Energy Resources

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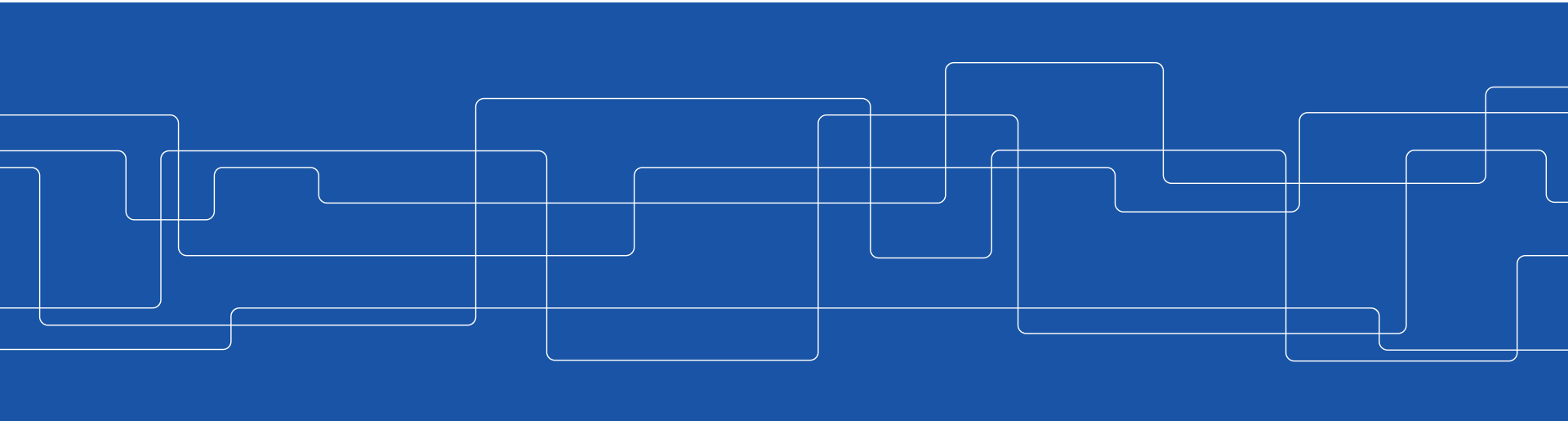


Ocean Thermal Energy Conversion

- Introduction to OTEC
- Techniques to utilize OTEC
- OTEC Potential
- Advantages and Disadvantages

What is OTEC?

- *Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology that uses the natural temperature difference in oceans to produce clean, reliable electricity, day and night, year-round.*
- *The heat from the warm ocean surface and cold from the deep ocean drives a Rankine Cycle, which produces electricity.*

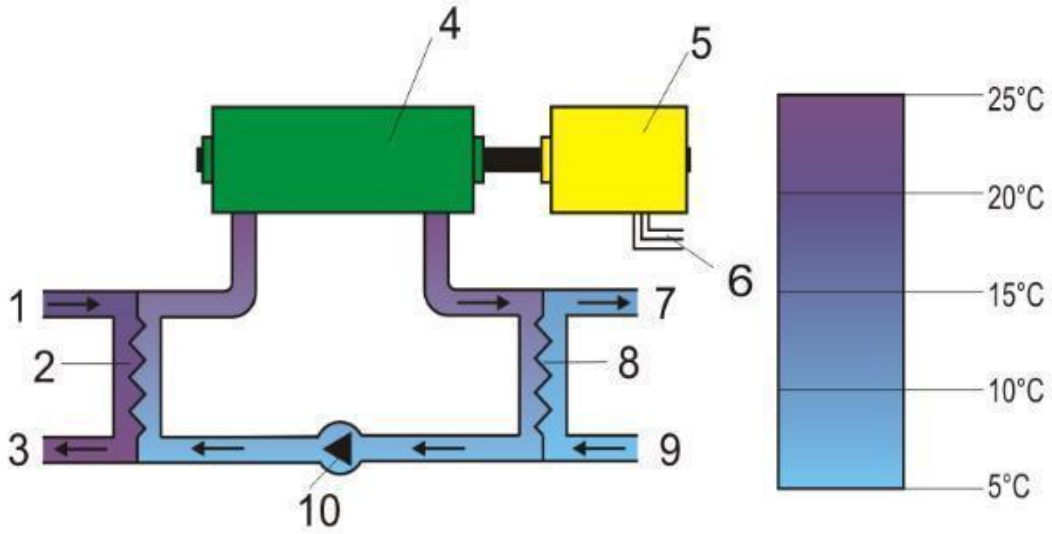
What is OTEC?

- With efficient equipment, electricity power generation could be sustained day and night at 200 kWe from access to about 1 km2 of tropical sea, equivalent to 0.07% of the solar input.

Energy from Oceans

- The ocean is the world's largest solar collector.
- Interesting areas for OTEC are in the tropical, equatorial zone, where the ocean temperature difference is highest.
- In tropical seas, temperature differences of about 20−25 ºC may occur between the warm, solar-absorbing near-surface water and the cooler 500–1000 m depth 'deep' water at and below the thermocline.

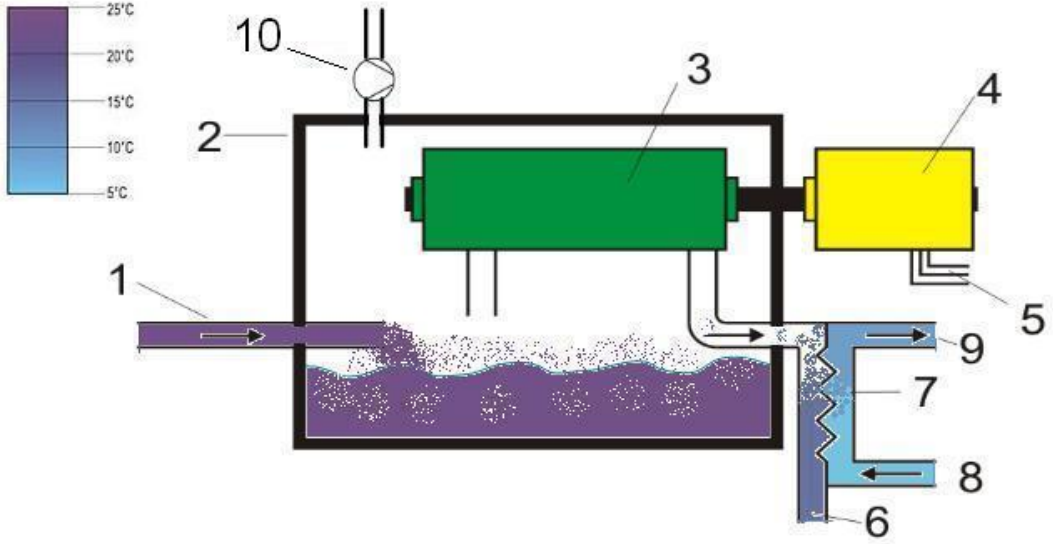
Conversion Method Closed Cycle



1 Surface water ~ 25°C
2 Evaporator
3 Waste water ~ 23°C
4 Turbine
5 Generator

6 Line to the grid
7 Waste water ~ 7°C
8 Condenser
9 Deep water ~ 5°C
10 Circulation pump

Conversion Method Open Cycle



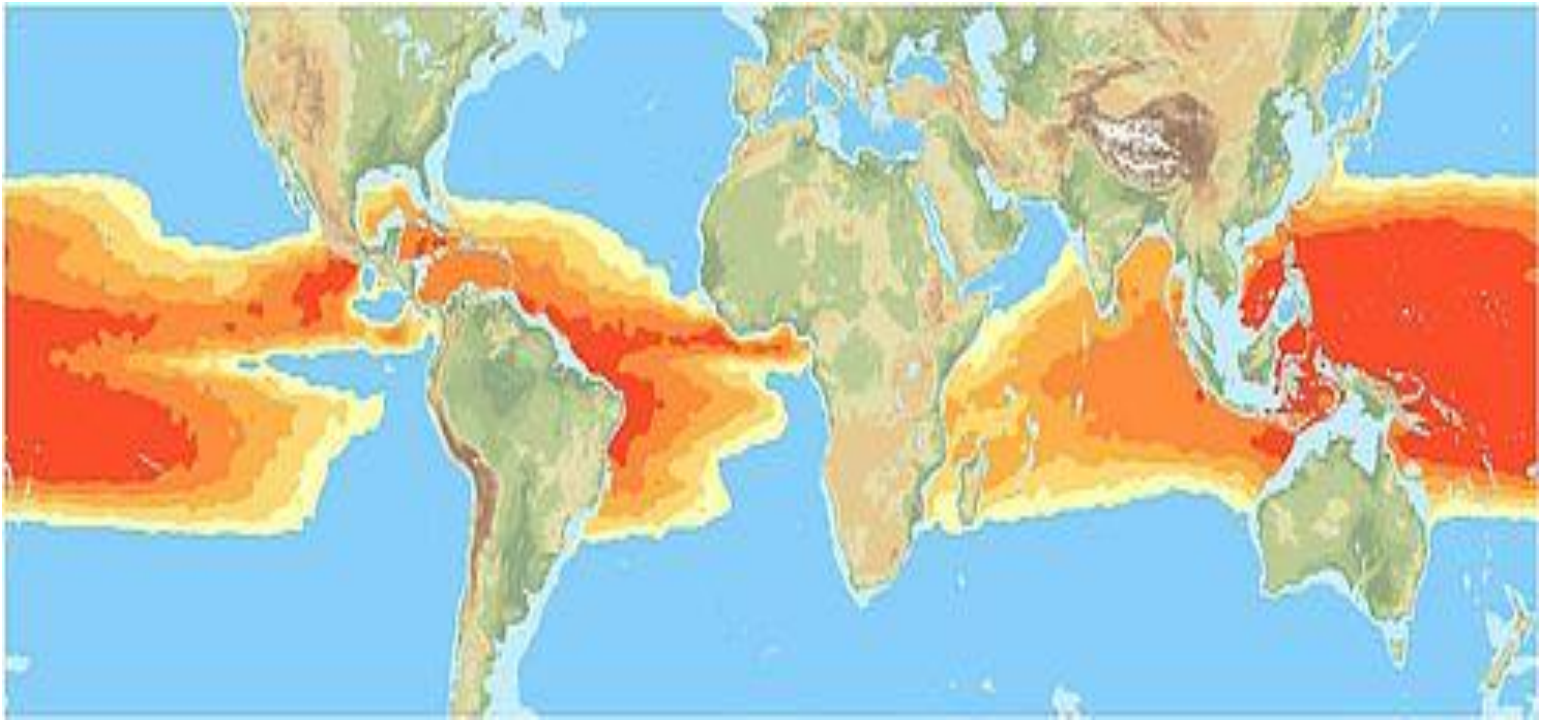
1 Surface water ~ 25°C
2 Vacuum chamber, 3 % to 1 % of atmospheric pressure
3 Turbine
4 Generator
5 Line to the grid

6 Desalinated water ~ 23°C
7 Condenser
8 Deep water ~ 5°C
9 Waste water ~ 7°C
10 Vacuum pump

Worldwide OTEC Potential

An estimate suggests that the amount of energy that can be practically harvested through OTEC may be of the order of 3 to 5 terawatts, without affecting the temperature of the ocean or the world's environment. That’s about twice the global electricity demand. The oceans are thus a vast renewable resource.

Worldwide OTEC Potential



Power Generation Capacity

$$P_0 = \rho c Q \Delta T$$

$$E_1 = \eta_{\text{Carnot}} E_0$$

$$\Delta T = T_h - T_c$$

$$P_1 = \eta_{\text{Carnot}} P_0$$

where

$$\eta_{\text{Carnot}} = \Delta T / T_h$$

The efficiency of Carnot Cycle ~ temp difference 20ºC ~ 7%

Real Efficiency ~ 2-3%

Pros & Cons of OTEC

Advantages

1. At a suitable site, the resource is essentially limited only by the size of the machinery.
2. The machinery to exploit it economically requires only marginal improvements in such well-tried engineering devices as heat exchangers and turbines. No dramatically new or physically impossible devices are required.

Pros & Cons of OTEC

Disadvantages

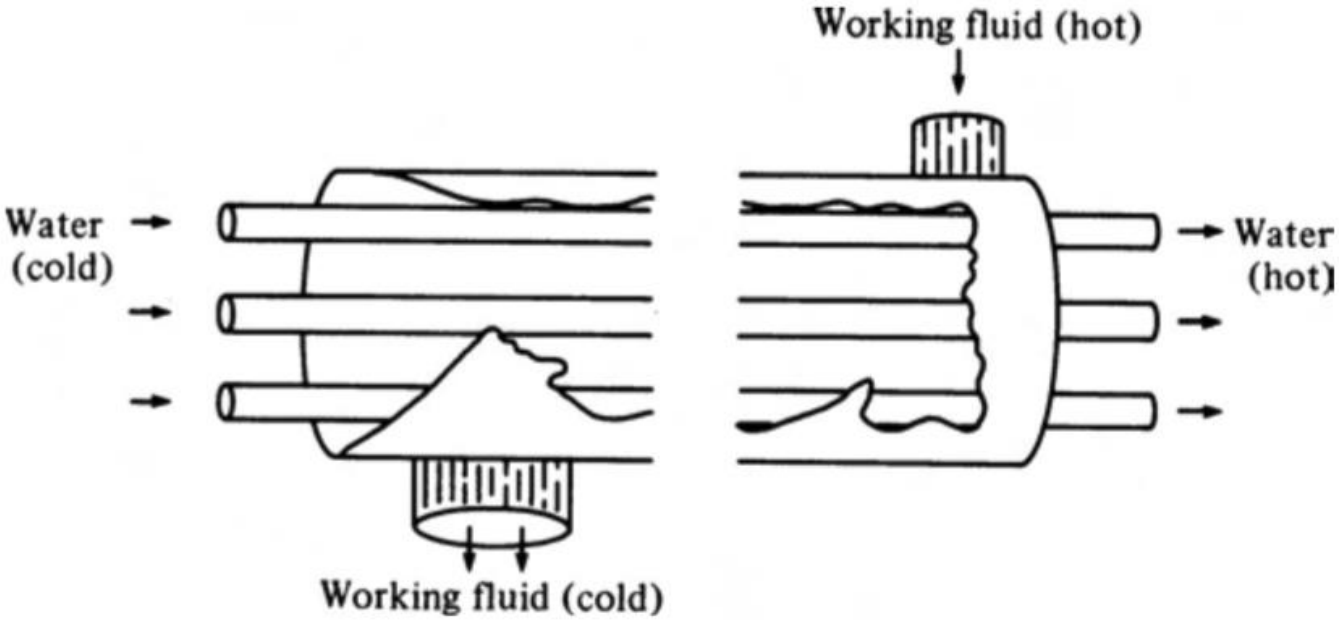
1. High Costs: Even if the ideal power was obtainable, the costs per unit output would be large, but resistances to the flow of heat and to fluid motion reduce the useful output considerably and therefore increase unit costs.
2. Maintenance at sea and submarine cabling is complex

Heat Exchangers

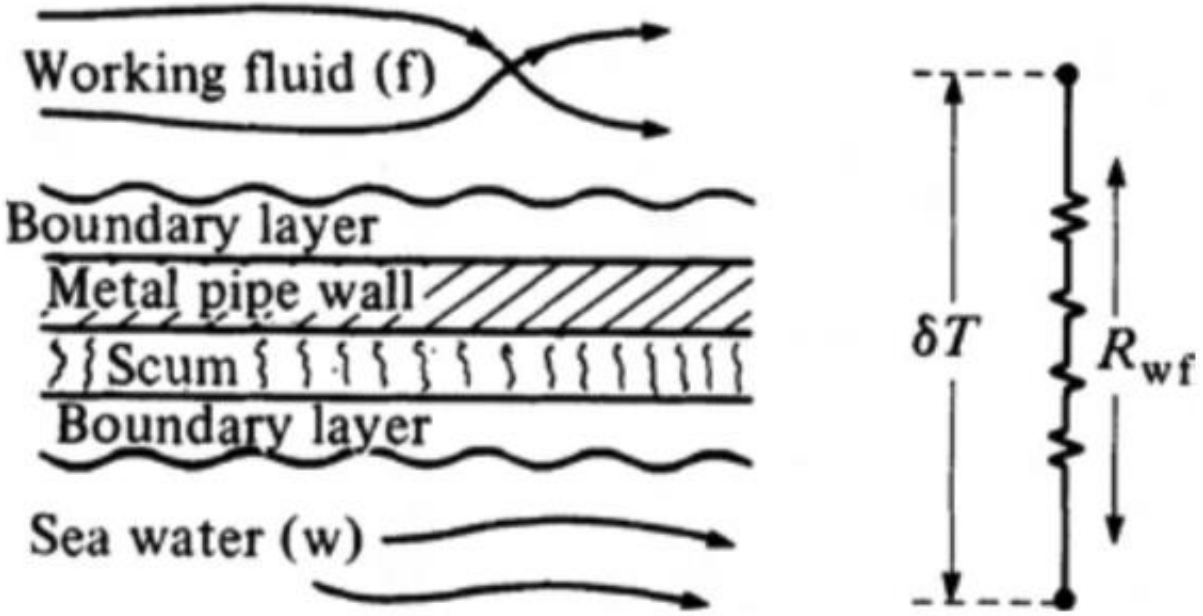
Large heat exchangers required to provide greater heat transfer as temperature difference is low.

There is significant thermal resistance, even with the best available heat exchangers and with chemical ‘cleaning’ to lessen internal bio fouling.

Heat Exchangers



Resistance in Heat Exchangers



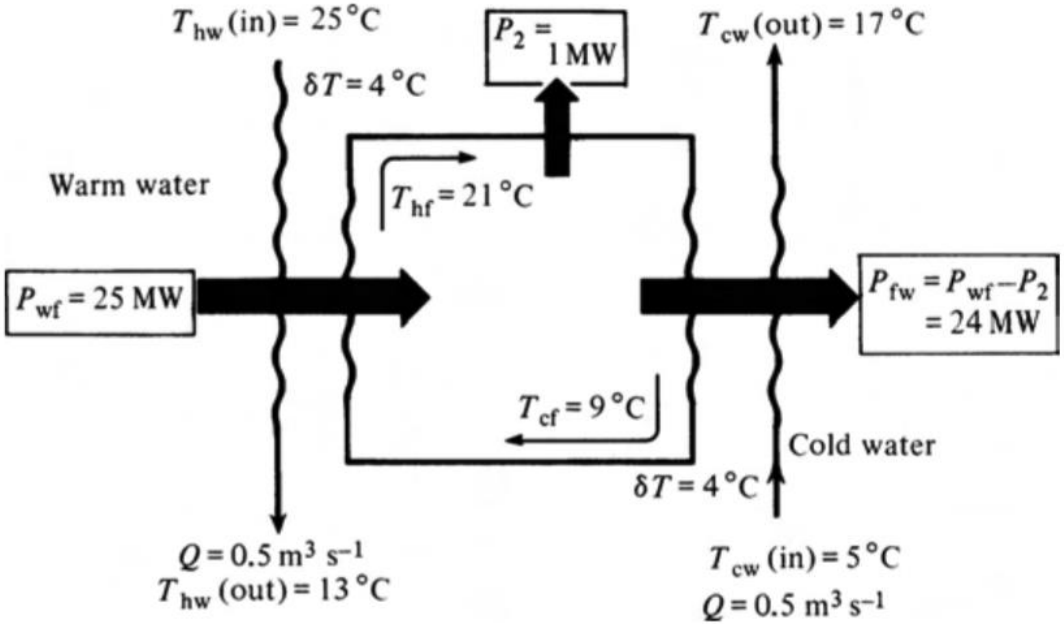
Resistance in Heat Exchangers

$$P_{wf} = \delta T / R_{wf}$$

$$\Delta_2 T = \Delta T - 2\delta T$$

$$P_2 = \left(\frac{\Delta T - 2\delta T}{T_h} \right) \frac{\delta T}{R_{wf}}$$

Flows in OTEC



Advantages

1.Reserves are enormous- virtually infinite on historical scale.

2.Less polluting than combustible fuels or nuclear energy.

3.Indigenous resource that can be developed and make a country less reliant politically and economically and can alleviate the national balance of payments. As a rule of thumb; one kilowatt of geothermal base load can substitute about 2 tons of oil annually.

4.Highly versatile

5.Not subject to the variations of the weather.

6.Not labour intensive.

Disadvantages

1.Not many places on the earth that are highly suitable for exploit.

2.Expensive exploration

3.Brines are corrosive and poisonous

4.Complicated reservoir management

5.Sensitive to underground disturbances

Thank You