

Ocean Thermal Energy Conversion (OTEC) : Electricity and Desalinated Water Production

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Visionary Perspective

- Solar energy absorbed by oceans is $\approx 4000 \times$ humanity annual consumption;
- Less than 1 % of this energy would satisfy all needs.
[@ thermal \rightarrow electric conversion ≈ 3 %]

Engineering Perspective

- Ocean's vertical temperature distribution:

Two layers with $\Delta T \approx 25^\circ\text{C}$ in equatorial waters...

heat source and heat sink
required to operate heat engine

OTEC Concept

- Ocean Thermal Resource (fuel)
- Cold Water: @1000 m depth
4 °C to 5 °C
- Warm Water: Tropical seas at
"surface"
24 °C to 30 °C

What is known about OTEC Technology?

- Continuous production of electricity and desalinated water has been demonstrated with experimental plants:

MiniOTEC (1979)

50 kW CC-OTEC



Nauru (1982)

100 kW CC-OTEC



210 kW OC-OTEC Experimental Plant



OTEC

(1993-1998) ⁹



**Desalinated
Water
Production
(1994-1998)**

What is known about OTEC Economics ?

- Economic feasibility achievable under certain (fuel-and-water-costs) scenarios:

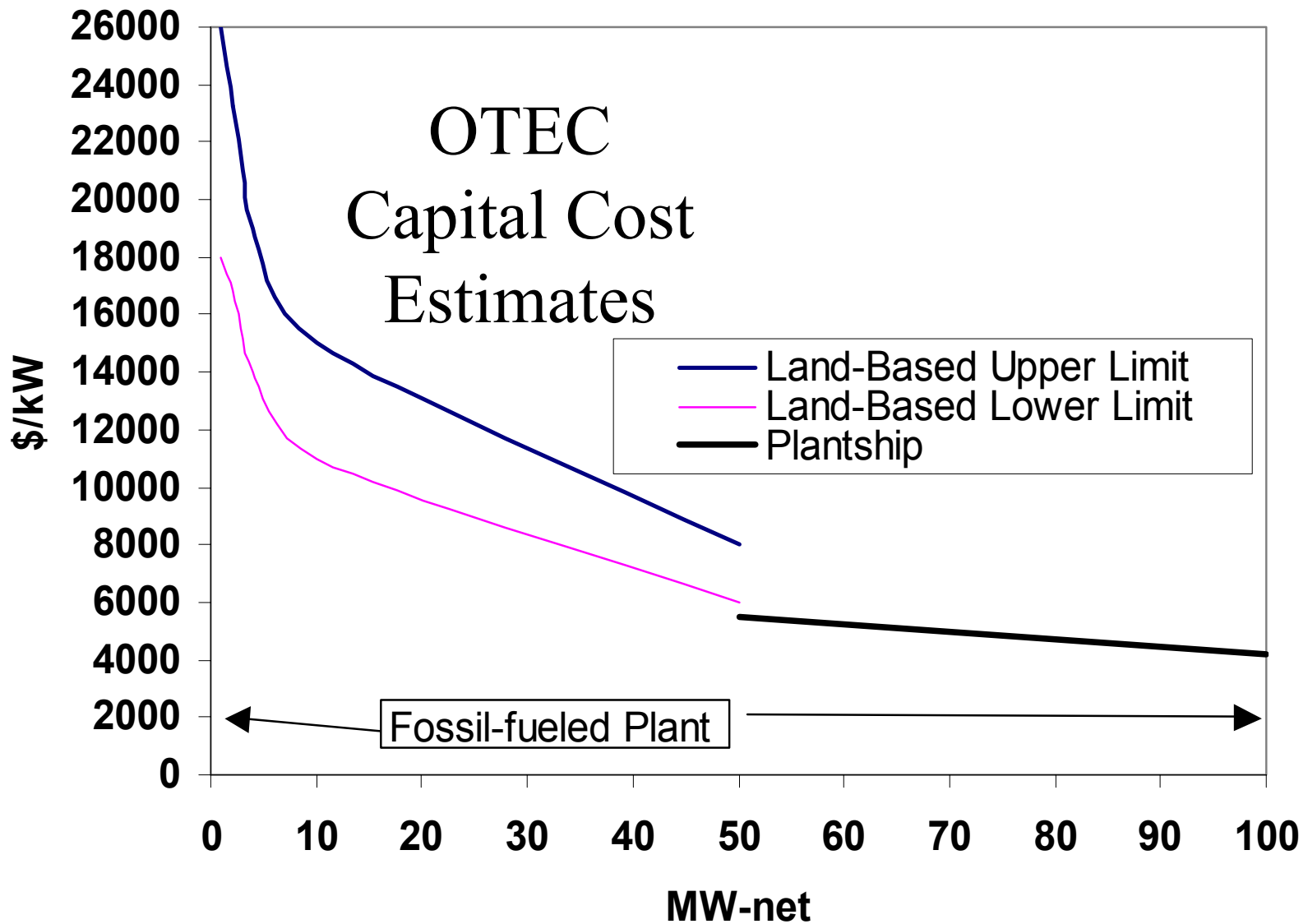
Cost of Electricity Production

$$\text{COE (\$/kWh)} = \text{CC} + \text{OMR\&R} + \text{Profit} \\ + \text{Fuel} \\ - \text{Environmental Credit}$$

CC = Capital Cost Amortization

OMR&R = Operations + Maintenance
+ Repair + Replacement

$$\text{Tariff} = \text{COE} - \text{Subsidy}$$



Cost of Electricity Production

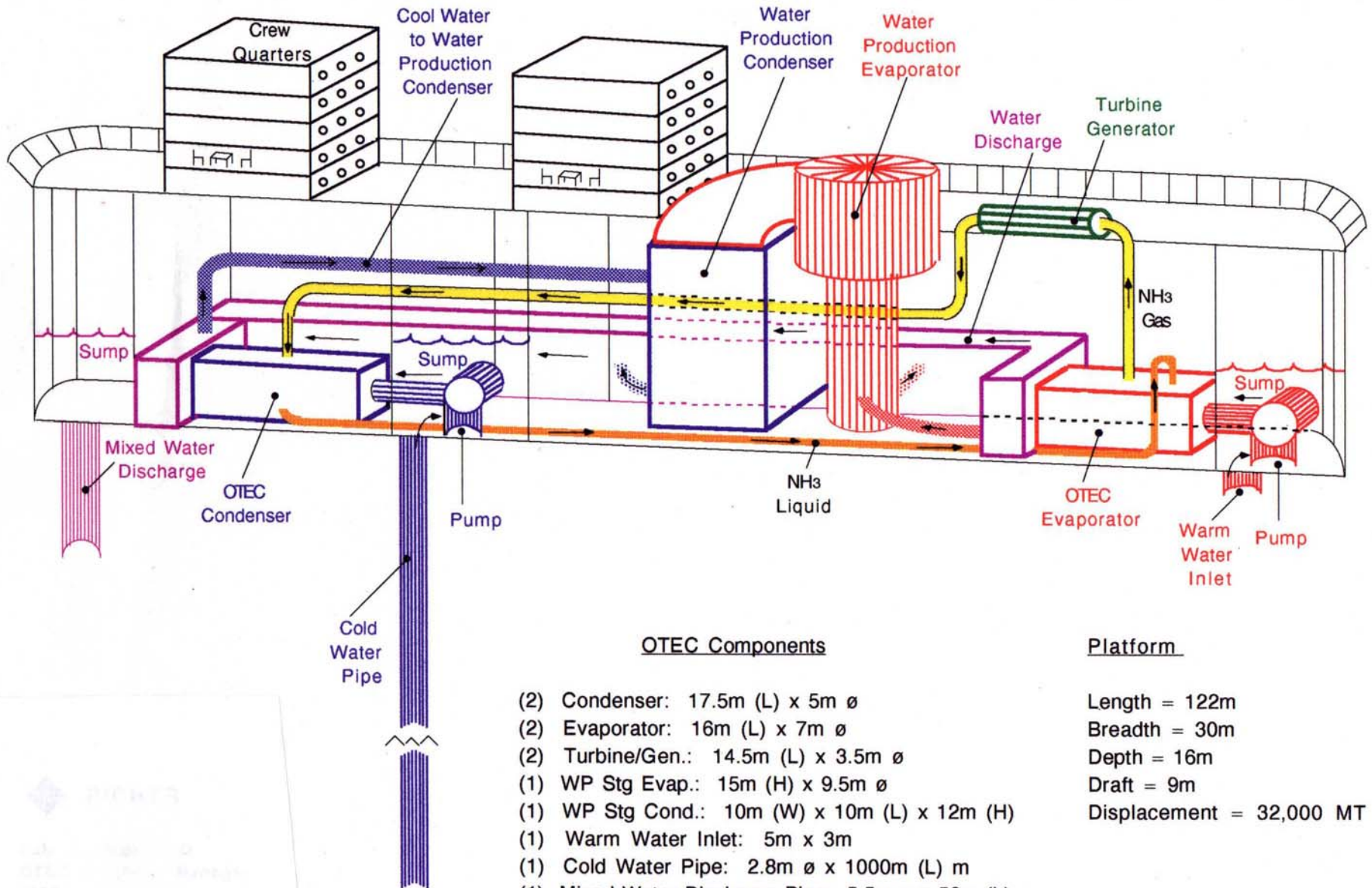
Offshore Distance, km	Capital Cost, \$/kW	COE, \$/kWh
10	4200	0.07
50	5000	0.08
100	6000	0.10
200	8100	0.13
300	10 200	0.17
400	12 300	0.22

Table 2. Cost Estimates for 100 MW CC-OTEC Plantship (COE for 10 % Fixed Rate, 20 years, Annual O&M 1% of Capital Cost).

Commercialization (Hawai'i)

- Hawai'i could use OTEC to Generate all Electricity Consumed (100%);
- Commercial-size \approx 100 MW floater
 - \$4500/kW (\$450M)
 - C.O.E from 0.07 to 0.10 \$/kWh

5 MWe OTEC Pre-Commercial Plant



OTEC

and the State of Hawaii . . .

OTEC can satisfy all present and future residential, industrial, and commercial power, as well as domestic water needs in the State of Hawaii.

With the development of electric vehicles, OTEC could also provide the electricity required to support land transportation.

- Envision two to three floating OTEC plants (50 MW/16 MGD* to 100 MW/32 MGD*) tailored to the islands of Hawaii, Kauai and Maui . . .
 - Seven to ten large floating OTEC plants deployed around the Island of Oahu can meet all present and future power and water needs.
 - A smaller plant could meet all water and power requirements in Molokai. In the case of Lanai, it would be more cost effective to supply power from Maui via a submarine power cable.
- Environmental pollution would be minimal and the State would only have to import aviation fuels.
- Presently, 30% of the energy consumed is for aviation—therefore, by implementing OTEC, petroleum imports could be reduced by approximately 70%.

* MGD = Million Gallons of Water per day; e.g., 16 MGD is enough for 100,000 residents.

ISLAND	DE FACTO POPULATION (1990)	INSTALLED CAPACITY (1988)
HAWAII	135,000	130 MW
KAUAI	68,000	160 MW
LANAI	2,500	5 MW
MAUI	130,000	140 MW
MOLOKAI	8,000	5 MW
OAHU	910,000	1,200 MW

Hawaii map section: Copyright Raven Maps & Images, 1988.

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Development Barriers (Hawai'i)

Tech. Issues: Need to Build &
Operate Pre-Commercial Size Plant

Cost Issues: Cost Effective for Size
 ≈ 100 MW

Enviro. Issues: Relatively Minimal

Political Issues: Need Federal Help...
only Hawai'i benefits (1/250
citizens)?

Energy Carriers

OTEC energy could be transported via electrical, chemical, thermal and electrochemical carriers:

all yield costs higher than those estimated for the submarine power cable (< 400 km offshore).