our planet's surface. This energy is stored in the form of heat. The surface waters warm up first but since warm water is lighter or less dense than cold water it tends to remain on top. This reduces the rate at which ocean waters mix and, as a consequence, the Earth's large saltwater bodies have become thermally stratified. Very deep waters are universally cold but surface waters, particularly in the tropics, can be quite warm by comparison.

It is this difference in temperature between surface and deep waters which is exploited in generating ocean thermal energy conversion (OTEC) power. With a temperature differential of about 18°C, an OTEC plant can convert the water's stored thermal energy into mechanical and, subsequently, electrical energy.

The exploitation of temperature gradients in the sea for energy production looks attractive to some tropical nations for a variety of reasons. First, oceanic thermal gradients offer a virtually limitless energy supply and, second, OTEC plants require no fuel. But there are other considerations as well. The energy output of OTEC installations would vary only marginally with seasonal water-temperature differences and the thermal energy resource itself is continuously exploitable. OTEC plants do not require any radically new technology, although existing technology would have to be refined and optimized before commercial installations are constructed.

OTEC facilities could generate electricity directly or, alternatively, they could produce a variety of energy-intensive products such as hydrogen, methanol, ammonia, aluminum, chlorine and magnesium. The circulation of large quantities of nutrient-rich, cold, deep water required for energy production could enhance biological production in the vicinity of the plant. And, finally, OTEC-derived electricity could help reduce future polarizations among nations over energy resources.

On the other hand, there are some difficulties associated with OTEC development which cannot be overlooked. The installations will be very large and very capital intensive. They could also have detrimental environmental effects although these have yet to be determined and much study has to be done in this area. The best sites for OTEC development are often located far from centres of power consumption; thus there may be difficulties and losses in the transmission of energy from the production site.

The main problem with developing closed-system OTEC power plants arises out of the necessity of exchanging heat from the seawater to a working fluid. With the relatively small temperature differences being exploited in this process, large surface areas for heat exchange are required and large flows of water are necessary in order to extract utilizable quantities of heat. The cost of the heat exchangers very much increases the capital cost of an OTEC installation (they can repre-

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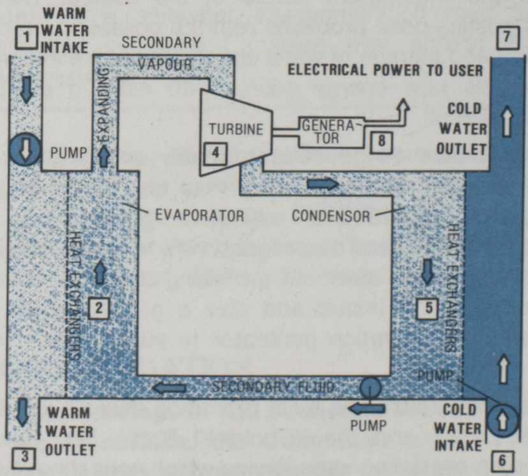
There are two types of OTEC plants which have been considered for development. In the *open* OTEC process, warm surface water is evaporated and the resultant water vapour drives a turbine to generate power. The steam is then condensed by cold water which is pumped up from the depths and subsequently returned to the ocean. This is called an open system because seawater drives the plant and no working fluid is required. The main problems with this design are the size of the turbine required (some 14 metres in diameter), the removal of dissolved gases from the seawater and the corrosive properties of saltwater.

OTEC installations may perhaps more profitably operate using a *closed* system. In this process, warm water is used to heat a working fluid such as ammonia, propane or fluorocarbons, which evaporates, drives the turbine and is subsequently condensed by cold water (Figure 6-26). Warm water enters the OTEC plant at location 1, is pumped through the heat exchanger at location 2, and leaves the plant at location 3. The heat exchanger-evaporator (2) vapourizes the working fluid. This vapour is expanded in a turbine (4); then it leaves the turbine to enter the condenser (5). From there a pump returns the working fluid to the heat exchanger-evaporator (2). The cold water enters at location 6 and flows through the heat exchanger-condenser (5), leaving the plant at location 7. The turbine operates the electric generator (8), providing electric power to the user.

Figure 6-26: SCHEMATIC DIAGRAM OF A CLOSED-CYCLE OCEAN THERMAL POWER PLANT



Source: Knight *et al*, 1977, p. 3.