	CMR INSTITUTE OF TECHNOLOGY	
	Renewable Energy Systems -17EE563	Date: 15/10/2019
	Internal Assesment Test-1 .	Semester: V
	Solution Manual	Dept. EEE/ECE/ISE

Answer any five FULL Questions. Sketch neat figures wherever necessary.

1. (a) What is geothermal energy and write two geothermal provinces in India.
   - Geothermal energy is thermal energy generated and stored in the Earth.
   - Thermal energy is the energy that determines the temperature of matter.
   - The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials.
   - The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.
   - There are seven geothermal provinces in India : the Himalayas, Sohana, West coast, Cambay, Son-Narmada-Tapi (SONATA), Godavari, and Mahanadi.

   (b) Explain Binary cycle geothermal power plant with neat sketch.

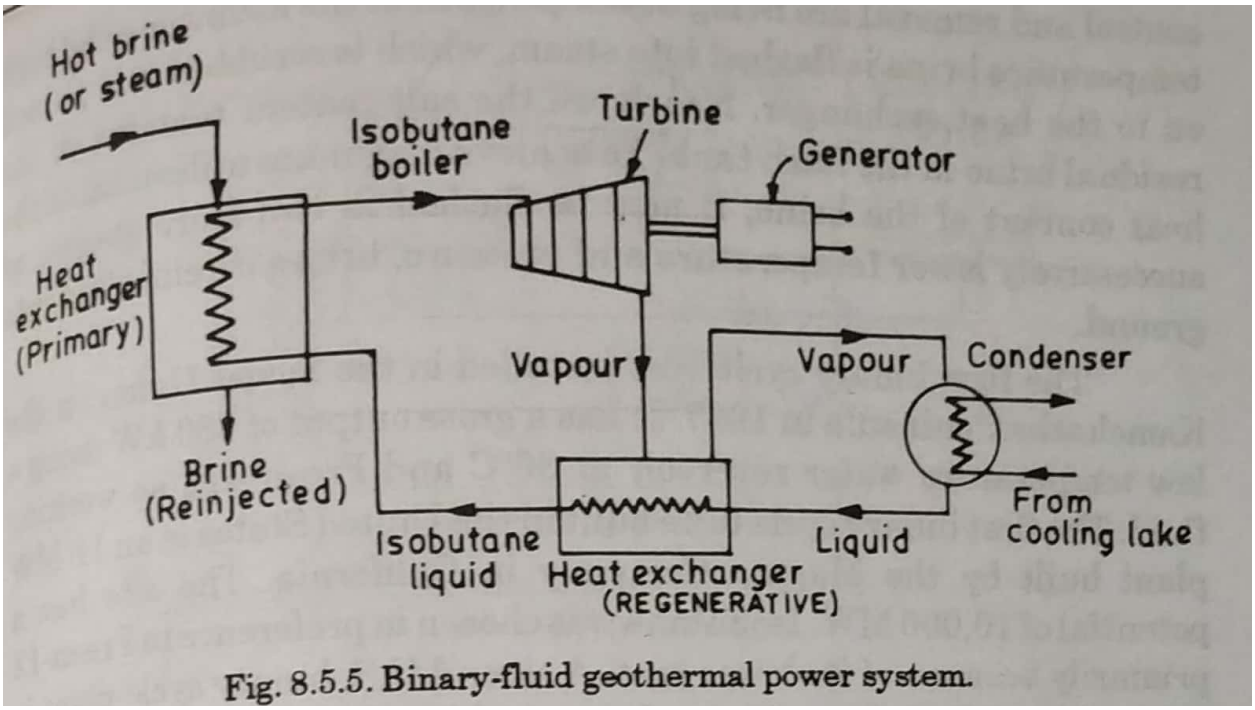


Fig. 8.5.5. Binary-fluid geothermal power system.

(*b*) **Liquid-Dominated Systems : Binary Cycle.** In order to isolate the turbine from corrosive or erosive materials and/or to accommodate higher concentration of noncondensable gases, the binary cycle concept is now receiving considerable attention as an alternate power cycle concept. This is basically a Rankine cycle with an organic working fluid. A heat exchanger system is used to transfer a fraction of the brine enthalpy to vaporize the secondary working fluid. Expansion through a turbine to a lower pressure, fixed by the heat rejection temperature, provides the means for power generation.

About 50 per cent of hydrothermal water is in the moderate temperature range of ~ 153 to 205°C. This water which is available in lower temperature ranges is unsuitable for power production. It is however suitable for direct utilization for domestic and industrial process heating. If this water is used in a flashed-steam system, it would have to be throttled down to such a low pressures that results in excessively large specific volume flows as well as even poor cycle efficiencies. Instead this water is used as a heat source for a closed cycle that uses another working fluid that has suitable pressure temperature volume characteristics. As stated above the binary fluid (or two fluid) system, is being investigated to overcome these limitations of flashed steam system. In the binary system an organic fluid with a low boiling point, such as *isobutane* (2 methal propane) C_4H_{10} (normal boiling point at one atm. pressure = 10°C) and Freon—12 (normal boiling point – 29.8°C) are usually recommended. Ammonia and propane may also be used. The working fluid would operate at higher pressures, corresponding to the source water and heat-sink temperatures.

Flow diagram of a binary-cycle system is shown schematically in Fig. (8.5.5). Hot water or brine from the under-ground reservoir,

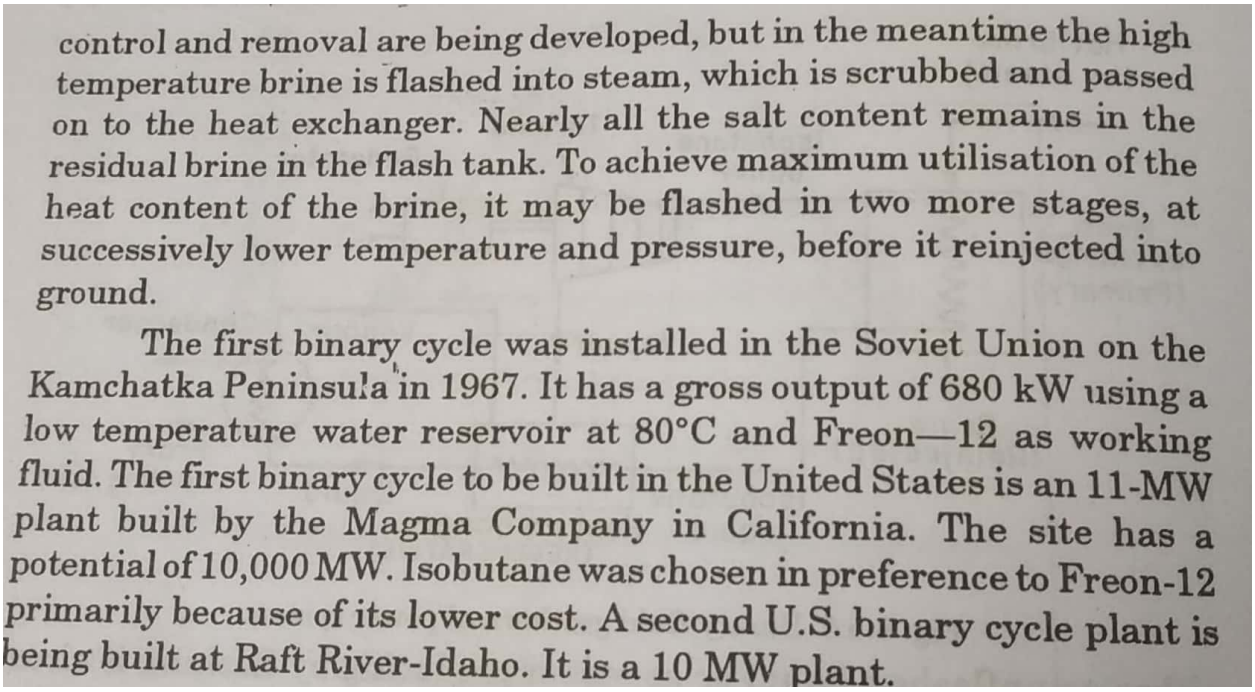
either as unflashed liquid or as steam producing by flashing is circulated through a primary heat exchanger. In the heat exchanger the hot brine transfer its heat to the organic fluid thus converting it to a superheated vapour that is used in a standard closed Rankine cycle. The vapour drives the turbine-generator. The exhaust vapour from the turbine is cooled in the regenerative heat exchanger and then condensed, using either and air-cooled condenser or a water-cooled condenser and cooling tower. The condensed liquid organic fluid is returned to the primary heat exchanger by way of the regenerative heat exchanger. The hot geothermal fluid and the organic fluid, constitute the two fluids of the binary-fluid system.

The condenser is cooled by water from a natural source, if available, or a cooling tower circulation system. The blow down from the tower may be reinjected to the ground with the cooled brine. Make-up of the cooling-tower must be provided however.

In the binary cycle there are no problems of corrosion or scaling in the working cycle components, such as the turbine and condenser. Such problems are confined only to the well casing and the heat exchanger. The heat exchanger is a shell-and-tube type so that no contact between brine and working fluid takes place.

If the temperature and salinity of the geothermal brine are not high, the tendency for solids (scale) to deposit on surfaces in the heat exchanger is not too great. The liquid brine under pressure may then be pumped directly through the heat exchanger and reinjected into the geothermal reservoir.

However, where the temperature and salinity of the brine are high, this procedure may not be practical because the heat exchangers may soon be rendered ineffective by scale deposition. Methods for scale

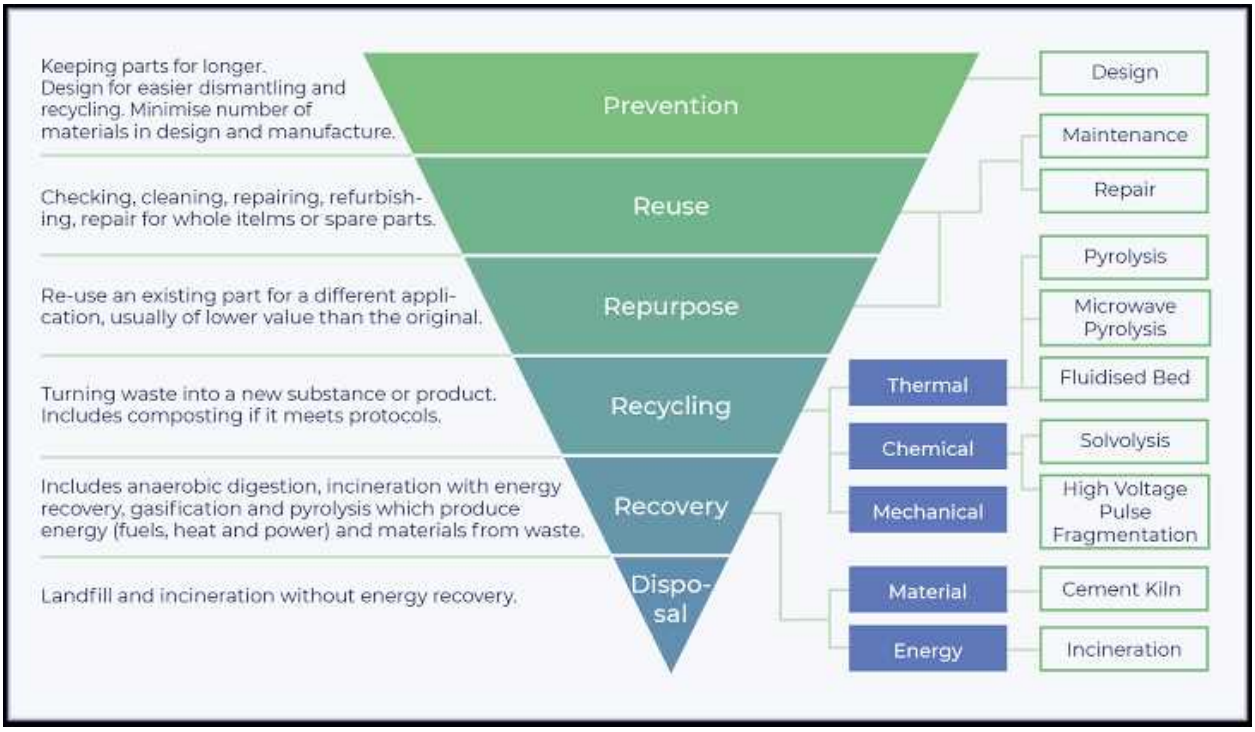


control and removal are being developed, but in the meantime the high temperature brine is flashed into steam, which is scrubbed and passed on to the heat exchanger. Nearly all the salt content remains in the residual brine in the flash tank. To achieve maximum utilisation of the heat content of the brine, it may be flashed in two more stages, at successively lower temperature and pressure, before it reinjected into ground.

The first binary cycle was installed in the Soviet Union on the Kamchatka Peninsula in 1967. It has a gross output of 680 kW using a low temperature water reservoir at 80°C and Freon—12 as working fluid. The first binary cycle to be built in the United States is an 11-MW plant built by the Magma Company in California. The site has a potential of 10,000 MW. Isobutane was chosen in preference to Freon-12 primarily because of its lower cost. A second U.S. binary cycle plant is being built at Raft River-Idaho. It is a 10 MW plant.

2. (a) What is waste and write the types of waste.
   - It is defined as Waste (also known as rubbish, trash, refuse,garbage, junk) is any unwanted or useless materials.
   - Any materials unused and rejected as worthless or unwanted and "A useless or profile less activity using or expanding or consuming thoughtlessly or carefully."
   - Types of waste
     - Solid waste
     - Liquid waste
     - Gaseous waste
     - Animal by-product(ABPs)
     - Biodegradable waste
     - Chemical waste
     - Commercial waste/Business waste
     - Biomedical waste
     - Bulky waste

   (b) Explain waste management Hierarchy.
   There are a number of concepts about waste management which vary in their usage between countries or regions. Some of the most general,widely used concepts include:
   - Waste hierarchy - The waste hierarchy refers to the "3 R's" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The waste hierarchy remains the cornerstone of most waste minimization strategies.
   - The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.
   - Polluter pays principle - the Polluter Pays Principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material.



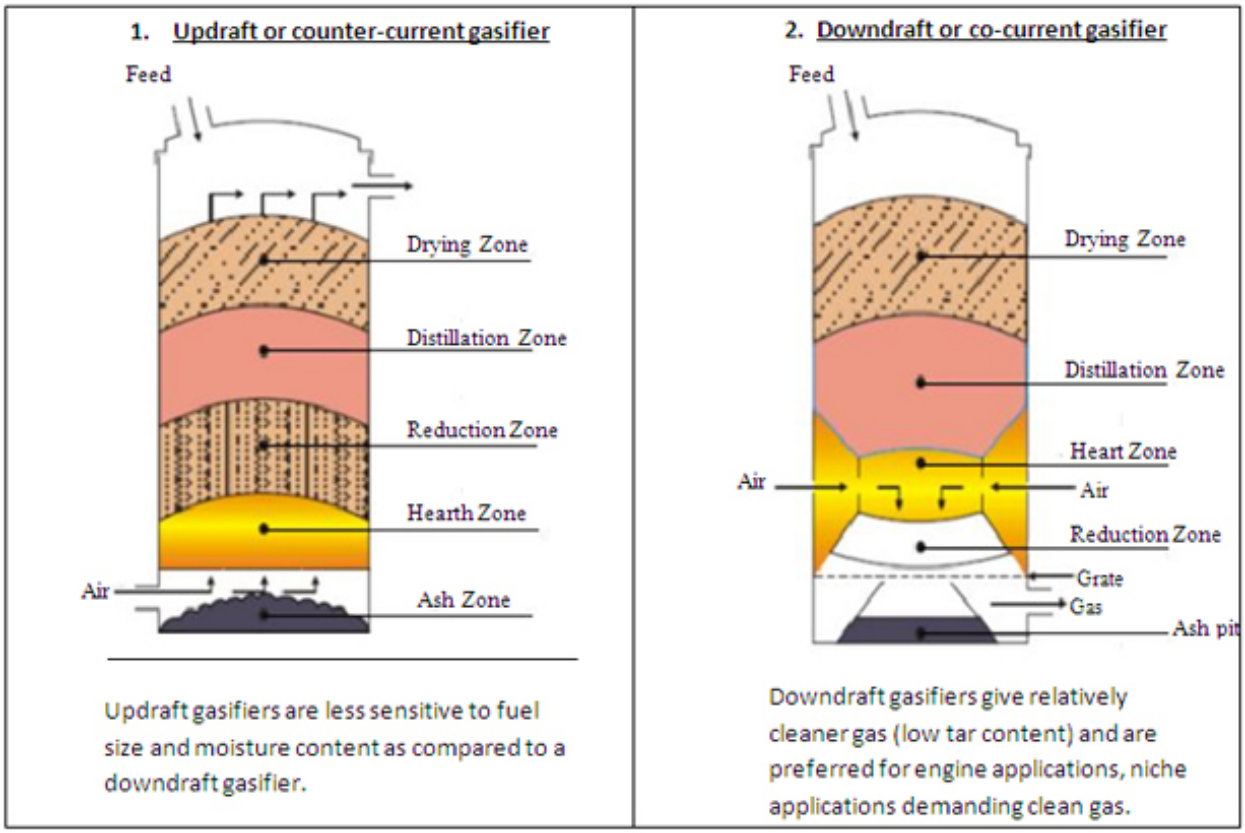
(c) Explain methods of waste disposal.
Methods of waste disposal

- Industrialized nations are grappling with the problem of expeditious and safe waste disposal. Non-biodegradable and toxic wastes like radioactive remnants can potentially cause irreparable damage to the environment and human health if not strategically disposed of.
- Though waste disposal has been a matter of concern for several decades, the main problem has been taking massive proportions due to growth in population and industrialization, the two major factors that contribute to waste generation. Though some advancement is being made in waste disposal methods, they are still not adequate. The challenge is to detect newer and unhazardous methods of waste disposal and put these methods to use.

3. (a) Define Biomass and Bio-mass Gasification
Biomass is plant or animal material used for energy production (electricity or heat), or in various industrial processes as raw material for a range of products. It can be purposely grown energy crops (e.g. miscanthus, switchgrass), wood or forest residues, waste from food crops (wheat straw, bagasse), horticulture (yard waste), food processing (corn cobs), animal farming (manure, rich in nitrogen and phosphorus), or human waste from sewage plants

Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. The gas is a low-heating value fuel, with a calorific value between 1000- 1200 kcal/Nm3 (kilo calorie per normal cubic metre).

(b) Draw the schematics of any two biomass gasifiers with neat sketch

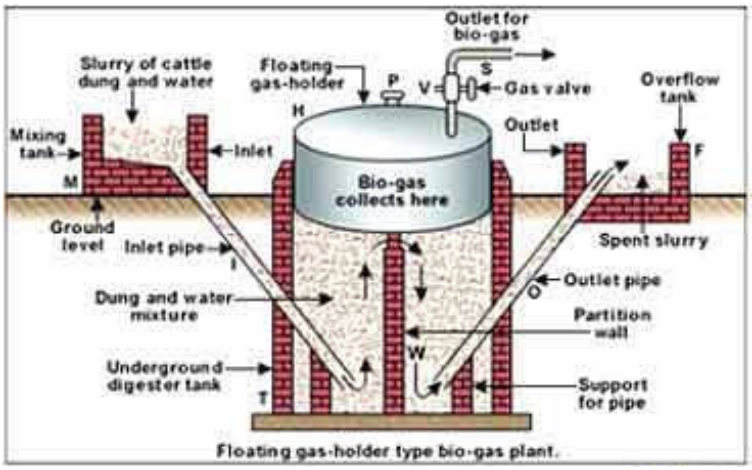


4. (a) Explain the composition of Bio-gas

Typical composition of biogas

Compound	Formula	%
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulphide	H_2S	0–3
Oxygen	O_2	0–0

(b) Draw the schematic of (a) KVIC model and (b) Janata model with a neat sketch



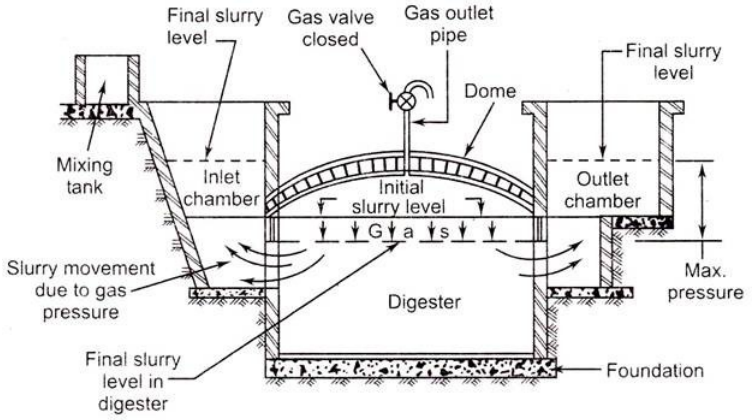


Fig. 6.4. Janata model gober gas plant.

5. (a) Write short notes on Tidal Energy

Tides are the rising and falling of Earth's ocean surface caused by the tidal forces fo the Moon and the Sun acting on the oceans The tidal force is the vectorial difference between the gravitational force of the Earth and the gravitational force of the Moon. Tidal power or tidal energy is the form of hydro power that converts the energy obtained from tides into useful forms of power, mainly electricity.

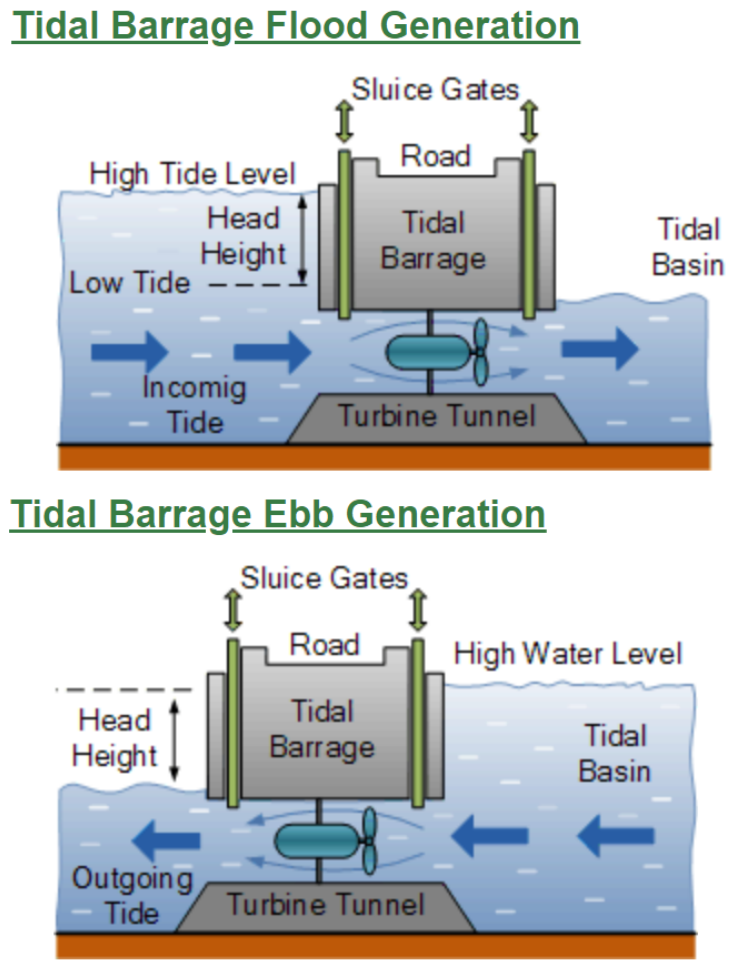
Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels.

(b) Explain the single basin system based tidal power plant with neat sketch

Single basin system- Ebb generation: During flood tide basin is filled and sluice gates are closed , trapping water. Gates are kept closed until the tide has ebbed sufficiently and thus turbines start spinning and generating electricity.

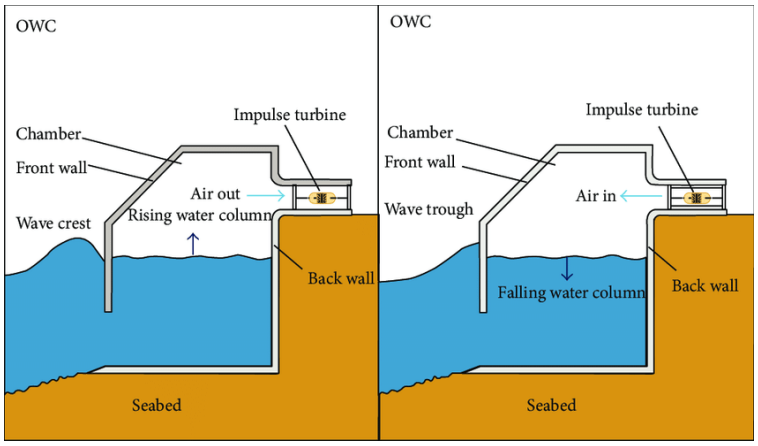
Flood generation: The basin is filled through the turbine which generate at flood tide.

Two way generation: Sluice gates and turbines are closed until near the end of the flood tide when water is allowed to flow through the turbines into the basin creating electricity. At the point where the hydrostatic head is insufficient for power generation the sluice gates are opened and kept open until high tide when they are closed. When the tide outside the barrage has dropped sufficiently water is allowed to flow out of the basin through the turbines again creating electricity.



6. (a) Describe with diagram, principle of oscillating water column ocean wave machine
Oscillating water columns (OWCs) are a type of Wave Energy Converter (WEC) that harness energy from the oscillation of the seawater inside a chamber or hollow caused by the action of waves. OWCs have shown promise as a renewable energy source with low environmental impact. Because of this, multiple companies have been working to design increasingly efficient OWC models. OWC are devices with a semi-submerged chamber or hollow open to the sea below, keeping a trapped air pocket above a water column. Waves force the column to act like a piston, moving up and down, forcing the air out of the chamber and back into it. This continuous movement force a bidirectional stream of high-velocity air, which is channelled through a Power-Take-Off (PTO). The PTO system converts the airflow into energy. In models that convert airflow to electricity, the PTO system consists of a bidirectional turbine. This means that the turbine always spins the same direction regardless of the direction of airflow, allowing for energy to be continuously generated. Both the collecting chamber and PTO systems will be explained further under "Basic OWC Components."
As illustrated in Figure 1,an OWC system has an air chamber with a mouth at the bottom of the

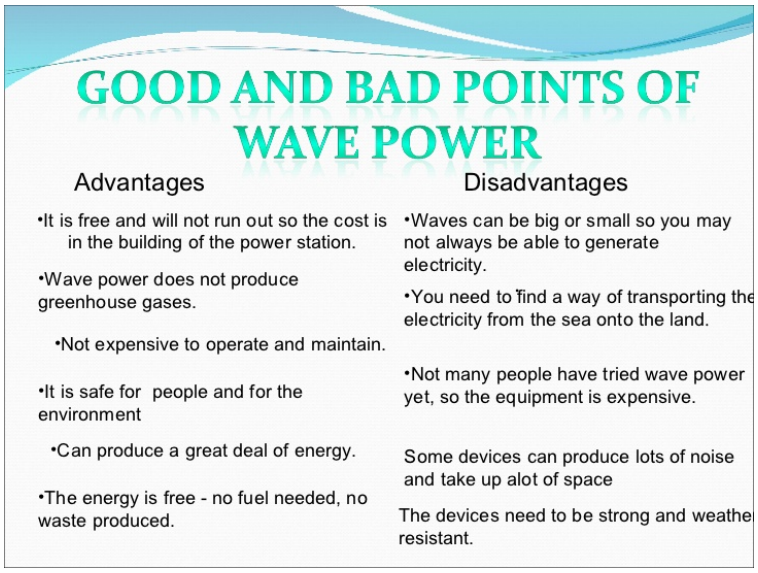
front wall to take in incident waves. The reciprocating air flows are driven by the oscillating water column in the air chamber,which are generated by the incident waves. Self-rectifying air turbines can rotate in one direction to drive the electricity generator under the bidirectional air flows, which are expected to improve the energy converting efficiency of OWC systems.



(b) What are the types of devices used to harness the wave energy?

There are multiple different technologies used for Wave energy. There are five main types of technology used including; Absorbers, Attenuators, Oscillation water columns, overtopping and Inverted-Pendulum device.

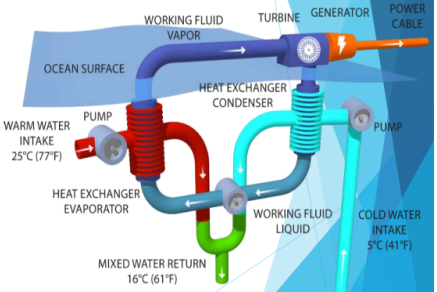
(c) Write two advantage and disadvantages of wave power



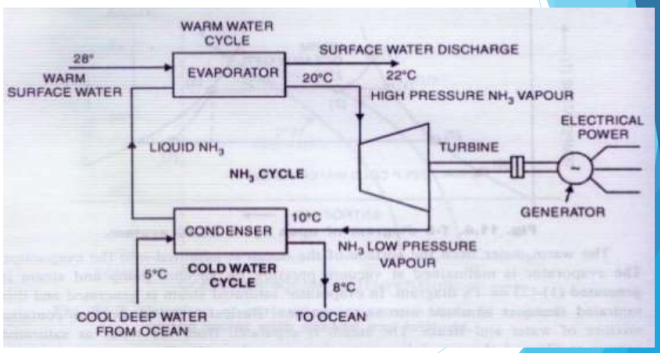
7. (a) Explain how the ocean temperature difference can be used to generate electrical power using (a) open cycle (b) closed cycle system

CLOSED CYCLE OTEC SYSTEM

- In the closed cycle, a working fluid, such as ammonia, is pumped through a heat exchanger (evaporator) and vaporized.
- This vaporized steam spins a turbine.
- The cold water found at the depths of the ocean condenses the vapor back to a fluid where it returns to the heat exchanger (condenser).
- Evaporated fluids expands in turbine, which runs a generator to produce power.
- Boiling point of ammonia is (-33°C).

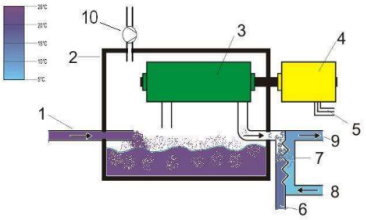


CLOSED CYCLE OTEC SYSTEM

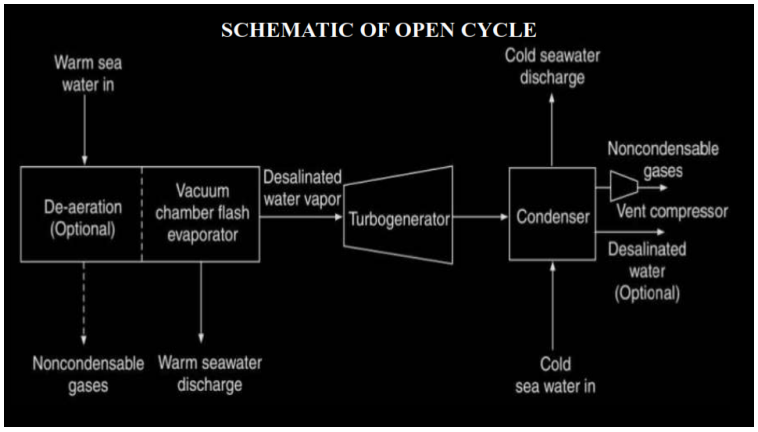


OPEN CYCLE OTEC SYSTEM

- In open-cycle, the sea water is itself used to generate heat without any kind of intermediate fluid.
- Warm seawater is expanded rapidly in a vacuum chamber where some of it 'flashes' to steam.
- This steam is used to drive a steam turbine.
- From the exhaust of the turbine, the vapor is condensed using cold seawater.
- Vapor expands and spins a turbine coupled to a turbo-generator to produce current.



1 Surface water ~ 25°C
2 Vacuum chamber, 3 % to 1 % of atmospheric pressure
3 Turbine
4 Generator
5 Line to the grid
6 Desalinated water ~ 23°C
7 Condenser
8 Deep water ~ 5°C
9 Waste water ~ 7°C
10 Vacuum pump



(b) State the merits and demerits of OTEC plants

Advantages:

Power developed is continuous and it is independent of weather. There is a small variation in power output from season to season . The system uses conventional power plants needing only small changes in design. It can produce simultaneously the desalinated water and nutrients for agriculture.

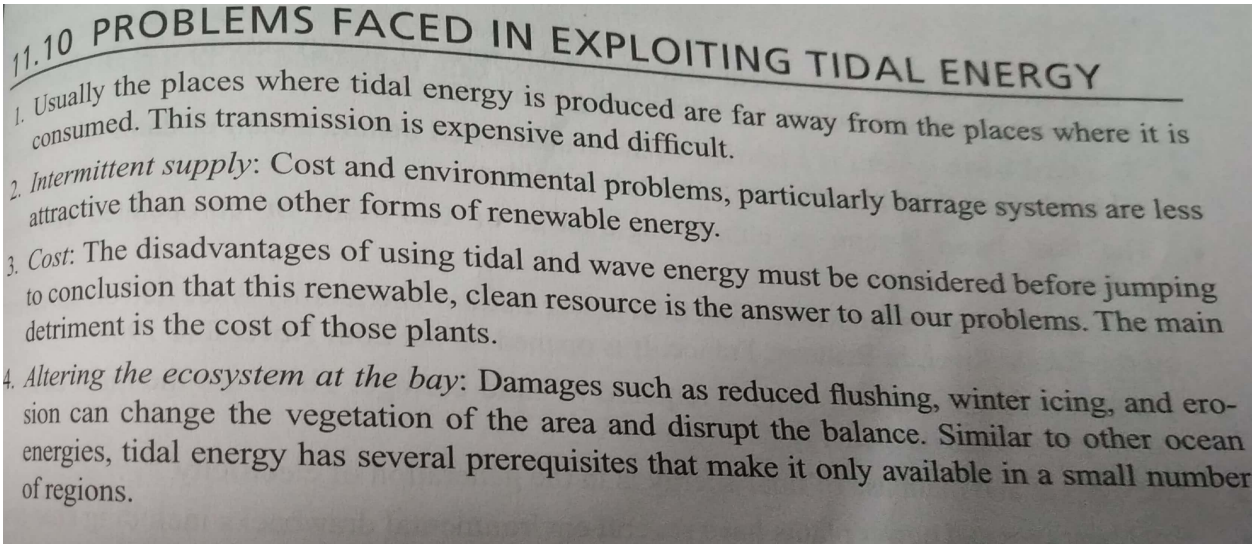
Disadvantages:

Capital cost is very high. Efficiency of energy conversion is very low. Needs very large sized turbines due to use of low pressure of steam having high specific volume in case of open cycle. It uses expensive power working fluids in case of closed cycle. Cost of electric power generation per kWh is very high.

8. (a) Name the different Bio-gas power plants in India

- Floating Drum or Constant pressure or KVIC (Khadi Village Industries Commision) model
- Fixed Dome or Constant Volume or Chinese model or Janata model
- Taper Digester with floating gas holder model (Nepal Design)
- Pragathi Bio-gas Model
- Ganesh Bio-gas model
- Jwala Biogas model
- Ferro-cement Biogas plant
- Floating Drum Fiberglass reinforced polyester plant
- ARTI Model of foating drum type biogas plant
- deenbandhu Biogas plant
- CAMATEC Model
- Bag/Tube/Flexi/Balloon Biogas Plant

(b) Discuss the problems associated with tidal energy harnessing.



11.10 PROBLEMS FACED IN EXPLOITING TIDAL ENERGY

1. Usually the places where tidal energy is produced are far away from the places where it is consumed. This transmission is expensive and difficult.
2. *Intermittent supply*: Cost and environmental problems, particularly barrage systems are less attractive than some other forms of renewable energy.
3. *Cost:* The disadvantages of using tidal and wave energy must be considered before jumping to conclusion that this renewable, clean resource is the answer to all our problems. The main detriment is the cost of those plants.
4. *Altering the ecosystem at the bay*: Damages such as reduced flushing, winter icing, and erosion can change the vegetation of the area and disrupt the balance. Similar to other ocean energies, tidal energy has several prerequisites that make it only available in a small number of regions.

(c) Explain the factors affecting Bio-gas power plant
The main factors affect in the production of biogas have been identified as: 1) Sub-layer composition; 2) Temperature inside the digester; 3) Retention time; 4) Working pressure of the digester; 5) Fermentation medium pH; 6) Volatile fatty acids (VFA)