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Ocean Thermal Energy Conversion (OTEC): Technical Viability, Cost Projections and Development Strategies

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Abstract

Ocean thermal energy conversion (OTEC) is a baseload renewable energy source particularly suited for tropical zones. It uses the temperature difference between the warm surface ocean water and the cold deep ocean water to generate electricity and, if desired, potable water. This alternate energy source does not depend on fossil fuels, is not vulnerable to world market fluctuations, and has less environmental impact than other energy sources. During the 1970's and 1980's R&D projects such as Mini-OTEC and OTEC-1 in Hawaii and the Japanese 100-kW land-based pilot plant at the Republic of Nauru demonstrated the technical viability of OTEC, specifically with a closed-cycle system to generate electric power. Between 1993 and 1998, the Natural Energy Laboratory of Hawaii (NELHA) built and operated a 210-kW open-cycle pilot plant for the co-production of electricity and potable water. The facility was shutdown by the federal government. Today, this facility is used primarily for aquaculture and desalinated bottled Deep Ocean Water. Due to the recent progress in systems design, heat exchangers efficiency, the high costs of fossil fuels experienced in 2008, combined with the fluctuations in the oil world market, several companies have re-evaluated the use of OTEC. At present, a number of projects focused on the commercial implementation of OTEC at various sites are under consideration. Puerto Rico possesses specific conditions that make it an ideal site to implement OTEC.

Conceptual design and capital cost estimates for the proposed 75-MWe closed-cycle plant for Puerto Rico are based on commercially available components and manufacturing practices. A modular and integrated design has been applied which is readily adaptable to other plant sizes. OTEC is a benign and environmentally compatible technology. Its potential impact to the environment can be minimized through proper design and engineering & construction best practices. The first plant would include a periodical program to study long-term environmental effects of OTEC, to optimize the design and operation of future plants. This paper summarizes efforts dedicated to commercial implementation of OTEC in Puerto Rico and other locations, concentrating on the technical and economical viability, and the associated environmental and socio-economical implications.

Introduction

Ocean thermal energy conversion (OTEC) is a renewable energy technology that is applicable to most parts of the world's deep oceans between 20^{o} North and 20^{o} South latitude including the Caribbean and Gulf of Mexico, the Pacific, Atlantic and Indian Oceans, and the Arabian Sea, where the temperature difference between the warm surface ocean water and the cold deep ocean water is equal or greater than 20 ^{o}C. In essence, OTEC basically recovers part of the solar energy absorbed by the ocean. Its main application is in tropical zones where deep ocean water is available at short distance from the shore (less than 6 miles or 10 km). In addition, the potential site must have a marine environment that allows the operation of a stable system (Avery et al. 1994).

One of OTEC's greatest advantages is that it allows the co-production of potable water, in addition to electric power through desalination. It is possible to produce up to 2 million liters per day (0.5 million gallons per day) for each megawatt of electricity generated (Cohen 1982). Since OTEC does not utilizes fuel, the produced electricity has a fixed cost, thus, it is not susceptible to the volatility of costs that affects other energy sources such as petroleum, coal and natural gas. Moreover, the environmental impact is less than other sources of energy since no products of combustion are generated during the power production process. All of these aspects have caused a revival of interest in OTEC.