generate electricity.
-> It operates in synchronization with natural tidal movements.

Working

- High Tide :-
  -> The sluice gate open, allowing water to fill the basin from the sea.
  -> The water level in the basin matches the high tide level.

- Low Tide :-
  -> The sluice gate close, and the stored water is released through turbine as the tide recedes.
  -> The potential energy from the height difference (head) drive the turbines to generate electricity.

- Direction of flow :-
  -> Can operate in one-way flow (during ebb tide) or two-way flow (during both ebb and flood tides).



2. Double Basin System :-

→ Two basins are used : one for high tide and another for low tide.

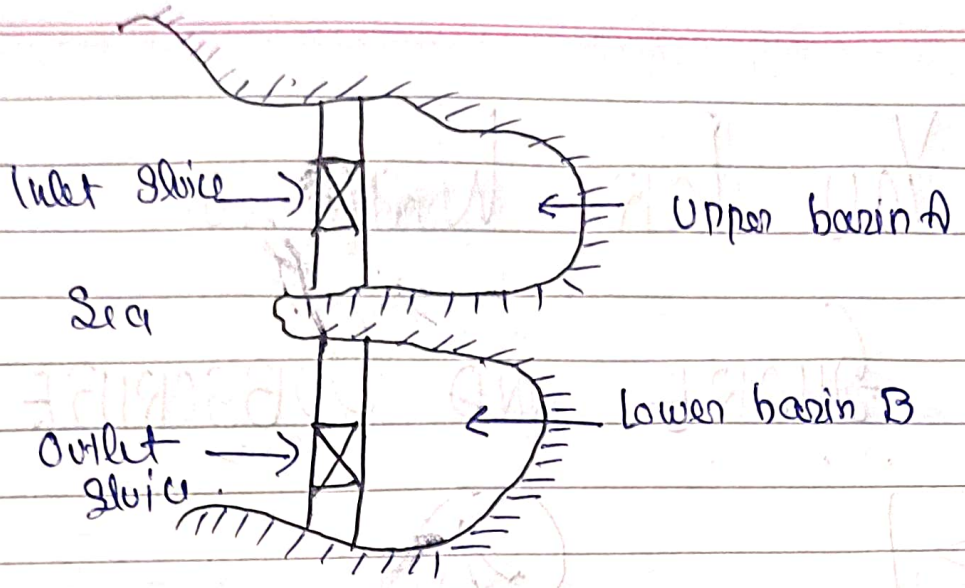
→ Water is managed between the basins and the sea to continously drive the turbines

Working

→ High tide Basin
- water flows into the high-tide basin during tide, storing potential energy

→ low tide Basin
- water from the high-tide basin is released into the low-tide basin through turbines as the tide recedes.

→ Continuous Operation
- By alternating between the two basins, turbines can operate more consistently



Advantage :-

1. Renewable and Sustainable
2. Low Carbon Emissions
3. Reliable Energy Source
4. Longevity

Disadvantage :-

1. High Initial cost
2. Environmental Impact
3. Geographical Limitation
4. Maintenance challenges

Application :-

1. Electricity Generation
2. Flood control.
3. Tourism and Economy.

THANK YOU FOR WATCHING

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