Renewable-Energy-Systems-Module-2-Important-Topics-PYQs

    - How Does Biofouling Affect Efficiency?
    - How Can Biofouling Be Minimized?
- 10. What are the different classifications of tidal power plants. Explain the components and detailed working operation of double basin tidal power plant with neat sketch.
  - Single Basin System
  - Double Basin System
    - Components of Double Basin Tidal Power Plant
    - Working of Double Basin Tidal Power Plant
    - Advantages of Double Basin System
- 11. What are the limitations of the tidal power production?
- 12. Elaborate on how the tidal phenomena occur with suitable sketches. List 2 advantages and disadvantages of tidal energy conversion systems.
    - Tidal Energy
    - Advantages of Tidal Energy Conversion Systems
    - Disadvantages of Tidal Energy Conversion Systems
- 13. With a neat diagram explain the working of a Hybrid Cycle OTEC system
    - How It Works (Step by Step)
    - Why Use a Hybrid OTEC System?
- 14. Explain the advantages of OTEC systems
- 15. Explain the various methods of tidal power generation. What are the limitations of each method.
    - 1. Single Basin System
    - 2. Double Basin System
- 16. What are the site requirements to construct a tidal power plant?
- 17. Open Cycle OTEC-Working and diagram
    - Open Cycle:
- 18. Closed Cycle OTEC-Working and diagram
    - Closed Cycle:

Important Topics and PYQs

1. List out any four environmental impacts of OTEC systems

1. Harm to Marine Life

- **Impact**: OTEC systems circulate large amounts of water, which can destroy small marine organisms like eggs, larvae, and small fish.
- **Explanation**: These organisms get trapped or damaged in the process of pumping water from the ocean's depths to the surface, disrupting the marine ecosystem's food chain.

2. Damage to Ecosystems

- **Impact**: The plant can affect nearby ecosystems, including coral reefs, and might also influence ocean currents and weather patterns.
- **Explanation**: Changes in water temperature and movement caused by the plant can disrupt the delicate balance of marine ecosystems and alter local climates.

3. Temperature changes

- **Impact**: OTEC releases large amounts of cold water from deep ocean layers into warmer surface environments, which can harm marine species adapted to specific temperatures.
- **Explanation**: This sudden temperature change can stress or kill marine life, altering the habitat and biodiversity.

4. Greenhouse Gas Emissions

- **Impact**: Carbon dioxide dissolved in warm ocean water is released into the atmosphere during the process, contributing to the greenhouse effect.
- **Explanation**: Although OTEC is renewable, the release of CO_2 can still contribute to climate change in systems using open cycles.

2. What are the different components of the tidal power plant? Explain.

What is a Tidal Power Plant?

A tidal power plant is a facility that generates electricity using the rise and fall of sea levels (tides). It uses the potential energy created by the difference in water levels during high and low tides to produce power.

Main Components of a Tidal Power Plant

1. **Dam or Dyke**
    - **Purpose**: Acts as a barrier between the sea and the reservoir (or basin).
    - **Function**: Helps store water during high tides and separates the tidal basin from the open sea.
    - **Extra**: If there are multiple basins, additional dams may be built between them.
2. **Sluiceways**
    - **Purpose**: Allow water to flow in and out of the basin.
    - **Function**: During high tides, sluice gates open to let water into the basin, and during low tides, they allow water to flow out.
    - **Control**: Gates are used to regulate the water flow for maximum energy capture.
3. **Powerhouse**
    - **Purpose**: Contains the machinery that converts tidal energy into electricity.
    - **Key Components**:
        - **Turbines**: Water flows through these to produce mechanical energy.
        - **Generators**: Convert the mechanical energy into electrical energy.
        - **Auxiliary Equipment**: Supports the main operations, ensuring smooth functioning.

3. What are the important criteria for selecting a site for the installation of an OTEC system?

To successfully install an Ocean Thermal Energy Conversion (OTEC) system, specific conditions and criteria must be met. These are:

1. **Temperature Difference**
    - A **minimum temperature difference of 20°C** between the warm surface water (about 27°C) and the cold deep water (around 4°C) is essential for efficient operation.
    - This condition is generally met in tropical oceans.

2. **Depth of Cold Water**
    - The site should have access to **deep ocean water close to the shore** to minimize the length and cost of pipelines used to pump cold water.
3. **Proximity to Shore**
    - Sites near the shoreline reduce costs for laying power transmission cables and pipelines.
    - Floating plants are an alternative for offshore locations but are costlier and face harsher environmental conditions.
4. **Marine Conditions**
    - The site should have **calm ocean conditions** to ensure plant stability and prevent damage from strong waves or storms.
    - Areas with low risk of severe weather events are preferred.
5. **Environmental Impact**
    - The site must minimize harm to marine ecosystems, such as coral reefs and marine life.
    - Environmental studies are essential to assess and mitigate impacts.
6. **Infrastructure**
    - The location should have the necessary infrastructure, such as ports for construction and maintenance and facilities to transport the generated electricity.
7. **Economic Viability**
    - The site should offer cost-effective operations, considering factors like proximity to energy demand centers and potential for by-products like desalinated water.

4. Explain the principle of tidal energy conversion.

What is Tidal Energy?

Tidal energy comes from the rise and fall of sea levels (tides), caused by the gravitational pull of the Moon and the Sun. The difference in water levels between high tide and low tide creates potential energy that we can convert into electricity.

How Tidal Power Plants Work

1. **Tides and Energy**:
    - **High Tide**: Water flows into a reservoir behind a dam.

- **Low Tide**: The stored water is released back to the sea, flowing through turbines.

2. **How Energy is Created**:
    - The flowing water spins turbines.
    - The turbines power generators, producing electricity.
3. **Minimum Tidal Range**:
    - The height difference between high and low tides (tidal range) must be at least **5 meters** for the plant to work efficiently.

Ways Tidal Power Plants Operate

1. **Ebb Generation**: Water flows out of the reservoir during low tide to generate electricity.
2. **Flood Generation**: Water flows into the reservoir during high tide to generate electricity.
3. **Two-Way Generation**: Power is generated during both high and low tides by reversing water flow.
4. **Pumping and Turbining**: Water is pumped into the reservoir during high tide and released to generate power during low tide.

5. Differentiate between Open Cycle and Closed Cycle OTEC systems

Open Cycle OTEC:

1. **Working Principle**:
    - Uses **warm surface seawater** directly.
    - Warm seawater is placed in a **low-pressure flash evaporator**, causing it to boil at a lower temperature.
    - The resulting **low-pressure steam** drives a turbine to generate electricity.
    - After energy extraction, the steam is condensed using **cold seawater** pumped from deep in the ocean.
2. **Key Features**:
    - Produces **desalinated water** as a by-product.
    - Requires a vacuum system to maintain low pressure.
    - Complexity arises in handling low-pressure steam and managing evaporator and condenser design.

3. **Advantages**:
    - Directly uses seawater, no need for a separate working fluid.
    - Desalinated water can be an additional benefit.
4. **Challenges**:
    - Large and complex vacuum systems.
    - Difficult to design and maintain turbines for low-pressure steam.

Closed Cycle OTEC (Anderson Cycle):

1. **Working Principle**:
    - Uses a **working fluid** with a low boiling point (e.g., ammonia or freon).
    - Warm surface seawater heats the fluid in a **heat exchanger (boiler)**, causing it to vaporize.
    - The vapor drives a turbine, generating electricity.
    - The vapor is then cooled and condensed using **cold deep seawater**, completing the cycle.
2. **Key Features**:
    - A **working fluid** circulates in a closed loop.
    - Requires **compact heat exchangers** and efficient turbines.
3. **Advantages**:
    - More compact and cost-effective compared to open cycle systems.
    - Easier to control due to the closed loop.
4. **Challenges**:
    - Handling and safety concerns of the working fluid.
    - Large heat exchangers needed for effective operation.

Aspect	Open Cycle OTEC	Closed Cycle OTEC
Heat Source	Warm seawater	Warm seawater
Working Fluid	Water (from the ocean)	Low boiling point refrigerant (e.g., ammonia)
Turbine Input	Low-pressure steam	Refrigerant vapor
By-product	Desalinated water	None

Aspect	Open Cycle OTEC	Closed Cycle OTEC
Design Complexity	Flash evaporator & vacuum system	Heat exchangers & refrigerant handling
Efficiency	Lower	Higher
Environmental Impact	Minimal water treatment required	Handling refrigerants carefully needed

6. Explain the environmental impacts of Tidal Energy conversion systems

- **Habitat Disruption:**
  - Tidal energy plants, especially those involving dams or barrages, can disrupt the natural habitats of marine species. The construction of these systems may interfere with local ecosystems, including the habitats of fish, birds, and other aquatic life.
  - The change in water levels and currents can affect the migration patterns of species, especially those that rely on estuaries for breeding or feeding.
- **Water Quality Changes:**
  - Tidal plants can cause changes in water quality, particularly in terms of salinity and oxygen levels. The movement of water in and out of reservoirs can alter local water conditions, potentially harming marine life that is sensitive to such changes.
  - If silt builds up in reservoirs, it can lead to reduced water quality, as well as increased costs and complexity in maintaining the plant.
- **Corrosion and Wear:**
  - The corrosive nature of seawater can shorten the lifespan of the turbines, generators, and other equipment in tidal power plants. Regular maintenance and replacement of these components are necessary, which can have additional environmental and economic costs.
- **Impact on Fish and Marine Life:**
  - The turbines in tidal power systems can pose a risk to marine animals, particularly fish and small marine creatures, which may become entrained in the turbines. While some plants use fish-friendly designs to minimize these risks, they remain a concern for aquatic biodiversity.
- **Coastal Erosion:**

    - The construction of dams or other structures associated with tidal power plants can interfere with natural coastal processes, potentially increasing the risk of coastal erosion in the surrounding areas. This can lead to long-term changes in the landscape and coastal ecology.
- **Noise and Visual Impact:**
    - The operation of tidal energy plants may generate underwater noise, which can disturb marine life, particularly species that rely on sound for communication or navigation.
    - On the surface, the presence of large structures like dams and turbines can alter the visual appearance of the coastline, which could affect tourism and local communities who rely on scenic coastal environments.
- **Sediment Management:**
    - Sedimentation and silt deposition in tidal basins can be problematic. These materials accumulate over time and need to be removed to ensure the efficient operation of the system. The removal process itself can be environmentally disruptive.

7. List out the factors influencing the demand of energy.

1. **Consumer Needs**:
    - Energy demand arises from the consumer's need for services. For example:
        - Petrol is needed to drive cars.
        - Electricity is used to power air conditioners, refrigerators, or TVs.
2. **Technology Availability and Efficiency**:
    - The type and efficiency of energy-using devices play a big role.
        - Efficient cars use less petrol for the same distance.
        - Advanced air conditioners consume less electricity.
3. **Cost of Energy and Technologies**:
    - Higher energy prices can lower demand.
        - If petrol becomes expensive, people might drive less or buy fuel-efficient cars.
        - High electricity prices might push people to use energy-saving appliances.
4. **Alternatives to Energy Use**:
    - Consumers may shift to alternatives when energy prices rise.

- For example, instead of using gas for heating, people might invest in better home insulation.

8. Discuss the basic principle of OTEC.

Ocean Thermal Energy Conversion (OTEC) is a process that generates energy by using the temperature difference between warm surface water and cold deep ocean water. Here's a simplified explanation:

1. **Source of Energy**:
   - The ocean absorbs solar radiation, heating the surface water.
   - Deep ocean water, shielded from sunlight, remains cold.
2. **Temperature Difference**:
   - A minimum temperature difference of about **20°C** between the warm surface water (around 27°C) and the cold deep water (around 4°C) is required for OTEC to work effectively.
3. **How it Works**:
   - Warm surface water is used to heat a liquid with a low boiling point (like ammonia).
   - This liquid turns into high-pressure vapor, which drives a turbine to generate electricity.
   - Cold deep water cools the vapor, turning it back into liquid to repeat the cycle.
4. **Key Components**:
   - **Heat Source**: Warm surface water.
   - **Heat Sink**: Cold deep water.
   - **Heat Engine**: Converts heat energy into mechanical energy.
5. **Efficiency**:
   - The efficiency of an OTEC system is low (around **6-7%**), as it depends on the small temperature difference between the surface and deep water.
6. **Benefits**:
   - Renewable and sustainable energy source.
   - Tropical oceans provide consistent temperature gradients.

9. What is biofouling? How it affects efficiency of energy conversion and how can it be minimised?

What is Biofouling?

Biofouling is the accumulation of microorganisms, like algae and bacteria, inside the pipes of evaporators and condensers in energy systems. These organisms stick to the surfaces and grow over time, creating problems.

How Does Biofouling Affect Efficiency?

1. **Reduced Heat Transfer**:
   - The layer of microorganisms acts as insulation, blocking the transfer of heat.
   - This reduces the efficiency of the energy conversion process.
2. **Lowered Performance**:
   - With less effective heat transfer, the system generates less power.
3. **More Surface for Fouling**:
   - A larger surface area in the system gives more room for microorganisms to attach and grow, worsening the problem.

How Can Biofouling Be Minimized?

1. **Mechanical Cleaning**:
   - Use circulating balls that clean the pipes continuously.
2. **Chemical Cleaning**:
   - Add chemicals like chlorine to water to kill microorganisms.
3. **Controlled Use of Biocides**:
   - Biocides can kill biofouling organisms but may cause pollution.
   - Chlorine use is kept within strict environmental limits to reduce harm.

10. What are the different classifications of tidal power plants. Explain the components and detailed working operation of double basin tidal power plant with neat sketch.

Tidal power plants are classified based on the type of basins used:

1. **Single Basin System**
2. **Double Basin System**

Single Basin System

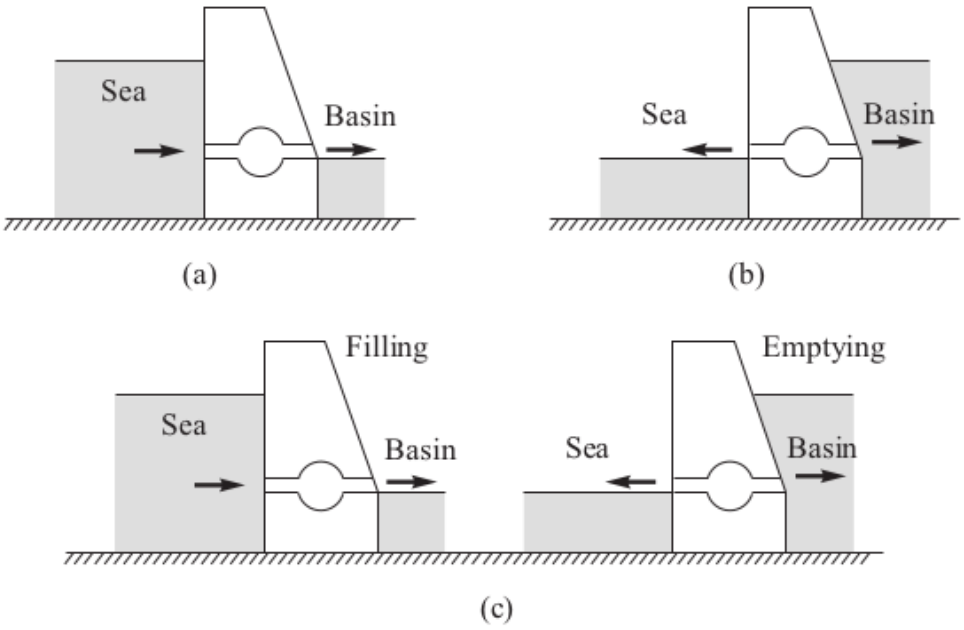


Figure 10.7 Single basin arrangements. (a) Single ebb cycle (b) Single tide cycle and (c) Double cycle system.

This system uses a single basin to store tidal water, separated from the sea by a dam. The turbines and generators are placed within ducts inside the dam.

- **Types of Single Basin Systems**:
  1. **Single Ebb Cycle System**:
     - The basin is filled during high tide through sluice valves.
     - Power is generated during low tide when water flows out through turbines.
     - Power generation is intermittent, only during low tides.
  2. **Single Tide Cycle System**:
     - The basin is filled during high tide through turbines.
     - Power generation stops as the sea level reduces, and water is drained during low tides.
     - Power output is intermittent.
  3. **Double Cycle System**:
     - Uses reversible turbines for power generation during both the filling and emptying of the basin.

- Power is generated in both directions of water flow, but it is still intermittent due to transition time between modes.

Double Basin System

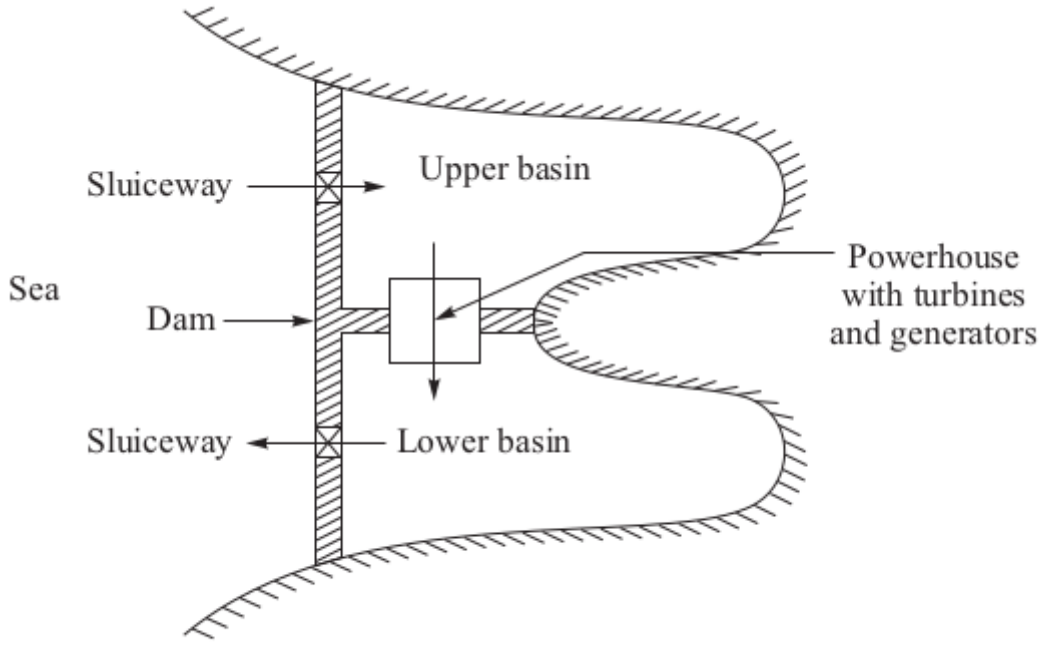


Figure 10.8 Double basin system.

This system employs two basins, typically at different levels:

- **Upper Basin**: Filled with seawater during high tides.
- **Lower Basin**: Discharges water to the sea during low tides.
- A dam separates the basins and also separates the basins from the sea.

Components of Double Basin Tidal Power Plant

1. **Upper Basin**: Stores water at a higher level.
2. **Lower Basin**: Maintains a lower water level and acts as a discharge area.
3. **Dam**: Separates the basins and houses the turbines and generators.
4. **Turbines and Generators**: Convert the flow of water into electricity.
5. **Sluice Gates**: Control the water flow between basins and the sea.

Working of Double Basin Tidal Power Plant

1. **High Tide**:
    - Water flows from the sea into the upper basin.

    - The upper basin is filled, and the lower basin remains at a lower level.
2. **Low Tide**:
    - Water from the upper basin flows through the turbines into the lower basin.
    - This flow generates electricity.
3. **Discharge**:
    - Water in the lower basin is released into the sea during low tide.

- The difference in water levels between the upper and lower basins drives the turbines, generating power during both high and low tides.

Advantages of Double Basin System

- Power generation is relatively continuous compared to single basin systems.
- More efficient utilization of tidal energy.

11. What are the limitations of the tidal power production?

1. **Limited Availability**: Tidal energy can only be harnessed in specific natural locations like bays and estuaries, which are rare.
2. **Remote Locations**: Suitable sites are often far from cities or areas that need electricity, increasing transmission costs.
3. **Variable Operation**: Tidal turbines work with changing water levels, making power output inconsistent.
4. **High Construction Cost and Time**: Building dams and basins takes a long time and is very expensive.
5. **Sedimentation Issues**: Over time, silt and sediment build up in the basin, requiring costly maintenance to remove.
6. **Dependence on Lunar Cycle**: Power output changes with the moon’s phases, making it less predictable.
7. **Non-Continuous Supply**: Since tides occur at specific times, power generation isn’t continuous.
8. **Corrosion from Sea Water**: The salty water damages equipment, reducing the lifespan of turbines and generators.
9. **Low Efficiency**: Variations in tidal range can reduce the overall efficiency of the plant.

10. **Need for More Turbines**: Because tidal water levels (heads) are usually low, more turbines are required to generate enough power.

12. Elaborate on how the tidal phenomena occur with suitable sketches. List 2 advantages and disadvantages of tidal energy conversion systems.

Tides are caused by the **gravitational pull** of the moon and the sun on the Earth's oceans.

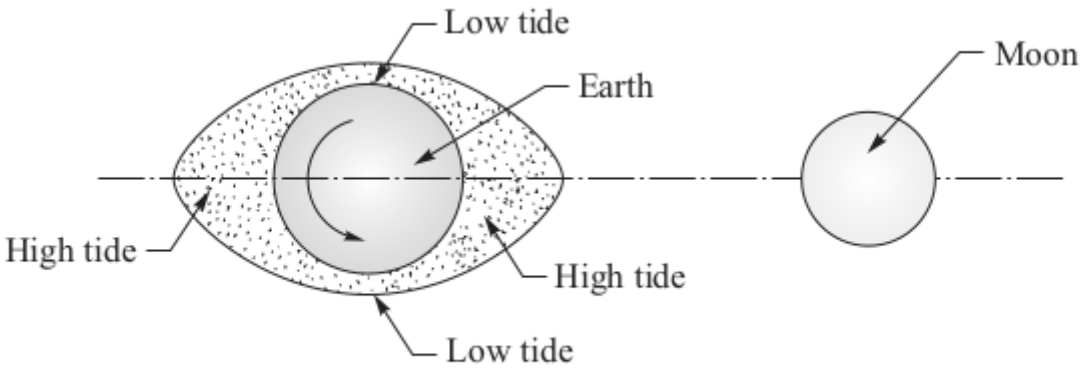


Figure 10.1 Origin of tides.

1. **High Tides**:
    - When the moon's gravity pulls water towards it, the water level rises, creating a high tide.
    - Simultaneously, on the opposite side of the Earth, another high tide occurs due to the centrifugal force caused by the Earth's rotation.
2. **Low Tides**:
    - As the Earth rotates, the areas between the high tides experience low tides.

Each tidal cycle lasts approximately **12 hours and 25 minutes**, during which the water level rises and falls.

Tidal Energy

Tidal energy is harnessed from the difference in water levels between **high tides** and **low tides**.

- During **high tide**, water is stored in a reservoir or basin behind a dam.

- During **low tide**, the stored water is released through turbines, generating electricity.

Note: The tidal range (difference between high and low tide) must be at least **5 meters** for efficient energy generation.

Advantages of Tidal Energy Conversion Systems

1. **Renewable and Clean**: Tidal energy is sustainable and produces no greenhouse gases.
2. **Predictable**: Tides follow a regular pattern, making power generation highly predictable.

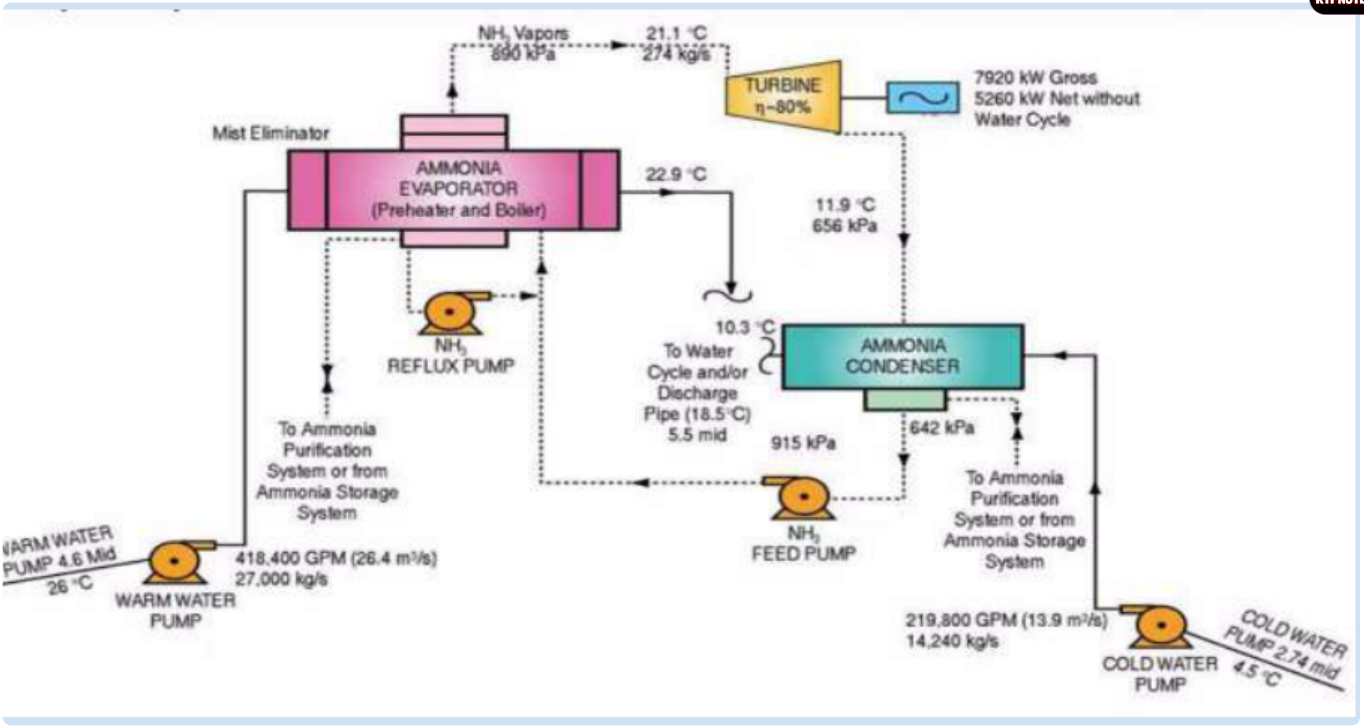
Disadvantages of Tidal Energy Conversion Systems

1. **High Cost**: Building tidal power plants requires significant investment.
2. **Environmental Impact**: Construction can disrupt marine ecosystems and affect wildlife.

13. With a neat diagram explain the working of a Hybrid Cycle OTEC system

A **Hybrid Cycle Ocean Thermal Energy Conversion (OTEC)** system uses the temperature difference between warm surface seawater and cold deep seawater to produce **electricity** and **freshwater**. It combines features of two systems:

1. **Open Cycle**: Uses seawater directly.
2. **Closed Cycle**: Uses a liquid like ammonia to transfer heat.



How It Works (Step by Step)

1. **Warm Seawater Turns to Steam**:
   - Warm seawater is pumped into a low-pressure tank called a **vacuum chamber**.
   - Inside, the water boils and turns into steam due to the low pressure.
2. **Steam Heats a Special Liquid**:
   - The steam is used to heat a liquid like **ammonia**, which has a low boiling point.
   - This liquid turns into gas and is part of a **closed loop** system.
3. **Electricity is Generated**:
   - The gas (ammonia vapor) spins a **turbine**, which generates electricity.
4. **Freshwater is Made**:
   - The seawater steam is cooled by cold deep seawater, turning it back into liquid **freshwater**.

Why Use a Hybrid OTEC System?

1. **Produces Two Things**:
   - **Electricity** from the turbine.
   - **Freshwater** from cooled steam.
2. **Efficient Use of Resources**: Combines two methods to make better use of ocean water.

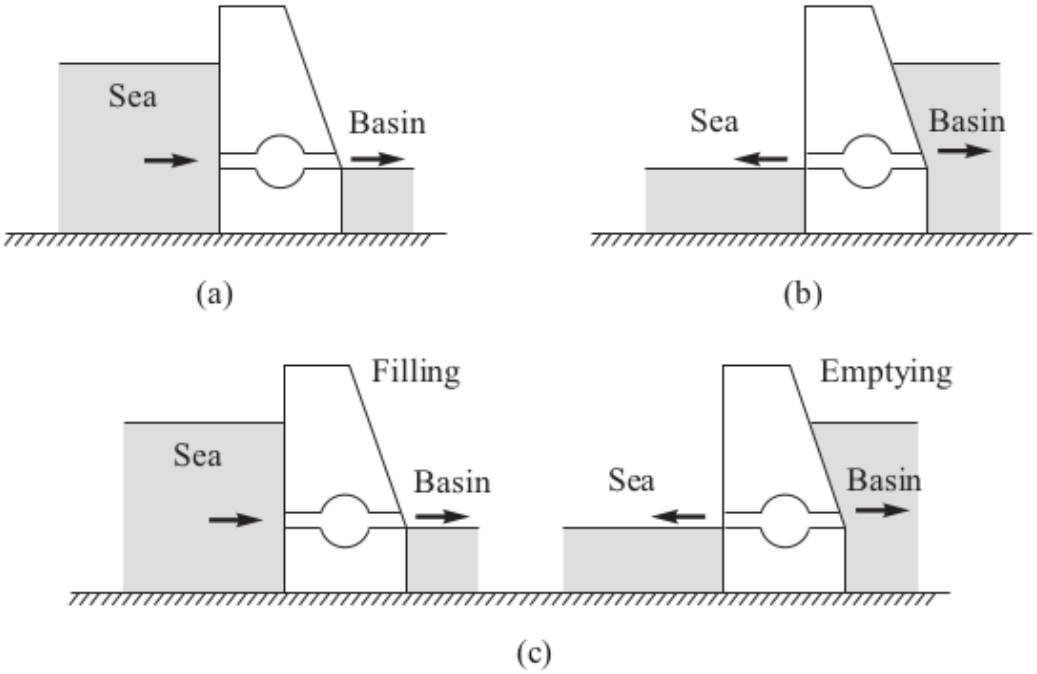
14. Explain the advantages of OTEC systems

1. **Stable Power Supply**:
    - OTEC plants provide steady electricity without being affected by weather or seasonal changes.
2. **Clean and Renewable Energy**:
    - OTEC uses the ocean’s temperature difference to generate power, making it an eco-friendly and sustainable energy source.
3. **Multiple Benefits**:
    - In addition to electricity, OTEC systems can produce **desalinated freshwater** and bring up **nutrient-rich water** for marine life and aquaculture.
4. **Location Flexibility**:
    - Plants can be built along coastlines or as floating platforms in the ocean.
5. **Scalable Design**:
    - OTEC plants can be constructed in various sizes depending on the energy needs and site suitability.

15. Explain the various methods of tidal power generation. What are the limitations of each method.

Tidal power generation uses the rise and fall of tides to produce electricity. There are two main systems: **Single Basin** and **Double Basin**.

1. Single Basin System



.7 Single basin arrangements. (a) Single ebb cycle (b) Single tide cycle and (c) Double cycle system.

- **One basin** stores water separated by a dam.
- **Types**:
  - **Single Ebb Cycle**: Power is generated when water flows out at low tide.
  - **Single Tide Cycle**: Power is generated when water flows in and out, but only during part of the tide cycle.
  - **Double Cycle**: Reversible turbines generate power when water flows in **and** out.

Limitation: Power is intermittent, meaning it's only generated at certain times.

2. Double Basin System

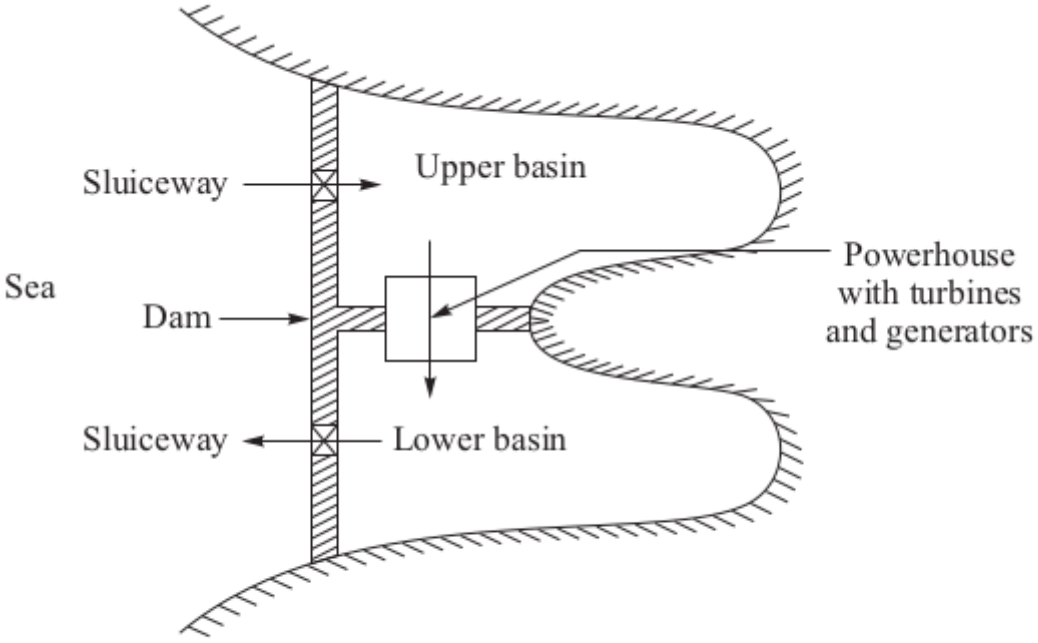


Figure 10.8 Double basin system.

- **Two basins**: One higher, one lower.
- Water flows between them through turbines, generating power.

Limitation: It's more complex and expensive to build.

16. What are the site requirements to construct a tidal power plant?

1. **High Tidal Range**:
   - A significant difference between high and low tides is needed to generate enough energy. A large tidal range helps produce more power.
2. **Short Length of Dam**:
   - The dam should not be too long. It's best to build the dam at a narrow inlet or bay where the water can be efficiently stored and released.
3. **Proximity to Load Location**:
   - The site should be close to where the electricity is needed, to minimize transmission losses and costs.
4. **Protection from High Waves**:

- The site should be shielded from strong waves, which can damage the plant's infrastructure.

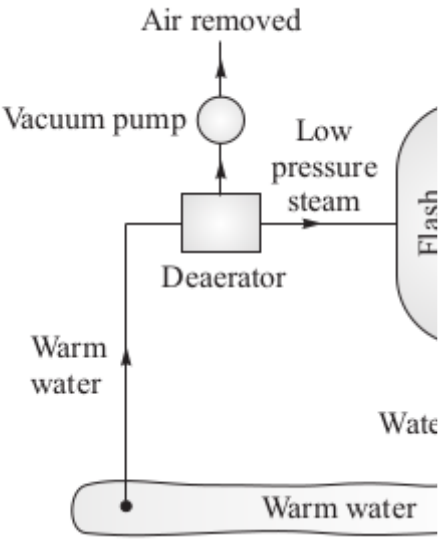
5. **Avoid Interference with Shipping**:
    - The site should not disrupt shipping routes or harbor activities to prevent conflicts with maritime traffic.

17. Open Cycle OTEC-Working and diagram

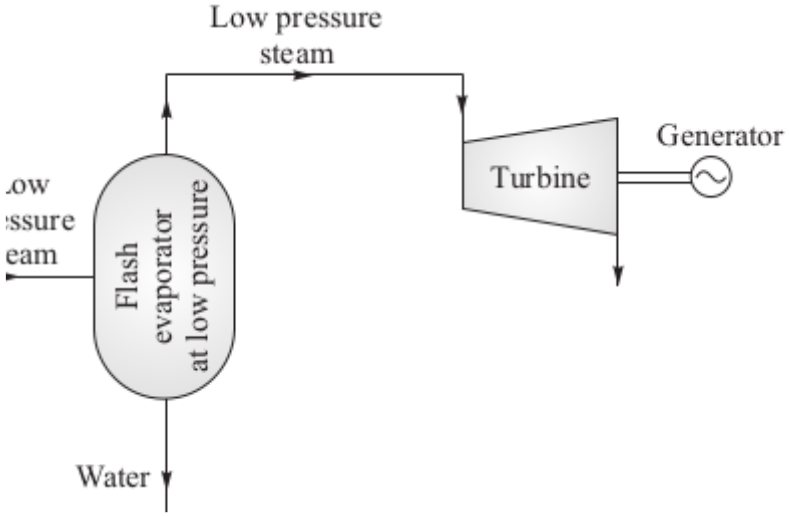
- Ocean Thermal Energy Conversion (OTEC) is a sustainable way to generate energy by harnessing the natural temperature differences in ocean water.
- **Ocean Thermal Energy:** The sun heats the surface of the ocean, making the water warmer at the top compared to the deeper, colder layers. This creates 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.

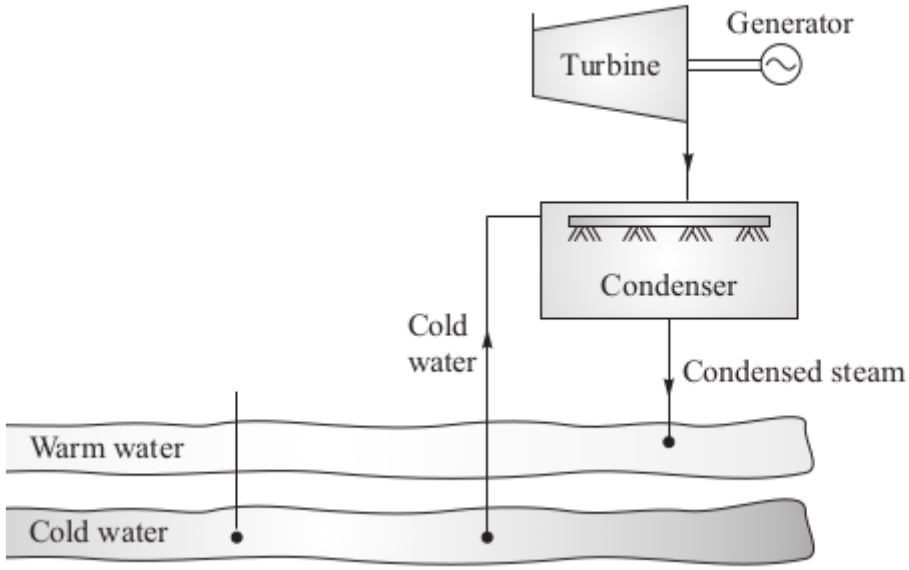
1. 

Figure 13.1 Open cycle OTEC plant.

4. Full diagram

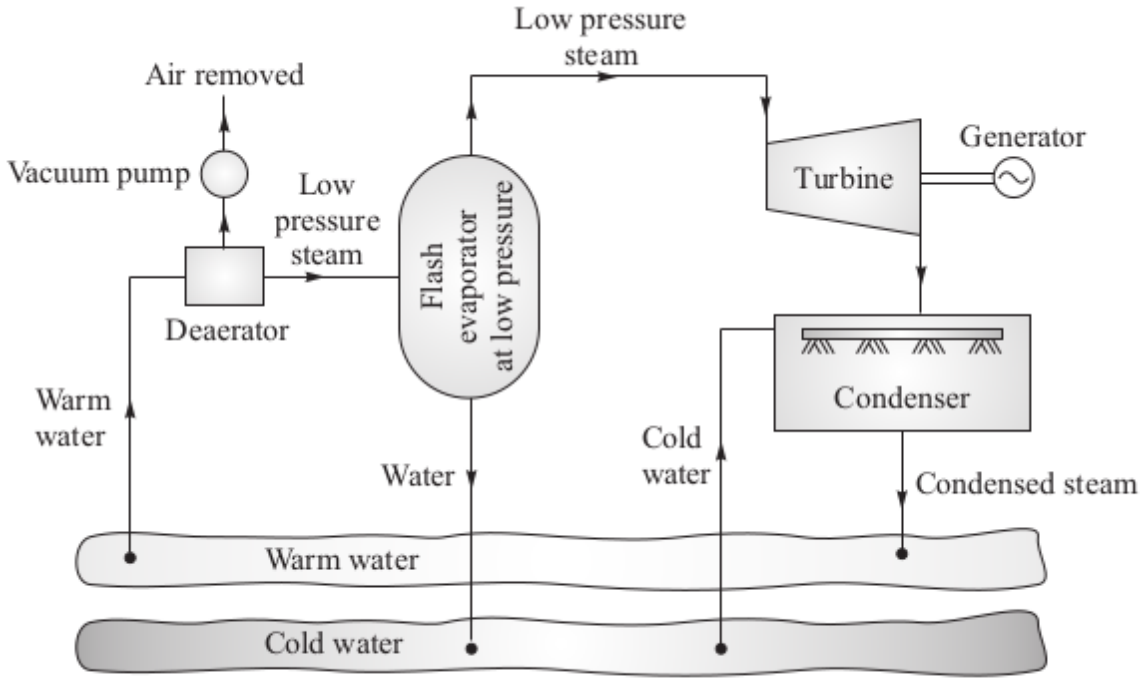


Figure 13.1 Open cycle OTEC plant.

1.

18. Closed Cycle OTEC-Working and diagram

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.

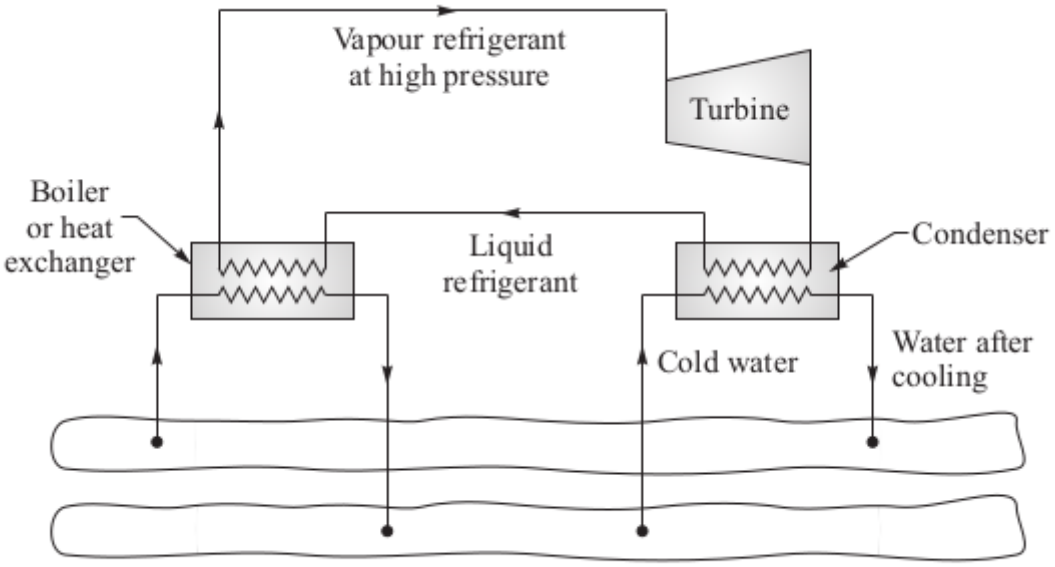


Figure 13.2 Closed cycle OTEC plant.

5.