Overview

- Two-thirds of earth's surface covered with water, more so for island countries
- Ocean energy can be harnessed as
  - Mechanical (waves, tides and currents)
  - Chemical (salinity gradients, biomass)
  - Thermal (temperature gradients)

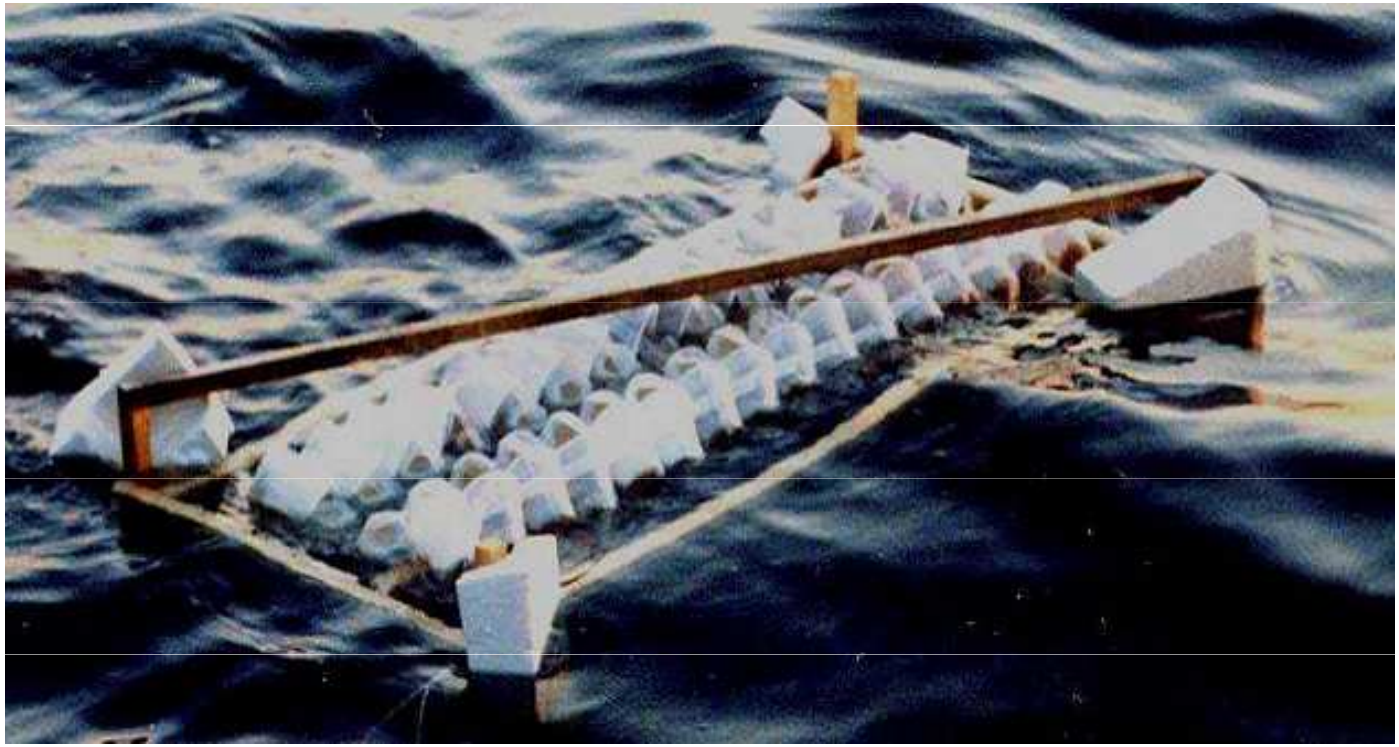
Wave Power

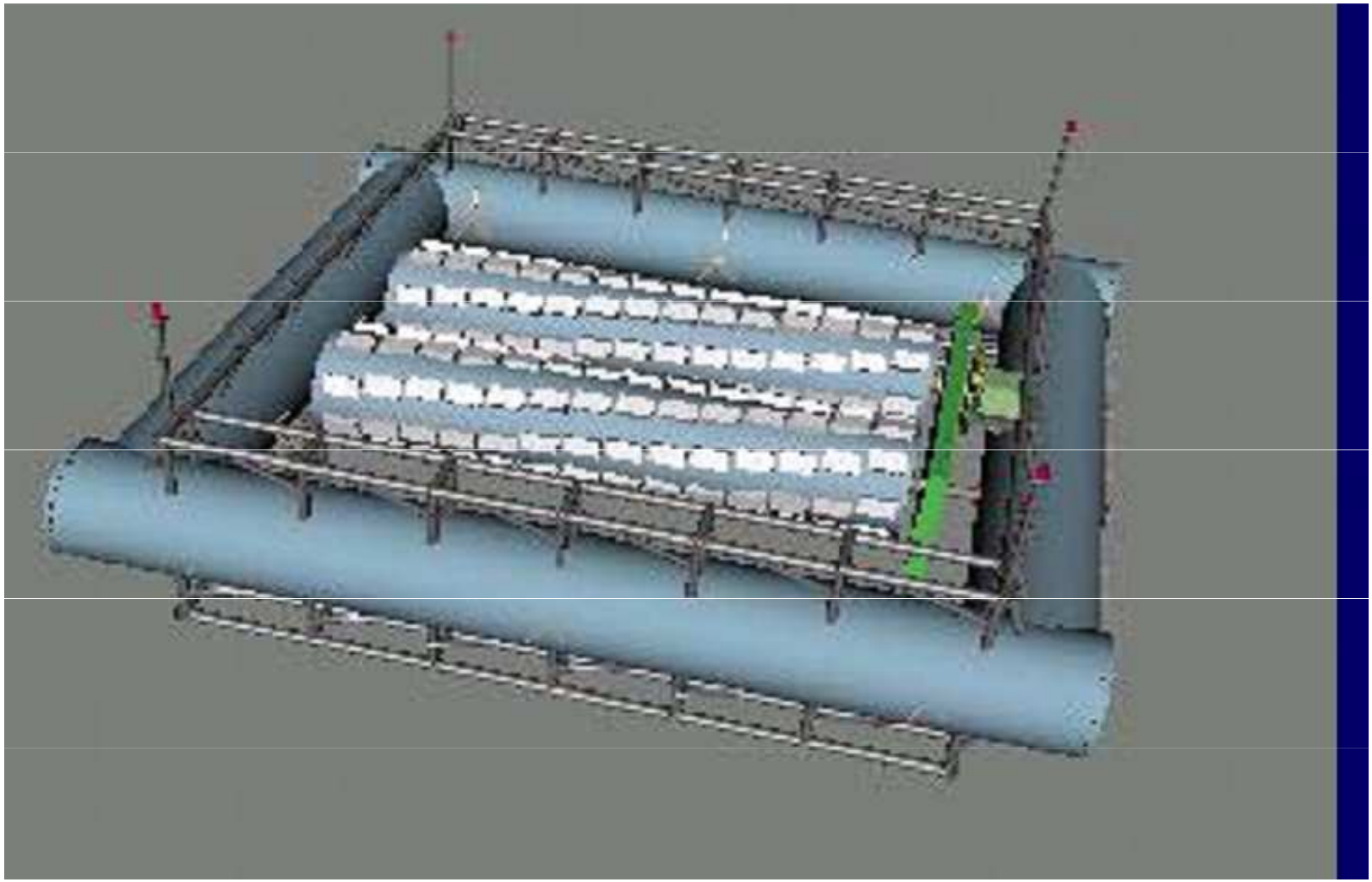
- The power in the waves, P is given as

$$P = (\rho\, g^2\, H^2\, T) / 32\pi$$

H = amplitude of the waves, T = period

P is directly proportional to H and T.





Tidal Power

- **Tides due to gravitational field due to sun and moon.**

  For semi-diurnal tidal regime

  - $E = 7.09\ A\ r^2$
  -

E = gross energy production (TJ)
A = area of the basin (km^2)
r = average tidal range (m)

OTEC

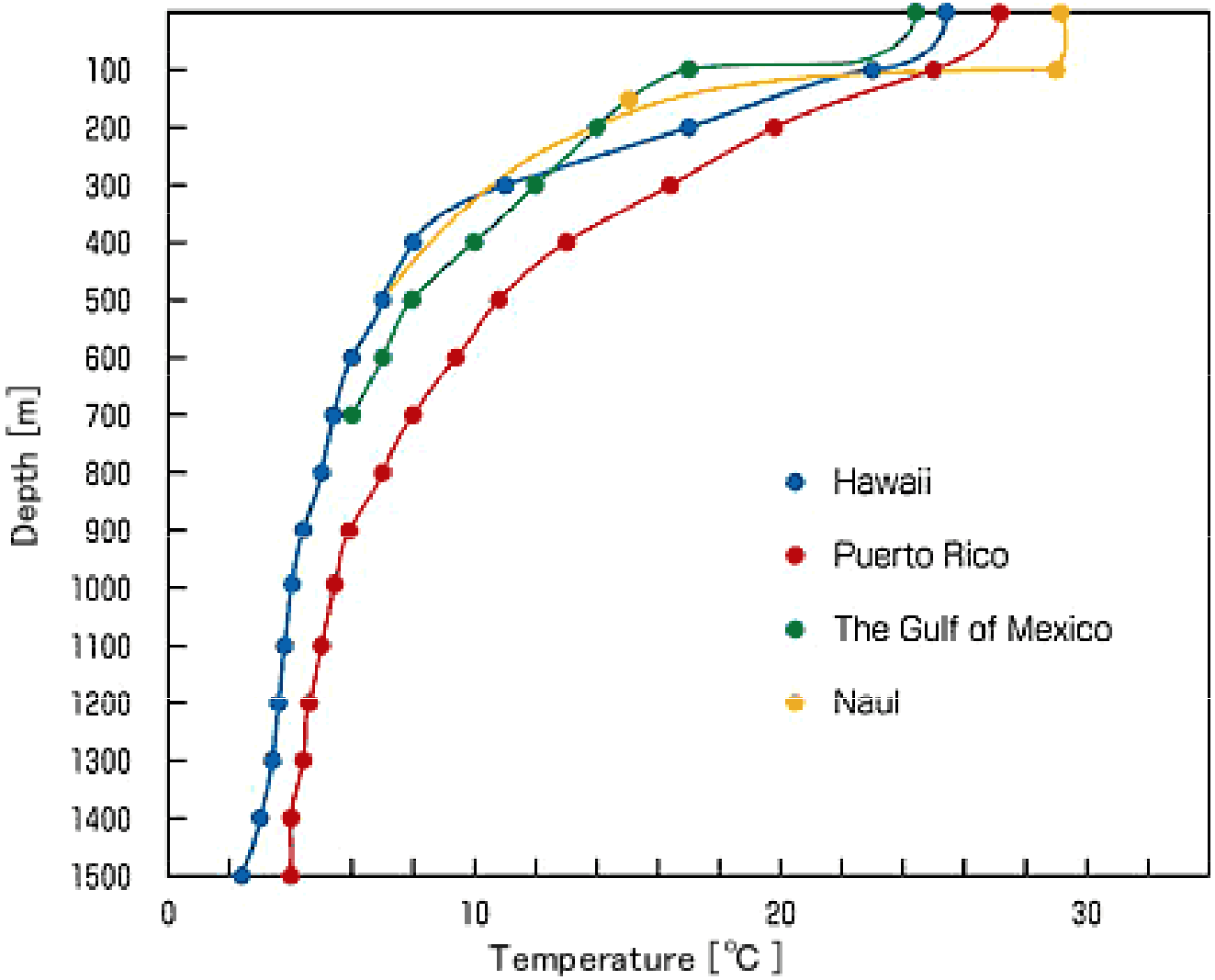
- OTEC system is essentially a heat engine operating between the 'cold' temperature T_c of the water at some substantial depth, and the hot temperature T_h of the surface water.

- Temperature difference of 20°C between warm, solar absorbing surface water and cooler 'bottom' water can occur.

There are 3 types of OTEC systems:

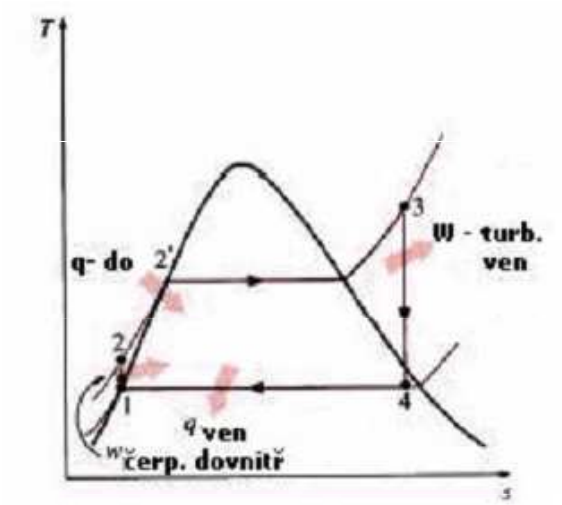
1. Closed cycle – this uses working fluid such as ammonia which is pumped a closed loop.
2. Open cycle - uses warm sea water as the working fluid.
3. Hybrid – uses both closed and open cycle system, produces electricity and desalinated water.

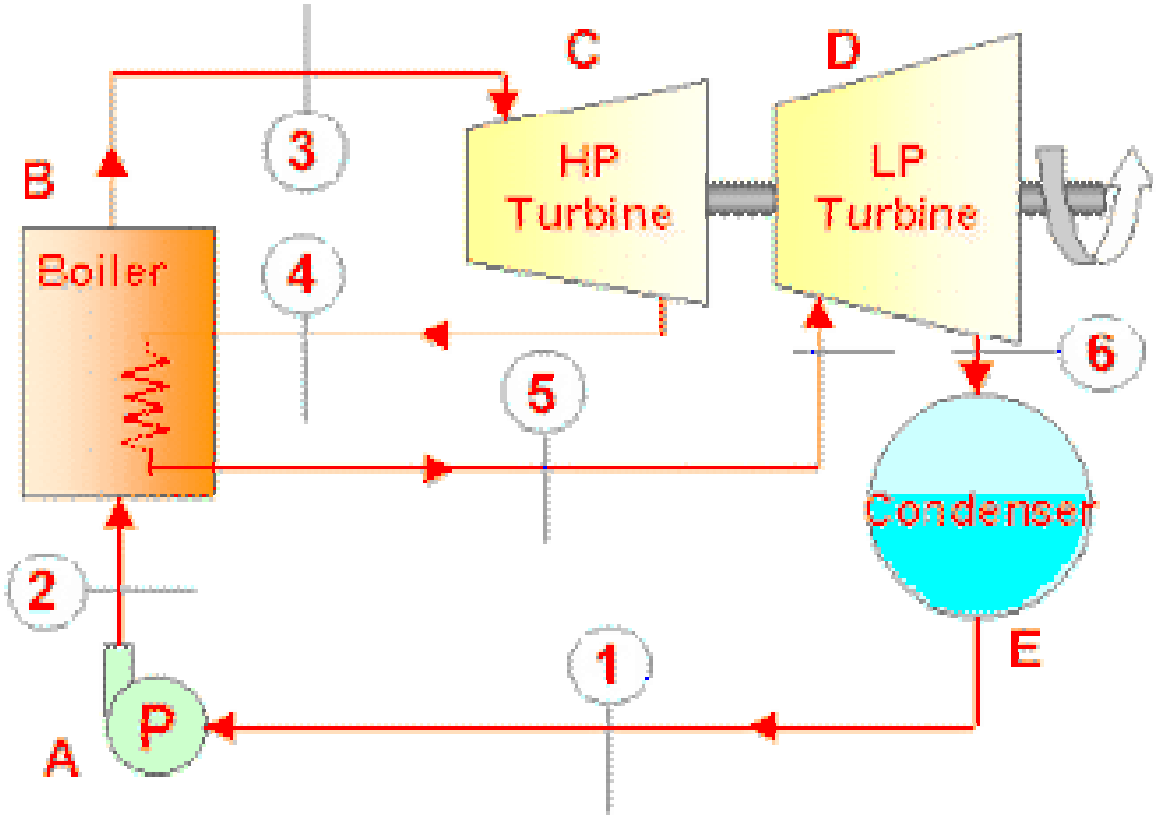
- Surface Seawater around 25 degrees
- Bottom seawater around 4 degrees

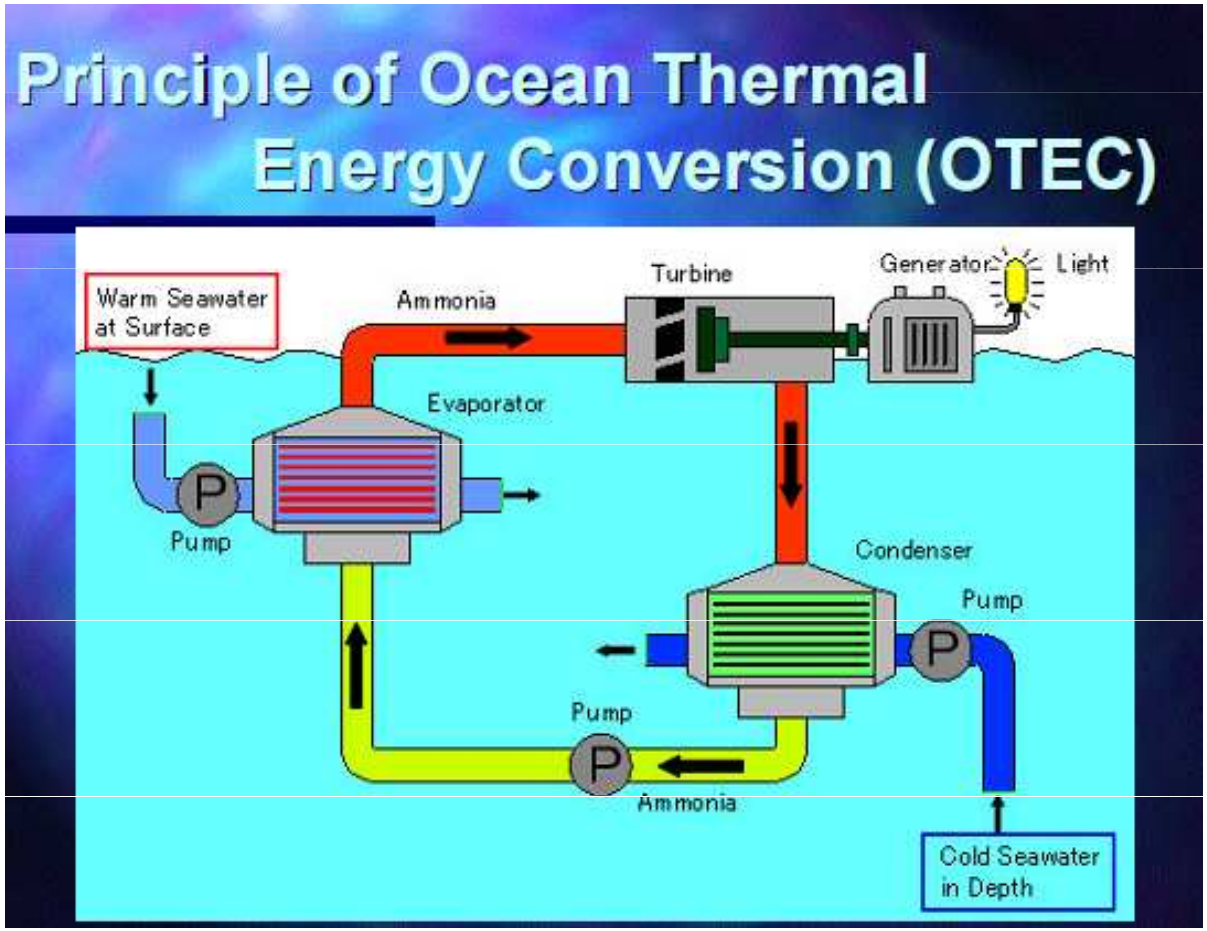


Rankine Cycle

Require a gas that boils at about 20 degrees



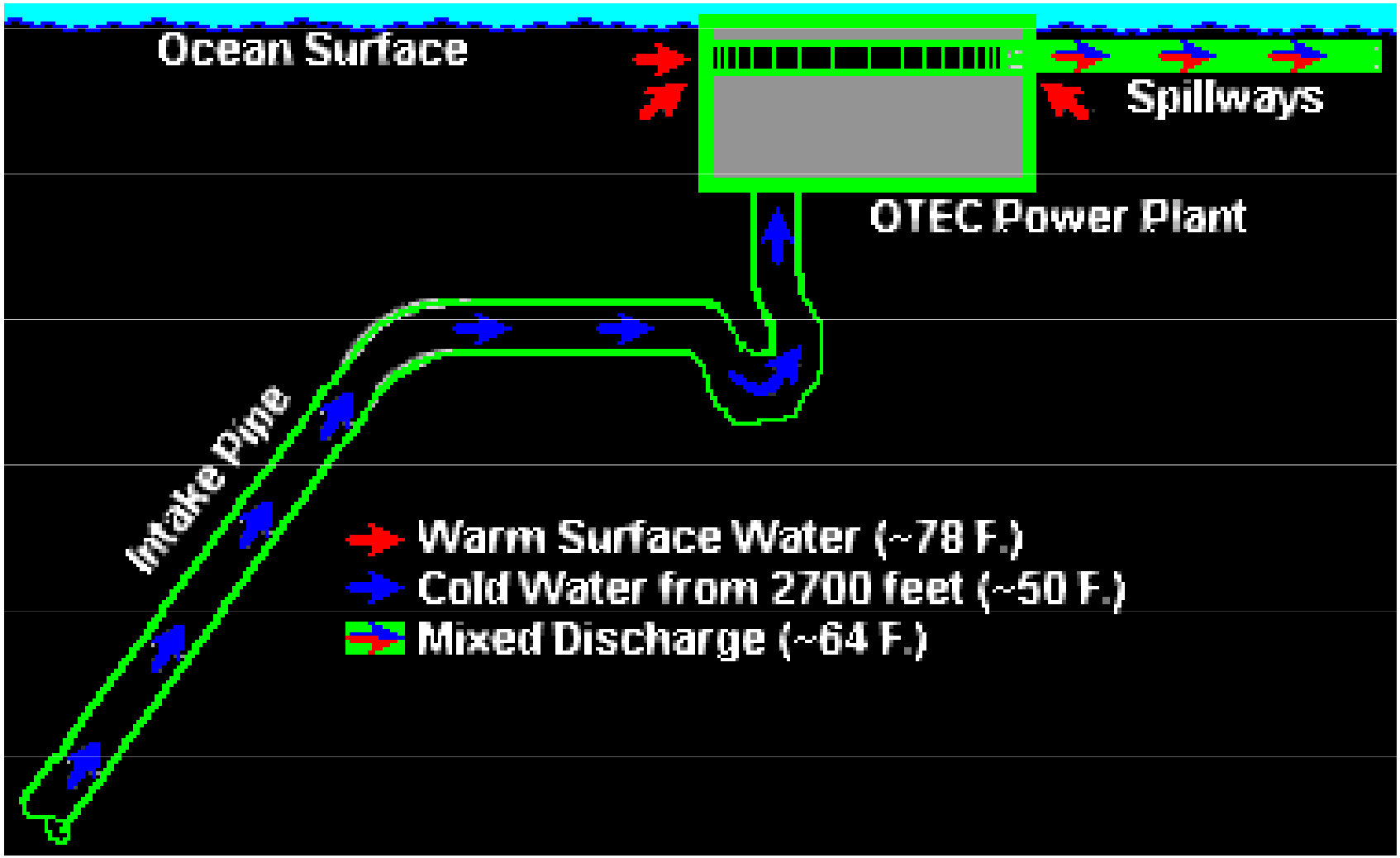


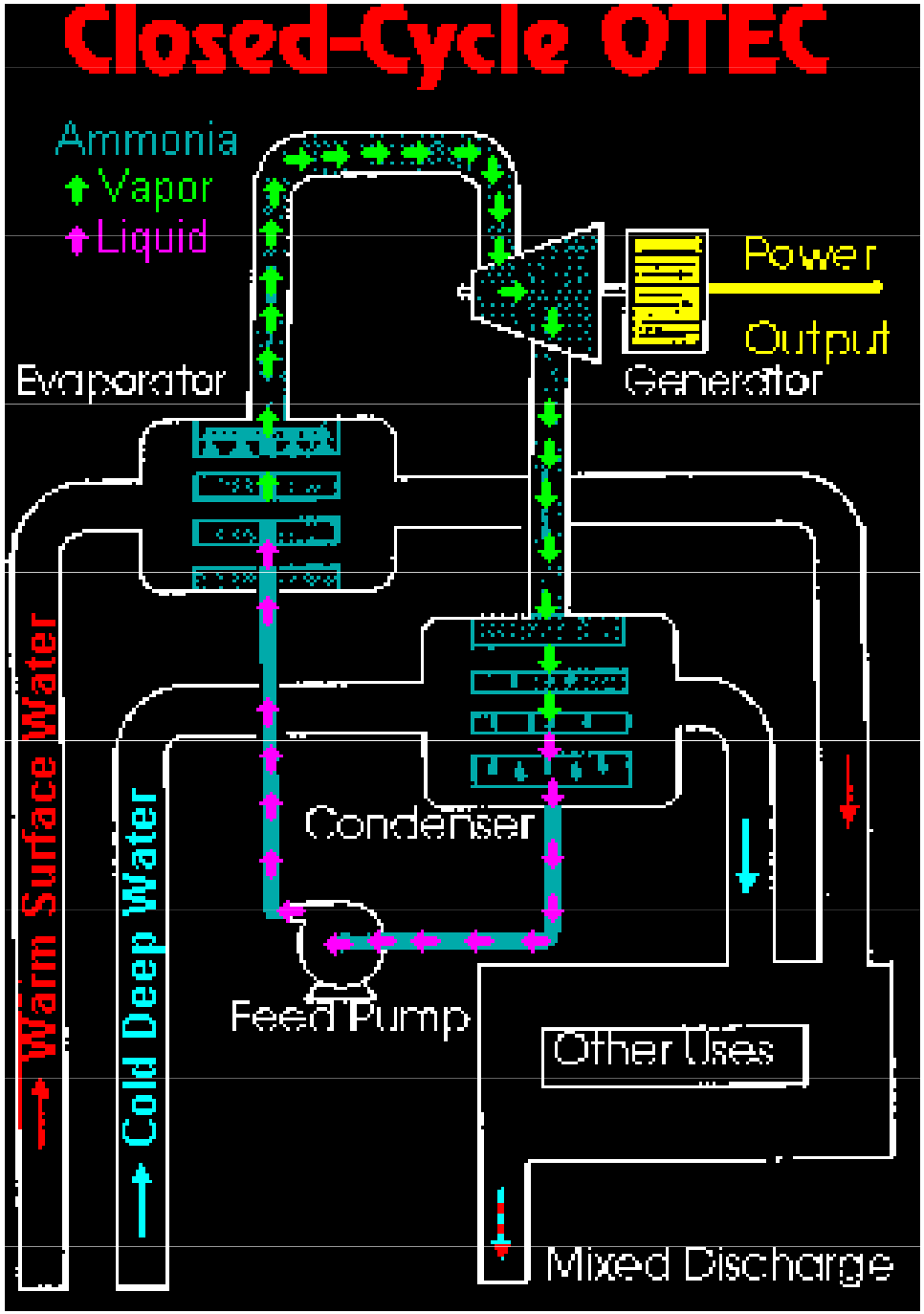


$$\eta = \frac{T_H - T_C}{T_H} \times 100$$

Problem

- As the temperature difference between the hot end and cold end gets smaller, the efficiency decreases
- Diesel engine ΔT =500 degrees
- OTEC ΔT =20 degrees
- Diesel Engine Efficiency is about 25%
- OTEC Efficiency is at most 7%
- Submarine Cable
- Moorings
- Extreme environment (Salt Water)


Ocean Surface
Spillways
OTEC Power Plant
Intake Pipe
Warm Surface Water (~78 F.)
Cold Water from 2700 feet (~50 F.)
Mixed Discharge (~64 F.)


Closed-Cycle OTEC
Ammonia
Vapor
Liquid
Power
Output
Evaporator
Generator
Warm Surface Water
Cold Deep Water
Condenser
Feed Pump
Other Uses
Mixed Discharge

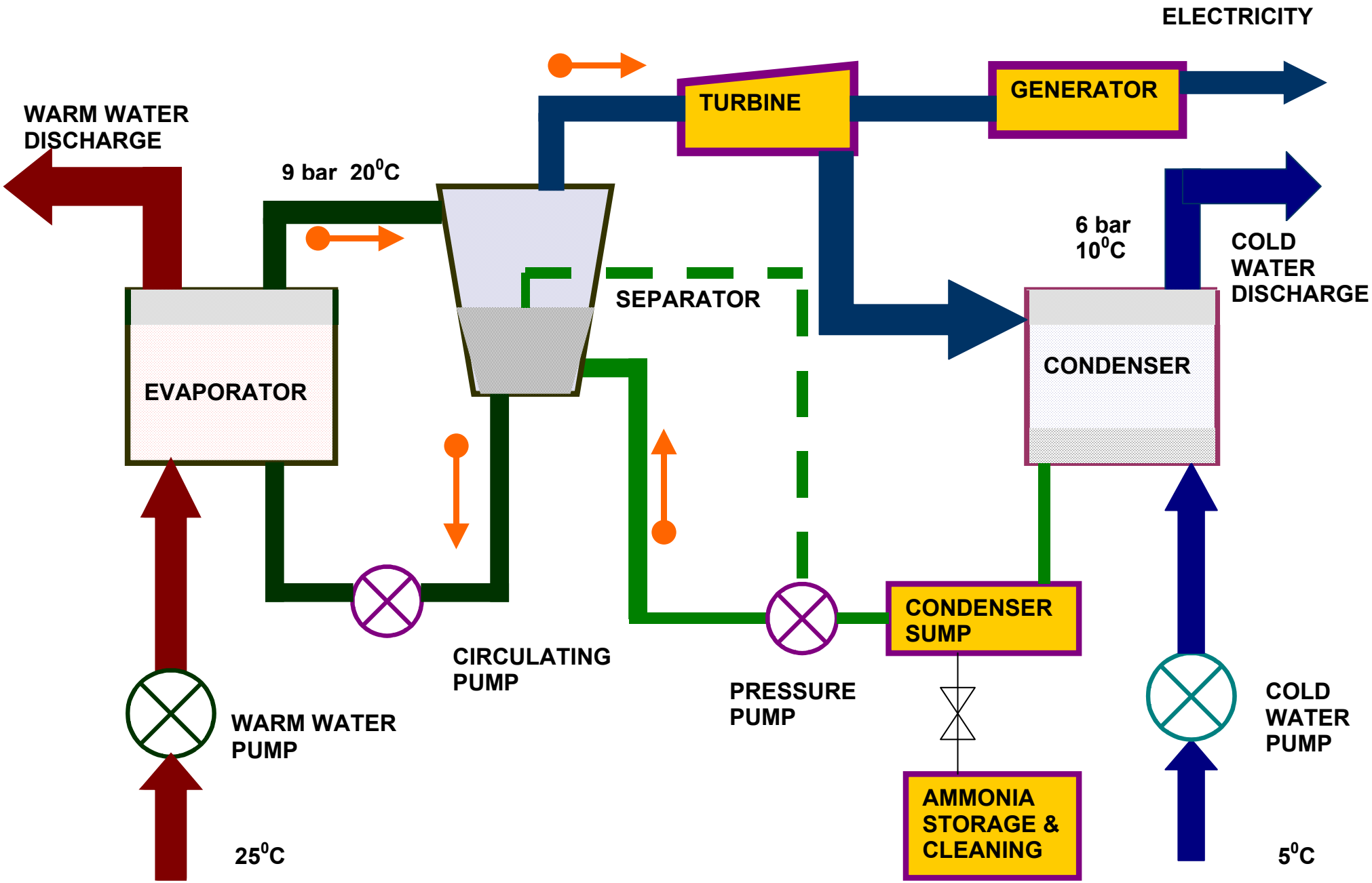
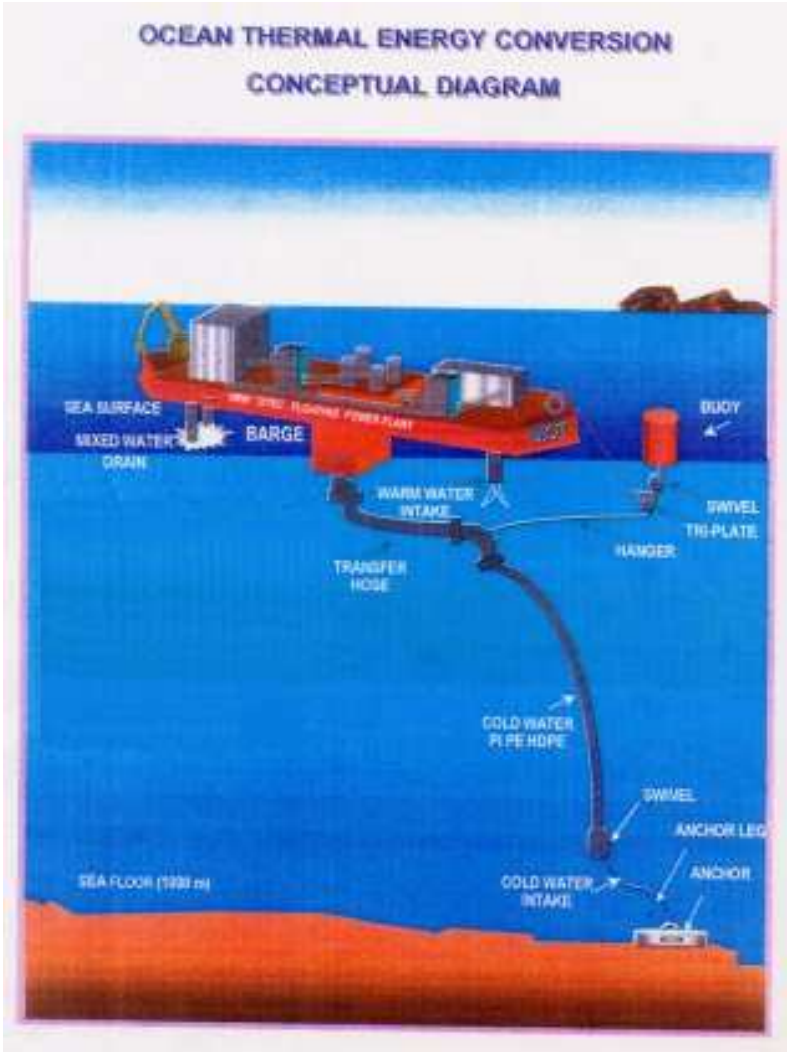
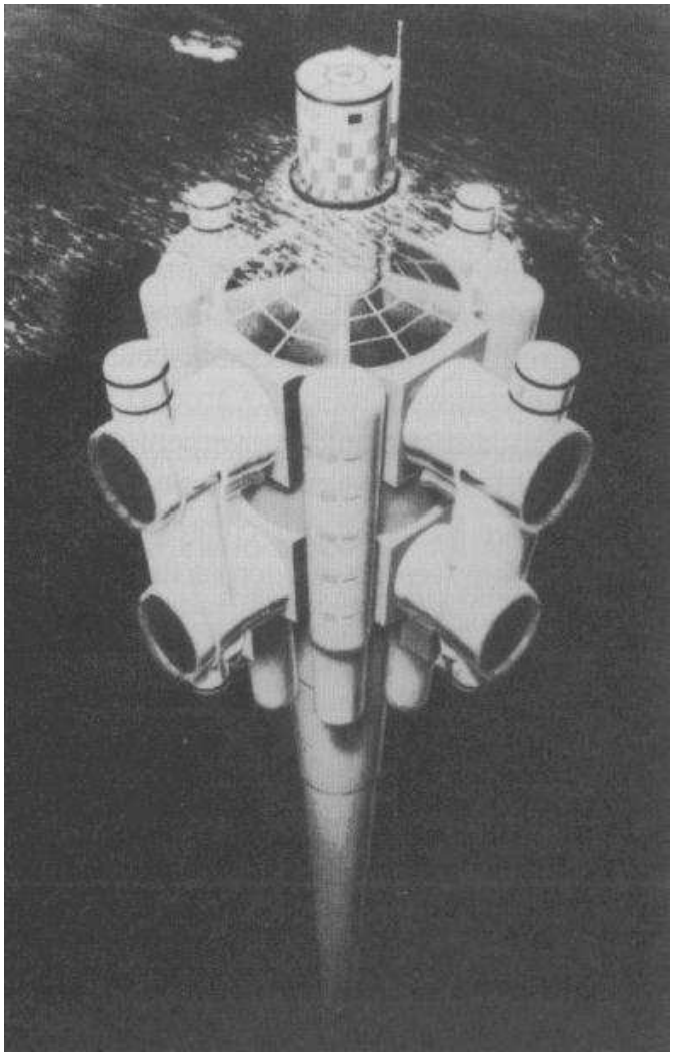


Figure 1. Schematic of a closed-cycle ocean thermal energy conversion (OTEC) system.


OCEAN THERMAL ENERGY CONVERSION
CONCEPTUAL DIAGRAM
SEA SURFACE
MIXED WATER DRAIN
BARGE
BUOY
WARM WATER INTAKE
SWIVEL
TRI-PLATE
HANGER
TRANSFER HOSE
COLD WATER PIPE HDPE
SWIVEL
ANCHOR LEG
ANCHOR
SEA FLOOR (1000 m)
COLD WATER INTAKE



Consider 1000 MWatt plant

- Assume 3% efficiency
- Require 1000 cubic meters/sec flow rate
- Pipe of radius of 10 m with flow rate of 3 m/s
- Approximately the same flow rate as the Tully River in moderate flood
- Energy loss is relatively small as pumping head is equivalent about 6 m. Perhaps 60 MW