

UNIT - 5

(SUB-CODE-KOE-074)

RENEWABLE

ENERGY RESOURCES

ONE-SHOT

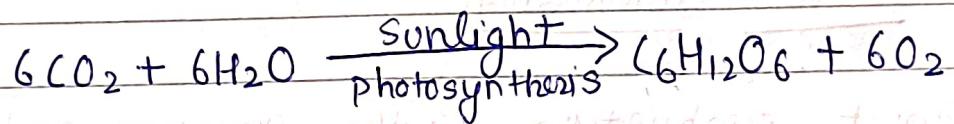
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Topics :-

- ① Biomass
- ① Availability, Energy conversion from biomass.  
    {AIKTU 2021-2022}
- ① DESHBANDHU Biogas Plant
- ① Classification, Composition      {AIKTU 2021-2022}
- ① OTEC      {AIKTU 2021-2022, 2022-2023, 2023-2024}
- ① 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 things like wood, crops, food scraps, and animal manure.
- ⇒ Biomass can be burned directly for heat or converted to liquid and gaseous fuel through various processes.



- ⇒ Biomass does not add  $\text{CO}_2$  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.

## Sal 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

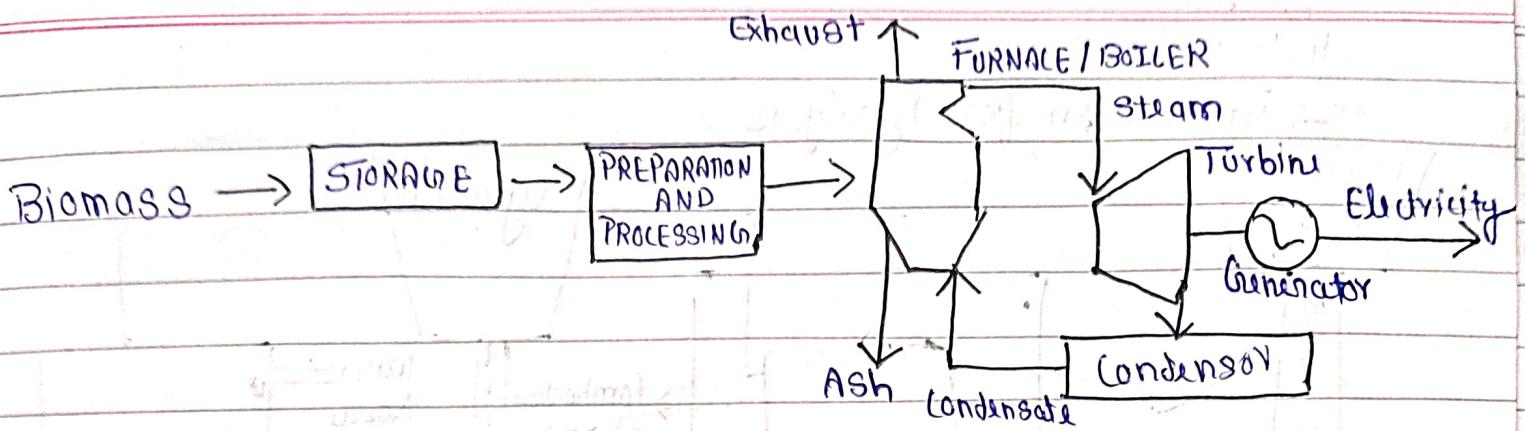
- Availability depends on factor like:-
- Location :- Rural area often have better access to agricultural and animal waste
- Seasonality :- Agricultural residues are more abundant after harvest seasons.
- Population density :- Urban areas produce more organic waste.

### Biomass Conversion :-

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

#### a). Direct Combustion :-

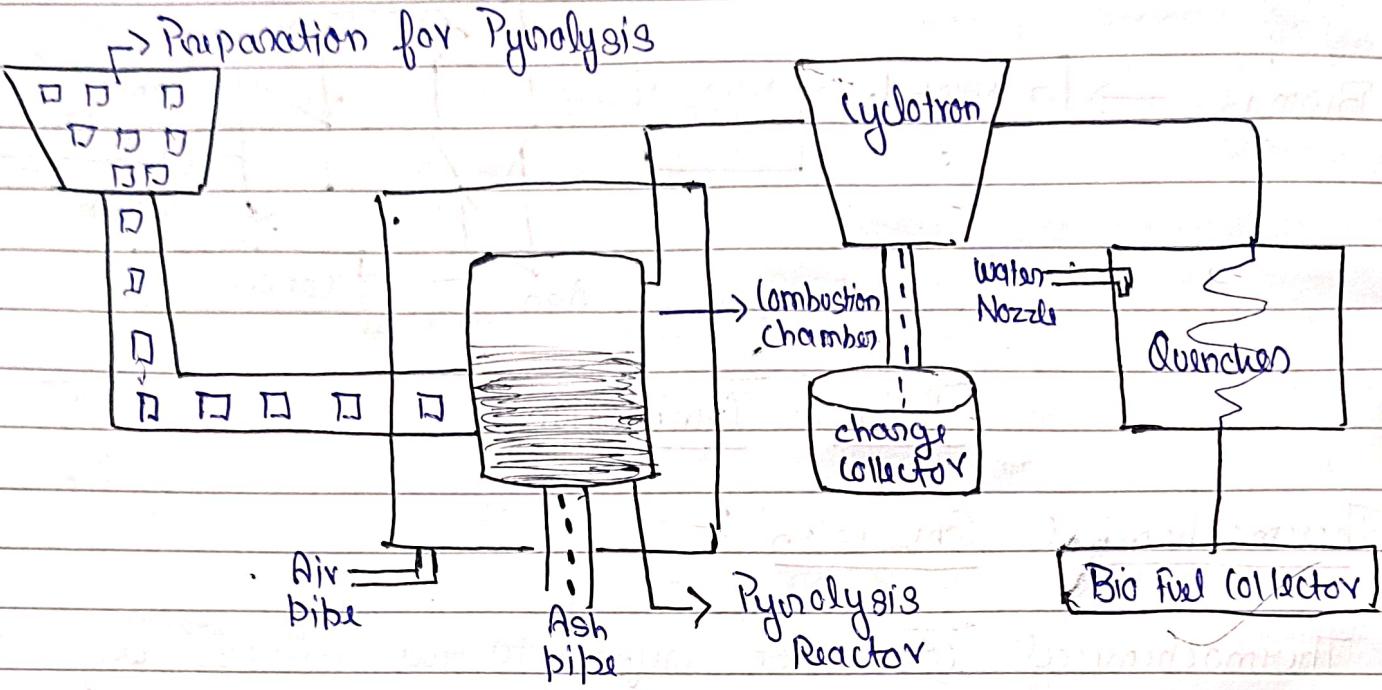
- Direct combustion is the simplest and most common method of converting biomass into energy.
- It involves burning organic materials like wood, crop residues, or animal waste to produce heat, which can be used for various purposes.
- In the pyrolysis process, the organic material is converted to gases,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



### Direct Combustion

#### b) Thermochemical Conversion :-

- Thermochemical conversion refers to the process of using heat to convert biomass to energy such product like syngas, bio-oil or charcoal.
- Thermochemical conversion takes two forms:
  - Gasification.
  - Liquefaction.
- Gasification:-
- 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:

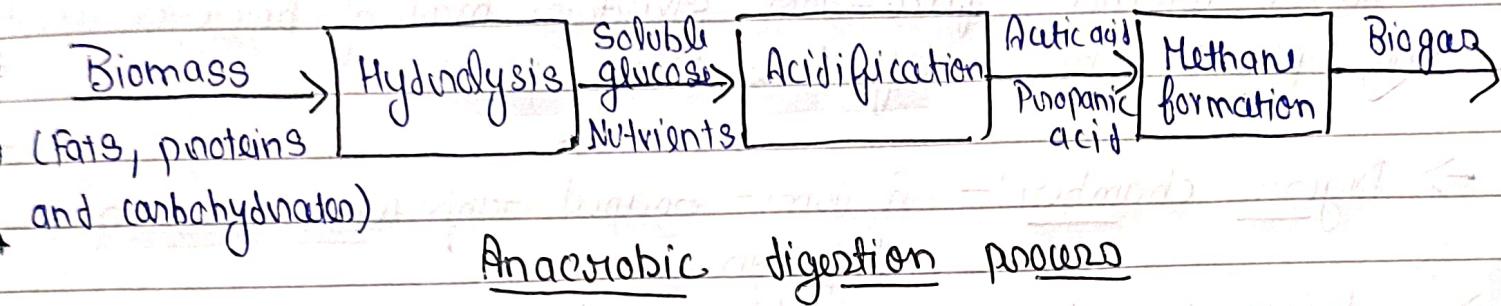
- 1) Anaerobic digestion
- 2) Fermentation

⇒ 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  $\text{CO}_2$ ).

② 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.



- ⇒ 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 consists 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 makes it cost-effective and easy to maintain.

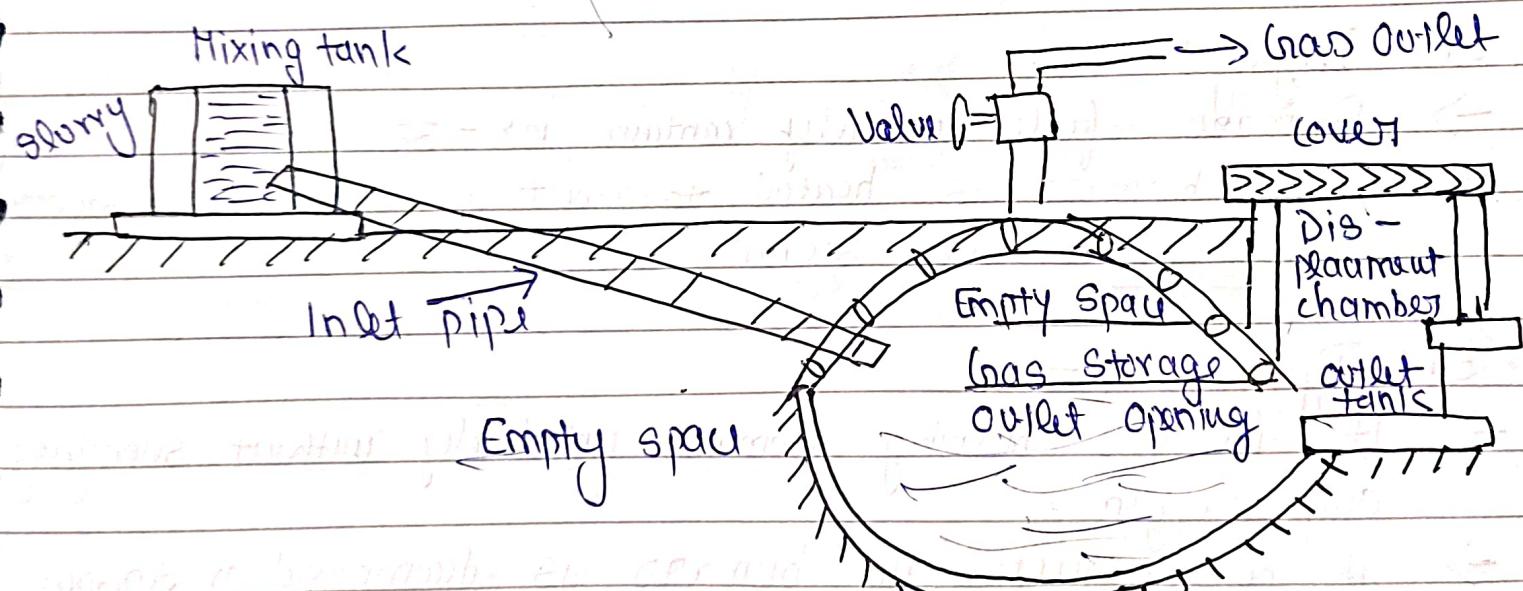
Working Principle:-

- 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 applications? [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  $100^{\circ}\text{C}$ , the moisture is converted into steam.

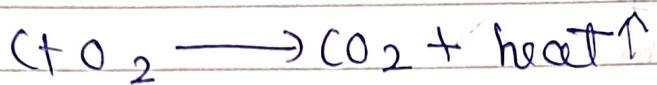
b. Pyrolysis :-

- 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 ! -

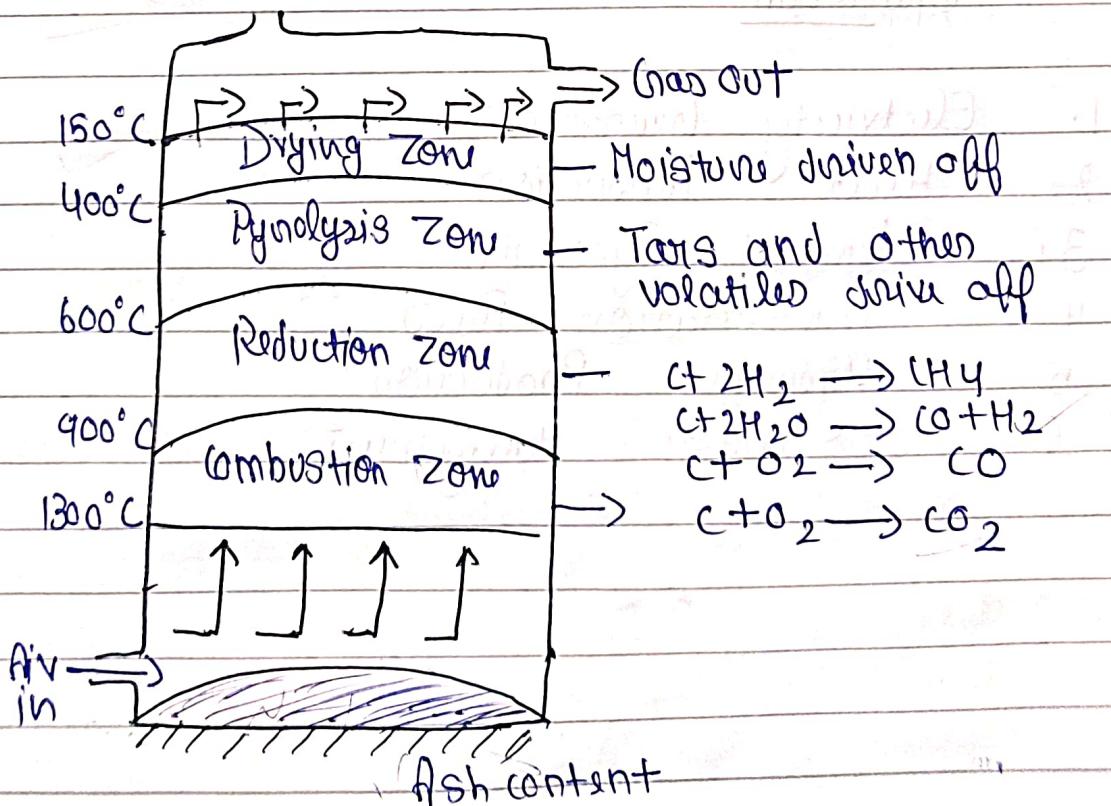
- Air is introduced into the gasifier after the decomposition process.

→ 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



### iii. Reduction :-

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



## 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<sup>3</sup>.

## 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 Thermal 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 source of energy

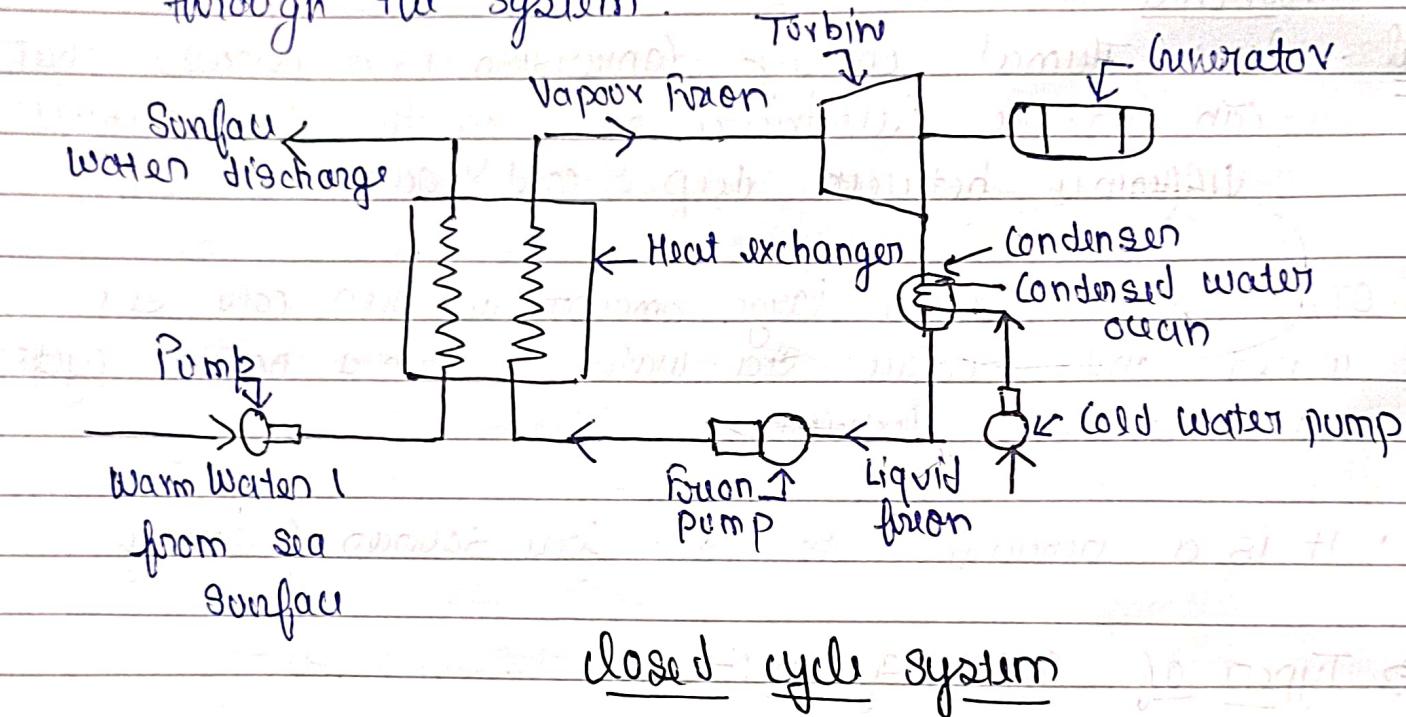
⇒ Types of OTEC System :-

- 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 recycled through the system.



### Key components of closed - cycle OTEC

1. Evaporator :-  
→ A heat exchanger where warm seawater transfers 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.

⇒ Advantages :-

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 temperatures.

2. Turbine :-

Converts 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.

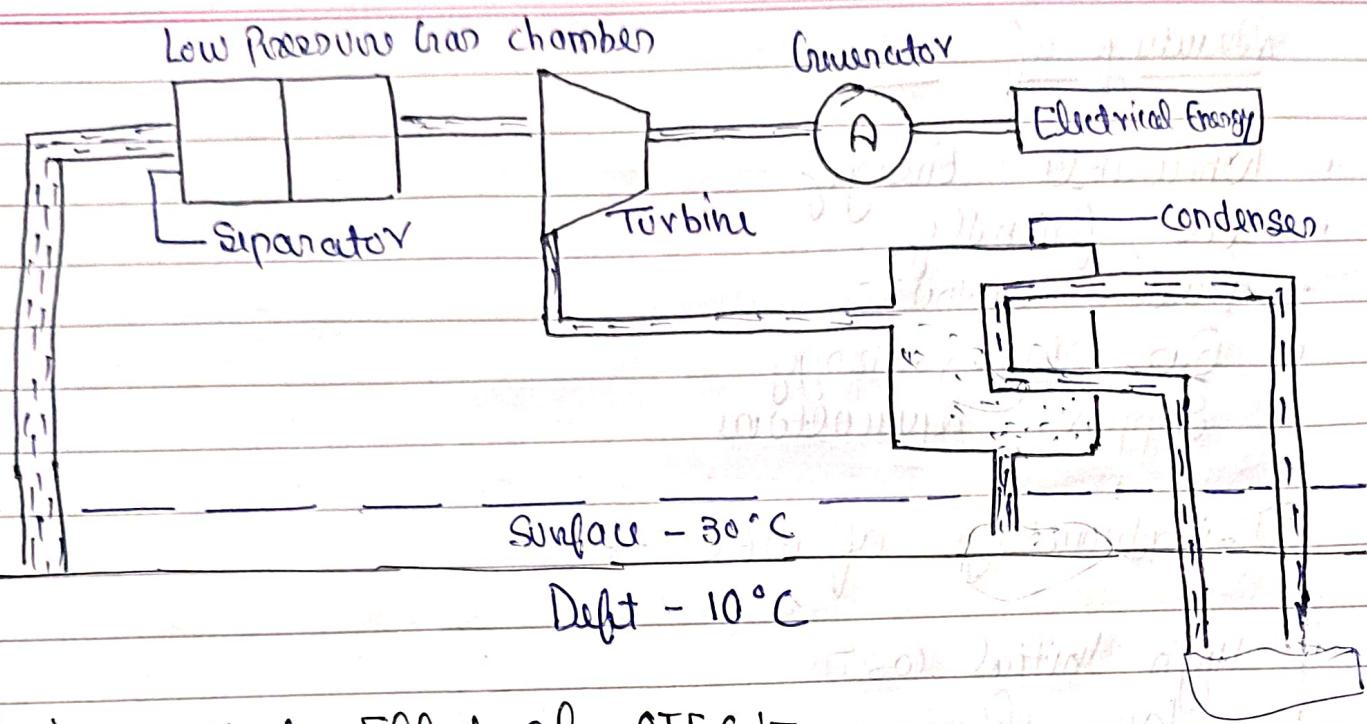
### # Advantage

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:-

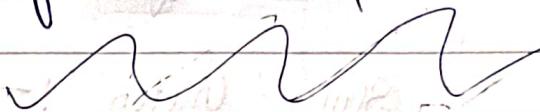
- High Initial cost
- Low efficiency
- Geographical limitation
- Environmental concerns

## 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 turbines 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 a tidal basin to control water flow and store tidal water and generate electricity.

### 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 electrical energy with generator and cables.

### 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 types 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! -

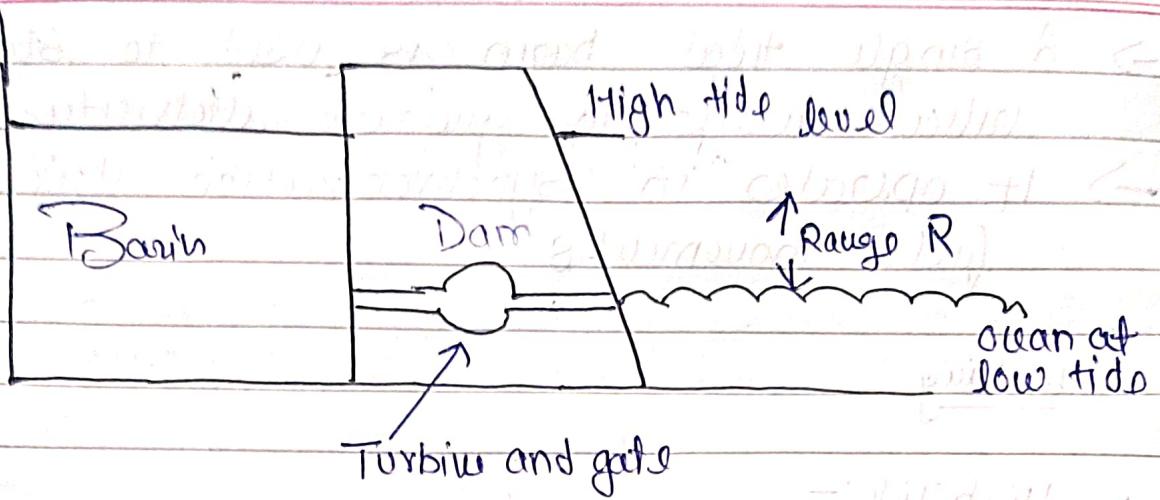
- The sluice gate opens, allowing water to fill the basin from the sea.
- The water level in the basin matches the high tide level.

#### • Low Tide! -

- The sluice gate closes, and the stored water is released through turbines as the tide recedes.
- The potential energy from the height difference (head) drives the turbines to generate electricity.

#### • Direction of flow! -

- Can operate in one-way flow (during ebb tide) besides two-way flow (during both ebb and flood tides).

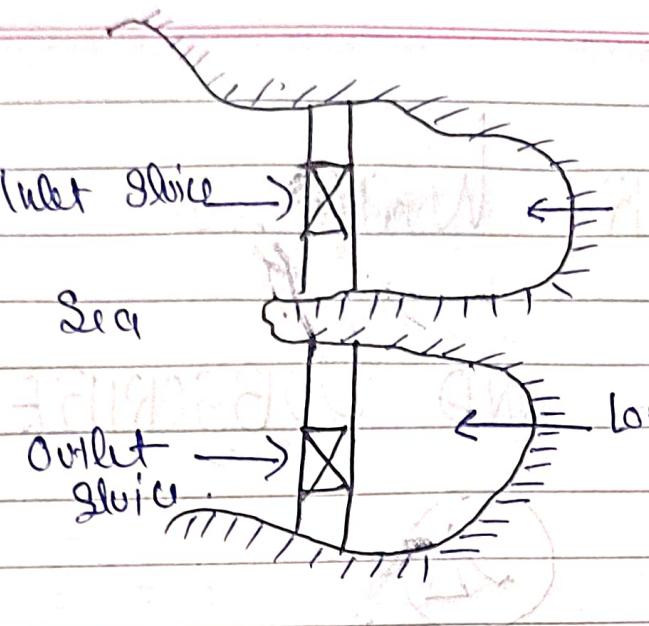


## 2. Double Basin System :-

- Two basins are used - one for high tide and another for low tide.
- Water is managed between the basins and the sea to continuously drive the turbines

### Working

- High tide Basin : water is managed
  - 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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