Summary

Ocean Thermal Energy Conversion (OTEC) is a concept for using the temperature difference that exists between warm waters at the surface of oceans and cold waters in the deep oceans to release stored solar energy to power a turbine.

The number of sites where a sufficient temperature difference exists between the surface and a reasonable ocean depth is limited—there are few off the continental United States—but at these sites the solar energy stored in the ocean is an abundant, renewable source of power. However, harnessing this energy requires complex and potentially expensive equipment of enormous size.

Research on OTEC has been underway since the early 19th century and has been funded by the U.S. Government since 1972. The concept has been touted as one which may be used to provide an important source of energy for the generation of electricity or power for manufacturing energy-intensive products such as ammonia and aluminum.

The Office of Technology Assessment (OTA) Oceans Program, in the course of this assessment, has found that OTEC technology is not yet proven and probably could not become a viable part of the U.S. energy supply system in this century. The concept was demonstrated by Georges Claude on a small scale in 1926, proving that thermal energy can, in fact, be extracted from the temperature difference in the waters of the oceans. But the technology is not developed to the point where acceptably precise estimates can be made about the technical feasibility of large-scale systems, potential products of those systems, the economics of the systems, or the social and environmental impacts.

No scientific breakthroughs are needed to build an OTEC plant, but the technology is not in routine use. Proposed OTEC designs use standard heat-engine cycles which are typical of those used in all powerplants when the heat from burning fuel is converted into electrical power. In conventional powerplants, temperature differences of hundreds or thousands of degrees are sought to get maximum efficiency. An OTEC design will attempt to create useful power from the temperature difference that is usually discarded as unusable in a conventional powerplant.

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No OTEC plant has been fully designed; many components of the system have not yet been proven reliable in the hostile marine environment. No ocean energy plant of any size has ever been built and operated which generated more energy than was required to operate the equipment. The technical problems which must be solved are by no means minor, and satisfactory solutions to the critical engineering problems will require long-term laboratory and at-sea testing.

The primary technical problems in the types of OTEC plants currently being proposed involve the heat exchangers, the cold water pipe, the working fluid, the ocean platforms, and the underwater transmission lines from plants which would generate electricity.

Even when a plant is designed and proven, there is little engineering experience which is directly pertinent to the at-sea assembly and mooring problems which may be encountered. And finally, it is not yet possible to project how reliable an OTEC plant would be once it is sited and operating.

The economics of OTEC depend primarily on the capital cost of constructing OTEC plants and the cost per kilowatt hour of the energy produced.

Because no OTEC sysyem is yet fully designed, quantitatively precise knowledge about these costs is impossible and there are large uncertainties about lifetime reliability and the interruptions in production which result should an OTEC plant fail.

The basic product of most current OTEC concepts is power—power for use in the U.S. electric grid or for use in the production of other products. The busbar cost of producing electricity is dependent upon a number of variables, including the thermal resource available, capital cost of the plant, plant capacity factor, fixed annual charge rate, cost of fuel, and the cost of operation and maintenance. Reliable estimates for these variables cannot yet be made. Therefore, it is impossible to predict the busbar cost of electricity from OTEC. Unknown electrical transmission costs add another element of uncertainty.

These still unknown costs will determine whether or not OTEC is useful in the future production of other products.

In the case of ammonia, for example, the most promising market areas are located near the most promising OTEC sites; however, these areas are the Lesser Developed Countries which require very low-cost products. In addition, existing producers are expanding their ammonia facilities to meet present and future demands with existing processes and there are potentially low-cost alternatives to OTEC/ammonia, especially ammonia made from flare gas in the Middle East nations.

For aluminum, world production capacity is currently greater than consumption of the product and little expansion is predicted in the foreseeable future. However, in theory, the use of OTEC could allow aluminum plants to be located in coastal areas nearer dependable sources of raw materials. In that case, the price and dependability of electricity from OTEC would be crucial factors.

The relative value of OTEC depends heavily on the future price of alternative energy sources. At this time, there is no economically competitive product among those which have been proposed in connection with OTEC. But these economic considerations are based on short-term projections of supply and demand for specific commodities compared with the uncertainties associated with present OTEC technology. The value of developing OTEC technology, however, cannot be measured by simple economic projections because in the long term alternative energy supply options could become much more critical to the United States and to the world. Sometime during the 21st century a renewable source of energy could become a necessity.

Because of the uncertain technical status of OTEC and the lack of conclusive information about its feasibility, there is no obvious amount of funding which should be committed for future research on the concept.

In the long term, decisions about funding are ideally made in the context of an evaluation of the total Department of Energy budget for research on future alternative energy sources. In the absence of such a comparison of alternative energy concepts at this time, Congress could cease to fund a separate research program for OTEC or it could continue to investigate the possibility of OTEC as an ultimately usable technology.

If funding is continued, fairly level research and development money in the tens of millions of dollars for the next 5 to 10 years could result in a program geared toward solving important technical problems. This type of funding would probably result in continuation of many of the present OTEC research projects, but would not result in construction of a large-scale prototype until decisions about type of plants, construction, location, and products could be made in the light of solutions to the major engineering problems.

Large appropriations rapidly amounting to billions of dollars, could influence the program toward development of a working prototype plant as soon as possible. This is a high-risk approach. It could produce the most rapid demonstration of some technology, but it could also result in skipping essential long-term testing and environmental studies. It could also force a premature choice among several concepts and possible products in order to concentrate on development of one specific system.