

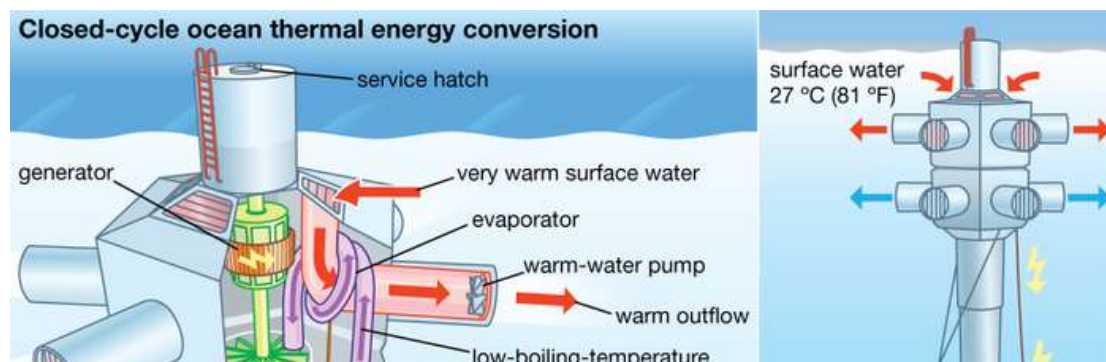
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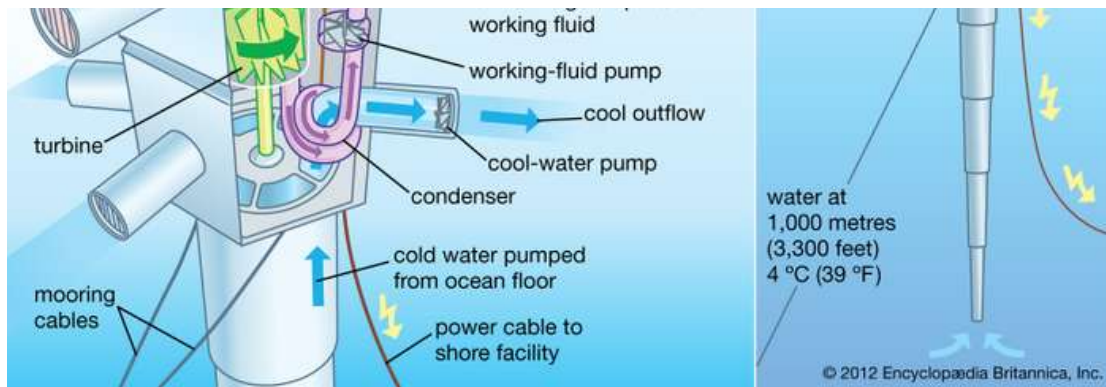
Ocean thermal energy conversion | technology

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Ocean thermal energy conversion (OTEC), form of [energy conversion](#) that makes use of the [temperature](#) differential between the warm surface waters of the [oceans](#), heated by [solar radiation](#), and the deeper cold waters to generate [power](#) in a conventional [heat](#) engine. The difference in temperature between the surface and the lower water layer can be as large as 50 °C (90 °F) over vertical distances of as little as 90 metres (about 300 feet) in some [ocean](#) areas. To be economically practical, the temperature differential should be at least 20 °C (36 °F) in the first 1,000 metres (about 3,300 feet) below the surface. In the first decade of the 21st century, the [technology](#) was still considered to be experimental, and thus far no commercial OTEC plants have been constructed.





ocean thermal energy conversion An example of the closed-cycle ocean thermal energy conversion (OTEC) process. *Encyclopædia Britannica, Inc.*

The OTEC concept was first proposed in the early 1880s by the French engineer Jacques-Arsène d'Arsonval. His idea called for a [closed-cycle system](#), a design that has been adapted for most present-day OTEC pilot plants. Such a system employs a secondary working [fluid](#) (a refrigerant) such as [ammonia](#). Heat transferred from the warm surface ocean water causes the working fluid to [vaporize](#) through a [heat exchanger](#). The vapour then expands under moderate pressures, turning a [turbine](#) connected to a generator and thereby producing [electricity](#). Cold [seawater](#) pumped up from the ocean depths to a second heat exchanger provides a surface cool enough to cause the vapour to [condense](#). The working fluid remains within the closed system, vaporizing and relieving continuously.

Some researchers have centred their attention on an open-cycle OTEC system that employs water vapour as the working fluid and dispenses with the use of a refrigerant. In this kind of system, warm surface seawater is partially vaporized as it is

injected into a near [vacuum](#). The resultant [steam](#) is expanded through a low-pressure steam turbogenerator to produce [electric power](#). Cold seawater is used to condense the steam, and a vacuum pump maintains the proper system [pressure](#). Hybrid systems, which combine elements of closed-cycle and open-cycle systems, also exist. In these systems, steam produced by warm water passing through a vacuum chamber is used to vaporize a secondary working fluid that drives a turbine.

During the 1970s and '80s the United States, Japan, and several other countries began experimenting with OTEC systems in an effort to develop a viable source of [renewable energy](#). In 1979 American researchers put into operation the first OTEC plant able to generate usable amounts of electric power—about 15 kilowatts of net power. This unit, called Mini-OTEC, was a closed-cycle system mounted on a U.S. Navy barge a few kilometres off the coast of [Hawaii](#). In 1981–82 Japanese companies tested another experimental closed-cycle OTEC plant. Located in the Pacific island republic of [Nauru](#), this facility produced 35 kilowatts of net power. Since that time researchers have continued developmental work to improve heat exchangers and to devise ways of reducing [corrosion](#) of system hardware by seawater. By 1999 the Natural Energy Laboratory of Hawaii Authority (NELHA) had created and tested a 250-kilowatt plant.

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The prospects for commercial application of OTEC technology seem bright, particularly on islands and in developing countries in the tropical regions where conditions are most favourable for OTEC plant operation. It has been estimated that the tropical ocean waters absorb solar radiation equivalent in [heat content](#) to that of about 250 billion barrels of [oil](#) each day. Removal of this much heat from the ocean would not significantly alter its temperature, but it would permit the generation of tens of millions of megawatts of electricity on a continuous basis.

Beyond the production of clean power, the OTEC process also provides several useful by-products. The delivery of cool water to the surface has been used in [air-conditioning](#) systems and in chilled-soil agriculture (which allows for the cultivation of temperate-zone [plants](#) in tropical environments). Open-cycle and hybrid processes have been used in seawater [desalination](#), and OTEC [infrastructure](#) allows access to trace elements present in deep-ocean seawater. In addition, [hydrogen](#) can be extracted from water through [electrolysis](#) for use in [fuel cells](#).

OTEC is a relatively expensive technology, since the construction of costly OTEC plants and infrastructure is necessary before power can be generated. However, once facilities are made operational, it may be possible to generate relatively inexpensive electricity. Floating facilities may be more [feasible](#) than land-based ones, because the number of land-based sites with access to deep water in the tropics is limited. Few cost analyses exist; however, one study, which

was performed in 2005, placed the cost of electricity produced by OTEC at 7 cents per kilowatt-hour. Although this figure was based on the assumption of a 100-megawatt OTEC facility located some 10 km (6 miles) off the coast of Hawaii, it is comparable to the cost of energy derived from [fossil fuels](#). (The cost of [coal](#)-generated electricity is estimated at 4–8 cents per kilowatt-hour.)

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