Renewable-Energy-Series-1-Important-Topics

For more notes visit

https://rtpnotes.vercel.app

Classification and various types of solar collectors

- Solar collector is a device for collecting solar radiation and then transferring the absorbed energy to a fluid passing through it.
- A solar collector absorbs solar energy in the form of heat and simultaneously transfers this heat to a fluid so that heat can be transported by the fluid.

Classification of solar collectors

- There are mainly 2 types of solar collectors
  - Non concentrating or flat plate solar collector
  - Concentrating type solar collector

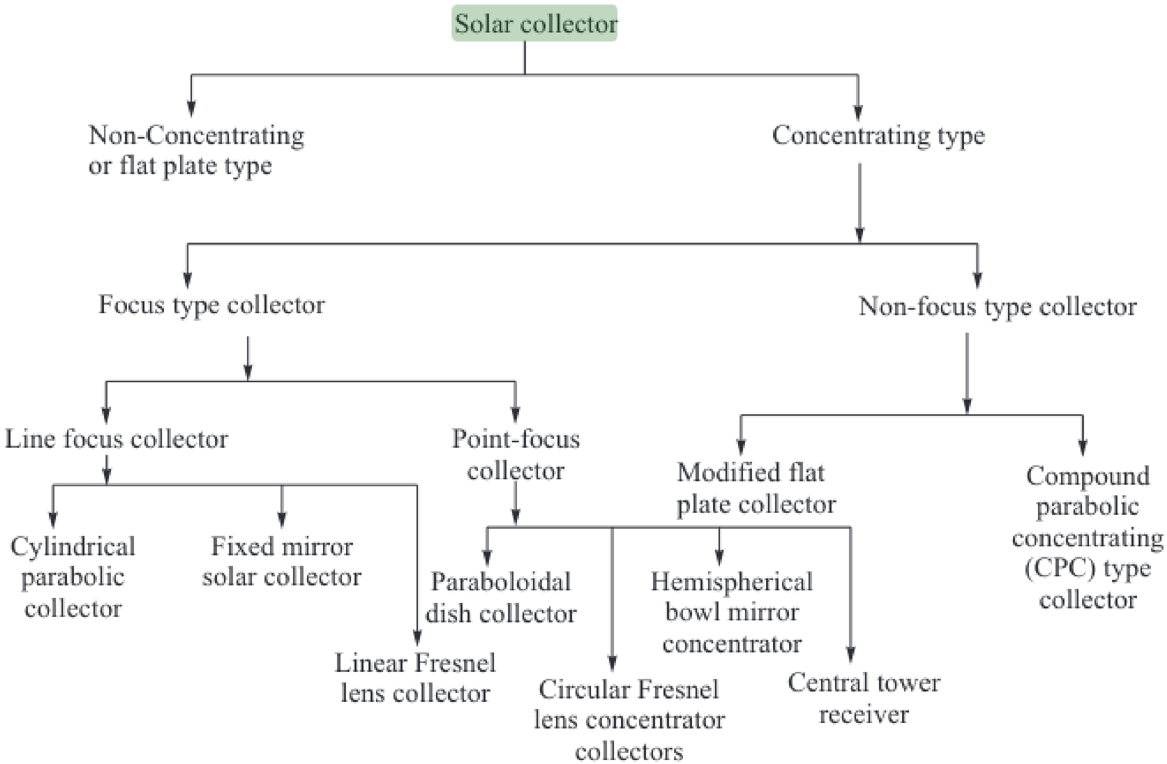


Figure 3.1 Classification of collectors.

1. Flat plate collector

- A flat plate collector consists of the following components
  - Absorber plate
    - Intercept and absorb incident solar radiation
    - Blackened heat absorbing plate
  - Transparent Cover
    - Placed above absorber plate, allows radiation to reach absorber
  - Fluid tubes or channels
    - Heat is transferred from absorber to fluid in tubes or channels
  - Thermal insulation
    - Provided under absorber plate and fluid tubes to minimise heat loss
  - Tight container or box
    - Above components are protected by tight container

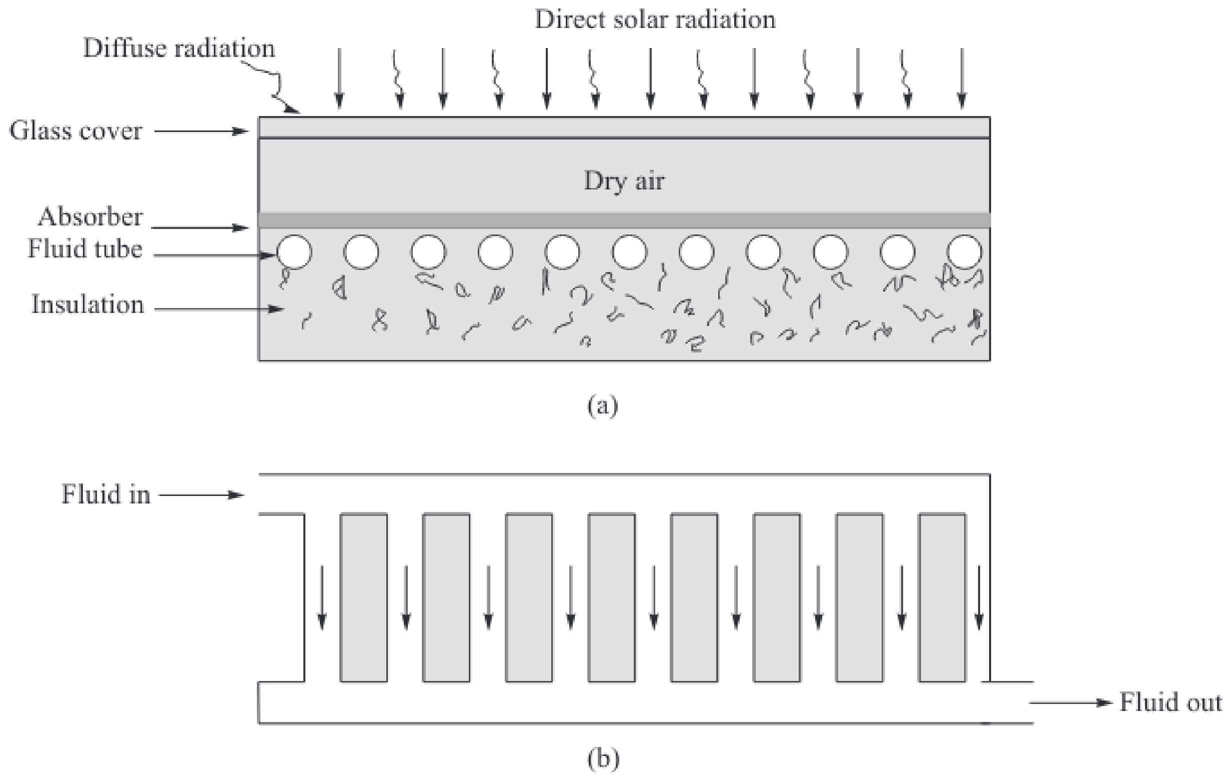


Figure 3.3 Flat plate solar collector. (a) Layout of transparent cover, absorber and fluid tubes. (b) Fluid tube connection and fluid flow.

2. Modified Flat plate collector

- Modified form of flat plate collector, as it has plain reflectors at edges to reflect additional radiation to the absorber or receiver and so there is some concentratiion of solar radiation at the receiver
- Concentration ratio 1->4

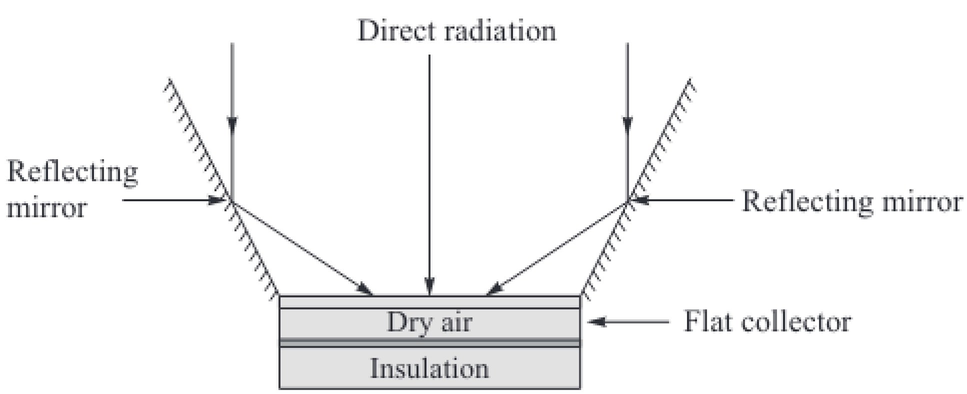


Figure 3.4 Modified flat plate collector.

3. Compound parabolic concentrator

- Compound parabolic concentrator is a flat collector having 2 parabolic mirrors attached at the edge of flat plate collector

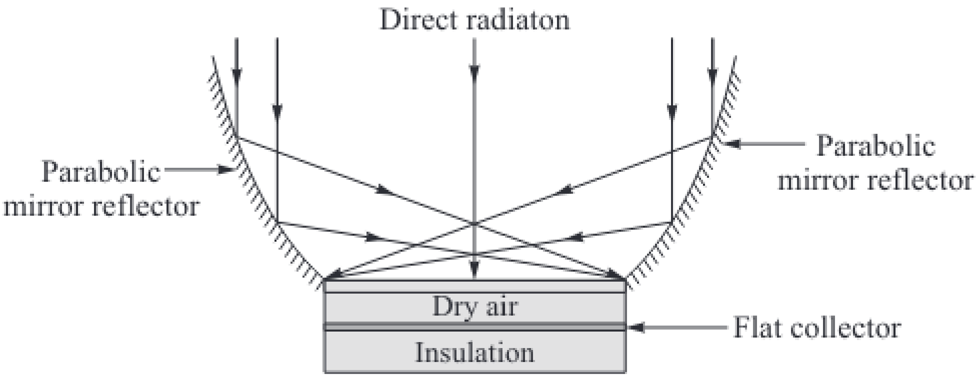


Figure 3.5 Compound parabolic concentrator.

- The parabolic mirrors are adjusted such that focus of one mirror is located at bottom end of the other mirror in contact with the receiver. The arrangement helps in increasing acceptance angle
- Concentration ratio: 3 -> 7

4. Cylindrical parabolic concentrator

- Consists of a cylindrical parabolic trough reflector with a metallic fluid tube or receiver tube containing fluid at its focal line
- Fluid tube is blackened for better absorption of solar radiation
- The concentrated fluid tube heats up the transport fluid flowing through it.
- Concentration ratio 5 - 30

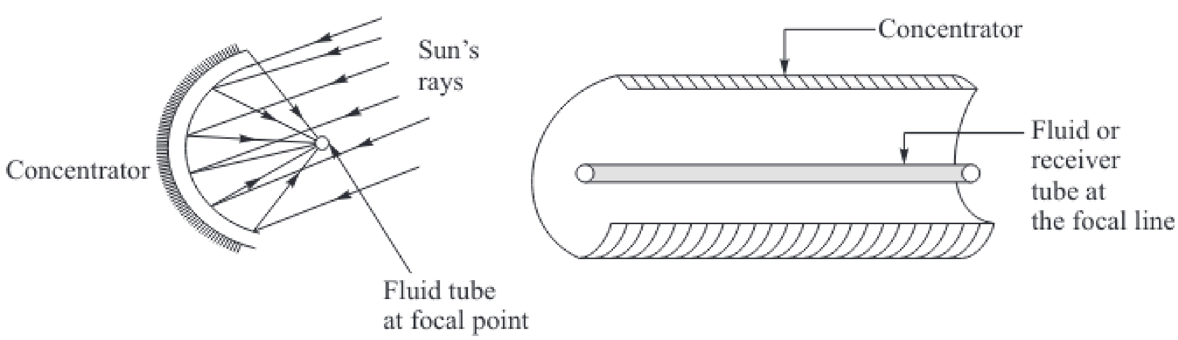


Figure 3.6 Cylindrical parabolic concentrator. (a) Focussing of sun's rays. (b) Arrangement of cylindrical concentrator and fluid tube.

5. Linear Fresnel Lens Collector

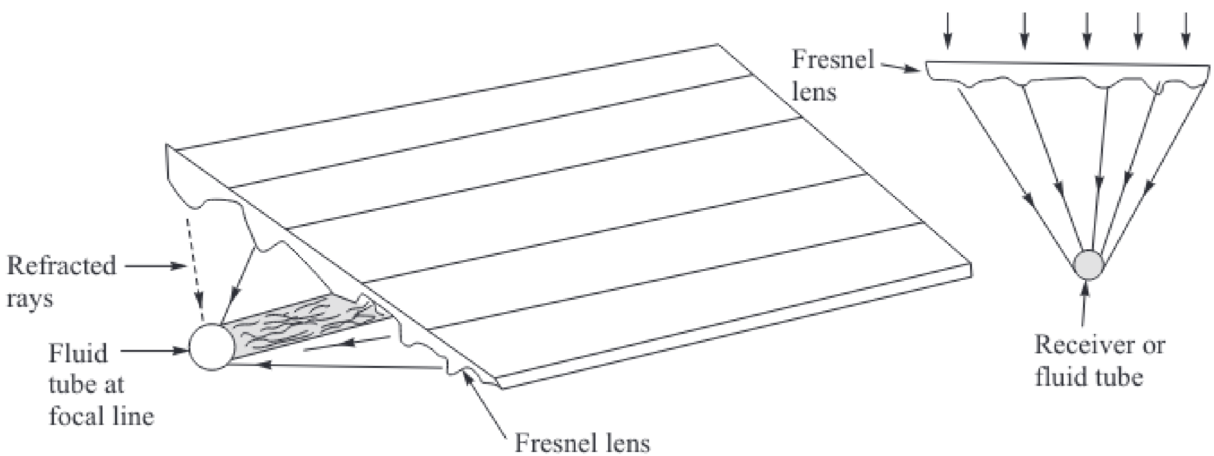
- Concentrator in the form of Fresnel lens is used.
- Fresnel lens consist of fine and linear grooves formed on one of the surfaces of some refracting materials, while other surface is flat.
- The grooves are designed in sucha way that it behaves similar to spherical lens, so it converges to focal line of lens where fluid tube is provided.
- The heat is transferred to transport fluid flowing in the fluid tube.
- Concentration ratio of 10 to 30
- Temperature range: 150 -> 300
- 

Figure 3.7 Linear Fresnel lens collectors.

6. Fixed Mirror Solar Concentrator

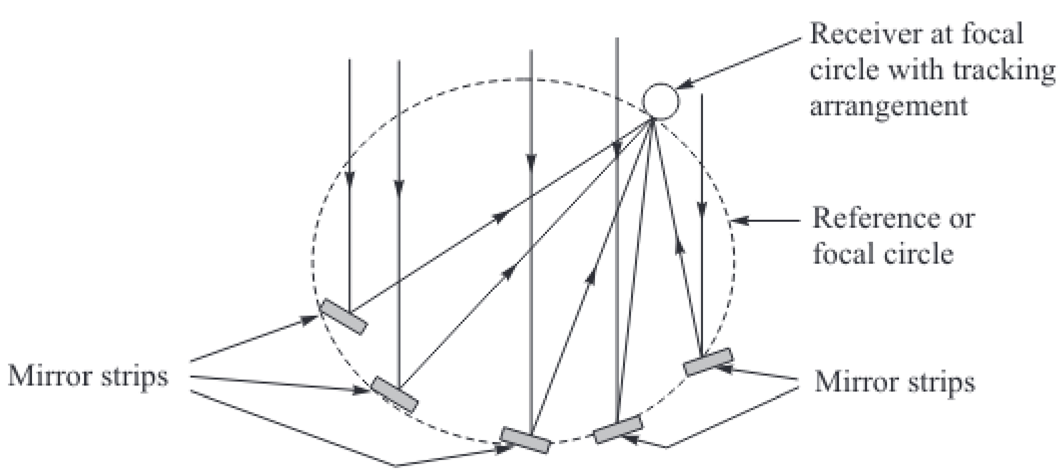
- The concentrator consists of a number of long narrow mirror strips fixed on circumference of a certain reference cylinder with a fluid tube moving at the same circular circumference or focal circle
- 

Figure 3.8 Fixed mirror solar concentrator.

- The mirrors are arranged in such a manner that incident radiation on them is focused on the receiver tube on their common focal circle
- The receiver tube can move along focal circle as per the movement of sun in the sky
- Concentration ratio = number of mirrors used

7. Paraboloidal dish collector

- A point focus collector has a dish in the shape of a paraboloidal.
- It concentrates all radiation parallel to its axis to a point where receiver tube is positioned

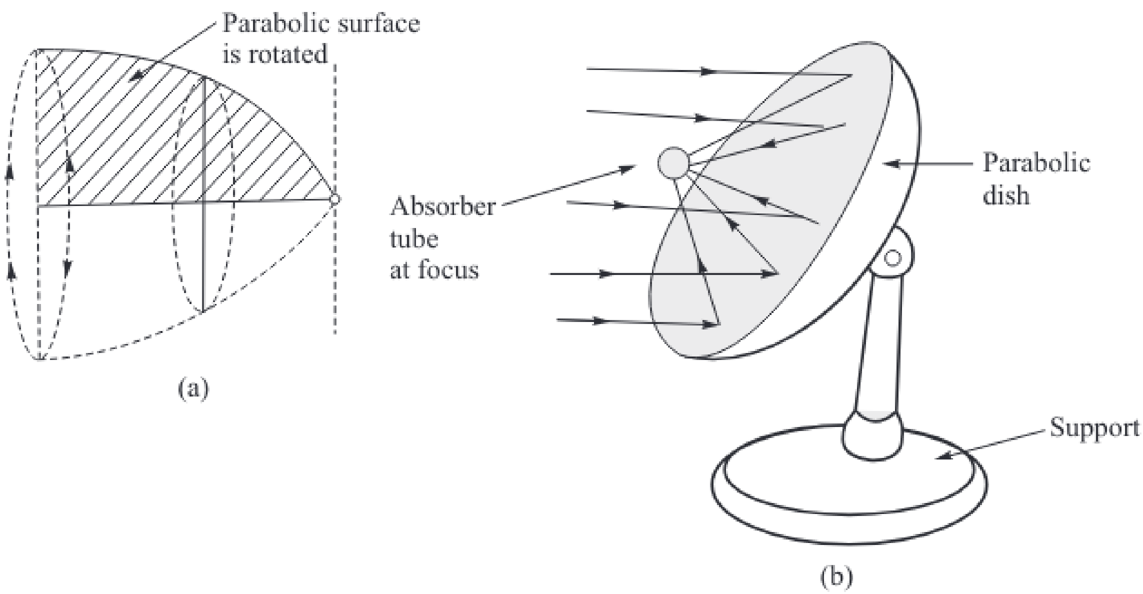


Figure 3.9 Paraboloid point focus solar collector. (a) Generation of paraboloid surface. (b) Parabolic surface concentrating radiation.

-
- Concentration Ratio ranging from 10 to 1000
- Produces temperature upto 3000C

8. Hemispherical Bowl Mirror Concentrator

- Hemispherical Bowl Mirror Concentrator is a point focus concentrator in which reflector remains stationary
- Receiver is made to track 2 axes per movement of sun in the sky.
- All sun rays after reflection are concentrated at focal point

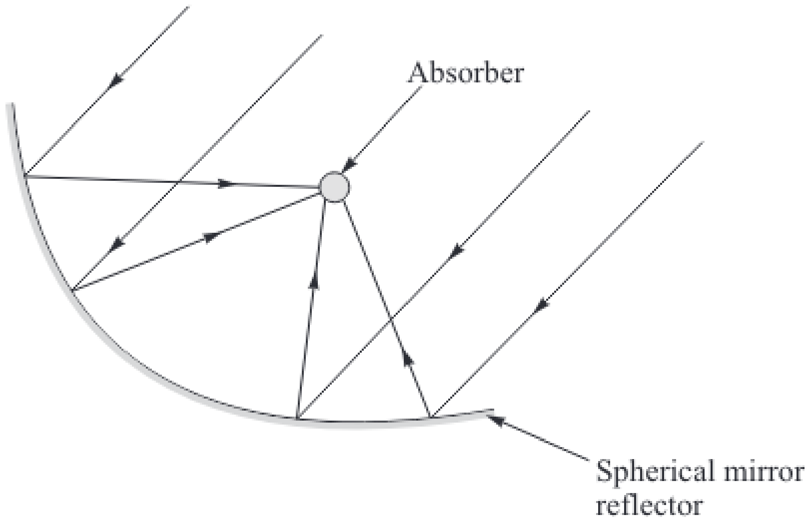


Figure 3.10 Hemispherical bowl mirror concentrator.

9. Circular Fresnel Lens Concentrator

- Principle of working is similar to linear fresnel collector
- This type of collector is designed to concentrate the radiation at one focal point instead of line focus.
- Concentration ratio = 2000

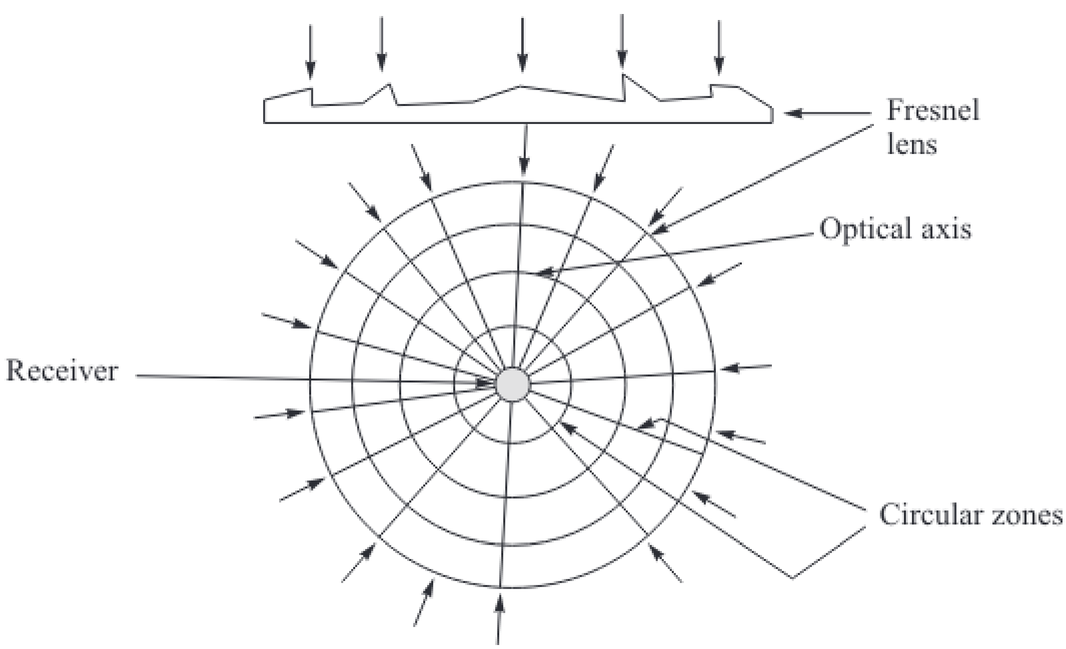


Figure 3.11 Circular Fresnel lens concentrator.

10. Central Tower Receiver Collector

- In this type of collector, the receiver is located at the top of a tower and solar radiation is reflected on it from a large number of independently controlled flat mirrors called heliostats
- Heliostats are spread over a large area on ground surrounding the absorber mounted on the tower
- Number of heliostats can be high as thousands, they track the sun to reflect the radiation
- Concentration ratio = 3000

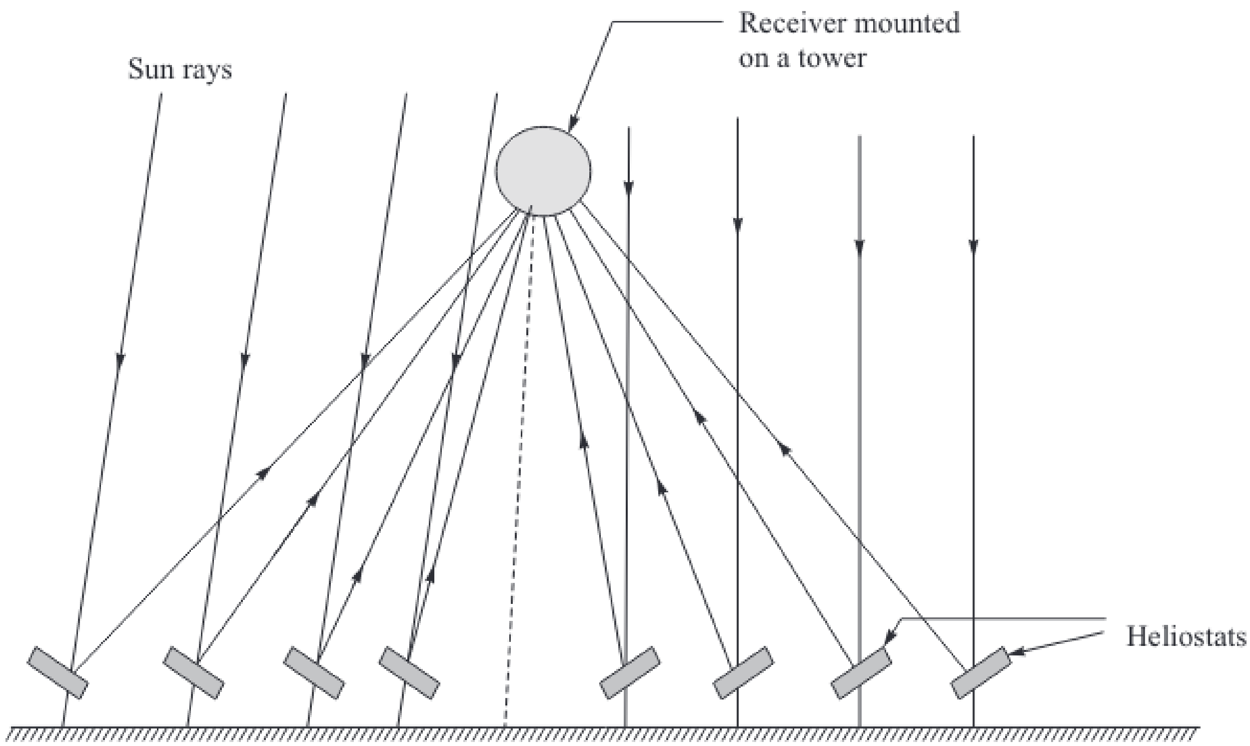


Figure 3.12 Heliostats and the receiver in a central tower receiver collectors.

-

Working of Solar Pond

A solar pond is a special type of pond designed to collect and store solar energy in the form of heat, which can then be used for various purposes such as electricity generation or industrial processes.

Principle

- In ordinary pond, when water is heated by by sun rays, the heated water rises to top of the pond

- Hot water loses heat to the atmosphere, net temperature at the top of the pond remains nearly at atmospheric temperature
- Solar pond technology ensures that heated brine water remains at the bottom of the pond due to more brine concentration and density

What is a solar pond?

- Solar pond consist of a large size brine pond
- Most concentrated and dense part of the brine solution is at the bottom of the pond
- It has 3 zones, top zone, non convective zone, bottom zone
- **Top zone** is surface zone with least salt content
- **Bottom zone** is having maximum salt content and high temperature
- Solar energy is collected and stored in the **bottom zone.**

Working

- The hot brine solution from bottom of solar pond is taken out
- The solution is taken to the heat exchanger to remove heat from the brine solution
- These vapours are used to run a turbine which is coupled to a generator to generate power.

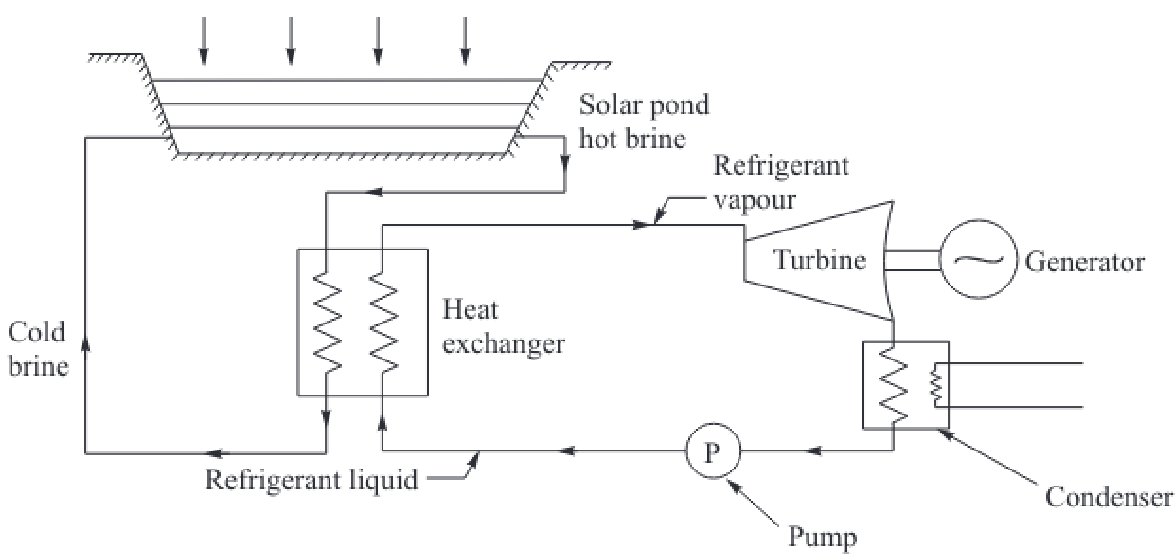


Figure 3.18 Layout of a solar pond electric power plant.

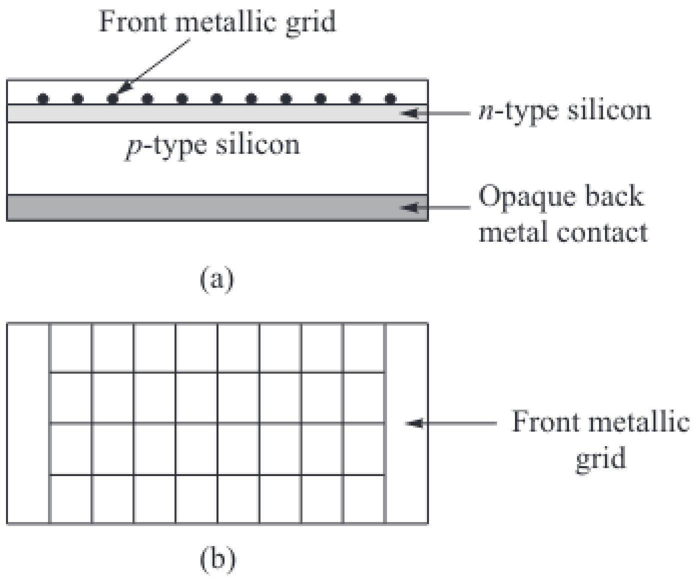
Solar Thermal Systems

- Solar energy can be utilized directly in two ways:
  - by collecting the radiant heat and using it in a thermal system -Solar Thermal
  - by collecting and converting it directly to electrical energy using Photovoltaic system. - 'Solar Photovoltaic' (SPV)system
- **Solar thermal systems** provide thermal energy for various processes. In cold climate regions,large amount of low-grade thermal energy is required for heating air for comfort and hot water for domestic needs
- **Solar thermal energy** is also being utilized in drying and process industries. It can also be converted and utilized as mechanical and electrical energy in the same way as in any conventional thermal system.
- Some Solar Thermal Systems
  - **Solar Collectors**: Devices that capture and convert sunlight into thermal energy for various applications.
  - **Solar Energy Storage**: Systems designed to store thermal energy collected from the sun for later use.
  - **Solar Pond**: A special pond that captures and stores solar energy by using layers of water with different levels of salt to trap heat.
  - **Solar Water Heater**: A system that uses solar energy to heat water for domestic or industrial use.
  - **Solar Thermal Pump**: A pump powered by solar thermal energy, typically used in heating or cooling systems.
  - **Solar Furnace**: A structure that uses concentrated solar energy to generate extremely high temperatures.
  - **Solar Refrigeration and Cooling System**: Systems that use solar thermal energy to provide cooling or refrigeration.
  - **Solar Cookers**: Devices that use solar energy to cook food by concentrating sunlight.
  - **Solar Greenhouse**: A greenhouse that uses solar energy to create an optimal growing environment for plants.

Solar cell characteristics

- The solar cell consists of

- p-type silicon material layer
- n-type silicon material layer
- front metallic grid
- opaque black metal contact



How it works

- p-n junction is forward biased, electrons from p-region start moving towards the positive terminal of the battery

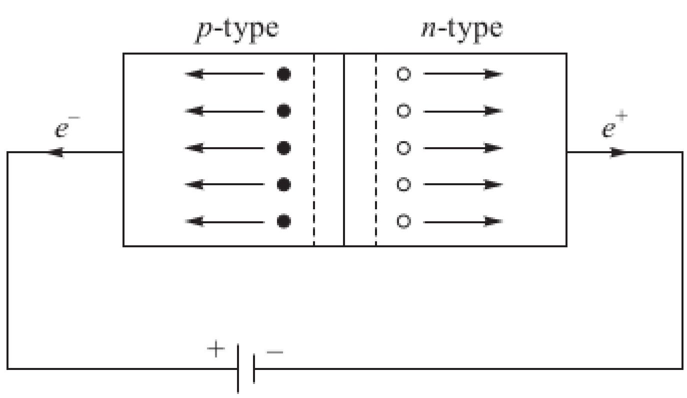


Figure 4.12 The *p-n* junction forward biased.

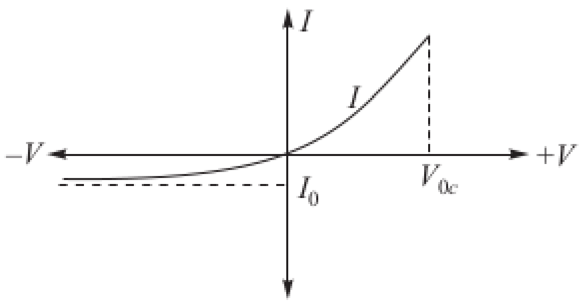


Figure 4.13 Current–Voltage characteristic of *p*-*n* junction when forward and backward biased.

-
- As Voltage increases, current also increases,
- When reverse voltage is applied, there is a small reverse saturation current I0 instead of the current being 0

Solar PV systems

Classification of Solar PV systems

- The classification of solar PV systems are

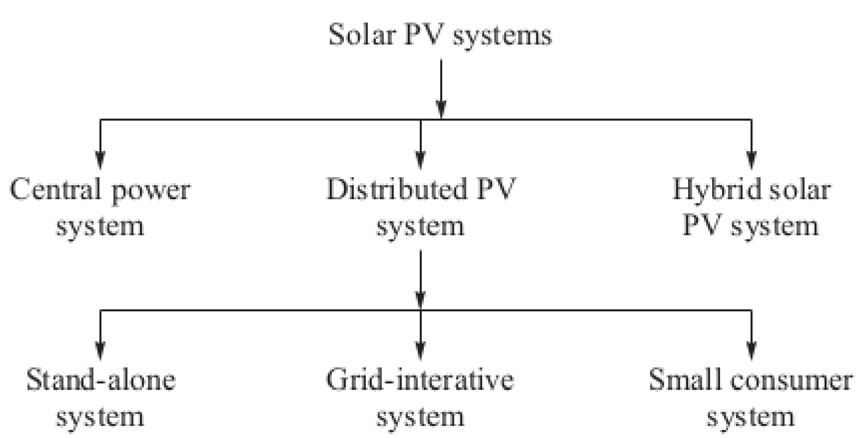


Figure 4.16 Classification of solar PV systems.

-

Central Power station system

- A central power station system is a large-scale solar power plant designed to generate electricity on a scale similar to conventional power stations, with the key difference being that it harnesses solar energy.

- This type of solar power station is similar to other conventional power stations which are required to feed generated power into some national grid.
- This type of solar power stations are designed to meet high peak daytime load only and these have large generation capacity in megawatt.
- Only few such power stations have been installed as the capital cost of theses plants is high

Stand-Alone System

A stand-alone solar photovoltaic (PV) system is an independent power station designed to generate electricity from sunlight. It's particularly useful in remote areas where connection to the main power grid is not feasible.

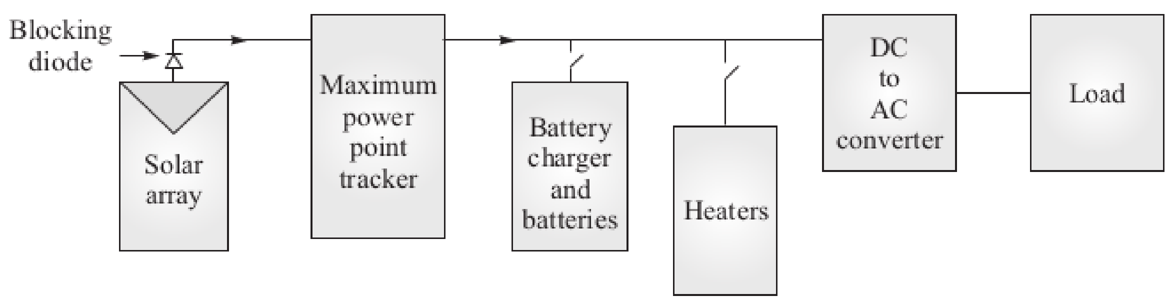
Key Components and Functions:

1. **Solar PV Power Station:**
    - **Location:** The solar panels are installed at the load center, meaning close to where the electricity is needed, such as in a remote village, isolated area, or a specific installation.
    - **Purpose:** The entire system is designed to meet the electrical needs of the area without relying on external power sources.
2. **Maximum Power Point Tracker (MPPT):**
    - **Function:** The MPPT is a crucial component that optimizes the efficiency of the solar panels. It continuously monitors the voltage and current output from the solar array (the group of solar panels) and adjusts the operating point to ensure the panels are generating the maximum possible power under current conditions.
3. **Power Conversion:**
    - **DC to AC Conversion:** The electricity generated by the solar panels is in direct current (DC) form. Since most household appliances and electrical systems operate on alternating current (AC), an inverter is used to convert the DC output to AC. This AC electricity is then used to power the electrical loads (like lights, fans, and other devices).
4. **Energy Storage:**
    - **Battery Storage:** Excess electricity generated by the solar panels, which isn't immediately needed, is stored in batteries. These batteries are charged during the

day when solar radiation is available.

- **Backup Supply:** When sunlight isn't available (e.g., at night or during cloudy weather), the stored energy in the batteries is used to power the electrical load, ensuring a continuous power supply.

5. **Excess Power Management:**
    - **Electric Heaters:** If the batteries are fully charged and there's still excess power being generated, this surplus energy can be diverted to electric heaters or other devices that can safely consume the extra power, preventing waste and ensuring the system runs efficiently.

- 

Grid Interactive Solar PV System

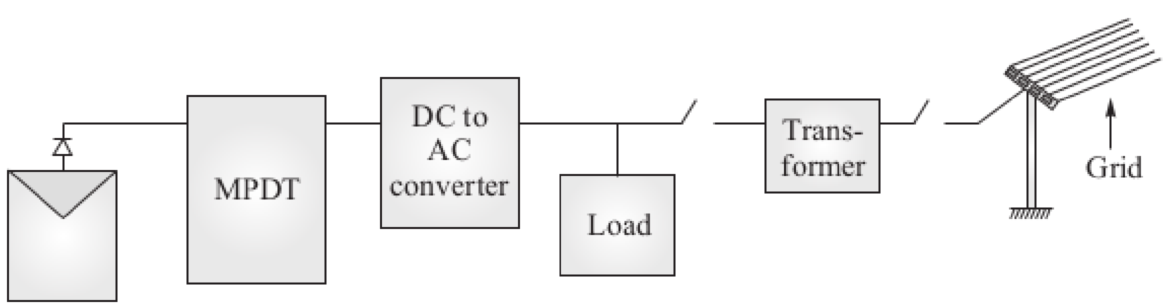
- The system first meets the requirement of house, village, and all excess power is fed into electric grid
- During absence of insufficient sunshine, the supply of electricity is maintained from the electric grid, so no need of battery
- 

Figure 4.18 Grid interactive solar PV system.

Small consumer systems

- These systems are designed to meet power requirement of low energy devices which are generally used for indoor applications, like calculators, watches etc.

Hybrid Solar PV System

- Hybrid solar PV system is designed to provide electric power by some other means beside solar electricity.
- It uses things like windmills, fuel cells, diesel or petrol generators

OTEC Open Type and Closed Type

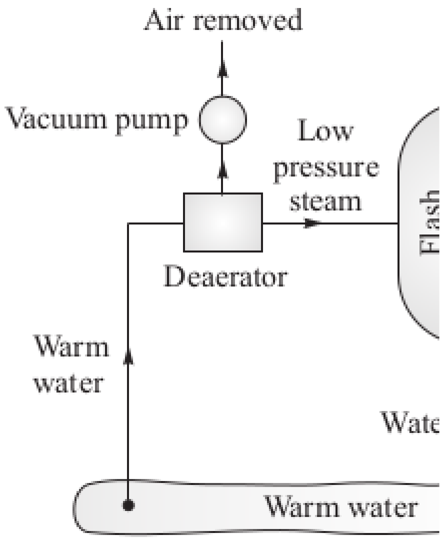
Ocean Thermal Energy Conversion (OTEC) is a sustainable way to generate energy by harnessing the natural temperature differences in ocean water.

What is OTEC?

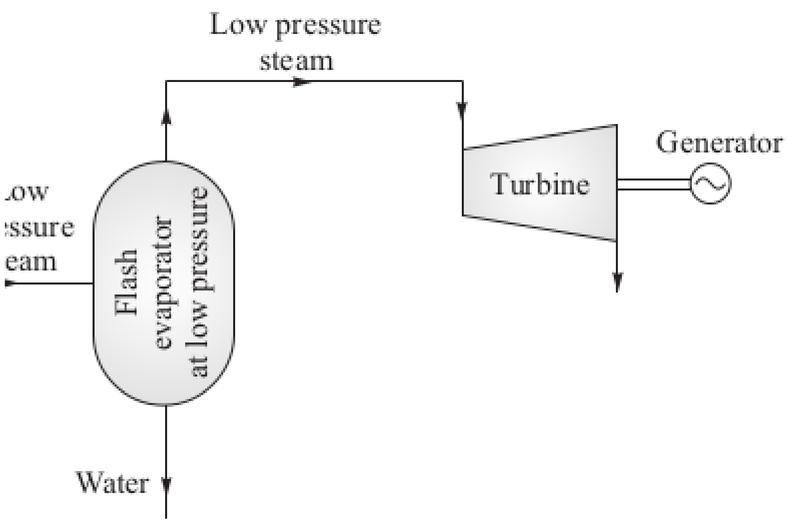
- **Ocean Thermal Energy:** The sun heats the surface of the ocean, making the water warmer at the top compared to the deeper, colder layers. This creates a temperature gradient (difference).
- **OTEC (Ocean Thermal Energy Conversion):** OTEC systems use this temperature difference to generate electricity. The basic idea is that warm water from the surface and cold water from the deep ocean are used to drive a heat engine, much like a steam engine, to produce power.

Open Cycle:

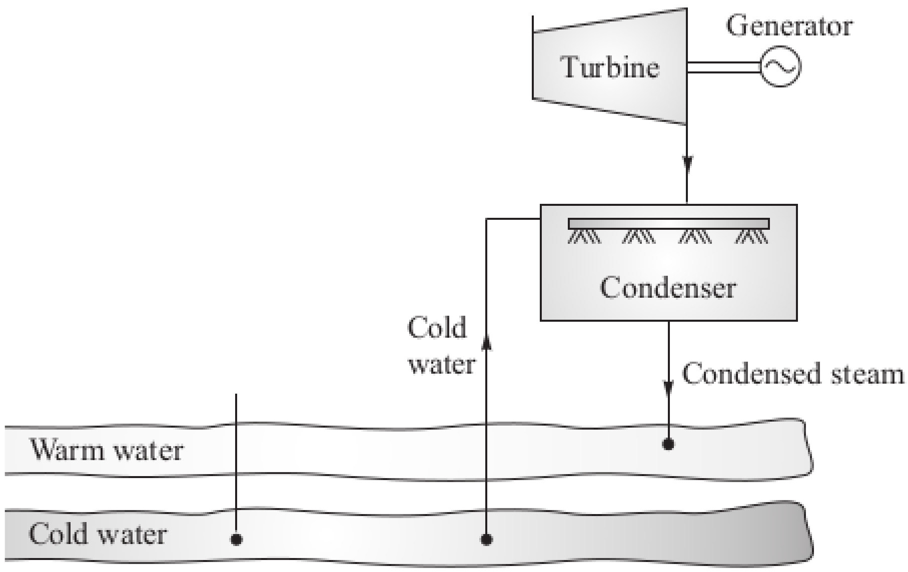
1. **Evaporation:** Warm surface water is pumped into a low-pressure chamber (flash evaporator), where it boils rapidly at a lower temperature due to the reduced pressure. This creates low-pressure steam.

1. 

2. **Energy Extraction:** The steam is then directed through a turbine, which spins and generates mechanical energy. This energy is then converted into electricity.

1. 

3. The steam after energy removal in turbine is condensed into water in a condenser which is cooled by cold water drawn from the depths in the ocean.



1. **Figure 13.1** Open cycle OTEC plant.

4. Full diagram

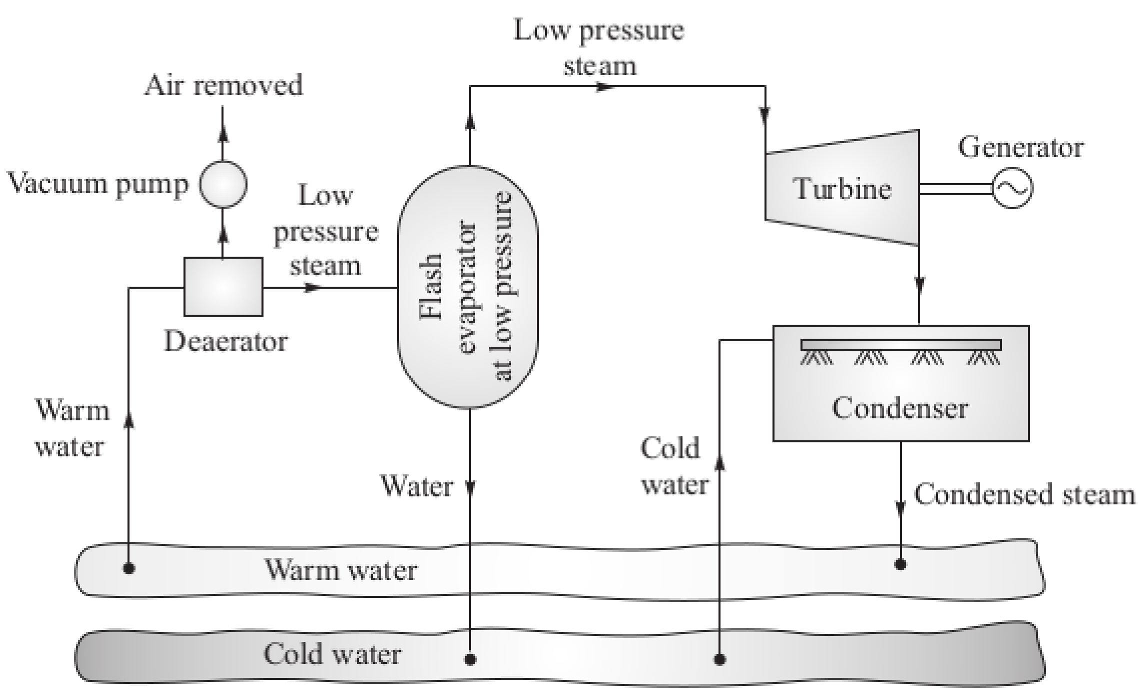


Figure 13.1 Open cycle OTEC plant.

1.

Closed Cycle:

1. **Evaporation:** Instead of using water, a special fluid with a low boiling point (like ammonia or a refrigerant) is heated by the warm surface water, causing it to evaporate.

2. **Energy Extraction:** The vaporized fluid is used to spin a turbine, just like in the open cycle.
3. **Condensation:** After passing through the turbine, the vapor is cooled by cold deep-sea water, turning it back into a liquid, ready to be reused in the cycle.
4. **Advantages:** Closed-cycle OTEC systems are typically more compact and cost-effective than open-cycle systems.

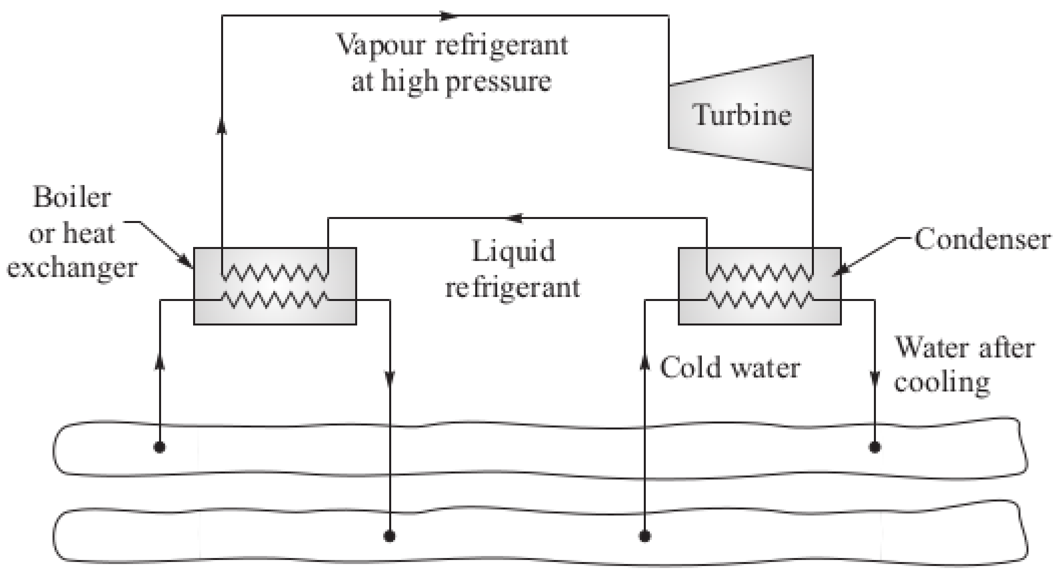


Figure 13.2 Closed cycle OTEC plant.

5.