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AN ALTERNATIVE ENERGY SYSTEM FOR TRANSPORTATION

RENEWABLE ENERGY FROM THE OCEAN: A GUIDE TO OTEC
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I commend Avery and Wu for authoring this book on ocean thermal energy conversion (OTEC) systems. Before its publication, information covering the subject could only be found in project reports, proceedings of workshops and conferences, and articles in technical journals.

The book addresses our national need for a new energy system that can provide a practical, timely, cost-effective, and nonpolluting alternative to petroleum-based fuels for transportation. The three introductory chapters review the technologies required by OTEC systems and their historical background. Detailed design studies of various OTEC systems are also presented. The six remaining chapters constitute a series of rigorous systems engineering studies devoted to proving that some versions of OTEC can fulfill the alternative energy system requirements for replacing petroleum-based fuels.

The first chapter, an introduction and overview, defines the ocean thermal resource and design requirements of a system through which power may be obtained. The resource is the thermal difference between the water in the upper 300 ft of the ocean surface, which absorbs solar heat, and the deeper body of cold water from a depth of about 2500 ft to the bottom. These two large bodies of water in the tropical oceans have a temperature difference (thermal resource) of 22 to 25°C (40 to 45° F). The OTEC process uses this temperature difference to operate a heat engine, which drives a generator to produce electrical power, which in turn may be converted to transportable fuel such as methanol, ammonia, or hydrogen.

The major subsystems of the heat engine for such an OTEC power plant are heat exchangers, turbines, an electric generator, water and working fluid pumps, plumbing and controls, a water ducting system with a warm-water intake pipe, a cold-water intake pipe, and an exhaust flow pipe. The platform used to contain the system may be floating (moored or grazing) or shore-based. The OTEC power systems may be divided into two categories: closed-cycle and open-cycle. In the closed-cycle system, the working fluid, usually ammonia, is pumped back into an evaporator and reused. In the open-cycle system, water is the working fluid and is vented after use.

The overview continues with a detailed discussion of the design requirements for the OTEC system, a status review of critical issues needing further research and development effort, and a summary of energy transfer problems from floating platforms (i.e., the production of the liquid fuel from the generated electric power or the transmission of the electric power to shore). Floating systems for producing liquid fuels are emphasized throughout the book. These systems can use the vast thermal resource of the entire tropical oceans to produce OTEC fuels. They also can produce power at a higher efficiency by searching out ocean areas with the greatest thermal differences. This extensive first chapter concludes with a short survey of the work done on the environmental impact of OTEC systems.

The second chapter reviews the history of OTEC systems, beginning with the first use of heat engines in 1698 (the work of Carnot, D'Arsonval, and Claude) and the early French OTEC experiments. Initial work in the United States by the Andersons and a review of U.S., Japanese, and French programs up to 1990 are also presented.

The third chapter sets up the systems engineering approach used to examine the OTEC system and its capability to supply a major source of energy that can replace petroleum fuels. The study begins by listing the overall requirements and options the authors believe are necessary for an alternative energy source, and presents their view of how OTEC fulfills those requirements. Avery and Wu believe that the system must be able to furnish a significant fraction of the world's liquid fuel demand—100,000 barrels per day petroleum fuel equivalent by about the year 2000, possibly 1.5 million barrels per day by 2025. The cost of delivered fuel must be low enough to withstand competition from remaining petroleum or synthetic alternatives. The system must be environmentally acceptable, safe, and *perceived* to be safe by the public. The authors also recognize that the

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OTEC system must be developed commercially to accomplish these requirements; however, industrial and political support are essential to the success of such a plan.

Avery and Wu then launch their rigorous (280-page) systems engineering study of various potential OTEC systems to determine how well they can fulfill the established requirements. They conclude that the technology required for pilot plant demonstrations of sea- and land-based systems is available. The remaining questions of cost and environmental compatibility are addressed in the last three chapters of the book.

The cost study is based on a work breakdown structure required by the Department of Energy that evaluates OTEC systems and subsystems in terms of cost and development uncertainties. Eight detailed tables cover the various design studies. The data from these tables are then used to conduct a Mossman adjusted present value analysis of the various OTEC systems. Accompanying charts relate profitability to the value of plant investment, interest rates, environmental charges, operating and maintenance charges, and prices of the produced fuels.

The economic potential of OTEC liquid fuels and electric power is compared with other existing and proposed alternative power sources. Comparisons are made using another series of Mossman charts on the fuels (oil sands, shales, natural gas, methanol, ammonia, and hydrogen) produced by the various methods. This information is summarized in tables.

The last chapter includes a discussion of the economic and social benefits of OTEC commercialization. Tables present the economic impact of the use of OTEC plant ships to replace petroleum production, and charts show the profitability to investors of the various OTEC-produced fuels in relation to petroleum fuels. There is also an analysis of environmental effects that OTEC plants would have on the surrounding ocean waters. The chapter concludes with general comments on the benefits of an OTEC commercialization program.

It is difficult to review a book of this type so that the extensive work entailed in its production is truly reflected. Also, this is not a textbook, as one might expect from the title, but a systems engineering evaluation of the state of OTEC technology up to 1990. The text contains 214 figures, many of which are complex engineering drawings, and 72 detailed tables. Each chapter concludes with many pages of references.

As for the overall program proposed by the authors, I believe that considerable time will elapse before such a massive renewable energy program is initiated. The smaller shore-based OTEC power plants for the tropical islands should be built and operated commercially before a larger program is undertaken. By starting on a smaller scale, environmental effects can be assessed and reliability and cost data can be obtained, thus enabling investors to better determine their risks with regard to the larger investments required for the proposed petroleum replacement program.