Energy Resources and Policy
Handout:
Ocean thermal energy conversion (OTEC)

1. The resource

In tropical regions, the temperature of the sea close to the surface can be as high as 25^o C. The possibility therefore arises of operating a heat engine between this region and the deep ocean water, where temperatures are fairly stable at below 10^o C. There are many places in the tropics where the sea is deep enough (1 km or more) to allow OTEC systems to function. The energy resource is of course confined to these regions, but is potentially very large.

2. Technology

The system presently favoured is a closed cycle with ammonia, propane or freon as the working fluid (Figure 1). A heat exchanger evaporates the fluid, which then drives a gas turbine connected to an electrical generator. The fluid is finally condensed by heat exchange with cold water pumped up from the depths.

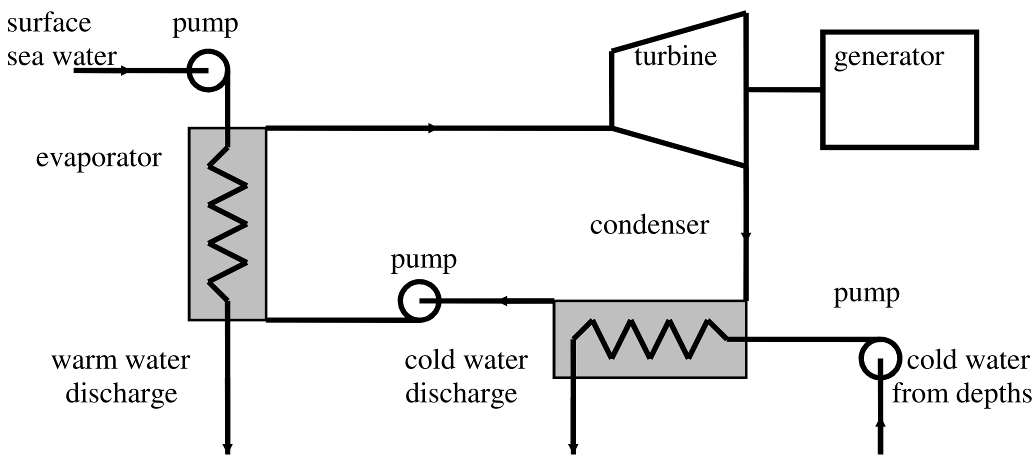

Figure 1: Closed-cycle OTEC schematic.

The small temperature differentials impose a very low thermal efficiency and if a substantial power output is required, large mass flow rates are essential. Some statistics for a 100 MW plant designed in the USA will illustrate the problem:

- anticipated thermal efficiency: 2%
- water flowrate through each heat exchanger: 450 m^3/s
- heat exchanger surface area: 10^6 m^2
- cold water pipe dimensions: 20m diameter, 1000m length.

It is clearly necessary to have a very large structure on the surface, to house the pumps, heat exchangers and other machinery and possibly to accommodate persons to operate the plant. Its mooring (in water depths of at least 1 km) may cause difficulties. An alternative suggestion is that the OTEC plant be free-floating, with no connection to the sea bed: in that case, energy storage or conversion to a useful product (fresh water or hydrogen are possibilities) must take place on board. The design and mounting arrangements for the enormous cold water pipe present a further engineering challenge. To minimise structural loads, it is important to select sites which avoid strong ocean currents and tropical storms. Fortunately, there appear to be plenty which meet these criteria.

Despite these difficulties, estimates of costs (principally from the USA) suggest that OTEC may be competitive even with fossil fuels as a means of electricity production. A number of small demonstration systems have been constructed in recent years, and have proved the feasibility of the OTEC concept. Further progress, which would require major capital investment, depends upon the support of governments or international agencies.

3. Environmental impact

OTEC plants are likely to be located well offshore, so the only adverse local impact is potential interference with shipping. A beneficial effect may be produced from the raising of large quantities of cold, nutrient-rich water to the surface: the potential is created for the concentration and harvesting of fish stocks in the surrounding area.

If exploited on a large scale, OTEC may influence the patterns of water movement in our oceans, with complex and potentially devastating effects on local climate. For this reason, estimates of the global potential for OTEC should be viewed with caution.

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