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Ocean Thermal Energy Conversion: The Codification of a Potential Technology

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OCEAN THERMAL ENERGY CONVERSION: THE CODIFICATION OF A POTENTIAL TECHNOLOGY*

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I. INTRODUCTION

Rapid technological advancement has been the hallmark of post-industrial societies for more than a quarter of a century. This progress is forever disrupting our established legal systems.[1]

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* The opinions expressed herein do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Maritime Administration.

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1. Examples of contemporary scientific challenges to the legal system abound. For instance, ultra-large crude carriers were developed but to this day a liability and compensation scheme for damages to persons or property injured by oil from those vessels does not exist. Legislation languishes in the Congress despite passage of the Comprehensive Environmental Response, Compensation

Nowhere is this tension more evident than in the discoveries of the developing energy industry. An exception to this process is the infant industry of ocean thermal energy conversion (OTEC). The United States Congress recently enacted legislation establishing the legal framework for the OTEC process, which has not yet been proven on a commercial scale.[2]

OTEC is a form of solar energy that takes advantage of the vertical temperature differentials in those regions of the ocean generally between twenty degrees North latitude and twenty degrees South latitude. An OTEC system consists of a power plant, a floating platform[3] to house the plant, a surface-level seawater system, a deepwater seawater system, and a method of transmitting or utilizing the energy produced. Warm surface water is pumped into a heat exchanger to vaporize a working fluid. A turbo-generator converts the resulting vapor's thermal energy into mechanical and then electrical energy. The vapor leaving the turbine flows into a condenser where it is cooled by cold water pumped up from the deep ocean through a long pipe descending as much as 700 meters or deeper.[4]

Although commercial facilities are not expected to be available prior to the late 1980's, two types of OTEC systems are presently under consideration.[5] The closed cycle system[6] is closer to com-

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and Liability Act of 1980, Pub. L. No. 96-510, 94 Stat. 2767 (1980)(to be codified in 42 U.S.C. § 9601)(mysteriously omitted oil from its coverage). Another example would be the attempt by General Electric to patent its newly created life form. *See* Diamond v. Chakrabarty, 447 U.S. 303, 206 U.S.P.Q. 193 (1980).

2. OTEC Research, Development, and Demonstration Act, Pub. L. No. 96-310, 94 Stat. 941 (1980)(to be codified in 42 U.S.C. § 9001); OTEC Act of 1980, Pub. L. No. 96-320, 94 Stat. 974 (1980)(to be codified in 42 U.S.C. § 9101)(subsequent references are to the future codifications). "It is important to recognize that the foregoing estimates of OTEC economics remain speculative and uncertain because a commercial demonstration OTEC powerplant has not as yet been built . . . ." H.R. REP. No. 994, 96th Cong., 2d Sess. 26 (1980).

3. OTEC systems can also be land-based, with intake and discharge pipes extending into the ocean.

4. Reprint from OTEC hearings held by House Subcommittee on Oceanography, 96th Cong., 2d Sess. 184-85 (1979)(figures accompanied statement of James G. Wenzel, Vice President, Ocean Systems of Lockheed Missiles and Space Co., Inc.).

5. *Ocean Thermal Energy Conversion Act of 1980: Hearings on S. 2492 Before the Senate Comm. on Commerce, Science and Transportation,* 96th Cong., 2d Sess. 102 (1979-80)(statement of Bennett Miller) [hereinafter cited as *Hearings on S. 2492*].

6. DIVISION OF SOLAR TECHNOLOGY, UNITED STATES DEPARTMENT OF ENERGY

mercial realization. In this system, heat derived from surface waters evaporates a working fluid such as ammonia and forces the resulting vapor through a turbine. The turbine powers a generator to create electricity. The vapor returns to liquid form after being chilled with cold water from the ocean depths. The second system is the open cycle system. In this process, warm surface seawater is evaporated in a vacuum. The resulting steam powers a turbine and is then condensed with cold seawater drawn from the ocean depths.

OTEC has the potential to fulfill the energy needs of oil-dependent communities.[7] Because OTEC's energy source is solar, it is renewable. Unlike other solar technologies, however, OTEC can operate twenty-four hours a day, year-round due to the ocean's immense solar-collection properties.[8] Yet OTEC will be used for much more than electrical power generation. It has the potential for ammonia production, which presently requires nearly three percent of the total United States output of natural gas.[9] OTEC can be used to process and refine minerals and produce other energy-intensive products such as aluminum.[10] OTEC power can be used to produce fuel for fuel cells that can be transported and used for electricity elsewhere. Considering all these potential uses, OTEC will be a promising area of renewable energy technology if it evolves in a cost-effective and environmentally acceptable manner.

II. Economic Viability of OTEC

In August 1979 an OTEC demonstration plant first produced

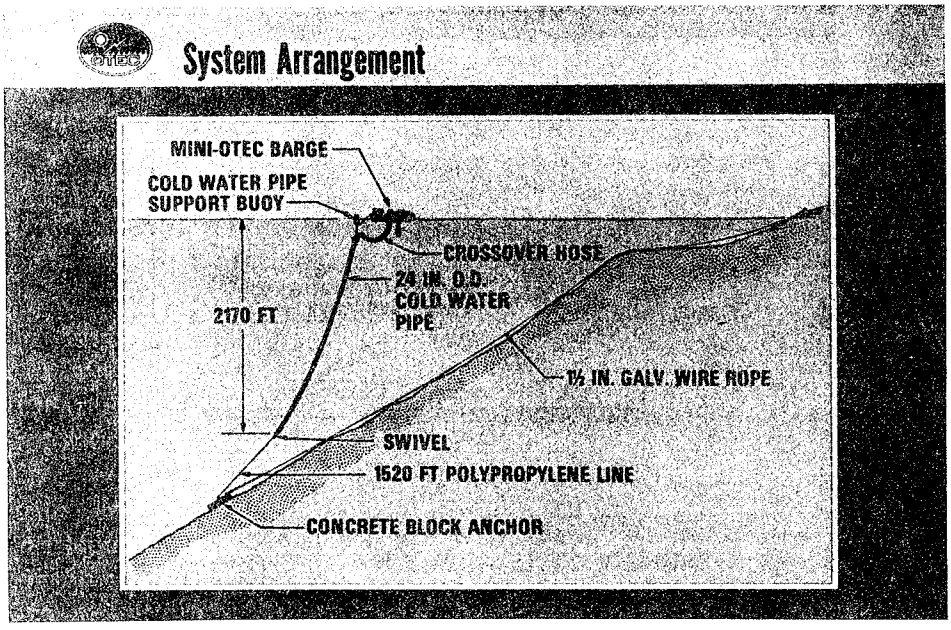
Power Cycle and Components Plan 3 (1978).

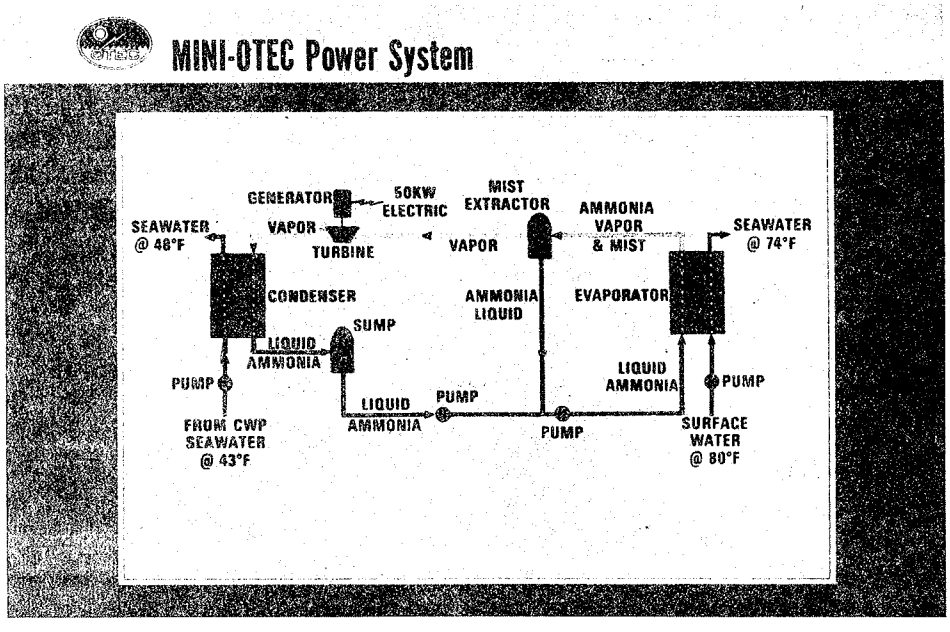
7. Cohen, Ocean Systems Branch, Division of Central Solar Technology, United States Department of Energy, *An Overview of U.S. OTEC Development Program* (Nov. 1978). Puerto Rico, for instance, generates 98% of its electricity with oil-powered generators. With the ever increasingly prohibitive cost of oil, areas such as Puerto Rico must turn to alternate energy sources.

8. Krueger, *The Promise of OTEC,* Marine Tech. Soc'y J., June 1980, at 33.

9. National Oceanic and Atmospheric Administration, Ocean Thermal Energy Conversion: Preliminary Regulatory Impact Analysis/Initial Regulatory Flexibility Analysis 9 (March 1981).

10. Marine mineral mining is not expected to begin until 1988. In tandem with the passage of OTEC legislation, Congress passed the Deep Seabed Hard Mineral Resources Act, Pub. L. No. 96-283, 94 Stat. 553 (1980)(to be codified in 30 U.S.C. § 1401).


System Arrangement
MINI-OTEC BARGE
COLD WATER PIPE SUPPORT BUOY
CROSSOVER HOSE
24 IN. O.D. COLD WATER PIPE
2170 FT
1½ IN. GALV. WIRE ROPE
SWIVEL
1520 FT POLYPROPYLENE LINE
CONCRETE BLOCK ANCHOR


MINI-OTEC Power System
GENERATOR
50KW ELECTRIC
MIST EXTRACTOR
AMMONIA VAPOR & MIST
SEAWATER @ 46°F
VAPOR
TURBINE
VAPOR
SEAWATER @ 74°F
CONDENSER
AMMONIA LIQUID
EVAPORATOR
SUMP
LIQUID AMMONIA
LIQUID AMMONIA
PUMP
PUMP
LIQUID AMMONIA
PUMP
PUMP
FROM CWP SEAWATER @ 43°F
SURFACE WATER @ 80°F

more power than it consumed.[11] No utility, however, will invest in an OTEC system unless it is demonstrated to be technologically and economically viable. The first pilot plants will test subsystems and materials; later demonstration plants will examine the long-term operation. Meeting the challenge of designing a commercially viable OTEC plant will require extensions of the most advanced technology. The water flow for a 400-megawatt plant will equal that of the Mississippi River.[12] OTEC plants work on a gross power conversion efficiency of two to three percent, so maintaining maximum efficiency will be critical.[13] Heat exchangers must operate at high efficiency despite biofouling and corrosion. Although these plants will be situated in less than optimal offshore environments, cold water pipes over 700 meters long must present no motion problems in high seas, and moorings must allow stable operations in depths over 1,000 meters. OTEC power cables must function under conditions unprecedented for underwater cables.[14]

Many unknown technological and economic variables affect OTEC's viability.[15] Significant cost variables are associated with virtually every element of technology that has yet to be engineered, such as the underwater electrical transmission system or the mooring system. The cost of heat exchangers, which is estimated to comprise nearly half the OTEC plant's total cost, depends on the materials used to construct the heat exchangers and methods employed to keep the exchangers highly efficient.[16] An important economic variable is the interest rate at which the initial investment will have to be amortized, particularly in view of the large capital investment required. Other unknown economic factors include the costs of governmental taxation or licensing and the benefits of any governmental promotional programs. Although it is difficult to estimate the final life-cycle costs for

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11. Krueger, *supra* note 8, at 32.

12. Bender, *The OTEC Gamble,* SEA TECH., Aug. 1979, at 16.

13. M. Bloom, The Emerging Legal and Economic Environment of OTEC (Apr. 21, 1980)(unpublished).

14. Rumbaugh, et al., *Thermal Energy Conversion: Tapping the Sea Depths,* SPECTRUM (The Institute of Electrical and Electronics Engineers, Inc.), Aug. 1979, at 42.

15. OFFICE OF TECHNOLOGY ASSESSMENT, RENEWABLE OCEAN ENERGY SOURCES, PART I: OCEAN THERMAL ENERGY CONVERSION 16 (1978).

16. *Hearings on H.R. 6154, infra* note 31, at 487 (statement of Paul R. Sutherland, Florida Power and Light Company).

OTEC systems, it is also difficult to estimate the future life-cycle costs of established technological competitors such as nuclear and coal-powered plants or such exotic systems as wind and wave power and electrical solar cells.[17] After the production of commercial units begins, application of a learning curve should lead to an economy of scale in production and provide an acceptably accurate estimate of total life-cycle costs. Once a standard design is proven, OTEC facilities could be built on a series basis at the nation's currently underutilized shipyards and then towed to mooring sites, thus greatly reducing per unit construction costs.

In the near term, projected commercialization will probably be in the form of small OTEC electrical plants (ten to forty megawatts) to supply incremental baseload requirements for United States islands in the Pacific and Carribean. Hawaii and Puerto Rico are likely candidates for early commercial OTEC development due to near-shore availability of the thermal resource, which reduces electrical transmission cable costs. These islands have sizable populations almost totally dependent on imported oil for energy needs, and each megawatt of annual electricity demand met by OTEC would eliminate the need to import forty barrels of oil per day. For example, if OTEC supplied Puerto Rico's current average annual use of 2,000 megawatts, the need to import 80,000 barrels of oil per day would be eliminated.[18] The Department of Energy (DOE) estimates that energy from OTEC could penetrate the United States islands' market at a rate of several gigawatts by the year 2000 and about 10 gigawatts by 2014.[19]

Another potential area for early commercialization is ammonia production on OTEC plantships. A large portion of United States

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17. Sanchez, *Puerto Rico Electric Power Authority, The OTEC Alternative for Puerto Rico v. Coal-Oil-Nuclear*, PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE IIC/2-1 (1980). The study concluded that while nuclear power is the most inexpensive means of producing electricity, OTEC is not far behind and is cheaper than either coal- or oil-powered electricity.

18. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, UNITED STATES DEPARTMENT OF COMMERCE, OCEAN THERMAL ENERGY CONVERSION ENVIRONMENTAL ISSUES DISCUSSION PAPER 14 (1980) [hereinafter cited as PAPER]. In March 1981 NOAA released the Draft Environmental Impact Statement to accompany its notice of proposed rulemaking on OTEC, 46 Fed. Reg. 19,418 (1981). This document updates and explores in detail many environmental questions that accompany the introduction of this technology.

19. A watt is a unit of power. One horsepower is equal to 746 watts. A gigawatt is equal to one billion watts.

ammonia is used in manufacturing fertilizer. Although the feedstock currently used for ammonia production is natural gas, an OTEC ammonia production plantship would rely instead upon hydrogen gas produced from seawater as a feedstock. A 325-megawatt ammonia production plantship would be capable of producing 1,000 metric tons of ammonia per day, and each plantship would eliminate the need for twelve billion cubic feet per year of natural gas as ammonia production feedstock. Current annual United States natural gas production is about twenty trillion cubic feet. Thirty such 325-megawatt plantships would be required to meet projected post-1985 increases in United States fertilizer demand.[20]

A more advanced use of OTEC might be to power floating manufacturing plants at sea. A likely use would be to smelt aluminum ore, a process requiring a great amount of electricity. The ore could be shipped from Australia and smelted at an OTEC plantship in the central Pacific. The resulting processed aluminum could be shipped to the United States at a great energy and cost saving. Looking far into the future, whole cities could be built under the sea and powered by OTEC.[21] These underwater cities could be designed to produce aquaculture products, mine deep sea minerals, and provide living space for the world's growing population. Advanced OTEC systems need not be limited to use in the tropical zone since the systems could also be adapted for use in the polar regions where there are great differences in temperatures between local sea water and the ambient air. Thus OTEC could be instrumental in opening these remote areas of the earth to productive human habitation.

III. Enactment of OTEC Legislation

Sponsors of OTEC legislation have employed alternative tactics in order to promote OTEC's development as the most promising solar technology for domestic use. The OTEC Research, Development, and Demonstration Act[22] increased research and development funding and targeted bold national energy goals, including:

(1) demonstration by 1986 of at least one hundred megawatts of

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20. Paper, *supra* note 18, at 14.

21. Lamp, *Why Not Grow a Building Under Water*, Next, Mar.-Apr. 1980, at 57.

22. 42 U.S.C. § 9001 (1980).

> electrical capacity or energy product equivalent from OTEC systems;
> (2) demonstration by 1989 of at least five hundred megawatts of electrical capacity or energy product equivalent from OTEC;
> (3) achievement in the mid-1990's, for the Gulf Coast region of the continental United States and for islands in the United States and its territories, of an average cost of electricity or energy product equivalent produced by installed OTEC systems that is competitive with conventional energy sources;
> (4) establishment as a national goal of ten thousand megawatts of electrical capacity or energy product equivalent from OTEC by 1999.[23]

The goals of the Act presuppose that such a program cannot be accomplished overnight. Congress provided a program formulated to design, construct, and operate OTEC systems to demonstrate technical and economic feasibility and established a consultation program between affected federal agencies.[24] The agencies are mandated to prepare a comprehensive technological plan that will permit realization of the 10,000 megawatt national goal by the year 1999.

A major impetus for early development has come from non-federal sources. The state of Hawaii, Lockheed Missiles and Space Company, Dillingham Corporation and Alfa-Laval have collaborated to build and operate Mini-OTEC, a minature experimental system that does everything that a commercial plant would.[25] The system was tested in the territorial waters off the coast of Hawaii. The concept has been proven at the initial pilot plant stage, and the legislation authorizing research and development funding would allow further important research to be conducted.[26] The first commercially viable plants are anticipated to be constructed in the early 1990s,[27] but some predict a land-based plant is com-

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23. *Id.* § 9001(2)(b) (1980).

24. 42 U.S.C. § 9002(3)(a)(2) (1980).

25. White, *Ocean Power Hits Hawaii*, MECHANIX ILLUSTRATED, Feb. 1980, at 40; *see* Reprint, *supra* note 4.

26. 42 U.S.C. §§ 9009(10)(a)-(d) (1980). Though the increased funding has been authorized in this legislation, the Reagan Administration has not requested that any funds be allocated to the DOE OTEC demonstration program in 1982.

27. OTEC-1, a DOE demonstration plan, was deployed off Hawaii in June 1980. Its purpose is to test heat exchangers, the cold water pipe, mooring systems, and the environmental impacts of an OTEC system. OTEC-10 is expected to be deployed in 1984. If completed it would represent a small-scale version of a commercial OTEC power plant and would graze untethered on the ocean sur-

mercially viable now, and could be in place by 1985.[28]

The Ocean Thermal Energy Conversion Act of 1980 was signed into law just a few days after the OTEC Research and Demonstration Bill.[29] Its enactment put the OTEC program on solid footing. The most important features of this legislation are the establishment of a stable OTEC legal regime and the designation of an OTEC facility or plantship as a "vessel" for purposes of some of the financial assistance programs in the Merchant Marine Act of 1936 (MMA).[30] The Maritime Administration (MARAD) expressed concern over this particular feature of the bill and supported both a requirement for larger equity investment by the participants and a finding of economic soundness by the Secretary.[31] This was necessary to ensure that one default would not wipe out the entire Federal Ship Financing Fund of the Title XI vessel mortgage obligation guarantee program.[32] As passed, however, the legislation allows the federal government to guarantee up to eighty-seven and one-half percent of the cost of construction, reconditioning, or reconstruction of OTEC plantships or facilities.[33] The authority for the United States to guarantee up to two billion dollars in OTEC financing has been granted.[34] Additionally, earnings and accrued depreciation from OTEC facilities and plantships can be placed in a tax-deferred fund under amended section 607 of the MMA, known as the Capital Construction Fund program.[35] Any vessels used to provide shipping service to or from any OTEC facility or plantship would be eligible for construction and operation differential subsidies under

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face. The 1982 proposed budget, however, allots no money for this research.

28. Interview with Richard D. Norling, NOAA OTEC Program Coordinator and former Staff Director of House Subcommittee on Oceanography, in Washington, D.C. (March 30, 1981).

29. *See* note 2 *supra.*

30. 46 U.S.C. §§ 1101-1294 (1979).

31. *Ocean Thermal Energy Conversion Act of 1980: Hearings on H.R. 6154 Before the Subcomm. on Oceanography of the House Comm. on Merchant Marine and Fisheries,* 96th Cong., 2d Sess. 434 (1979-80) (statement of Wallace T. Sansone, Maritime Administration) [hereinafter cited as *Hearings on H.R. 6154*].

32. *Id.*

33. 42 U.S.C. § 9112(f) (1980).

34. 46 U.S.C. §§ 1271-1280, *as amended by* the OTEC Act of 1980, Pub. L. No. 96-320, 94 Stat. 994 (1980).

35. *Id.* at 94 Stat. 991.

section 501 of the MMA.[36] Such vessels must be documented under the laws of the United States.

The Ocean Thermal Energy Conversion Act also deals with the right of OTEC facility owners and operators to noninterference with their use of a particular ocean area. Due to the high initial capital outlays involved, owners and operators wanted assurance that this concern was dealt with. Under the Act, a one-stop license review authority was centralized in the National Oceanic and Atmospheric Administration (NOAA). NOAA contacted other agencies having potential jurisdiction over OTEC activities to delineate agency responsibilities under the legislation in order to further intergovernmental coordination and early implementation.[37] Those agencies include, among others, the Department of Energy, the Department of State, the Department of Transportation, the Environmental Protection Agency, and the Maritime Administration. NOAA has also established the Office of Ocean Minerals and Energy to implement the major provisions of the OTEC Act.[38]

IV. Proposed Implementation of OTEC Legislation

Upon introduction of legislation to promote OTEC, Chairman Gerry E. Studds of the House Oceanography Subcommittee stated:

> It appears to me that there are two principal steps which must be taken before OTEC can become a normal commercial technology: OTEC systems must be demonstrated on a large scale, and legislation must be passed to specify how the federal government will license OTEC plants and to clarify some of the legal and financing questions which would otherwise be institutional barriers to commercial OTEC construction or to private participation in the large-scale demonstrations.[39]

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36. *Id.* at 992.

37. 42 U.S.C. § 9112(c) (1980). Under this section, those agencies must transmit "written descriptions of their expertise or statutory responsibilities" to NOAA.

38. The Director of the new office is Robert W. Knecht, United States Department of Commerce Representative to the United Nations Law of the Sea Conference. Mr. Knecht served as Assistant Administrator of NOAA's Office of Coastal Zone Management from its inception in the early 1970s until 1979.

39. *Hearings on H.R. 6154, supra* note 31, at 239-40 (statement of the Hon. Gerry E. Studds, Chairman of the House Oceanography Subcomm.).

Richard Norling of Congressman Studds' staff further elaborated on these ideas at the Seventh Annual Ocean Energy Conference.[40] Norling explained that because most OTEC activities will take place in the ocean beyond the limits of national jurisdiction, specific jurisdictional and legal questions must be addressed, such as guarantees of noninterference with the necessary thermal resource, licensing procedures, judicial review, dispute settlement among OTEC operators, and the regulatory and siting authority.[41] The Ocean Thermal Energy Conversion Act attempts to answer these questions.

Congressman Studds and Senator Inouye, chief sponsors of the bill, viewed achievement of OTEC commercialization as a high priority goal and made the regulatory system as simple and expeditious as possible in order to reduce any delays in implementing the OTEC statute.[42] The Act outlines a one-window review procedure similar to the Deepwater Port Act[43] with NOAA serving as the chief regulator, sets up an application procedure, and directs the NOAA Administrator to consult with other government agencies and issue regulations within one year.[44]

The DOE and NOAA have been involved in the development of OTEC during the past several years. DOE promoted the development of OTEC demonstration facilities through a series of con-

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40. The Seventh Ocean Energy Conference—1980, sponsored by the Division of Ocean Energy Systems, Office of Solar Power Applications, Conservation, and Solar Energy, United States Department of Energy, and organized by Gibbs and Cox, Inc., was held in June 1980 at the Shoreham Americana Hotel in Washington, D.C.

41. Norling, *The Proposed OTEC Act of 1980: Analysis and Prospects for Enactment*, PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE I IIE/1-1 (1980).

42. *Hearings on H.R. 6154, supra* note 31, at 240 (statement of Hon. Gerry E. Studds, Chairman, House Oceanography Subcommittee); *Hearings on S. 2492, supra* note 5, at 1 (statement of the Hon. Daniel K. Inouye, Chairman, Subcomm. on Merchant Marine and Tourism).

43. Deepwater Port Act of 1974, Pub. L. No. 93-627, § 1, 88 Stat. 2126 (1974). The Deepwater Port Act (DPA) permitted the issuance of a license for the ownership, construction, and operation of a deepwater port after the Secretary of Transportation determined that the port (which would be beyond both the three-mile and twelve-mile territorial zone) would not unreasonably interfere with international navigation or other *reasonable uses* of the high seas.

44. 42 U.S.C. § 9112(a) (1980). Final regulations were published at 46 Fed. Reg. 39,388 (1981) (to be codified in 15 C.F.R. Part 981). The Final Environmental Impact Statement and Regulatory Impact Analysis/Regulatory Flexibility Analysis were made available at the same time.

tracts designed to improve the state-of-the-art technology, especially in subsystems and components that require further development such as heat exchangers, cold water pipes, electrical transmission cables, hull structures, and seakeeping systems.[45] NOAA's main efforts have been through reimbursable funding from DOE. Since early 1977, NOAA has managed over twelve million dollars of research activity in conjunction with DOE. NOAA has not yet participated in extensive environmental, legal, and institutional studies because of DOE's more explicit legislative mandate in these areas.[46] The OTEC Commercialization Act[47] significantly expands NOAA's current role because of the heavy reliance on NOAA expertise in ocean affairs and multiple-use decisionmaking and the designation of NOAA as the prime licensing authority for the location, construction, and operation of commercial OTEC plants.[48]

Under the OTEC Act, the NOAA Administrator is charged with publishing notice of applications in the *Federal Register* and conducting public hearings on applications within stringent time constraints.[49] An applicant need only file one application with the Administrator, who must forward copies to other federal agencies and departments with jurisdiction over any aspect of the request.[50] The other agencies must respond within a set time limit, and the Administrator may take whatever action he deems appropriate if they fail to respond.[51] The Administrator's decision on an application is required ninety days after the conclusion of the public hearings.[52] The Act also provides for environmental and antitrust review, as well as for participation by the governors of adjacent coastal states.[53] The Administrator must oversee the

45. *Hearings on H.R. 6154, supra* note 31, at 424, 430 (statement of James P. Walsh, Deputy Administrator, NOAA).

46. *Id.* at 432.

47. 42 U.S.C. § 9101 (1980).

48. *Hearings on S. 2492, supra* note 5, at 113 (statement of James P. Walsh, Deputy Administrator, NOAA).

49. 42 U.S.C. § 9112(d), (e), (g), (i) (1980).

50. *Id.* § 9112(f) (1980).

51. *Id.*

52. *Id.* § 9112(i)(1) (1980).

53. This legislation follows the current trend toward allowing coastal states more authority over policies that directly affect their shores. *See* Coastal Zone Management Act, 16 U.S.C. § 1451-1464 (1976 & Supp. III 1980); the Deepwater Port Act of 1974, Pub. L. No. 93-627, § 1, 88 Stat. 2126 (1974); the Outer Continental Shelf Lands Act Amendments of 1978, Pub. L. No. 95-372, 92 Stat. 629

program once licenses are granted.[54] The United States Coast Guard is responsible for issuing regulations governing safety, pollution control, and navigational aspects of OTEC operations.[55]

NOAA is particularly qualified to manage the growth and development of OTEC in light of the history of NOAA's previous involvement and its coastal zone management responsibilities. The Federal Coastal Zone Management Act[56] (CZMA) and the state coastal programs produced under its aegis could dovetail with the increased management responsibilities. NOAA's experience with Coastal Zone Management (CZM) programs could provide important tools for making rational siting decisions. Coordination with the states, essential for any facility siting program, occurs under the CZMA. For example, a key aspect of the CZMA is its federal consistency provision.[57] Once a state has its coastal program approved by the federal government, the statute requires that activities requiring federal licenses and permits that affect the coastal zone of a state under an Office of Coastal Zone Management (OCZM) approved coastal zone management program be consistent with the state program.[58] This intergovernmental tool provides an incentive for states to attain CZM program status. OCZM consults closely with states on energy facility issues both during the development and review of CZM programs, and in providing impact assistance through the Coastal Energy Impact Program (CEIP).[59]

In 1978 a number of important amendments were added to the CZMA, including a provision requiring states to include an energy facility planning process in their CZM programs.[60] As one part of its overall management program, a state must demonstrate that its CZM programs are designed to protect and balance two major national concerns, the siting of needed energy facilities and the protection of valuable and sensitive coastal resources.[61] The amendments also require that management programs include a planning process for anticipating and managing the environmen-

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(1978).

54. 42 U.S.C. § 9120 (1980).
55. *Id.* § 9112(f) (1980).
56. 16 U.S.C. §§ 1451-1464 (1976 & Supp. III 1980).
57. *Id.* § 1456(c)(3)(A) (1976 & Supp. III 1980).
58. *Id.*
59. 15 C.F.R. § 931.31 (1980).
60. 16 U.S.C. § 1454(b)(8) (1976 & Supp. III 1980).
61. *Id.*

tal, economic, and social impacts of energy activities under consideration.[62] The CEIP provides impact planning assistance to help states study and plan for "any economic, social, or environmental consequence which has occurred, is occurring, or is likely to occur in such state's coastal zone as a result of the siting, construction, expansion, or operation of such new or expanded energy facilities."[63]

Under the OTEC Act, NOAA must assess the effects of the OTEC facilities and plantships on the environment through baseline studies, research, and monitoring of OTEC operations.[64] The purpose of the assessment program is to ascertain the magnitude of any cumulative environmental effect of large numbers of OTEC facilities and plantships.[65] The program must be designed to address several specific questions, "including whether any of the cumulative environmental effects require that a ceiling be placed on the number or capacity of OTEC facilities and plantships to be licensed for simultaneous operation, either overall or within specific geographic areas."[66] The research program is intended to begin at once and proceed until decisions concerning the magnitude of cumulative impacts can be made.[67] "Because the monitoring of the effects of large OTEC facilities and plantships is a necessary part of this research program, the issuance of licenses is to proceed while the research program is underway."[68] If the research indicates that a ceiling must be imposed on the number or the total capacity of OTEC facilities and plantships, limits will be established by regulation only after completion of a formal rulemaking and environmental impact statement process.[69]

V. LEGAL ISSUES

The OTEC Act of 1980 is a unilateral action by the United

62. 16 U.S.C. § 1456a(c) (1976 & Supp. III 1980).
63. 15 C.F.R. § 931.31 (1980).
64. 42 U.S.C. §§ 9117(a)-(d) (1980).
65. *Id.* § 9117(a) (1980).
66. H.R. REP. No. 994, 96th Cong., 2d Sess. 47 (1980) [hereinafter cited as H.R. REP. No. 994].
67. *Id.*
68. *Id.*
69. *Id.*

States Government in a new field of ocean technology.[70] The action has precedent and basis in customary international law. A spokesman for Congressman Studds summarized the legal and institutional arrangements that the drafters perceived:

> Under the Law of the Sea Treaty which is still being negotiated, OTEC activities more than 200 miles from any country will continue to be reasonable uses of the high seas, and OTEC activities will be regulated by each coastal country within its 200 mile economic zone. The OTEC Act of 1980 uses jurisdictional bases of current international law to regulate OTEC activities under U.S. flag or by U.S. citizens, and OTEC facilities in U.S. waters or connected to the U.S. by cable or pipeline. The bill is structured so that the transition of the different jurisdictional basis of the draft Law of the Sea Treaty will be simple and expeditious when the Treaty is ratified and enters into force.[71]

A review of the national and international issues is relevant to this analysis, because the potential for international legal ramifications exists when a national jurisdiction undertakes unilateral action.

A. *Traditional International Law*

Traditionally, coastal states have enjoyed exclusive rights within three marine miles of land, except for innocent passage of foreign vessels.[72] This traditional view has been widely debated, however, and article 24(1) of the 1958 Convention on the Territorial Sea and Contiguous Zone[73] provides a coastal state with authority to assert limited jurisdiction over the high seas contiguous to its territorial waters, but not beyond twelve miles of the baseline from which the breadth of the territorial sea is measured.[74] Under traditional international law, therefore, an OTEC device deployed for research or commercial purposes within territorial

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70. *See* 125 CONG. REC. E 6174 (daily ed. Dec. 15, 1979) (statement of Gerry E. Studds: Title IV of the OTEC bill "requires the administrator to modify regulations issued pursuant to this act to conform to the provision of any Law of the Sea treaty ratified by the United States").

71. Norling, *supra* note 41, at IIIE/1-4.

72. Nanda, *Ocean Thermal Energy Conversion Development Under U.S. and International Law and Institutions*, 8 DEN. J. INT'L L. & POL'Y 245, 246 (1979).

73. *Done* Apr. 29, 1958, 15 U.S.T. 1606, T.I.A.S. No. 5639, 516 U.N.T.S. 205 (effective Sept. 10, 1964) [hereinafter cited as Territorial Sea Convention].

74. *Id.* art. 24(2).

waters would be within the exclusive competence of the coastal state, because it has sovereign rights in territorial waters.[75] Any third-party state that wants to locate an OTEC facility or plantship in the coastal state's twelve-mile contiguous zone may also have to receive permission from the coastal state.

Ocean law in this area is in flux since diplomats are currently negotiating the Law of the Sea (LOS) Treaty. The Draft Convention, which represents the current LOS position, sets the breadth of the territorial sea at twelve nautical miles under article 3 and that of the contiguous zone at twenty-four nautical miles under article 33(2).[76] Sovereignty is again limited by the right of innocent passage. Thus, there is almost a universal consensus on the twelve-mile limit for the territorial seas. Within the territorial sea, the coastal state will have almost total control over the installation and operation of an OTEC facility for research and commercial use.[77]

B. *OTEC Devices on the Exclusive Economic Zone*

The Draft Convention recognizes a special area known as the Exclusive Economic Zone (EEZ), which extends seaward to a distance of 200 nautical miles.[78] This economic zone has a special relevance for OTEC, because article 56 of the Draft Convention grants the coastal state

> sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or nonliving, of the seabed and subsoil and the superadjacent waters, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds.[79]

Article 56 also extends coastal state jurisdiction within the EEZ to "(i) the establishment and use of artificial islands, installations and structures; (ii) marine scientific research; (iii) the protection

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75. Nanda, *supra* note 72 at 247. *See also* H.R. REP. No. 994, *supra* note 66 at 65.

76. U.N. Third Conference on the Law of the Sea, Draft Convention on the Law of the Sea, 9th Sess., U.N. Doc. A/CONF.62/WP.10/Rev/Add. 1 (1980) [hereinafter cited as Draft Convention].

77. Nanda, *supra* note 72, at 248.

78. Draft Convention, *supra* note 76, art. 55.

79. *Id.* art. 56(1)(a). *See also* H.R. REP. No. 994, *supra* note 66, at 64.

and preservation of the marine environment."[80] Article 60 specifically extends article 56 by providing the coastal states the

> exclusive right to construct and to authorize and regulate the construction, operation and use of: (a) Artifical islands; (b) Installations and structures for the purpose provided for in Article 56 and other economic purposes; (c) Installations and structures which may interfere with the exercise of the rights of the coastal state in the zone.[81]

Article 247 provides that the coastal state must approve marine scientific research undertaken by a third party in the EEZ.[82] Professor Nanda of the Denver University College of Law believes that

> there is such an overwhelming consensus among the participants at LOS III on the EEZ that even if the efforts to formalize a comprehensive treaty on the Law of the Sea were to fail, EEZ will in the near future be accorded legitimacy by state practices, transforming it into a rule of customary international law.[83]

C. *OTEC Devices on the Outer Continental Shelf and the High Seas*

The Draft Convention on the Law of the Sea modifies the boundaries of the continental shelf and extends it to the outer edge of the continental margin or to a distance of 200 miles, whichever is greater.[84] Article 30 grants the coastal states the exclusive right to authorize and regulate construction, operation, and use of artificial islands, installations, and structures; and to approve scientific research on the outer continental shelf that would help establish proper sites for OTEC facilities and plantships. The Draft Convention gives a coastal state exclusive authority over the installation of any OTEC devices located over its continental shelf for research or commercial purposes.[85]

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80. Draft Convention, *supra* note 76, art. 56(1)(b); *see Hearings on H.R. 6154, supra* note 31, at 403 (statement of Gary Knight, Companile Professor of Marine Resource Law, Louisiana State University), and at 444 (statement of Morris Busby, Acting Deputy Assistant Secretary of State Oceans and Fisheries Affairs).

81. Draft Convention, *supra* note 76, art. 60(1).

82. *Id.* art. 247.

83. Nanda, *supra* note 72, at 250.

84. Draft Convention, *supra* note 76, art. 76.

85. Nanda, *supra* note 72, at 252.

The traditional standard for managing conflicting ocean uses on the high seas is that of reasonableness. Under this standard a user cannot unreasonably interfere with the interests of others.[86] The Deepwater Port Act provides an appropriate precedent for this reasonable use theory,[87] and the OTEC Act of 1980 was carefully patterned after that bill. States traditionally have had "the primary responsibility for regulating the activities of vessels flying their flags on the high seas. Applying that analogy to OTEC devices, any OTEC installation owned or authorized by a state on the high seas would be under its authority and control."[88]

D. *Law of the Sea Draft Convention*

Some commentators question whether OTEC activities beyond the 200-mile economic zone should be considered and treated, for purposes of international agreement, in the same manner as deep-seabed mining activities.[89] If this happens, OTEC development could be subject to interpretation under the concept of the common heritage of mankind,[90] an idea that has been the starting point for nearly all negotiations on deep sea activities over the past ten years. Less developed countries (LDCs), landlocked countries, and countries with land-based mineral resources have joined forces to argue that ocean resources beyond territorial limits should be considered community property, and no single nation holds exclusive rights. The Draft Convention very carefully excludes anything in the water column from being organized or controlled by the deep-seabed mining text which resulted from these "common heritage" negotiations.[91] Any movement to regulate international energy development in the same manner as deep-seabed mining could spell delay and disaster for this infant industry, at least beyond the limits of the exclusive economic zone.

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86. Convention on the High Seas, *done* Apr. 29, 1958, 13 U.S.T. 2312, T.I.A.S. No. 5200, 450 U.N.T.S. 82 (entered into force Sept. 30, 1962).

87. *See* note 43 *supra.*

88. Nanda, *supra* note 72, at 253.

89. *Id.* at 255, 256.

90. G.A. Res. 2749 (XXV)(1970), *reprinted in* 10 INT'L LEGAL MATERIALS 220 (1971)(adopted by 108 votes to none with fourteen abstentions). Resolution 2749 passed overwhelmingly, but it does not serve as evidence of customary international law because of the vague generality of most of its provisions.

91. Draft Convention, *supra* note 76, arts. 1, 134.

There are parallels between the controversial deep-seabed mining issue and the development of OTEC beyond the 200-mile economic zone. Both involve resources located in an area far beyond jurisdictional control of nation states. Development of both could upset the current exploitation patterns for land-based mineral and energy resources. The similarities end there, however, because many LDCs are located in geographic areas where a thermal differential would support OTEC plantships. It was not surprising, therefore, to learn that when the Ninth session of the Law of the Sea Conference adjourned in the summer of 1980, the international authority designed to organize and control deep-seabed activities and to administer those resources was not delegated control over thermal energy.[92] OTEC activities beyond the 200-mile zone will not be regulated by the International Seabed Authority, which will have only "jurisdiction over activities in the area, *i.e.*, exploration for and exploitation of, the resources of the seabed and ocean floor and subsoil thereof beyond the limits of the continental shelf. . . . Resources of the deep seabed cannot be construed to encompass thermal energy extracted from the water column."[93]

It is important to note that some issues remain to be resolved in the future LOS sessions if the Convention is to have broad acceptance. Elliott L. Richardson, the recently retired United States Ambassador to the Law of the Sea Conference, indicated that the Draft Convention in its current form will not hamper OTEC development, and he urges United States ratification and support for this multilateral agreement.[94] The agreement will "make clear that such [OTEC] activities can be conducted beyond the exclusive economic zone as a reasonable use of the high

92. Draft Convention, *supra* note 76, art. 157(2) ("The powers and functions of the Authority shall be those expressly conferred upon it by the relevant provisions of this Convention. The Authority shall have such incidental powers consistent with the provisions of this Convention, as are implicit in and necessary for the performance of these powers and functions with respect to activities in the Area."). See art. 1 for the definition of "Area."

93. Letter from Elliot L. Richardson, then United States Ambassador to the Law of the Sea Conference, to Gerry E. Studds, Chairman of the House Oceanography Subcomm. (Sept. 18, 1980), *reprinted in* 126 CONG. REC. E 5088-89 (daily ed. Dec. 1, 1980) [hereinafter cited as Letter].

94. Interview with Elliot L. Richardson, former Ambassador to the Law of the Sea Conference, in Washington, D.C. (Dec. 3, 1980).

seas."[95] Mr. Richardson stated that "[t]he eventual Convention will provide added predictability and legal certainty to OTEC activities. . . . Indeed, the LOS provisions are not only consistent with the provisions of [The OTEC Act of 1980] but will provide a broader internationally agreed jurisdictional basis for the regulation of these important activities."[96]

VI. ENVIRONMENTAL ISSUES

Since OTEC is an unproven technology, many of its environmental consequences are virtually unknown, especially in light of the massive physical size contemplated by the engineers. An OTEC baseload plant would be two and one-half times larger than the Empire State Building, and the cold water pipe would be the size of the Holland Tunnel.[97] In the context of ocean uses and activities, however, the OTEC plant is not an extraordinary engineering feat.[98] The Cognac oil drilling rig in the Gulf of Mexico and many petroleum supertankers are as large as an OTEC plant. Nuclear power plants and pumps, exemplified by the Bath nuclear facility, can draw water volumes equivalent to those drawn by an OTEC plant. OTEC facilities require a year-round temperature gradient of about 36°F. This temperature gradient is greatest in the tropical regions of the ocean generally located in a band extending twenty degrees latitude north and south from the equator.[99] The Department of Energy is currently assessing the location and quality of this thermal resource and relating this information to determine energy needs. United States island communities are the focal point of the current strategy for OTEC

95. Letter, *supra* note 93, at E 5089.

96. *Id.* Mr. James L. Malone, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, now chairs the U.S. delegation to the LOS Conference. He is conducting a complete review of the LOS Treaty, focusing particularly on those provisions which govern access to deep seabed minerals and the transfer of technology to developing countries. As a consequence, the United States role at the Spring and Summer 1981 LOS Conference has been that of observer rather than an active participant, and no major changes in text have been advanced or agreed upon.

97. Address by William E. Richards, Acting Director, Division of Ocean Energy Systems, United States Department of Energy, at the Plenary Session of the Seventh Ocean Energy Conference, *supra* note 40.

98. A 400-megawatt OTEC plant is about the size of a small nuclear power plant.

99. H.R. REP. No. 994, *supra* note 66, at 33.

demonstration and deployment. Environmental monitoring studies are currently being conducted in the waters of Puerto Rico, the Gulf of Mexico, Hawaii, and Guam for potential moored OTEC facilities. Studies for possible grazing plantship operations are underway in the equatorial South Atlantic off the coast of Brazil.

The 1980 Act acknowledges that OTEC has potentially adverse environmental effects, such as artificial upwelling and changes in climate due to ocean temperature fluctuations, and thus provides for development of an environmental assessment program to monitor OTEC-related activity.[100] Environmental concerns include the displacement of ocean water mass, heat balance alterations, release of carbon dioxide, nutrient redistribution, entrainment and impingement of marine organisms, biofouling, working fluid leaks, corrosion and erosion of metal surfaces, artifical reef effects, and crew support system discharges.[101] Untold benefits may accrue, however, and some scientists hazard that the artificial upwelling may result in abundant fisheries similar to those fishery resources that occur in natural upwellings such as the Humboldt Current off Peru.[102]

Since the issuance of a license for an OTEC facility or plantship will be a major federal action significantly affecting the quality of the human environment, a full environmental impact statement (EIS) will be required in connection with the decision to issue the license to comply with the National Environmental Policy Act of 1969.[103] When multiple applications have been received for OTEC facilities in the same designated application area, a single EIS of the area is sufficient for the applications.[104] The OTEC Act requires that each licensee obtain a National Pollutant Discharge Elimination System permit to meet the requirements of the Federal Water Pollution Control Act governing discharge of effluents into the ocean.[105]

A generic environmental assessment was prepared for an OTEC

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100. 42 U.S.C. § 9117(a) (1980). *See also* H.R. REP. No. 994, *supra* note 66, at 47; S. REP. No. 721, 96th Cong., 2d Sess. 8 (1980).

101. PAPER, *supra* note 18, at iii.

102. *Hearings on H.R. 6154*, *supra* note 31, at 324 (statement of Dr. Gordon L. Dugger, Deputy Director, Ocean Energy Programs, Johns Hopkins University/Applied Physics Laboratory).

103. 42 U.S.C. § 4332(2)(C) (1976).

104. 42 U.S.C. § 9117(e) (1980).

105. *Id.* § 9117(f) (1980); *see* H.R. REP. No. 994, *supra* note 66, 47.

pilot plant deployed offshore Hawaii in 1980. Potential biological impacts of the facility's physical presence, seawater intakes, and discharge plumes on the local environment were examined.[106] Some studies note that OTEC platforms will provide food and protection to macrozooplankton, micronekton and nekton, and are expected to establish new communities with large biomass abundances. These additional organisms, however, will be exposed to trace contaminants. The primary impacts on marine ecosystems will result from the large volumes of warm and cold seawater withdrawn from the ocean. The studies estimate the mortality rates from impingement and entrainment may approach one hundred percent considering the mechanical action, pressure, and temperature differentials.[107] The effect such a facility will have on the communication systems of marine mammals remains an open question.

NOAA has prepared a discussion paper identifying the scope of the environmental issues raised by OTEC technology.[108] Public meetings have been held throughout the OTEC rulemaking proceeding to encourage interested parties to contribute their knowledge and expertise to the process. Other considerations beyond the scope of the environmental impacts include the effect OTEC will have on other ocean uses such as marine transportation, fishing, and oil and gas activities.

VII. CONCLUSION

There is no doubt that when OTEC joins the growing list of ocean use activities such as ocean dumping, nuclear waste disposal, deepwater ports, marine transport, and OCS development, conflicts will arise despite the pre-arranged OTEC package delivered to the executive branch for implementation. The foresight exhibited by the lawmakers is commendable, however, since the

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106. M. SANDS, OCEAN THERMAL ENERGY CONVERSION DRAFT PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (1980), prepared for the United States Department of Energy, Contract No. W-7405-ENG-48 (Interstate Electronics Corporation, Anaheim, Cal.).

107. *Id.* at 3-42.

108. U.S. DEP'T OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, OCEAN THERMAL ENERGY CONVERSION ENVIRONMENTAL ISSUES DISCUSSION PAPER (Sept. 1980). *See also* U.S. DEP'T OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DRAFT ENVIROMENTAL IMPACT ANALYSIS, (Mar. 1981)(a more recent environmental overview).

initial framework will be established while encouraging flexibility as information becomes available. Government planners and industrial strategists can work together, instead of at cross-currents, in establishing a vital new solar energy industry. This activity signals the beginning of a new progressive environmentalism that contemplates potential problems in the earliest stages and then follows with aggressive conflict resolution in concert with actual development.