OCEAN THERMAL ENERGY CONVERSION ACT OF 1980

HEARINGS

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

S. 2492

TO REGULATE COMMERCE, PROMOTE ENERGY SELF-SUFFICIENCY, AND PROTECT THE ENVIRONMENT, BY ESTABLISHING PROCEDURES FOR THE LOCATION, CONSTRUCTION, AND OPERATION OF OCEAN THERMAL ENERGY CONVERSION FACILITIES AND PLANTSHIPS TO PRODUCE ELECTRICITY AND ENERGY-INTENSIVE PRODUCTS OFF THE COASTS OF THE UNITED STATES; TO AMEND THE MERCHANT MARINE ACT, 1936, TO MAKE AVAILABLE CERTAIN FINANCIAL ASSISTANCE FOR CONSTRUCTION AND OPERATION OF SUCH FACILITIES AND PLANTSHIPS; AND FOR OTHER PURPOSES

APRIL 10 AND MAY 1, 1980

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OCEAN THERMAL ENERGY CONVERSION ACT OF 1980

THURSDAY, April 10, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Honolulu, Hawaii.

The committee met at 2:30 p.m. in Court Room No. 3, Prince Kuhio Federal Building, Hon. Daniel K. Inouye, presiding.

OPENING STATEMENT BY SENATOR INOUYE

Senator INOUYE. I would like at the outset to apologize for this delay. As some of you may be aware, I have been trying my best to meet as many people as I can, but along the way little details have haunted me, constantly holding me up. So forgive me.

As a continued reliance on imported oil places an increasing burden on the American economy, and as fossil fuels are being depleted worldwide, the Nation's interest is turning to renewable energy resources. These include synthetic fuels, solar power, and energy derived from the oceans.

Ocean thermal energy conversion (OTEC) uses the temperature difference between the warm surface layer of sea water—a collector of solar heat—and the colder subsurface layers to power a turbine which generates electricity. That electricity may either be transmitted to onshore power grids by underwater cables or used at sea to produce hydrogen, fresh water, ammonia, or other products. Although estimates of potential output from OTEC plants vary, experts suggest that the process could be commercially operational for island baseloads by the mid-1980's. About one-third to one-half of the lower 48 States could be supplied with electricity from facilities in the Gulf of Mexico at competitive prices by the year 2000. Grazing plantships can use the process to produce hydrogen and ammonia for fertilizer, bringing the benefits of this technology to the heart of the farm country.

The principal barriers to immediate commercialization of OTEC are first, the need for demonstration of large-scale OTEC systems, and second, the need for a Federal regulatory and siting framework and financial assistance. The first of these was addressed in the U.S. Senate by S. 1830, providing for demonstration projects and setting national goals for energy generated by OTEC. The bill, introduced by Senator Matsunaga, passed the Senate in January of this year and is now pending in the House of Representatives. The second of the barriers is addressed in the legislation before us today. It provides for one-stop Federal licensing of OTEC facilities and plantships, provides that these facilities be treated as vessels under the laws of the United States, and make both commercial

and demonstration facilities eligible for Federal loan guarantees under title XI of the Merchant Marine Act. The two pieces of legislation are complementary, and passage of both is needed to assure prompt commercial development of OTEC.

Eight years ago the cost of fuel was less than 20 percent of the total cost of electricity. Today it comprises over 51 percent, and the percentage is expected to rise to as high as 61 percent next year. In January, the cost of electricity in Hawaii rose by 17 percent from December 1979 as a result of adjustments for the higher cost of fuel. For OTEC, the fuel is solar energy, which is free. Electricity costs in Hawaii rank second highest among the 50 States. A recent analysis by Dr. Avery of the Johns Hopkins Applied Physics Laboratory indicates that the projected costs of delivered power from the first full-scale moored OTEC plants at sites a few kilometers offshore in Hawaii and Puerto Rico are in the range of 4 to 7½ cents per kilowatt hour. This is lower than the projected cost of power from imported oil. Clearly OTEC offers real promise of holding down or even reducing costs of electricity in Hawaii and elsewhere.

Hawaii has taken the lead among the States toward the development of OTEC. The first OTEC plant to generate more power than it consumed was placed in operation off of Hawaii in August 1979. "Mini-OTEC" was a project of the State of Hawaii, Lockheed, and Dillingham with no Federal funding. Work is underway now for a second pilot project. "OTEC-1," a plantship to test heat exchangers and other key components, is due to be on station in June of this year off of Keahole Point. This will be the beginning of a 3-year ocean test for that facility under the auspices of the Department of Energy.

I believe that OTEC has immense potential as an alternative, clean, and renewable source of energy. It promises to be a technology capable of fulfilling a significant percentage of our energy needs in the next 20 years. We take this opportunity to welcome all of you here today, especially those of you who had to travel. I look forward to hearing your comments on this important measure before us.

I have a statement from Senator Packwood for the record.

[The statement follows:]

STATEMENT OF HON. BOB PACKWOOD, U.S. SENATOR FROM OREGON

Mr. Chairman, Ocean Thermal Energy is the type of renewable energy source which this country must pursue with increased vigor.

Alternatives to petroleum are no longer pipedreams. In many cases, the technology is here. This bill, which I am cosponsoring, will encourage investors to develop, produce and market technologies which will wean Americans away from dependence on petroleum products generally and OPEC oil specifically.

Events of recent months have convinced Americans that dramatic action is needed now. Congress has responded with an unprecedented amount of energy-related legislation. Last summer I introduced a bill to provide incentives for various renewable energy sources including OTEC. These incentives were included in the Crude Oil Windfall Profits Tax Act. They survived a tough Conference and have now become law. OTEC is now provided a 15 percent energy tax credit on top of the basic 10 percent investment tax credit. This should prove to be a tremendous incentive for increased private investment in OTEC.

The bill we are discussing today compliments those tax provisions by providing additional investment incentives to spur commercialization.

It is a bill which emphasizes the role private enterprise can play in developing new energy sources. Licensing procedures are streamlined, and the Federal over-

sight minimized. This is the approach which we must have if this country is to regain energy independence.

[The bill and agency comments follow:]

96TH CONGRESS
2D SESSION

S. 2492

To regulate commerce, promote energy self-sufficiency, and protect the environment, by establishing procedures for the location, construction, and operation of ocean thermal energy conversion facilities and plantships to produce electricity and energy-intensive products off the coasts of the United States; to amend the Merchant Marine Act, 1936, to make available certain financial assistance for construction and operation of such facilities and plantships; and for other purposes.

IN THE SENATE OF THE UNITED STATES

MARCH 27 (legislative day, JANUARY 3), 1980

Mr. INOUYE (for himself, Mr. CANNON, Mr. HOLLINGS, Mr. MAGNUSON, Mr. MATHIAS, Mr. MATSUNAGA, Mr. PACKWOOD, Mr. SARBANES, and Mr. STEVENS) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

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A BILL

To regulate commerce, promote energy self-sufficiency, and protect the environment, by establishing procedures for the location, construction, and operation of ocean thermal energy conversion facilities and plantships to produce electricity and energy-intensive products off the coasts of the United States; to amend the Merchant Marine Act, 1936, to make available certain financial assistance for construction and operation of such facilities and plantships; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Ocean Thermal Energy Conversion Act of 1980".

SEC. 2. DECLARATION OF POLICY.

(a) It is declared to be the purposes of the Congress in this Act to—

(1) authorize and regulate the construction, location, ownership, and operation of ocean thermal energy conversion facilities connected to the United States by pipeline or cable, consistent with the Convention on the Continental Shelf, the Convention on the High Seas, and general principles of international law;

(2) authorize and regulate the construction, location, ownership, and operation of ocean thermal energy conversion plantships documented under the laws of the United States, consistent with the Convention on the High Seas and general principles of international law;

(3) authorize and regulate the construction, location, ownership, and operation of ocean thermal energy conversion plantships by United States citizens, consistent with the Convention on the High Seas and general principles of international law;

(4) provide for the protection of the marine and coastal environment, and consideration of the interests of other ocean users, to prevent or minimize any adverse impact which might occur as a consequence of the development of such ocean thermal energy conversion facilities or plantships;

(5) make applicable certain provisions of the Merchant Marine Act, 1936, to assist in financing of ocean thermal energy conversion facilities and plantships;

(6) protect the interests of the United States in the location, construction, and operation of ocean thermal energy conversion facilities and plantships; and

(7) protect the rights and responsibilities of adjacent coastal States in ensuring that Federal actions are consistent with approved State coastal zone management programs and other applicable State and local laws.

(b) The Congress declares that nothing in this Act shall be construed to affect the legal status of the high seas, the superjacent airspace, or the seabed and subsoil, including the Continental Shelf.

SEC. 3. DEFINITIONS.

As used in this Act, unless the context otherwise requires, the term—

(1) "adjacent coastal State" means any coastal State which (A) would be directly connected by electric transmission cable or pipeline to an ocean thermal energy facility as proposed in an application; (B) would be located within fifteen miles of any such proposed ocean thermal energy conversion facility; or (C) is designated by the Administrator in accordance with section 105(a)(2) of this Act;

(2) "Administrator" means the Administrator of the National Oceanic and Atmospheric Administration;

(3) "antitrust laws" includes the Act of July 2, 1890, as amended, the Act of October 15, 1914, as amended, and sections 73 and 74 of the Act of August 27, 1894, as amended;

(4) "application" means any application submitted under this Act (A) for issuance of a license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship; (B) for transfer or renewal of any such license; or (C) for any substantial change in any of the conditions and provisions of any such license;

(5) "coastal State" means a State in, or bordering on, the Atlantic, Pacific, or Arctic Ocean, the Gulf of Mexico, Long Island Sound, or one or more of the Great Lakes;

(6) "facility" means an ocean thermal energy conversion facility;

(7) "Governor" means the Governor of a State or the person designated by law to exercise the powers granted to the Governor pursuant to this Act;

(8) "high seas" means that part of the oceans lying seaward of the territorial sea of the United States and outside the territorial sea, as recognized by the United States, of any other nation;

(9) "licensee" means the holder of a valid license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship that was issued, transferred, or renewed pursuant to this Act;

(10) "ocean thermal energy conversion facility" means any facility which is connected to the United States by pipeline or cable and which is designed to use temperature differences in ocean water to produce electricity or another form of energy capable of being used directly to perform work, and includes any equipment installed on such facility to use such electricity or other form of energy to produce, process, refine, or manufacture a product, and any cable or pipeline used to deliver such electricity, freshwater, or product to

shore, and all other equipment and appurtenances of such facility;

(11) "ocean thermal energy conversion plantship" means any vessel which is designed to use temperature differences in ocean water to produce, while moving through such water, electricity or another form of energy capable of being used directly to perform work, and includes any equipment installed on such vessel to use such electricity or other form of energy to produce, process, refine, or manufacture a product, and any equipment used to transfer such product to other vessels for transportation to users, and all other equipment and appurtenances of such vessel.

(12) "plantship" means an ocean thermal energy conversion plantship;

(13) "person" means any individual (whether or not a citizen or national of the United States), any corporation, partnership, association, or other entity organized or existing under the laws of any nation, and any Federal, State, local or foreign government or any entity of any such government;

(14) "State" means each of the several States, the District of Columbia, the Commonwealth of Puerto Rico, American Samoa, the United States Virgin Islands, Guam, the Commonwealth of the Northern

Marianas, and any other Commonwealth, territory, or possession over which the United States has jurisdiction;

(15) "thermal plume" means the area of the ocean in which a significant difference in temperature, as defined in regulations by the Administrator, occurs as a result of the operation of an ocean thermal energy conversion facility or plantship;

(16) "United States citizen" means (A) any individual who is a citizen or national of the United States; (B) any Federal, State, or local government in the United States, or any entity of any such government; or (C) any corporation, partnership, association, or other entity, organized or existing under the laws of the United States or of any State, which has as its president or other executive officer and as its chairman of the board of directors, or holder of similar office, an individual who is a United States citizen and which has no more of its directors who are not United States citizens than constitute a minority of the number required for a quorum necessary to conduct the business of the board.

TITLE I—REGULATION OF OCEAN THERMAL ENERGY CONVERSION FACILITIES AND PLANTSHIPS

SEC. 101. LICENSE FOR THE OWNERSHIP, CONSTRUCTION, AND OPERATION OF AN OCEAN THERMAL ENERGY CONVERSION FACILITY OR PLANTSHIP.

(a) No person may engage in the ownership, construction, or operation of an ocean thermal energy conversion facility which is documented under the laws of the United States or which is connected to the United States by pipeline or cable, except in accordance with a license issued pursuant to this Act.

(b) The Administrator is authorized, upon application and in accordance with the provisions of this Act, to issue, transfer, amend, or renew a license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship.

(c) The Administrator may issue a license in accordance with the provisions of this Act unless—

(1) he determines that the applicant cannot and will not comply with applicable laws, regulations, and license conditions;

(2) he determines that the construction and operation of the ocean thermal energy conversion facility or

plantship will be in the national interest and consistent with national security and other national policy goals and objectives, including energy self-sufficiency and environmental quality;

(3) he determines that the ocean thermal energy conversion facility or plantship will not be operated with reasonable regard to the freedom of navigation or other reasonable uses of the high seas or authorized uses of the Continental Shelf, as defined by United States law, treaty, convention, or customary international law;

(4) he has been informed, within forty-five days after the conclusion of public hearings on that application, or on proposed licenses for the designated application area, by the Administrator of the Environmental Protection Agency that the ocean thermal energy conversion facility or plantship will not conform with all applicable provisions of any law for which he has enforcement authority;

(5) he has received the opinion of the Attorney General, pursuant to section 104 of this Act, stating that issuance of the license would create a situation in violation of the antitrust laws, or the ninety-day period provided in section 104 has expired;

(6) he has consulted with the Secretary of Energy, the Secretary of Transportation, the Secretary of State, the Secretary of the Interior, and the Secretary of Defense, to determine their views on the adequacy of the application, and its effect on programs within their respective jurisdictions;

(7) the proposed ocean thermal energy conversion facility or plantship will not be documented under the laws of the United States;

(8) the applicant has agreed to the condition that no vessel may be used for the transportation to the United States of things produced, processed, refined, or manufactured at the ocean thermal energy conversion facility or plantship unless such vessel is not documented under the laws of the United States;

(9) if the license is for an ocean thermal energy conversion facility, he determines that the facility, including any submarine electric transmission cables and equipment or pipelines which are components of the facility, will not be located and designed so as to minimize interference with other uses of the high seas or the Continental Shelf, including cables or pipelines already in position on or in the seabed and the possibility of their repair;

(10) if the license is for an ocean thermal energy conversion facility, he has consulted with the Governor of each adjacent coastal State which has an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.) to determine his or her views on the adequacy of the application, and its effects on programs within his or her jurisdiction;

(11) if the license is for an ocean thermal energy conversion facility, any adjacent coastal State to which the facility is to be directly connected by electric transmission cable or pipeline does not have an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.);

(12) if the license is for an ocean thermal energy conversion facility, he determines that the thermal plume of the facility is expected to impinge unreasonably on any other ocean thermal energy conversion facility already licensed or operating, without the consent of its owner;

(13) if the license is for an ocean thermal energy conversion facility, he determines that the thermal plume of the facility is expected to impinge on the territorial sea or area of national resource jurisdiction, as

recognized by the United States, of any other nation, without the consent of such nation;

(14) if the license is for an ocean thermal energy conversion plantship, he determines that the applicant has not provided adequate assurance that the plantship will be able to operate in such a way as to prevent its thermal plume from impinging unreasonably on any other ocean thermal energy conversion facility or plantship without the consent of its owner, and from impinging on the territorial sea or area of national resource jurisdiction, as recognized by the United States, of any other nation without the consent of such nation; and

(15) issuance of the license will cause to be exceeded any upper limit placed on the number or total capacity of ocean thermal energy conversion facilities or plantships established as a result of determinations made pursuant to section 107(a) of this title.

(d)(1) In issuing a license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship, the Administrator shall prescribe conditions which he deems necessary to carry out the provisions of this Act, or which are otherwise required by any Federal department or agency pursuant to the terms of this Act.

(2) No license shall be issued, transferred, or renewed under this Act unless the licensee or transferee first agrees in writing that (A) there will be no substantial change from the plans, operational systems, and methods, procedures, and safeguards set forth in his application, as approved, without prior approval in writing from the Administrator, and (B) he will comply with conditions the Administrator may prescribe in accordance with the provisions of this Act.

(3) The Administrator shall establish such bonding requirements or other assurances as he deems necessary to assure that, upon the revocation, termination, relinquishment, or surrender of a license, the licensee will dispose of or remove all components of the ocean thermal energy conversion facility or plantship as directed by the Administrator. In the case of components which another applicant desires to use, the Administrator may waive the disposal or removal requirements until he has reached a decision on the application. In the case of components lying on or below the seabed, the Administrator may waive the disposal or removal requirements if he finds that such removal is not otherwise necessary and that the remaining components do not constitute any threat to navigation, fishing, or the environment.

(e) Upon application, licenses issued under this Act may be transferred if the Administrator determines that such transfer is in the public interest and that the tranferee meets

the requirements of this Act and the prerequisites to issuance under subsection (c) of this section.

(f) Any United States citizen who otherwise qualifies under the terms of this Act shall be eligible to be issued a license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship.

(g) Licenses issued under this Act shall be for a term of not to exceed twenty-five years. Each licensee shall have a preferential right to renew his license subject to the requirements of subsection (c) of this section, upon such conditions and for such term, not to exceed an additional ten years upon each renewal, as the Administrator determines to be reasonable and appropriate.

SEC. 102. PROCEDURE.

(a) The Administrator shall, as soon as practicable after the date of enactment of this Act, and after consultation with other Federal agencies, issue regulations to carry out the purposes and provisions of this Act, in accordance with the provisions of section 553 of title 5, United States Code, without regard to subsection (a) thereof. Such regulations shall pertain to, but need not be limited to, application, issuance, transfer, renewal, suspension, and termination of licenses. Such regulations shall provide for full consultation and cooperation with all other interested Federal agencies and departments and with my potentially affected coastal State,

and for consideration of the views of any interested members of the general public. The Administrator is further authorized, consistent with the purposes and provisions of this Act, to amend or rescind any such regulation. The Administrator shall complete issuance of final regulations to implement this Act within one year of the date of its enactment.

(b) Not later than thirty days after the date of enactment of this Act, the Secretary of the Interior, the Administrator of the Environmental Protection Agency, the Secretary of the department in which the Coast Guard is operating, the Chief of Engineers of the United States Army Corps of Engineers, and the heads of any other Federal departments or agencies having expertise concerning, or jurisdiction over, any aspect of the construction or operation of ocean thermal energy conversion facilities or plantships, shall transmit to the Administrator written description of their expertise or statutory responsibilities pursuant to this Act or any other Federal law.

(c)(1) Any person making an application under this Act shall submit detailed plans to the Administrator. Within twenty-one days after the receipt of an application, the Administrator shall determine whether the application appears to contain all of the information required by paragraph (2) of this subsection. If the Administrator determines that such information appears to be contained in the application, the Ad-

ministrator shall, no later than five days after making such a determination, publish notice of the application and a summary of the plans in the Federal Register. If the Administrator determines that all of the required information does not appear to be contained in the application, the Administrator shall notify the applicant and take no further action with respect to the application until such deficiencies have been remedied.

(2) Each application shall include such financial, technical, and other information as the Administrator determines by rule to be necessary to process the license pursuant to section 101.

(d)(1) At the time notice of an application for an ocean thermal energy conversion facility is published pursuant to subsection (d) of this section, the Administrator shall publish a description in the Federal Register of an application area encompassing the site proposed in the application for such facility and within which the thermal plume of one ocean thermal energy conversion facility might be expected to impinge on another ocean thermal energy conversion facility.

(2) The Administrator shall accompany such publication with a call for submission of any other applications for licenses for the ownership, construction, and operation of an ocean thermal energy conversion facility within the designated application area. Any person intending to file such an

application shall submit a notice of intent to file an application to the Administrator not later than sixty days after the publication of notice pursuant to subsection (d) of this section, and shall submit the completed application no later than ninety days after publication of such notice. The Administrator shall publish notice of any such application received in accordance with subsection (d) of this section. No application for a license for the ownership, construction, and operation of an ocean thermal energy conversion facility within the designated application area for which a notice of intent to file was received after such sixty-day period, or which is received after such ninety-day period has elapsed, shall be considered until action has been completed on all timely filed applications pending with respect to such application area.

(e) An application filed with the Administrator shall constitute an application for all Federal authorizations required for ownership, construction, and operation of an ocean thermal energy conversion facility or plantship. At the time notice of any application is published pursuant to subsection (d) of this section, the Administrator shall forward a copy of such application to those Federal agencies and departments with jurisdiction over any aspect of such ownership, construction, or operation for comment, review, or recommendation as to conditions and for such other action as may be required by law. Each agency or department involved shall

review the application and, based upon legal considerations within its area of responsibility, recommend to the Administrator the approval or disapproval of the application not later than forty-five days after public hearings are concluded pursuant to subsection (g) of this section. In any case in which an agency or department recommends disapproval, it shall set forth in detail the manner in which the application does not comply with any law or regulation within its area of responsibility and shall notify the Administrator of the manner in which the application may be amended so as to bring it into compliance with the law or regulation involved.

(f) A license may be issued, transferred, or renewed only after public notice, opportunity for comment, and public hearings in accordance with this subsection. At least one such public hearing shall be held in the District of Columbia and in each adjacent coastal State. Any interested person may present relevant material at any such hearing. After the hearings required by this subsection are concluded, if the Administrator determines that there exist one or more specific and material factual issues which may be resolved by a formal evidentiary hearing, at least one adjudicatory hearing shall be held in the District of Columbia in accordance with the provisions of section 554 of title 5, United States Code. The record developed in any such adjudicatory hearing shall be part of the basis for the Administrator's decision to approve

or deny a license. Hearings held pursuant to this subsection shall be consolidated insofar as practicable with hearings held by other agencies. All public hearings on all applications with respect to facilities for any designated application area shall be consolidated and shall be concluded not later than two hundred and forty days after notice of the initial application has been published pursuant to subsection (d) of this section. All public hearings on applications with respect to ocean thermal energy conversion plantships shall be concluded not later than one hundred and forty days after notice of the application has been published pursuant to subsection (d) of this section.

(g) Each person applying for a license pursuant to this Act shall remit to the Administrator at the time the application is filed a nonrefundable application fee, which shall be deposited into miscellaneous receipts of the Treasury. The amount of the fee shall be established by regulation by the Administrator, and shall reflect the reasonable administrative costs incurred in reviewing and processing the application.

(h)(1) The Administrator shall approve or deny any timely filed application with respect to a facility for a designated application area submitted pursuant to this Act not later than ninety days after public hearings on proposed licenses for that area are concluded pursuant to subsection (g) of this section. The Administrator shall approve or deny an

application for ownership, construction, and operation of an ocean thermal energy conversion plantship submitted pursuant to this Act no later than ninety days after the public hearings on that application are concluded pursuant to subsection (g) of this section.

(2) In the event more than one application for ownership, construction, and operation of an ocean thermal energy conversion facility is submitted pursuant to this Act for the same designated application area, the Administrator, unless one or a specific combination of the proposed facilities clearly best serves the national interest, shall issue licenses to the first applicant.

(3) In determining whether any one or a specific combination of the proposed ocean thermal energy conversion facilities clearly best serves the national interest, the Administrator shall consider the following factors:

(A) the goal of making the greatest possible use of ocean thermal energy conversion by installing the largest capacity practicable in each application area;

(B) the amount of net energy impact of each of the proposed ocean thermal energy conversion facilities;

(C) the degree to which the proposed ocean thermal energy conversion facilities will affect the environment;

(D) any significant differences between anticipated completion dates for the proposed ocean thermal energy conversion facilities; and

(E) any differences in costs of construction and operation of the proposed ocean thermal energy conversion facilities, to the extent that such differentials may significantly affect the ultimate cost of energy or products to the consumer.

SEC. 103. PROTECTION OF SUBMARINE ELECTRIC TRANSMISSION CABLES AND EQUIPMENT.

(a) Any person who shall willfully and wrongfully break or injure, or attempt to break or injure, or who shall in any manner procure, counsel, aid, abet, or be accessory to such breaking or injury, or attempt to break or injure, any submarine electric transmission cable or equipment being constructed or operated under a license issued pursuant to this Act shall be guilty of a misdemeanor and, on conviction thereof, shall be liable to imprisonment for a term not exceeding two years, or to a fine not exceeding $5,000, or to both fine and imprisonment, at the discretion of the court.

(b) Any person who by culpable negligence shall break or injure any submarine electric transmission cable or equipment being constructed or operated under a license issued pursuant to this Act shall be guilty of a misdemeanor and, on conviction thereof, shall be liable to imprisonment for a term

not exceeding three months, or to a fine not exceeding $500, or to both fine and imprisonment, at the discretion of the court.

(c) The provisions of subsections (a) and (b) of this section shall not apply to any person who, after having taken all necessary precaution to avoid such breaking or injury, breaks or injures any submarine electric transmission cable or equipment in an effort to save the life or limb of himself or of any other person, or to save his own or any other vessel.

(d) The penalties provided in subsections (a) and (b) of this section for the breaking or injury of any submarine electric transmission cable or equipment shall not be a bar to a suit for damages on account of such breaking or injury.

(e) Whenever any vessel sacrifices any anchor, fishing net, or other fishing gear to avoid injuring any submarine electric transmission cable or equipment being constructed or operated under a license issued pursuant to this Act, the licensee shall indemnify the owner of such vessel for the items sacrificed: *Provided*, That the owner of the vessel had taken all reasonable precautionary measures beforehand.

(f) Any licensee who causes any break in or injury to any submarine cable or pipeline of any type shall bear the cost of the repairs.

SEC. 104. ANTITRUST REVIEW.

(a) Whenever any application for issuance, transfer, or renewal of any license is received, the Administrator shall transmit promptly to the Attorney General a complete copy of such application. Within ninety days of the receipt of the application, the Attorney General shall conduct such antitrust review of the application as he deems appropriate, and submit to the Administrator any advice or recommendations he deems advisable to avoid any action upon such application by the Administrator which would create a situation in violation of the antitrust laws. If the Attorney General fails to file such views within the ninety-day period, the Administrator shall proceed as if such views had been received. The Administrator shall not issue, transfer, or renew the license during the ninety-day period, except upon written confirmation by the Attorney General that he does not intend to submit any further advice or recommendation on the application during such period.

(b) The issuance of a license under this Act shall not be admissible in any way as a defense to any civil or criminal action for violation of the antitrust laws of the United States, nor shall it in any way modify or abridge any private right of action under such laws. Nothing in this section shall be construed to bar the Attorney General or the Federal Trade Commission from challenging any anticompetitive situation

involved in the ownership, construction, or operation of an ocean thermal energy conversion facility or plantship.

SEC. 105. ADJACENT COASTAL STATES.

(a)(1) The Administrator, in issuing notice of application pursuant to section 102(d) of this title, shall designate as an "adjacent coastal State" any coastal State which (A) would be directly connected by electric transmission cable or pipeline to an ocean thermal energy conversion facility as proposed in an application, or (B) would be located within fifteen miles of any such proposed ocean thermal energy conversion facility.

(2) The Administrator shall, upon request of a State, designate such State as an "adjacent coastal State" if he determines that there is a risk of damage of the coastal environment of such State equal to or greater than the risk posed to a State directly connected by electric transmission cable or pipeline to the proposed ocean thermal energy conversion facility, or if he determines that the thermal plume of the proposed ocean thermal energy conversion facility is likely to impinge on possible locations for ocean thermal energy conversion facilities which could reasonably be expected to be directly connected by electric transmission cable or pipeline to such State. This paragraph shall apply only with respect to requests made by a State not later than the fourteenth day after the date of publication of notice of application for a

proposed ocean thermal energy conversion facility in the Federal Register in accordance with section 102(d) of this title. The Administrator shall make any designation required by this paragraph not later than the forty-fifth day after the date he receives such a request from a State.

(b)(1) Not later than ten days after the designation of adjacent coastal States pursuant to this section, the Administrator shall transmit a complete copy of the application to the Governor of each adjacent coastal State. The Administrator shall not issue a license without consultation with the Governor of each adjacent coastal State which has an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.). If the Governor of such a State notifies the Administrator that an application is inconsistent in some respect with the State's coastal zone management program, the Administrator shall condition the license granted so as to make it consistent with such State program.

(2) Any adjacent coastal State which does not have an approved coastal zone management program in good standing, and any other interested State, shall have the opportunity to make its views known to, and to have them given full consideration by, the Administrator regarding the location, construction, and operation of an ocean thermal energy conversion facility.

(c) The Administrator shall not issue a license for an ocean thermal energy conversion facility unless any adjacent coastal State to which the facility is to be directly connected by electric transmission cable or pipeline has an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.).

(d) The consent of Congress is given to two or more States to negotiate and enter into agreements or compacts, not in conflict with any law or treaty of the United States, (1) to apply for a license for the ownership, construction, and operation of an ocean thermal energy conversion facility or plantship or for the transfer of such a license, and (2) to establish such agencies, joint or otherwise, as are deemed necessary or appropriate for implementing and carrying out the provisions of any such agreement or compact. Such agreement or compact shall be binding and obligatory upon any State or other party thereto without further approval by the Congress.

SEC. 106. DILIGENCE REQUIREMENTS.

(a) The Administrator shall promulgate regulations requiring each licensee to pursue diligently the construction and operation of the ocean thermal energy conversion facility or plantship to which the license applies.

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(b) If the Administrator determines that a licensee is not pursuing diligently the construction and operation of the ocean thermal energy conversion facility or plantship to which the license applies, or that the project has apparently been abandoned, the Administrator shall cause proceedings to be instituted under section 111 of this title to terminate the license.

SEC. 107. PROTECTION OF THE ENVIRONMENT.

(a) The Administrator shall initiate a program to assess the effects on the environment of ocean thermal energy conversion facilities and plantships. The program shall include baseline measurements of locations where ocean thermal energy conversion facilities or plantships are likely to be sited or operated, and research and monitoring of the effects of ocean thermal energy conversion facilities and plantships in actual operation. The purpose of the program shall be to assess the environmental effects of individual ocean thermal energy facilities and plantships, and to assess the magnitude of any cumulative environmental effects of large numbers of ocean thermal energy facilities and plantships. The program shall be designed to determine, among other things—

(1) any short-term and long-term effects on the environment which may occur as a result of the operation of ocean thermal energy conversion facilities and plantships;

(2) the nature and magnitude of any oceanographic, atmospheric, weather, climatic, or biological changes in the environment which may occur as a result of deployment and operation of large numbers of ocean thermal energy conversion facilities and plantships;

(3) the nature and magnitude of any oceanographic, biological or other changes in the environment which may occur as a result of the operation of electric transmission cables and equipment located in the water column or on or in the seabed, including the hazards of accidentally severed transmission cables; and

(4) whether the magnitude of one or more of the cumulative environmental effects of deployment and operation of large numbers of ocean thermal energy conversion facilities and plantships requires that an upper limit be placed on the number or total capacity of such facilities or plantships to be licensed under this Act for simultaneous operation, either overall or within specific geographic areas.

Within one hundred and eighty days after enactment of this Act, the Administrator shall prepare a plan to carry out the program, including necessary funding levels for the next five fiscal years, and submit the plan to the Congress.

(b) The program established by subsection (a) of this section shall be reduced to the minimum necessary to perform baseline studies and to analyze monitoring data, when the Administrator determines that the program has resulted in sufficient knowledge to make the determinations enumerated in subsection (a) of this section with an acceptable level of confidence.

(c) The issuance of any license for ownership, construction, and operation of an ocean thermal energy conversion facility or plantship shall be deemed to be a major Federal action significantly affecting the quality of the human environment for purposes of section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(c)). For all timely applications covering proposed facilities in a single application area, and for each application relating to a proposed plantship, the Administrator shall, pursuant to such section 102(2)(C) of this title and in cooperation with other involved Federal agencies and departments, prepare a single, consolidated environmental impact statement, which shall fulfill the requirement of all Federal agencies in carrying out their responsibilities pursuant to this Act to prepare an environmental impact statement. Each such consolidated draft environmental impact statement relating to proposed facilities shall be prepared and published within one hundred and eighty days following the date established pursuant to section

102(e) as the deadline for submission of additional applications for the application area. Each such consolidated draft environmental impact statement relating to a proposed plantship shall be prepared and published within one hundred and eighty days of the date the application is received by the Administrator. Each final environmental impact statement shall be published not later than one hundred and eighty days following the date on which the draft environmental impact statement is published. The Administrator may extend the deadline for publication of a specific draft or final environmental impact statement to a later specified time for good cause shown in writing.

SEC. 108. MARINE ENVIRONMENTAL PROTECTION AND SAFETY OF LIFE AND PROPERTY AT SEA.

(a) The Secretary of the department in which the Coast Guard is operating shall, subject to recognized principles of international law, prescribe by regulation and enforce procedures with respect to any ocean thermal energy conversion facility or plantship including, but not limited to, rules governing vessel movement, procedures for transfer of materials between such a facility or plantship and transport vessels, designation and marking of anchorage areas, maintenance, law enforcement, and the equipment, training, and maintenance required (1) to prevent pollution of the marine environment, (2) to clean up any pollutants which may be dis-

charged, and (3) to otherwise prevent or minimize any adverse impact from the construction and operation of such ocean thermal energy conversion facility or plantship.

(b) The Secretary of the department in which the Coast Guard is operating shall issue and enforce regulations, subject to recognized principles of international law, with respect to lights and other warning devices, safety equipment, and other matters relating to the promotion of safety of life and property on any ocean thermal energy conversion facility or plantship.

(c) Whenever a licensee fails to mark any component of an ocean thermal energy conversion facility or plantship in accordance with applicable regulations, the Secretary of the department in which the Coast Guard is operating shall mark such components for the protection of navigation, and the licensee shall pay the cost of such marking.

(d)(1) Subject to recognized principles of international law and after consultation with the Secretary of Commerce, the Secretary of the Interior, the Secretary of State, and the Secretary of Defense, the Secretary of the department in which the Coast Guard is operating shall designate a zone of appropriate size around and including any ocean thermal energy conversion facility, and may designate such a zone around and including any ocean thermal energy conversion plantship, for the purpose of navigational safety. In such

zone, no installations, structures, or uses will be permitted which are incompatible with the operation of the ocean thermal energy conversion facility or plantship. The Secretary of the department in which the Coast Guard is operating shall by regulation define permitted activities within such zone. The Secretary of the department in which the Coast Guard is operating shall, not later than thirty days after publication of notice pursuant to section 102(d) of this title, designate such safety zone with respect to any proposed ocean thermal energy conversion facility or plantship.

(2) In addition to any other regulations, the Secretary of the department in which the Coast Guard is operating is authorized, in accordance with this subsection, to establish a safety zone to be effective during the period of construction of an ocean thermal energy conversion facility or plantship, and to issue rules and regulations relating thereto.

(e) For the purposes of the vessel inspection laws, an ocean thermal energy conversion facility or plantship shall be deemed to be a vessel.

(f) The Secretary of the department in which the Coast Guard is operating shall promulgate and enforce such regulations as he deems necessary to protect navigation in the vicinity of a vessel engaged in the installation, repair, or maintenance of any submarine electric transmission cable or

equipment, and to govern the markings and signals used by such a vessel.

SEC. 109. PREVENTION OF INTERFERENCE WITH OTHER USES OF THE HIGH SEAS.

(a) Each license shall include such conditions as may be necessary and appropriate to ensure that construction and operation of the ocean thermal energy conversion facility or plantship are conducted with reasonable regard for navigation, fishing, energy production, scientific research, or other uses of the high seas, either by citizens of the United States or by other nations in their exercise of the freedoms of the high seas as recognized under the Convention of the High Seas and the general principles of international law.

(b) The Secretary of the department in which the Coast Guard is operating shall promulgate in conjunction with the Administrator, and shall enforce, regulations governing the movement and navigation of ocean thermal energy conversion plantships to ensure that the thermal plume of one ocean thermal energy conversion plantship does not unreasonably impinge on the operation of any other ocean thermal energy conversion plantship or facility except in case of force majeure or with the consent of the licensee or owner of the other such plantship or facility, and to ensure that the thermal plume of an ocean thermal energy conversion plantship does not impinge on the territorial sea or area of national

resource jurisdiction, as recognized by the United States, of any other nation without the consent of such nation.

SEC. 110. MONITORING OF LICENSEES' ACTIVITIES.

Each license shall require the licensee—

(1) to allow the Administrator to place appropriate Federal officers or employees aboard the ocean thermal energy conversion facility or plantship to which the license applies, at such times and to such extent as the Administrator deems reasonable and necessary to assess compliance with any condition or regulation applicable to the license, and to report to the Administrator whenever such officers or employees have reason to believe there is a failure to comply;

(2) to cooperate with such officers and employees in the performance of monitoring functions; and

(3) to monitor any environmental effects of the operation of the ocean thermal energy conversion facility or plantship in accordance with guidelines issued by the Administrator, and to submit such information as the Administrator finds to be necessary and appropriate to assess environmental impacts and to develop and evaluate mitigation methods and possibilities.

SEC. 111. SUSPENSION, REVOCATION, OR TERMINATION OF LICENSES.

(a) Whenever a licensee fails to comply with any applicable provision of this Act or any applicable rule, regulation, restriction, or condition issued or imposed by the Administrator under the authority of this Act, the Attorney General, at the request of the Administrator, shall file an action in the appropriate United States district court to—

(1) suspend the license; or

(2) if such failure is knowing and continues for a period of thirty days after the Administrator mails notification of such failure by registered letter to the licensee at his record post office address, revoke such license.

No proceeding under this section is necessary if the license, by its terms, provides for automatic suspension or termination upon the occurrence of a fixed or agreed upon condition, event, or time.

(b) If the Administrator determines that immediate suspension of the construction or operation of an ocean thermal energy conversion facility or plantship or any component thereof is necessary to protect public health and safety or to eliminate imminent and substantial danger to the environment, or if the President determines that such suspension is necessary to avoid a conflict with any international obligation of the United States established by any treaty or convention

in force with respect to the United States, the Administrator may order the licensee to cease or alter such construction or operation pending the completion of a judicial proceeding pursuant to subsection (a) of this section.

SEC. 112. RECORDKEEPING AND PUBLIC ACCESS TO INFORMATION.

(a) Each licensee shall establish and maintain such records, make such reports, and provide such information as the Administrator, after consultation with other interested Federal departments and agencies, shall by regulation prescribe to carry out the provisions of this Act. Each licensee shall submit such reports and shall make available such records and information as the Administrator may request.

(b) The Administrator shall not disclose information obtained by him under this Act that concerns or relates to a trade secret, referred to in section 1905 of title 18, United States Code, except that such information may be disclosed, in a manner which is designed to maintain confidentiality—

(A) to other Federal and adjacent coastal State government departments and agencies for official use, upon request;

(B) to any committee of the Congress having jurisdiction over the subject matter to which the information relates, upon request;

(C) to any person in any judicial proceeding, under a court order formulated to preserve such confidentiality without impairing the proceedings; and

(D) to the public in order to protect the public health and safety, after notice and opportunity for comment in writing or for discussion in closed session within fifteen days by the party to which the information pertains (if the delay resulting from such notice and opportunity for comment would not in the opinion of the Administrator be detrimental to the public health and safety).

SEC. 113. RELINQUISHMENT OR SURRENDER OF LICENSES.

Any licensee may at any time, without penalty, surrender to the Administrator a license issued to him, or relinquish to the Administrator, in whole or in part, any right to conduct construction or operation of an ocean thermal energy conversion facility or plantship, including part or all of any right of way which may have been granted in conjunction with such license: *Provided,* That such surrender or relinquishment shall not relieve the licensee of any obligation or liability established by this Act, or of any obligation or liability for actions taken by him prior to such surrender or relinquishment, or during removal of any components required to be removed pursuant to this Act.

(b) If part or all of a right of way which is relinquished, or for which the license is surrendered, to the Administrator pursuant to subsection (a) of this section contains an electric transmission cable or pipeline which is used in conjunction with another license for an ocean thermal energy conversion facility, the Administrator shall allow the other licensee an opportunity to add such right of way to his license before informing the Secretary of the Interior that the right of way has been vacated.

SEC. 114. CIVIL ACTIONS.

(a) Except as provided in subsection (b) of this section, any person having a valid legal interest which is or may be adversely affected may commence a civil action for equitable relief on his own behalf, whenever such action constitutes a case or controversy—

(1) against any person who is alleged to be in violation of any provision of this Act or any regulation or condition of a license issued pursuant to this Act; or

(2) against the Administrator where there is alleged a failure of the Administrator to perform any act or duty under this Act which is not discretionary.

In suits brought under this Act, the district courts of the United States shall have jurisdiction, without regard to the amount in controversy or the citizenship of the parties, to enforce any provision of this Act or any regulation or condi-

tion of a license issued pursuant to this Act, or to order the Administrator to perform such act or duty, as the case may be.

(b) No civil action may be commenced—

(1) under subsection (a)(1) of this section—

(A) prior to sixty days after the plaintiff has given notice of the violation to the Administrator and to any alleged violator; or

(B) if the Administrator or the Attorney General has commenced and is diligently prosecuting a civil or criminal action with respect to such matters in a court of the United States, but in any such action any person may intervene as a matter of right; or

(2) under subsection (a)(2) of this section prior to sixty days after the plaintiff has given notice of such action to the Administrator.

Notice under this subsection shall be given in such a manner as the Administrator shall prescribe by regulation.

(c) In any action under this section, the Administrator or the Attorney General, if not a party, may intervene as a matter of right.

(d) The court, in issuing any final order in any action brought pursuant to subsection (a) of this section, may award costs of litigation (including reasonable attorney and expert

witness fees) to any party whenever the court determines that such an award is appropriate.

(e) Nothing in this section shall restrict any right which any person or class of persons may have under any statute or common law to seek enforcement or to seek any other relief.

SEC. 115. JUDICIAL REVIEW.

Any person suffering legal wrong, or who is adversely affected or aggrieved by the Administrator's decision to issue, transfer, modify, renew, suspend, or terminate a license may, not later than sixty days after such decision is made, seek judicial review of such decision in the United States court of appeals for the circuit within which the nearest adjacent coastal State is located. A person shall be deemed to be aggrieved by the Administrator's decision within the meaning of this Act if he—

(1) has participated in the administrative proceedings before the Administrator (or if he did not so participate, he can show that his failure to do so was caused by the Administrator's failure to provide the required notice); and

(2) is adversely affected by the Administrator's action.

TITLE II—MARITIME FINANCING FOR OCEAN THERMAL ENERGY CONVERSION

FACILITIES AND PLANTSHIPS

SEC. 201. (a) For the purposes of section 607 of the Merchant Marine Act, 1936 (46 U.S.C. 1177), any ocean thermal energy conversion facility or plantship licensed pursuant to this Act, and any vessel providing shipping service to or from such an ocean thermal energy conversion facility or plantship, shall be deemed to be a vessel operated in the foreign or domestic commerce of the United States.

(b) For the purposes of the shipping laws of the United States, any vessel documented under the laws of the United States and used in providing shipping service to or from any ocean thermal energy conversion facility or plantship licensed pursuant to this Act shall be deemed to be used in, and used in an essential service in, the foreign commerce or foreign trade of the United States, as defined in section 905(a) of the Merchant Marine Act, 1936 (46 U.S.C. 1244(a)).

SEC. 202. (a) Section 1101 of the Merchant Marine Act, 1936 (46 U.S.C. 1271), is amended—

(1) in subsection (b) by striking "and" immediately before "dredges" and inserting in lieu thereof a comma, and by inserting immediately after "dredges" the following: "and ocean thermal energy conversion facilities or plantships", and

(2) by adding at the end thereof a new subsection (i) to read as follows:

"(i) The term 'ocean thermal energy conversion facility or plantship' means any at-sea facility or vessel, whether mobile, moored, or standing on the seabed, which uses temperature differences in ocean water to produce electricity or another form of energy capable of being used directly to perform work, and includes any equipment installed on such facility or vessel to use such electricity or other form of energy to produce, process, refine, or manufacture a product, and any cable or pipeline used to deliver such electricity, freshwater, or product to shore, and all other equipment and appurtenances of such facility or vessel.".

SEC. 203. (a) Section 1104(a)(1) of the Merchant Marine Act, 1936 (46 U.S.C. 1274(a)(1)), is amended by striking out "or (E)" and inserting in lieu thereof "(E) as an ocean thermal energy conversion facility or plantship; or (F)".

(b) Section 1104(b)(2) of the Merchant Marine Act, 1936 (46 U.S.C. 1274(b)(2)), is amended by striking "vessel;" and inserting in lieu thereof "vessel: *Provided further*, That in the case of an ocean thermal energy conversion facility or plantship which is constructed without the aid of construction-differential subsidy, such obligations may be in an aggregate principal amount which does not exceed 87½

per centum of the actual cost or depreciated actual cost of the facility or plantship;".

SEC. 204. Title XI of the Merchant Marine Act, 1936 (46 U.S.C. 1271–1279(b)), is further amended—

(1) in section 1103(f) thereof (46 U.S.C. 1273(f)) by striking "$10,000,000,000." and inserting in lieu thereof "$12,000,000,000, of which $2,000,000,000 shall be limited to obligations pertaining to demonstration ocean thermal energy conversion facilities or plantships guaranteed pursuant to section 1110.", and

(2) by adding at the end thereof a new section 1110 to read as follows:

"SEC. 1110. (a) There is hereby created a special subaccount in the Federal Ship Financing Fund, to be known as the OTEC Demonstration Fund. The OTEC Demonstration Fund shall be used for obligation guarantees authorized under this section which do not qualify under other sections of this title. Except as specified otherwise in this section, the operation of the OTEC Demonstration Fund shall be identical with that of the parent Federal Ship Financing Fund. The aggregate unpaid principal amount of the obligations guaranteed with the backing of the OTEC Demonstration Fund and outstanding at any one time shall not exceed $2,000,000,000.

"(b) Pursuant to the authority granted under section 1103(a), the Secretary of Commerce, upon such terms as he shall prescribe, may guarantee or make a commitment to guarantee, payment of the principal of and interest on an obligation which aids in financing, including reimbursement of an obligor for expenditures previously made for, construction, reconstruction, or reconditioning of an ocean thermal energy conversion facility or plantship owned by citizens of the United States. Guarantees or commitments to guarantee under this subsection shall be subject to all the provisos, requirements, regulations, and procedures which apply to guarantees or commitments to guarantee made pursuant to section 1104(a)(1), except that—

"(1) any other provisions of this title to the contrary notwithstanding, guarantees or commitments to guarantee made pursuant to this section may be in an aggregate principal amount which does not exceed 100 per centum of the actual cost or depreciated actual cost of the ocean thermal energy conversion facility or plantship;

"(2) the provisions of section 1104(d) do not apply to guarantees or commitments to guarantee made pursuant to this section; and

"(3) a guarantee or commitment to guarantee may not be made under this section unless the Secre-

tary of Commerce determines, after consultation with the Secretary of Energy, that the ocean thermal energy conversion facility or plantship for which the guarantee or commitment to guarantee is sought is a demonstration plant for the development of alternative energy sources for the United States, and that sufficient guaranty of performance or payment is being provided by the Department of Energy and/or private industry to lower the risk of loss to a level which is reasonable, taking into account the need of the United States to develop new renewable sources of energy and the benefits to be realized from construction and operation of the proposed ocean thermal energy conversion facility or plantship.

"(c) The provisions of this section may be used to guarantee obligations for a total of not more than five separate ocean thermal energy conversion facilities or plantships.".

TITLE III—ENFORCEMENT

SEC. 301. PROHIBITED ACTS.

It is unlawful for any person who is a United States citizen, or a foreign national on board a vessel documented or numbered under the laws of the United States, or otherwise subject to the jurisdiction of the United States—

(1) to violate any provision of this Act, or any rule, regulation, or order issued pursuant to this Act,

or any term or condition of any license issued to such person pursuant to this Act;

(2) to refuse to permit any Federal officer or employee authorized to monitor or enforce the provisions of sections 110 and 303 of this Act to board an ocean thermal energy conversion facility or plantship or any vessel documented or numbered under the laws of the United States, for purposes of conducting any search or inspection in connection with the monitoring or enforcement of this Act or any rule, regulation, order, term, or condition referred to in paragraph (1) of this section;

(3) to forcibly assault, resist, oppose, impede, intimidate, or interfere with any such authorized officer or employee in the conduct of any search or inspection described in paragraph (2) of this section;

(4) to resist a lawful arrest for any act prohibited by this section; or

(5) to interfere with, delay, or prevent, by any means, the apprehension or arrest of another person subject to this section knowing that the other person has committed any act prohibited by this section.

SEC. 302. REMEDIES AND PENALTIES.

(a)(1) The Administrator or his delegate shall have the authority to issue and enforce orders during proceedings

brought under this Act. Such authority shall include the authority to issue subpenas, administer oaths, compel the attendance and testimony of witnesses and the production of books, papers, documents, and other evidence, to take depositions before any designated individual competent to administer oaths, and to examine witnesses.

(2) Whenever on the basis of any information available to him the Administrator finds that any person subject to section 301 of this title is in violation of any provision of this Act or any rule, regulation, order, license, or condition thereof, or other requirements under this Act, he may issue an order requiring such person to comply with such provision or requirement, or he may bring a civil action in accordance with subsection (b) of this section.

(3) Any compliance order issued under this subsection shall state with reasonable specificity the nature of the violation and a time for compliance, not to exceed thirty days, which the Administrator determines is reasonable, taking into account the seriousness of the violation and any good faith efforts to comply with applicable requirements.

(b) Upon a request by the Administrator, the Attorney General shall commence a civil action for appropriate relief, including a permanent or temporary injunction or a civil penalty not to exceed $25,000 per day of such violation, for any

violation for which the Administrator is authorized to issue a compliance order under subsection (a)(2) of this section.

(c) Upon a request by the Administrator, the Attorney General shall bring an action in an appropriate district court of the United States for equitable relief to redress a violation, by any person subject to section 301 of this title, of any provision of this Act, any regulation issued pursuant to this Act, or any license condition.

(d)(1) Any person subject to section 301 of this title is guilty of an offense if he willfully commits any act prohibited by this section.

(2) Any offense, other than an offense for which the punishment is prescribed by section 103 of this Act, is punishable by a fine of not more than $75,000 for each day during which the violation continues. Any offense described in paragraphs (2), (3), (4), and (5) of section 301 is punishable by the fine or imprisonment for not more than six months, or both. If, in the commission of any offense, the person subject to section 301 uses a dangerous weapon, engages in conduct that causes bodily injury to any Federal officer or employee, or places any Federal officer or employee in fear of imminent bodily injury, the offense is punishable by a fine of not more than $100,000 or imprisonment for not more than ten years, or both.

(e) Any ocean thermal energy conversion facility or plantship licensed pursuant to this Act and any other vessel documented or numbered under the laws of the United States, except a public vessel engaged in noncommercial activities, used in any violation of this Act or of any rule, regulation, order, license, or condition thereof, or other requirements of this Act, shall be liable in rem for any civil penalty assessed or criminal fine imposed and may be proceeded against in any district court of the United States having jurisdiction thereof, whenever it shall appear that one or more of the owners, or bareboat charterers, was at the time of the violation a consenting party or privy to such violation.

SEC. 303. ENFORCEMENT.

(a) Except where a specific section of this Act designates enforcement responsibility, the provisions of this Act shall be enforced by the Administrator. The Secretary of the department in which the Coast Guard is operating shall have exclusive responsibility for enforcement measures which affect the safety of life and property at sea, shall exercise such other enforcement responsibilities with respect to vessels subject to the provisions of this Act as are authorized under other provisions of law, and may, upon the specific request of the Administrator, assist the Administrator in the enforcement of any provision of this Act. The Administrator and the Secretary of the department in which the Coast

Guard is operating may, by agreement, on a reimbursable basis or otherwise, utilize the personnel, services, equipment, including aircraft and vessels, and facilities of any other Federal agency or department, and may authorize officers or employees of other departments or agencies to provide assistance as necessary in carrying out subsection (b) of this section. The Administrator and the Secretary of the department in which the Coast Guard is operating may issue regulations jointly or severally as may be necessary and appropriate to carry out their duties under this section.

(b) To enforce the provisions of this Act on board any ocean thermal energy conversion facility or plantship or other vessel subject to the provisions of this Act, any officer who is authorized by the Administrator or the Secretary of the department in which the Coast Guard is operating may—

(1) board and inspect any vessel which is subject to the provisions of this Act;

(2) search the vessel if the officer has reasonable cause to believe that the vessel has been used or employed in the violation of any provision of this Act;

(3) arrest any person subject to section 301 of this title if the officer has reasonable cause to believe that the person has committed a criminal act prohibited by sections 301 and 302(d) of this title;

(4) seize the vessel together with its gear, furniture, appurtenances, stores, and cargo, used or employed in, or with respect to which it reasonably appears that such vessel was used or employed in, the violation of any provision of this Act if such seizure is necessary to prevent evasion of the enforcement of this Act;

(5) seize any evidence related to any violation of any provision of this Act;

(6) execute any warrant or other process issued by any court of competent jurisdiction; and

(7) exercise any other lawful authority.

(c) Except as otherwise specified in section 115 of this Act, the district courts of the United States shall have exclusive original jurisdiction over any case or controversy arising under the provisions of this Act. Except as otherwise specified in this Act, venue shall lie in any district wherein, or nearest to which, the cause of action arose, or wherein any defendant resides, may be found, or has his principal office. In the case of Guam, and any Commonwealth, territory, or possession of the United States in the Pacific Ocean, the appropriate court is the United States District Court for the District of Guam, except that in the case of American Samoa, the appropriate court is the United States District

Court for the District of Hawaii. Any such court may, at any time—

(1) enter restraining orders or prohibitions;

(2) issue warrants, process in rem, or other process;

(3) prescribe and accept satisfactory bonds or other security; and

(4) take such other actions as are in the interest of justice.

(d) For the purposes of this section, the term "vessel" includes an ocean thermal energy conversion facility or plantship, and the term "provisions of this Act" or "provision of this Act" includes any rule, regulation, or order issued pursuant to this Act and any term or condition of any license issued pursuant to this Act.

TITLE IV—MISCELLANEOUS PROVISIONS

SEC. 401. EFFECT OF LAW OF THE SEA TREATY.

If the United States ratifies a treaty, which includes provisions with respect to jurisdiction over ocean thermal energy conversion activities, resulting from any United Nations Conference on the Law of the Sea, the Administrator, after consultation with the Secretary of State, shall promulgate any amendment to the regulations promulgated under this Act which is necessary and appropriate to conform such regulations to the provisions of such treaty, in anticipation of

the date when such treaty shall come into force and effect for, or otherwise be applicable to, the United States.

SEC. 402. EXEMPTIONS FOR DEMONSTRATION FACILITIES AND PLANTSHIPS

The provisions of title I of this Act shall not apply to ownership, construction, or operation of any ocean thermal energy conversion facility or plantship which the Secretary of Energy has designated in writing as a demonstration project for the development of alternative energy sources for the United States which is conducted by, participated in, or approved by, the Department of Energy. The Secretary of Energy, after consultation with the Administrator, shall require such demonstration projects to abide by as many of the substantive requirements of title I of this Act as he determines to be practicable without damaging the nature of or unduly delaying such projects.

SEC. 403. RELATIONSHIP TO OTHER LAWS.

(a)(1) The Constitution, laws, and treaties of the United States shall apply to an ocean thermal energy conversion facility or plantship licensed under this Act and to activities connected, associated, or potentially interfering with the use or operation of any such facility or plantship, in the same manner as if such facility or plantship were an area of exclusive Federal jurisdiction located within a State. Nothing in this Act shall be construed to relieve, exempt, or immunize

any person from any other requirement imposed by Federal law, regulation, or treaty.

(2) Ocean thermal energy conversion facilities and plantships licensed under this Act do not possess the status of islands and have no territorial seas of their own.

(3) Except as otherwise provided by this Act, nothing in this Act shall in any way alter the responsibilities and authorities of a State or the United States within the territorial seas of the United States.

(b) The law of the nearest adjacent coastal State to which an ocean thermal energy conversion facility licensed pursuant to this Act is connected by electric transmission cable or pipeline, now in effect or hereafter adopted, amended, or repealed, is declared to be the law of the United States, and shall apply to such facility, to the extent applicable and not inconsistent with any provision or regulation under this Act or other Federal laws and regulations now in effect or hereafter adopted, amended, or repealed. All such applicable laws shall be administered and enforced by the appropriate officers and courts of the United States.

(c) Except insofar as they apply to vessels documented under the laws of the United States, the customs laws administered by the Secretary of the Treasury shall not apply to any ocean thermal energy conversion facility or plantship licensed under the provisions of this Act, but all foreign arti-

cles to be used in the construction of any such facility or plantship, including any component thereof, shall first be made subject to all applicable duties and taxes which would be imposed upon or by reason of their importation if they were imported for consumption in the United States. Duties and taxes shall be paid thereon in accordance with laws applicable to merchandise imported into the customs territory of the United States.

SEC. 404. SUBMARINE ELECTRIC TRANSMISSION CABLE AND EQUIPMENT SAFETY.

(a) The Administrator, in cooperation with other interested Federal agencies and departments, shall establish and enforce such standards and regulations as may be necessary to assure the safe construction and operation of submarine electric transmission cables and equipment over which the United States has jurisdiction. Such standards and regulations shall include, but not be limited to, requirements for the use of the safest and best available technology for submarine electric transmission cable shielding, and for the use of automatic switches to shut off electric current in the event of a break in such a cable.

(b) The Administrator, in cooperation with other interested Federal agencies and departments, is authorized and directed to report to the Congress within sixty days after the date of enactment of this Act on appropriations and staffing

needed to monitor submarine electric transmission cables and equipment subject to the jurisdiction of the United States so as to assure that they meet all applicable standards for construction, operation, and maintenance.

SEC. 405. ANNUAL REPORT.

Within six months after the end of each of the first three fiscal years after the date of enactment of this Act, the Administrator shall submit to the President of the Senate and the Speaker of the House of Representatives a report on the administration of this Act during such fiscal year. Such report shall include, with respect to the fiscal year covered by the report—

(1) a description of progress in implementing this Act;

(2) a list of all licenses issued, suspended, revoked, relinquished, surrendered, terminated, renewed, or transferred; denials of issuance of licenses; and required suspensions and modifications of activities under licenses;

(3) a description of ocean thermal energy conversion activities undertaken pursuant to licenses;

(4) the number and description of all civil and criminal proceedings instituted under title III of this Act, and the current status of such proceedings; and

(5) such recommendations as the Administrator deems appropriate for amending this Act.

SEC. 406. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated to the Secretary of Commerce, for the use of the Administrator in carrying out the provisions of this Act, not to exceed $3,000,000 for the fiscal year ending September 30, 1981, not to exceed $3,500,000 for the fiscal year ending September 30, 1982, and not to exceed $3,500,000 for the fiscal year ending September 30, 1983.

SEC. 407. SEVERABILITY.

If any provision of this Act or any application thereof is held invalid, the validity of the remainder of the Act, or any other application, shall not be affected thereby.

DEPARTMENT OF THE TREASURY,
OFFICE OF THE GENERAL COUNSEL,
Washington, D.C., May 7, 1980.

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: The Department of the Treasury would like to offer its views on S. 2492, the "Ocean Thermal Energy Conversion Act of 1980."

This bill would establish the procedures for locating, constructing, and operating ocean thermal energy conversion (OTEC) facilities and plantships to produce electricity off the U.S. coast. The bill would also amend the Merchant Marine Act, 1936, to provide loan guarantees to such energy conversion projects from the existing revolving Federal Ship Financing Fund. The authorization for loan guarantees under this Fund would be increased from $10 billion to $12 billion, with the additional funding authorized to a sub-revolving fund for OTEC. The OTEC fund would provide loan guarantees to U.S. citizens, business entities, plus Federal, State and local governments and agencies for a maximum of five plantships and facilities. The Act would be financed with appropriations totalling $3 million in fiscal year 1981 and $3.5 million for each fiscal year 1982 and 1983.

Since the licensees under the program may include taxexempt issuers as States and local governments, the proposed loan guarantees may create Federally-guaranteed tax-exempt securities. The Administration and the Congress have opposed the Federal guarantee of such obligations because their full faith and credit provision plus exemption from Federal taxes make them superior to taxable U.S. obligations, create an adverse impact on the municipal bond market because of their superiority to other municipal issues, and provide inefficient financing because the revenue loss to the Treasury exceeds the interest benefits to the tax-exempt borrowers. Congress has enacted at least twenty-one statutes which specifically prohibit the guarantee of tax-exempt bonds.

Additionally, the Department of Energy is currently conducting an OTEC research and development study, and it will be some time before a pilot plant will be constructed. Because OTEC state-of-the-art has not yet passed the research and development stage, enactment of the bill at this time would seem premature.

Therefore, the Department of the Treasury does not support S. 2492, the "Ocean Thermal Energy Conversion Act of 1980", as currently drafted.

The Department has been advised by the Office of Management and Budget there is no objection from the standpoint of the Administration's program to the submission of this report to your Committee.

Sincerely yours,

DAVID R. BRENNAN,
Deputy General Counsel.

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., May 8, 1980.

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Your Committee currently has under consideration S. 2492, the "Ocean Thermal Energy Conversion Act of 1980". We are submitting the comments set forth below on S. 2492 for your consideration.

We note that the Administration opposes the enactment of S. 2492 as premature, and inappropriate, and we defer to the Department of Energy's testimony on the bill, which sets forth the rationale for this position. However, we take this opportunity to discuss several of the problems with the bill that are of particular interest to this Department.

S. 2492 establishes a program within the National Oceanic and Atmospheric Administration (NOAA) to license and regulate the ownership, construction, and operation of Ocean Thermal Energy Conversion (OTEC) moored facilities and vessels (plantships). OTEC facilities and plantships would use temperature differences in ocean water to produce electricity for both onsite use and transmission to onshore areas.

Title I of S. 2492 establishes the regulatory scheme, vests primary authority in NOAA, and provides for interdepartmental coordination of various separate departmental responsibilities. Title II modifies the definition of "vessels" in the Merchant

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Marine Act of 1936 (46 U.S.C. 1271) to include OTEC facilities and plantships, and makes financial assistance available under the Merchant Marine Act of 1936 for ocean thermal energy conversion facilities, plantships, and vessels providing shipping services to these facilities and plantships.

Title III defines criminal offenses relating to violations of the bill's provisions and to acts committed on or against OTEC facilities and plantships, vests NOAA and the Coast Guard with responsibility for enforcement of the provisions, and establishes civil and criminal penalities for violations and for interference with enforcement efforts. Title IV defines the relationship of this bill to other laws and treaties exempts demonstration projects designed by the Secretary of Energy from the requirements of Title I, provides for coordination of cables and equipment to ensure safety, and sets forth NOAA reporting requirements and appropriations to carry out the provisions of the bill.

We question making NOAA the lead agency for regulation and licensing of OTEC facilities. That authority could be vested in the Department of the Interior, the Department of Energy, and/or the Department of Transportation (Coast Guard), as well as NOAA.

We believe that assigning NOAA the lead on OTEC activities would, in all likelihood, result in needless duplication of the expertise developed by Interior in its Outer Continental Shelf (OCS) leasing program. NOAA would have to develop licensing, regulatory, and administrative functions paralleling those already in existence within Interior. Interior has an ongoing environmental studies program for OSC lands, yet NOAA would have to make environmental studies of likely sites for facilities and plantships in these same areas.

Giving NOAA OTEC authority would, in our opinion, complicate (1) coordinated planning in energy transportation corridors, and (2) Federal-State OCS coordination, thereby further fragmenting Federal OCS responsibilities. The Department of the Interior continuously coordinates the uses of the OCS with Coastal States, other Federal agencies, and the public.

In addition, we offer the following concerns about some of the specific provisions of this bill.

Sections 101(c)(10) and 105(b)(1) require approval of the application for an OTEC license by the governors of each adjacent coastal State with an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (CZMA) (16 U.S.C. 1451–1464) prior to issuance of that license. Section 105(b)(1) further provides for a consistency determination by the governor of any adjacent coastal State. In addition, section 101(c)(11) requires that any adjacent coastal State to which a facility is to be directly connected must have an approved coastal zone management program in good standing. In our opinion, these sections unnecessarily duplicate and also conflict with section 307(c)(3)(a) of the CZMA which establishes a procedure by which a coastal State can prevent the issuance of any license if it determines that any OTEC activity would affect the State's coastal zone in a manner inconsistent with its approved coastal zone management programs. As drafted, we believe OTEC activities could be denied licenses simply because a State does not have, and may never have, an approved coastal zone management program, or because a State's program loses its good standing for a cause totally unrelated to OTEC activities.

Section 101(d)(3) requires removal of all facilities and components from the seabed when the license has ended unless the requirement is waived by the Administrator. Further constraints to the Administrator's ability to grant waivers are needed. As this section is currently drafted, the Administrator can waive the removal requirement except where the remaining components constitute a threat to navigation, fishing, or the environment. At a minimum, the words "ocean mining", "oil and gas development", and "aquaculture" should be considered as additions to this list because of the potential for interference of abandoned equipment with these activities.

Section 101(c)(8) requires that anything coming from an OTEC facility or plantship to the United States must be transported in a vessel documented under the laws of the United States. We oppose this provision, and recommend that this section be deleted. This would place an undesirable constraint on potential development of OTEC facilities, plantships, and associated industries in the U.S. territories.

Section 202 and 403 appear to contain conflicting provisions. Section 202 includes OTEC facilities and plantships in the definition of "vessels" under section 1101 of the Merchant Marine Act of 1936 (46 U.S.C. 1271); section 403 extends State and Federal laws to OTEC facilities. At least for facilities, there is likely to be a conflict between admiralty laws (applicable since section 202 makes facilities vessels) and State and Federal laws (applicable by virtue of section 403). We recommend that

this apparent conflict between sections be examined further and that it be corrected if necessary.

We believe that consideration should be given to requiring OTEC licensees to pay to the Federal Government the fair market rental value for sites used by facilities and pipelines and submarine cables. Such a provision would parallel the requirements of section 5 of the Deepwater Port Act of 1974 (P.L. 93-627; 88 Stat. 2126).

We also note that under section 102(i)(2), the first application for a license could be denied in favor of a second regardless of the time lapse between the two applications.

The Office of Management and Budget has advised that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely,

LARRY E. MEIEROTTO,
Assistant Secretary.

Senator INOUYE. Our first witness is here to represent the State of Hawaii, the Governor of Hawaii, the Honorable George Ariyoshi, and he is the director of the department of planning and economic development, Mr. Hideto Kono.

As always, Mr. Kono, it is a great pleasure having you with us.

STATEMENT OF HIDETO KONO, DIRECTOR, DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT

Mr. KONO. Thank you very much.

Senator Inouye, Mr. Chairman, my name is Hideto Kono, director of planning and economic development and the State energy resources coordinator. I have the honor of reading the statement of Gov. George R. Ariyoshi, who regretfully is unable to be present for this presentation this afternoon.

Mr. Chairman and members of the committee, I am very pleased to welcome to Hawaii, on behalf of all our people, the distinguished members of the Committee on Commerce, Science, and Transportation of the U.S. Senate, and particularly our esteemed colleague and friend, Daniel K. Inouye. We are grateful to you for taking the time to come to the slands for this important hearing, and grateful, too, to your staff members who have been so helpful to us.

The work of our congressional delegation in the field of energy has been exceptional. I want to commend both Senator Inouye and Senator Spark M. Matsunaga for the leadership they have provided, for the cooperation they have extended, and for the accomplishments they have achieved. This teamwork—this continuing working together harmoniously to achieve results—is greatly needed in our world today, and your work in the field of Ocean Thermal Energy Conversion legislation is an exceptional example of its success.

You can well understand, therefore, how much I appreciate this opportunity to submit a statement on S. 2492, "The Ocean Thermal Energy Conversion Act of 1980."

The development of ocean thermal energy conversion—OTEC—is of great importance to the State of Hawaii. Our State relies upon oil for 92 percent of its energy needs. At the same time, Hawaii is rich in alternate energy potentials: wind, direct solar, geothermal, biomass, and OTEC. We are actively pursuing the development of all these resources.

We are aware of the many advantages which OTEC has to offer. The temperature differential required for OTEC operations is available all day, every day, all year round, which means that OTEC is available for base-load power.

It appears at present that OTEC plants will have no major negative environmental impacts.

While there are problems to be solved, no major technological breakthroughs are necessary for commercialization.

Floating OTEC plants can be moved from place to place, thus providing flexibility in meeting our future energy needs.

Floating OTEC plants conserve our land, a limited and precious resource.

We in Hawaii are committed to the development of OTEC. We are pleased that all three of the major OTEC seawater projects now in progress in the United States are located in Hawaii. These are Mini-OTEC, OTEC-1, and the OTEC Seacoast Test Facility.

We expect OTEC to play an important role in our energy future, and in the energy future of our Nation. It is in this light that I am pleased to submit these comments on S. 2492.

We agree with the comments of Senator Inouye in introducing S. 2492 on March 27, 1980, that the two principal barriers to immediate commercialization of OTEC are the need for large-scale demonstration plants, and the need for enactment of a Federal regulatory framework and financing assistance provisions. The OTEC research and development bill sponsored by Senator Matsunaga, S. 1830, which passed the Senate earlier this year, provides for the needed demonstration activities. S. 2492 will establish the needed Federal regulatory framework and financing provisions. These two pieces of legislation are complementary, and both are needed to speed commercialization of OTEC in the United States.

We strongly support S. 2492. The general provisions of the bill are timely and appropriate. We support one-stop Federal licensing, and the eligibility of OTEC facilities for Federal loan guarantees under the Merchant Marine Act of 1936. We are also pleased that S. 2492 is consistent with the international law of the sea.

To the ancient Hawaiians, the ocean was a natural extension of the land—a place to work, play, and travel. We look to the sea as a bountiful resource, rich in minerals, food, and energy. We are an ocean State, and we believe that our future will largely depend on our ability to understand this and to make wise use of our ocean resources. The management of our coastal zone, including our offshore ocean areas is thus of a vital interest to us. In order to protect and develop our ocean resources, we must carefully plan the use of our ocean space.

Because Hawaii is of volcanic origin and our shores drop off sharply to the ocean floor, we expect that OTEC plants will be sited within 3 miles of our shores. Our State Coastal Zone Management Act, sets forth the State's policy regarding economic uses within the coastal zone. That policy includes the mandate to:

> Insure that coastal dependent development such as harbors and ports, visitor industry facilities, and energy generating facilities are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area . . .

To meet this mandate, we must exercise State jurisdiction, including the authority given us under Federal laws such as the Submerged Lands Act.

Our State coastal zone extends to the limit of the United States' territorial sea. S. 2492 would appear to authorize and regulate the

construction, location, ownership, and operation of OTEC facilities and plantships both inside and outside the territorial sea. Thus, activities licensed by the Federal Government may impinge upon OTEC operations within our coastal zone.

In reviewing our coastal zone activities, we have two concerns. First, under the Federal Coastal Zone Management Act, a Federal license for a coastal zone activity cannot be issued until it has the concurrence of the coastal State. We believe the bill should be made compatible with the Coastal Zone Management Act in that regard. Second, the coastal State involvement in decisions should apply to OTEC plantships as well as facilities. These concerns and proposed amendments are set forth in more detail in an appendix submitted with this testimony. We urge these amendments because they would respect the integrity of our coastal zone program, and allow us to carry out our coastal zone responsibilities pursuant to the Federal Coastal Zone Management Act.

As with many alternate energy technologies, OTEC is capital-intensive. Large amounts of money are needed at the start, and this requires the confidence of the financial community which provides the funds. The loan guarantees provided in title II of the bill are exceptionally important. Under current economic conditions, they may in fact be critical to the successful commercialization of OTEC plants.

This legislation has our strong support. Our only recommendation is that S. 2492 be amended to allow approval by the Governor of an adjacent coastal State before a license is issued to either a "facility" or a "plantship."

Thank you, Mr. Chairman. That concludes the statement of Governor Ariyoshi, which I have had the pleasure of presenting before your committee today.

[The appendix follows:]

APPENDIX

We are assured in Sec. 2(a)(7) of the bill that it is the purpose of Congress in Senate Bill 2492 to "protect the rights and responsibilities of adjacent coastal States by ensuring that Federal actions are consistent with approved State coastal zone management programs and other applicable State and local laws." The mechanism for ensuring that Federal actions are consistent with coastal zone management programs appears to be Sec. 101(c)(10). It provides that:

"(c) The Administrator may issue a license in accordance with the provisions of this Act unless—

"(10) if the license is for an ocean thermal energy conversion facility, he has consulted with the Governor of each adjacent coastal State which has an approved coastal zone management program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.) to determine his or her views on the adequacy of the application, and its effects on programs within his or her jurisdiction * * *"

This language implies that it is up to the Administrator to decide whether or not to consult with the Governor of an adjacent coastal state, and if he does so, a license will not be issued. This provision is not clear, and may be in conflict with the Federal Coastal Zone Management Act, under which the State must be consulted. That Act provides at 16 U.S.C. 1456(c) that:

"(c)(1) Each Federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs.

"(2) Any Federal agency which shall undertake any development project in the coastal zone of a state shall insure that the project is, to the maximum extent practicable, consistent with approved state management programs.

"(3)(A) *After final approval by the Secretary of a state's management program, any applicant for a required Federal license or permit to conduct an activity affecting land or water uses in the coastal zone of that state shall provide in the application to the licensing or permitting agency a certification that the proposed activity complies*

with the state's approved program and that such activity will be conducted in a manner consistent with the program. At the same time, the applicant shall furnish to the state or its designated agency a copy of the certification, with all necessary information and data. Each coastal state shall establish procedures for public notice in the case of all such certifications and, to the extent it deems appropriate, procedures for public hearings in connection therewith. At the earliest practicable time, the state or its designated agency shall notify the Federal agency concerned that the state concurs with or objects to the applicant's certification. If the state or its designated agency fails to furnish the required notification within six months after receipt of its copy of the applicant's certification, the state's concurrence with the certification shall be conclusively presumed. *No license or permit shall be granted by the Federal agency until the state or its designated agency has concurred with the applicant's certification or until, by the state's failure to act, the concurrence is conclusively presumed,* unless the Secretary, on his own initiative or upon appeal by the applicant, finds, after providing a reasonable opportunity for detailed comments from the Federal agency involved and from the state, that the activity is consistent with the objectives of this chapter or is otherwise necessary in the interest of national security." (Emphasis added.) Thus, under the Coastal Zone Management Act, the State not only must be consulted, but it must also concur, before a Federal license can be issued.

Section 101(c)(10) and Section 105(b)(1) appear to conflict in the same way. Under Section 105(a)(1) of the bill, Hawaii will be designated an adjacent coastal State if the OTEC facility is connected to Hawaii by electric transmission cable or pipeline, or if Hawaii is within 15 miles of the OTEC facility. If Hawaii is designated an adjacent coastal State, a complete copy of the application of the OTEC facility will be forwarded to my office. The bill provides at Section 105(b)(1) that the Administrator shall not issue a license without consultation with the Governor of each adjacent State which has an approved coastal zone management program. It further states that if the Governor of such a State notifies the Administrator that an application is inconsistent in some respect with the State's coastal zone management program, the Administrator shall condition the license granted so as to make it consistent with such State program. This section does not allow for a situation in which the State would not concur under any condition.

Another problem is that Section 101(c)(10) and Section 105(b)(1) apply only to an "ocean thermal energy conversion facility." No provision is made for consultation with the Governor of an adjacent coastal state regarding an "ocean thermal energy conversion plantship." The possible effects of a plantship on the territorial sea of another nation are set forth in Section 101(c)(14), which provides that the Administrator may issue a license unless:

"(14) if the license is for an ocean thermal energy conversion plantship, he determines that the applicant has not provided adequate assurance that the plantship will be able to operate in such a way as to prevent its thermal plume from impinging unreasonably on any other ocean thermal energy conversion facility or plantship without the consent of its owner, and from impinging on the territorial sea or area of national resource jurisdiction, as recognized by the United States of any other nation without the consent of such nation * * *" Plantships licensed under Federal law could move within the territorial sea offshore Hawaii and impinge upon coastal zone uses established by the State.

These provisions of the bill are important to us because they affect our Coastal Zone Management Program. We urge the Committee to amend the bill so that no license for either an OTEC facility or an OTEC plantship will be issued without the approval of the Governor of an adjacent coastal State with an approved coastal zone management program. This could be done by amending the relevant sections to read as follows:

"Sec. 101. (c) The Administrator may issue a license in accordance with the provisions of the Act unless—

* * * * * * *

"(10) if the license is for an ocean thermal energy conversion facility or plantship, the issuance of the license is disapproved by the Governor of an adjacent coastal state which has an approved coastal zone managment program in good standing pursuant to the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq)."

The mechanism for involvement by the Governor in the decision-making process would still be set forth in Section 105(b)(1), which could be amended to add the sentence:

"If the Governor of such a State notifies the Administrator that an application cannot be conditioned in such a way as to make it consistent with such State

program, the Governor shall be deemed to have disapproved the application, and the license shall not be issued."

Senator INOUYE. Thank you very much, Mr. Kono. I can assure you that everything will be done to carry out your recommendations that the bill be amended to make sure that the Governor of an adjacent coastal State not only be consulted, but his approval be received before a license can be issued for either a facility or a plantship.

So I am happy to receive your testimony, and at times we are able to demonstrate that these hearings do bear fruit.

Mr. KONO. Thank you very much Mr. Inouye.

Senator INOUYE. Our next witness is one of the fathers of economic development in the State of Hawaii, a man who is an expert in matters of that sort, the Honorable T. C. Yim, who is the chairman of the Committee on Economic Development, Energy, and Natural Resources of the Hawaii State Senate.

STATEMENT OF T. C. YIM, CHAIRMAN, HAWAII STATE SENATE COMMITTEE ON ECONOMIC DEVELOPMENT, ENERGY, AND NATURAL RESOURCES

Mr. YIM. Senator, good to see you again. It is always a pleasure to come before you.

With your permission I would like to read my written testimony.

Senator INOUYE. All right.

Mr. YIM. Senator Inouye, I am happy to be here to testify in favor of S. 2492. This bill amends the Merchant Marine Act of 1936 to make available certain financial assistance for the construction and operation of ocean thermal energy conversion (OTEC) facilities and plantships to produce electricity and energy—intensive products off the coast of the United States. The bill further provides the needed legal basis for the licensing, siting, funding, and administering of OTEC plantships and facilities. This bill complements Senator Matsunaga's S. 1830 which sets a national goal for OTEC development, as well as provides funds for demonstration projects and research and development. I am pleased to see that Congress is now on the verge of launching a major effort in the development of an alternate energy resource which is so vital to Hawaii and our Nation as well.

The impact of the world energy crisis coupled with the drastic increase in oil prices threaten hardship and financial disaster for many Americans. These adverse events in recent years have brought forth the realization that the energy crisis is real and that an adequate and stable energy supply is essential for the security and well-being of our country. There is now a united national consensus that our country must take constructive and affirmative action to safeguard our Nation against the negative effects of oil supply disruptions and price increases. We must move boldly ahead to reduce our Nation's dependence on imported oil, to develop our alternate energy resources, and to develop these alternate resources as expeditiously as possible.

The development of OTEC offers many advantages besides reducing our extreme dependence on imported oil. In addition to producing electricity, one of the OTEC systems, the open-cycle system, is also capable of producing potable water. In this open-cycle system,

warm water is drawn into an evaporator and boiled under low pressure. The resulting steam turns a turbine to generate electricity and then is condensed to produce clean, potable water.

A new source of potable water is vital for the continued growth of Hawaii. According to the State department of land and natural resources, water drawn from the Pearl Harbor basin on Oahu is near the sustainably daily yield level. Accordingly, a restriction on additional drilling and use of water is likely to be imposed. This restriction, if imposed, would place a moratorium on growth in the Honolulu and Ewa areas and dampen the State's overall rate of growth. This problem could be resolved, however, if the plan of a certain corporation which has expressed an interest in building an open-cycle OTEC system off the coast of Oahu comes to fruition.

In addition to its freshwater production potential, OTEC has another significant spillover benefit. OTEC has the potential of producing nutrient rich water for aquaculture purposes. The combination of warm surface water and the cold nutrient rich deep ocean water used in the operation of OTEC has advantages for growing a variety of food products. Some analyses suggest that the economic benefits of growing food at the OTEC site, i.e., in the immediate vicinity of plantships and facilities, may even exceed the benefits derived from energy production.

As you can see from the foregoing, OTEC can be beneficial in many ways. Think of the possibilities for various areas throughout the world including the continental United States and Hawaii which need not only energy but, also, potable water and food products.

What is needed now to bring OTEC to its full potential is a game plan we can execute as expeditiously as possible. What has been researched and developed must now be put to work. We must take the attitude of being willing to take risks. The stakes are high. In view of our Nation's vulnerability to disruptions in oil supplies and the political instability of those sources, we must take bold immediate action. We must have leadership, and this leadership must come from the Federal Government.

S. 2492 is a solid example of a much needed action program to expedite our Nation's drive toward greater energy self-sufficiency.

Senator Inouye, you are to be commended for your extraordinary vision in sponsoring this far-reaching piece of legislation. Enactment of this important bill will not only heighten national awareness of the potential of OTEC, but will also benefit the Nation's as well as Hawaii's effort to gain energy independence. Enactment of this bill will also forge a firmer partnership between the Federal Government and Hawaii. I perceive such a partnership as the key to the development of OTEC in Hawaii and throughout the Nation as well.

We are honored and pleased that you are holding this hearing on you bill in Hawaii. We pledge to work closely with you in every way possible to make an exciting dream come true.

Thank you very much, Senator.

Senator INOUYE. Senator Yim, as expected, your statement is always good and helpful. I can assure you that with words of such support, it will make our work in the Senate that much easier. We

will do our best to see that S. 2492 becomes law. Thank you very much.

Mr. YIM. Thank you.

Senator INOUYE. Our next witness is the dean of the School of Engineering, University of Hawaii at Manoa, Dr. John W. Shupe.

STATEMENT OF JOHN W. SHUPE, DEAN, SCHOOL OF ENGINEERING, UNIVERSITY OF HAWAII AT MANOA

Dr. SHUPE. Thank you, Senator.

Mr. Chairman, I am John Shupe and it is my pleasure to chair the Governor's Advisory Committee of Alternate Energy Development. The emphasis of this advisory committee is on the development and commercialization aspects of energy alternatives, so I welcome the opportunity to add my strong endorsement to the Ocean Thermal Energy Conversion Act of 1980.

We are particularly pleased to see this act following so closely on the recent passage by the Senate of S. 1830, Senator Matsunaga's OTEC demonstration bill. Although adequate research funding is essential to initiate imaginative programs on the utilization of renewable resources as substitutes for imported oil, unless there are sufficient support and incentives as followup to carry the technology through the demonstration and commercialization phases, the rate of market penetration will be slow.

As an example, the first successful geothermal well in this State was drilled in the Puna district of the Big Island of Hawaii 4 years ago. The Puna well turned out to be one of the hottest wells in the world, and the quality of the geothermal fluid also is excellent. The geothermal reservoir associated with this well has the potential for producing significant amounts of energy, possibly a thousand megawatts for 50 years. Today there is still just the one geothermal well in the State capable of producing power, and the first small wellhead generator, 3 megawatts, is not scheduled to go on line until May of 1981, 5 years after the well was completed. Major commercial development will probably be delayed a number of additional years. Had adequate support and incentives been given to the aggressive development and commercialization of this resource, both for power generation and for nonelectric use as process heat, geothermal energy could have made a much earlier contribution to help relieve Hawaii's near-total dependence on imported oil. The passage and implementation of S. 2492 should help assure a more timely introduction of OTEC.

Hawaii initiated research and development programs on its indigenous energy resources, including OTEC, early in the 1970's, well before the Middle East oil embargo and resulting energy shortfall. Table I lists the levels of support that have gone into alternative energy projects, both by technology category and by funding source, over the last 8 years. This table illustrates both the variety of indigenous resources for which energy R. & D. programs are underway in Hawaii and the breadth of funding that has gone into these efforts.

TABLE 1.—FUNDING OF ENERGY PROJECTS IN HAWAII—1972–79

[In thousands of dollars]

	Federal	State/county	Private	Total
Geothermal	11,002	1,610	234	12,846
Solar/wind	10,389	1,635	659	12,683
OTEC	21,976	4,156	1,712	27,844
Biomass	1,241	1,718	880	3,839
Total	44,608	9,119	3,485	57,212

You will note that nearly half of the $57.2 million for all energy programs has been directed to OTEC, and that $6 million of local government and private support has gone into the development of this resource. Hawaii was initially and continues to be a strong advocate for the potential of OTEC, and welcome S. 2492 for the impetus it will provide in accelerating the commercialization of this vast resource.

For OTEC to move from an interesting theoretical concept, known for nearly a century, to an economically viable alternative for a dwindling oil supply requires the level of technical competence and manufacturing capability that can come only from the private sector. Hawaii recognizes this fact, and from the beginning, has engaged in joint endeavors with industry. Our first major OTEC proposal submitted to the Energy Research and Development Administration (ERDA) in August of 1975, was in partnership with TRW. This proposal was a precursor to Hawaii's Seacoast Test Facility, and had it been funded in 1975 would have shortened the leadtime required to develop OTEC technology by 3 years. Mini-OTEC was a joint venture of the State of Hawaii with Dillingham, Lockheed, and other industrial concerns. The encouragement provided to the private sector by including the incentives and provisions of the Merchant Marine Act of 1936 to floating OTEC plants should help assure the continuing participation and leadership from industry in making OTEC work.

One final point is that enactment of this measure would help reinforce the concept that Congress is serious in its commitment to supporting the development of renewable energy resources. There is still a great deal of inertia, or "accepted conventional wisdom," which feels that these renewable resources are exotic 21st century technologies, which will have little, if any, impact in the next two decades. Unfortunately, this is one of those prophecies which tends to be self-fulfilling; without sufficient support and incentives, these alternatives will have only marginal impact by year 2000. S. 2492 would help provide this support.

The concern on the future role of the renewables is not confined to this Nation alone. Recently at the Seventh Energy Technology Conference in Washington, Mexican Energy Minister Juan Eibenschutz told a surprised audience that tropical developing countries should not look to solar technologies for providing their energy needs. He reported that the time has not yet come to apply solar technologies to poor countries, and that the organized effort to promote solar energy in underdeveloped countries was being done in order to save the oil for the industrialized nations of the world. Eibenschutz advocates greater utilization of nuclear power.

Until this country does develop viable cost-competitive energy alternatives that can be used effectively as substitutes for imported oil, we will continue to encourage cynicism by the developing countries and the proliferation of nuclear energy, and its attendant spin-offs.

OTEC is the renewable energy resource with probably the highest potential for providing massive amounts of baseload power to energy deficient nations throughout the tropical and semitropical areas. Passage of the Ocean Thermal Energy Conversion Act of 1980 is an essential step in assuring orderly progress in the commercialization of this ocean resource for this Nation and for the world. It has my strong endorsement.

Senator INOUYE. Thank you very much, Mr. Shupe. Your statement is most helpful.

Our next witness is the dean of marine programs at the University of Hawaii at Manoa, Dr. John Craven. Welcome, sir.

STATEMENT OF DR. JOHN CRAVEN, DEAN, MARINE PROGRAMS, UNIVERSITY OF HAWAII AT MANOA

Dr. CRAVEN. Senator Inouye, I welcome the opportunity to testify in support of this bill for the development of OTEC. In your preamble to the bill, you very perceptively identified the potential for OTEC as a national energy resource. And I would like to amplify on that theme in my testimony.

As you pointed out, Dr. William Avery of the applied physics laboratory (Johns Hopkins) has demonstrated analytically and with conservative assumptions that OTEC plants constructed with today's technology should be economically competitive with electrical energy generated by nuclear power or fossil fuel. Even as these calculations were made, the results of mini-OTEC demonstrated conclusively that the calculations are conservative. The ratio of net power to total power in mini-OTEC was far beyond our most optimistic expectation. The implications of these very recent analytical and experimental results are thus enormous; for if electrical energy produced by OTEC is economically competitive by conservative economic calculations—that is, by calculations which amortize the plant in less than 20 years—then OTEC is an energy resource of world significance.

Following on that theme, four phases can be identified: First, the generation of electricity for use by coastal and island communities; second, the relocation of energy-intensive industry to OTEC sites; third, the production of hydrogen and ammonia for use as fuel: hydrogen as a fuel for commercial aircraft, and ammonia as a fuel for major power grids relying on the ammonia fuel cell; and finally, the substitution of ammonia as the best synthetic fuel replacement for gasoline and alcohol in internal combustion engines.

Let me go through these four phases.

The first phase is important for demonstration of concept and economic viability; but as significant as it may be for the island communities of Guam, Hawaii, and Puerto Rico, and for the Gulf Coast, this phase will not have a major effect on our national energy problem. But, success in the first phase should quickly lead to the second phase.

The manufacture of aluminum, titanium, and steel is energy-intensive, as is the processing of the manganese nodules for the production of copper, nickel and cobalt. It will be argued by some that investors will be reluctant to make the larger initial capital investment in OTEC as a power source for these industries, even though the amortized cost of energy is competitive. I would therefore ask you to ponder for a moment the problems which beset us now and in the future in the Middle East, to assess the probability that the Straits of Hormuz, through which 40 percent of the world supply of oil passes on a daily basis, will be closed even temporarily in the next two decades, and with those images in your mind then ask what initial premium you as an investor would pay for an energy plant whose major components will last for 50 years, whose costs are competitive, and for which no fuel is ever required throughout its lifetime. If you will write that premium down on a piece of paper, I will wager with you that it will be well in excess of the most pessimistic estimate of the initial capital costs of an OTEC industrial facility.

But, it is in phases three and four that OTEC will have its greatest value; in the generation of ammonia and hydrogen as fuels for the full spectrum of fuel uses. We are all so used to hydrocarbons as fuels that we fail to realize that such fuels are the product of nature and are far from ideal or optimum. Many of us know that the ideal fuel is hydrogen, for it has the highest energy per pound; and its combustion product is nonpolluting water vapor. OTEC can generate hydrogen, but because of hydrogen's low density, packaging or transporting it is inconvenient.

But it is the hydrogen in hydrocarbons that makes them good fuels; the carbon and other elements in the fuel act as a molecular container for this fundamental fuel. The energy per pound in hydrocarbons is high, because the carbon also burns, producing CO and CO_2. Other elements in the fuel—sulfur for example—also burn, producing pollutants such as sulfur dioxide. We are now learning that CO_2 will also become a pollutant on a global scale, and it may well be that by the turn of the century (only 20 years from now) we will reject fuels that contain carbon or sulfur or other polluting contaminants.

Ammonia seems to be the ideal replacement. It has only one-half of the energy-per-pound of gasoline, but its combustion product is pure water. It is easily adapted to automobiles, requiring only a catalytic heater (not unlike the catalytic converters in current automobiles) to break the ammonia down into nitrogen and hydrogen.

In order to substitute ammonia for conventional fuels, we must be able to produce it in huge quantities, and it is in the magnitude of the resource available to OTEC that it has its most remarkable potential. Current total world energy use is about 300 quads per year. A quad is 10^{15} Btu's. The United States' total energy use is about 70 quads per year, and our import from the Middle East is about 10 to 15 quads per year. Calculations by Avery indicate that world ocean thermal energy resources are well in excess of 300 quads per year, renewable forever. My own estimates indicate that within the 200-mile zones of islands under the U.S. jurisdiction, including the Marianas and the Marshall Islands, it should be

possible to produce about 70 quads a year of ocean energy product; and in the Hawaiian Archipelago, if we include Palmyra Island, it is possible to produce 10 to 15 quads per year—or, in other words, to replace the Middle East.

Is it worth it to the Nation to make the mammoth investment over the next 30 to 50 years that would be required to make this transition? I ask you once again to imagine in your mind the political future of the oil-rich nations, to think of the future environmental problems of a world burdened with acid rain and an excess of CO_2, and with those images in your mind, imagine that you are offered one of two automobiles for purchase: One a brand new standard four-door sedan of current design powered by gasoline, the second the same car with the same performance, but with a fuel tank just two times as large and with a guarantee of a continuous supply of fuel produced in essentially unlimited quantities in waters of U.S. jurisdiction, and which is absolutely pollution-free. What premium would you be willing to pay for that car, and what price would you be willing to pay for that fuel? If you will write that figure down, it is my wager that it will be in excess of the most pessimistic estimates of the cost which would result from a fully developed national OTEC fuel capability.

Thank you.

Senator INOUYE. Thank you, Dr. Craven. It is extremely exciting to hear you tell us about the potentials of OTEC-developed ammonia to be used as a basis for fuel for automobiles. What is the present state of technology in this area?

Dr. CRAVEN. I am not fully conversant with it, but a brief review indicates that there are very, very few programs, if any, which are looking at ammonia as a fuel. Private industry is looking at the possibility of using ammonia in a fuel cell. That is a device which generates electricity like a battery, only ammonia goes in at one terminal and air goes in the other. Hydrogen and oxygen are combined through an electrolytic process to produce electrical energy. And, I think that's being carried out by private industry.

I do not know of any research that's going on as a fuel for internal combustion energy. Curiously enough, not much research is required to make it available for present internal combustion engines. On the other hand, a great deal of research ought to take place to design engines and motors which operate in an optimum manner with respect to ammonia. And I would suggest that this is a fruitful area for research by the Department of Energy.

Senator INOUYE. You don't have any estimates of what it would cost to run an automobile for 20 miles?

Dr. CRAVEN. I would have to go back to Dr. Avery's comparison, and if his comparisons are correct, then essentially the cost would be—the gasoline cost should be about equivalent with the current gasoline cost, the fuel cost, or perhaps a little less.

Senator INOUYE. The university is presently involved in research on the environmental aspects of OTEC, is that right?

Dr. CRAVEN. The University has a good deal of environmental work going on with respect to OTEC, which is associated with the OTEC-1 plant with respect to NELH, and to other developments. All of them require environmental impact statements and environ-

mental assessments. And these have been taking place in connection with these developments.

Senator INOUYE. Have you studied the effect of thermal plume on marine organisms?

Dr. CRAVEN. There has been recently completed at the university a Ph. D. thesis on the dispersion of the plume. We now know how it moves. We have a great deal of investigation looking into the effect of the nutrients as they come to the surface. And our expectation is that there will be an increase in the biological production, because as Senator Yim has pointed out, OTEC results in artificial upwelling, a thing that has always been considered desirable in terms of the production of fish and marine products.

And as you may recall in mini-OTEC it was—for the people on the Kona Coast—a fisherman's paradise because of the very existence of that plant. It served as a fish attractant to bring in mahimahi.

Senator INOUYE. Will a copy of that dissertation be made available?

Dr. CRAVEN. It's quite thick, but it's available, yes sir.

Senator INOUYE. Have you done any study or research on the effects of biocides used to prevent fouling?

Dr. CRAVEN. Again, such research is going on in connection with the development of the plants. I would point out that the biocides that we use to prevent fouling are very similar to the chlorine that we use in our own sewage treatment plants, which we now dispense into the ocean without any major effect upon the environment. And that the intensity of biocides should not be much greater than the intensity we use in our standard sewage disposal system.

Senator INOUYE. Then it shouldn't be a matter of major concern?

Dr. CRAVEN. Not in my view, no sir.

Senator INOUYE. Thank you very much, Dr. Craven.

Our next witness is Dr. Doak Cox of the Environmental Center. Dr. Cox, welcome.

STATEMENT OF DR. DOAK COX, ENVIRONMENTAL CENTER

Dr. COX. Senator Inouye and members of the staff, my name is Doak Cox. In light of the number of persons who wish to testify concerning this important bill, I propose to present orally only a brief synopsis of the highlights of my written statement.

I'm director of the environmental center of the University of Hawaii, and my major interest in OTEC is principally environmental, although what I have to say does not reflect an institutional position of the University.

In my written statement I point out that among the factors determining OTEC benefits, an environmental factor is in the long term the major one. And that it is environmental conditions as well as technological capabilities that will determine OTEC costs.

However, in the main, my statement is concerned with the environmental side effects, the social and physical impacts, as we call them, of OTEC. These impacts have been addressed in OTEC and R. & D. efforts to date, and further investigations are to be expected and to be encouraged in connection with future R. & D. efforts.

I think there's little doubt that in the net the social environmental impacts will be considered beneficial, and probably overwhelmingly so. And from the evidence available to date, it does not seem that among the physical impacts there will be any major unreduceable detriments. With respect to the latter, I wish to point out that it is important to assess the physical impacts, not in terms of their magnitude, but in terms of their humanistic implications. And this should be recognized in determining what physical environmental standards should be applied to OTEC regulations.

The water drawn from depth in the ocean, as Dean Craven has pointed out, is not only cold but nutrient rich. The nutrients are conventionally regarded as pollutants in our Environmental Management program. The convention is appropriate in some environments, but we should not let it determine our decisions regarding nutrient transfers permissible in OTEC operations.

The offshore waters in most parts of the ocean are nutrient-deficient and increases in rates of production of the organisms on which fish live, and hence the fish themselves, will result in nutrient increases through transfer from depth.

In summary: First, from an environmental standpoint, the promotion of OTEC R. & D. and of eventual commercial OTEC that would be provided through S. 2492 is very appropriate; second, investigations of the potential environmental impacts of OTEC operations have already been undertaken in connection with R. & D. efforts, and further investigations of the impacts may be anticipated and should be encouraged in future R. & D. efforts; and third, environmental standards applied in the regulation of OTEC operations should reflect humanistic evaluations pertinent to the environments of the operations.

Thank you very much.

Senator INOUYE. Thank you very much. As I tried to suggest in my discussions with Dr. Shupe, we are very concerned with the environmental impact. Obviously none of us in the Congress are sufficiently knowledgeable to deal on matters on this sort and we would like to depend on people like you to guide us. So thank you very much.

Our next witness is the president of the League of Women Voters of Hawaii, Mrs. Patricia Shutt.

STATEMENT OF PATRICIA SHUTT, PRESIDENT, LEAGUE OF WOMEN VOTERS OF HAWAII

Mrs. SHUTT. Senator Inouye, I am Pat Shutt, president of the League of Women Voters of Hawaii. We thank you for this opportunity to present the views of our organization.

The League of Women Voters has a position supporting research and development of all types of alternate energy sources, and we therefore support continued research and development of OTEC.

It is our opinion that OTEC should become one of a mix of natural energy sources necessary to decrease Hawaii's dependence on imported oil. Hawaii is an ideal location for continued research into ocean thermal energy conversion for two major reasons: No. 1, deep ocean water is available near the shore; number two, the year-round mild climate insures a good temperature difference between the deep, cold water and the warmer surface water. OTEC's

potential for continual availability upon demand, as opposed to solar and wind which produce intermittent energy, makes OTEC desirable for direct hookup with the utilities.

Environmental protection is of great concern to the League, and we are pleased to see that this bill addresses the environmental impact of any proposed facility. We would also like to emphasize the need for consistency with the Coastal Zone Management Act. The bill should allow the Governor to deny licenses which he feels are not consistent with the State Coastal Zone Management program, pending an appropriate Federal action to override his denial. It is not clear whether the bill permits this.

We welcome the opportunity to lend our support to continued research and development of OTEC in the State of Hawaii.

Senator INOUYE. Thank you very much. As I assured Mr. Kono we will add the appropriate language to clarify the section so that the Governor of this State or adjacent States will have the approval to stop any actions.

Mrs. SHUTT. Thank you very much.

Senator INOUYE. Our next witness is a board member of Life of the Land, Mr. Dennis Callan. Welcome, sir.

STATEMENT OF DENNIS CALLAN, BOARD MEMBER, LIFE OF THE LAND

Mr. CALLAN. Thank you very much, Senator Inouye. I am pleased to say that Life of the Land fully supports OTEC as an important source of energy for Hawaii. The sooner we can convert from OPEC to OTEC the better off we will be.

Life of the Land is grateful that Congress, led by our Senators, is facilitating this energy alternative with the Ocean Thermal Conversion Act of 1980. We not only support the bill, we want it to move along at maximum speed. Just in the last few months we have seen the energy crisis explode into a massive international political emergency, which will probably get much worse as the entire Middle East gets drawn into a long-term revolution. The only effective way that we can fight back is to develop our alternative energy supplies.

Hawaii is more affected by this situation than any other State. We have the most extreme dependence on petroleum, since the common alternatives of coal and nuclear are not practical in Hawaii, which is lucky for us, since they both produce many environmental poisons. At the same time in Hawaii we have the greatest potential in—and, excuse me if I sound like the earlier speakers, but we all seem to agree—the greatest potential for the new wave of energy alternatives, including ocean thermal, geothermal, wind, and biomass. Life of the Land has always advocated development of these alternatives.

Our environmental organization has been helping to educate the public on the need for alternate energy since our founding in 1970. An example of this is a major article in our current newsletter which explains in some detail what OTEC is and how it can benefit Hawaii. And I will read a few excerpts from the article which show our support:

> Hawaii is the best place in the United States to build an OTEC site. The advantages our island possess * * * make OTEC a dependable and competitive energy source. * * * It is imperative that OTEC be considered as an important step to

Hawaii's goal of energy and economic self-sufficiency. * * * Existing data and conclusions show with further studies and research, OTEC can become environmentally acceptable as an energy alternative for Hawaii.

And for the Nation and the world, as Dr. Craven has pointed out, I might add.

We also note there are possible environmental problems, such as thermal stress and increased biostimulation in the vicinity of the OTEC machine, but there is an excellent chance that these will be more beneficial than harmful, as they can stimulate aquaculture, and plain old fishing. We hear that fish have been swarming all around the pilot plant off of Keahole, and this sounds very good. This is reminiscent of the great upwellings off the coast of Peru which produce vast quantities of anchovies. It may be that production of food may be more important to Hawaii than the energy produced from the OTEC device.

At any rate the environmental safeguards written into the OTEC Act of 1980 appear to deal adequately with this situation, particularly since an environmental impact statement will be required along with continual monitoring. In short, we feel the total benefits far outweigh any possible environmental problems, and even those small problems can likely be turned into benefits.

Considering this, it is extremely unlikely that Life of the Land would ever take any action to discourage OTEC production in Hawaii. On the contrary, we hope this will develop as soon as possible.

We are pleased that the bill sets up a streamlined procedure for one-stop permit processing of OTEC plants. This will further help to speed up the implementation. Private finances backed up by Federal loan guarantees seems the ideal way to pay for it.

Hawaii is most fortunate in having two Senators working hard for alternate energy. With the combination of our natural conditions and your determination, we are bound to become a model for the Nation.

Thank you very much.

Senator INOUYE. Thank you very much, sir. I know that you will be pleased to know that this June Hawaii will play host to the seventh annual OTEC Conference, and the keynote speaker at that time will be Jacques Cousteau.

Mr. CALLAN. Terrific.

Senator INOUYE. So, I gather that the major theme of this seventh annual conference will be the effect of the environment.

Mr. CALLAN. We will be sure to be there.

Senator INOUYE. So it should be a very interesting conference. I would suggest that all of you who have the time and inclination get to this conference. It should be well worth your while.

Mr. CALLAN. That is wonderful. It will be in Hawaii focusing on Hawaii as the center of the world for OTEC right now.

Senator INOUYE. I think all those interested in OTEC recognize that Hawaii is the leader in this area. So this is a recognition.

Mr. CALLAN. Thank you.

Senator INOUYE. Thank you very much.

Our next witness is vice president of engineering, Hawaiian Electric Co., Mr. Richard Bell.

Welcome, sir.

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STATEMENT OF RICHARD E. BELL, VICE PRESIDENT—ENGINEERING, HAWAIIAN ELECTRIC CO., INC.

Mr. BELL. Thank you, Senator.

Mr. Chairman, members of the Senate Committee on Commerce, Science, and Transportation, my name is Richard E. Bell; I am the vice president-engineering of Hawaiian Electric Co., Inc. I am also chairman of the OTEC coordinating committee, which is composed of members from private industry, the scientific community and the State government, and is organized to encourage the development in Hawaii of OTEC systems. The views expressed in my testimony will reflect Hawaiian Electric Co.'s interest and concern for reliable and economic development of sources of alternative energy in Hawaii; accordingly, my views will not conflict with those held by the OTEC coordinating committee.

Most of the electric energy consumed in Hawaii is produced by the Hawaiian Electric Co. from residual fuel oil. During the past 7 years, the cost of this basic source of energy has increased eightfold. Thus, as a consequence of our obligation to deliver reliable electric energy to our rate-payers at the lowest cost, we are continuously seeking alternative sources of electric energy. OTEC is one such source, and for this reason I am most pleased to give testimony in support of S. 2492.

OTEC development is at a very early stage. It will be several years before one could expect to find an OTEC plant included as an item in Hawaiian Electric Co.'s capital construction budget. I point this out by way of explaining that the measures included in S. 2492 that will encourage or enable OTEC plant construction will not be useful to Hawaiian Electric Co. for several years to come. However, these measures are important to the long-term OTEC program and thus have attracted our interest and support.

Last year, mini-OTEC demonstrated that net electric energy can be produced from the temperature differential that exists between the surface waters of the ocean and the cold water occurring 2,000 feet deeper. But during the next 20 years, Hawaiian Electric must add 45,000 times the net output energy capacity of mini-OTEC, and this energy must be available 24 hours a day, 365 days a year. Clearly, then, we aren't depending on OTEC alone to produce our future energy requirements. However, we see in a successful and timely OTEC development the opportunity to purchase firm power in quantities that can fit remarkably well with our future requirement. But, if OTEC is to produce some of our future energy requirements, it has a long way to go; and this bill, if enacted, will hasten and assure this progress.

OTEC is not a new concept—Lockheed, Dillingham, and others only breathed life into it, and this was a brilliant achievement—but a reliable, economical electrical system in the 1980's needs more than a working model. The foundation of a major electrical system is a highly structured and well organized industrial base producing high-quality components. S. 2492 will provide the legal, political, and social structure upon which this industrial base must be postured.

But the structure alone won't do any more for OTEC development than starting blocks do for a sprinter. S. 2492 goes far beyond structure—it provides implementation in the form of financial

guarantees under the provisions of the Merchant Marine Act of 1936. Further, by providing an efficient one-stop means of applying for Federal authorization, the paperwork and redtape which frequently inhibits or even sinks worthy projects will be markedly reduced. And all of this is accomplished with appropriate concern for the marine environment, as well as for the protection and safety of life and property at sea and use of the sea for purposes other than to produce electric energy.

Finally, by making special provisions available to OTEC demonstration projects, S. 2492 supplies the final impetus to OTEC that was launched last year by Senator Matsunaga in S. 1830. By complementing that bill, S. 2492 provides the requisite legal basis for licensing, siting, funding, and administering OTEC facilities.

Hawaiian Electric Co. firmly believes that OTEC can represent an important addition to the Nation's sources of alternative energy. Together with its submarine cable, which is particularly attractive to Hawaii with its potential for interconnecting the islands, OTEC is of unusual importance to Hawaii

Thus, in conclusion, I want to thank the committee for adding this important thrust to the launching of the OTEC industry at a time when alternative energy sources are so important to the country, and particularly to Hawaii.

Thank you, sir.

Senator INOUYE. Thank you very much, Mr. Bell. You have indicated that at the present time the state of the art will not affect Hawaiian energy needs. But what is your best estimate of the percentage of future Hawaiian energy needs which could be supplied by OTEC?

Mr. BELL. Based upon the studies we have made to date, my best estimate, Senator, would be 15 to 25 percent of our total needs could be provided by an OTEC platform.

Senator INOUYE. Do you have any estimate as to the time and money which would be needed to bring OTEC to commercialization?

This is a question that our colleagues are asking us. They want to know if they are in for a permanent grant program.

Mr. BELL. Well, basing my answer on what I have been told by the companies that are interested in developing production model OTEC plants, it appears to me that it will be perhaps 10 years before we have a commercial OTEC plant in operation. In perhaps 5 years I would hope we would have a pilot plant in operation which would be pushing energy into our system here on Oahu. That would not be a commercial plant. I would guess that another 5 years would produce a commercial plant.

That, incidently, quarrels somewhat with estimates given by other people. The year 2000 has been suggested, for example, by other people as being the year in which commercial OTEC plants will become a reality.

Senator INOUYE. You think it will come sooner than that?

Mr. BELL. I am optimistic, yes.

Senator INOUYE. Well, I hope you are correct. We are with you. Thank you very much, sir.

Mr. BELL. Thank you very much, sir.

Senator INOUYE. Our next witness is the president of the Hawaiian Dredging and Construction Co., Mr. Paul Banks.

Mr. Banks, welcome, sir.

STATEMENT OF PAUL BANKS, PRESIDENT, HAWAIIAN DREDGING & CONSTRUCTION CO.

Mr. BANKS. Thank you very much, Senator Inouye.

I am Paul Banks, president of Hawaiian Dredging & Construction Co., a Dillingham company. My testimony today strongly supports the objectives of S. 2492 to provide the needed legal basis for the licensing, siting, funding, and administering of OTEC facilities and plantships.

Through the efforts of many people in the community, Hawaii has now established itself as a leader in the field of ocean thermal energy conversion. The people who have made this possible include representatives in the legislature with their aggressive leadership, the administration, the university, the private sector and you and your colleagues in our congressional delegation. The three principal OTEC projects to date, the sea coast test facility, Mini-OTEC and OTEC-I, all located in Hawaiian waters, are the products of the hard work of that OTEC energy team. The Hawaiian team has developed a capability to perform sophisticated OTEC research and has developed a community that is knowledgeable about OTEC and that is prepared to make it a reality. However, we must not lose sight that the prime reason for this team effort has been to create an alternate energy source for the citizens of this State. We also see an opportunity for an OTEC construction industry for the support of OTEC plantships, offshore OTEC plants and for the development of an overseas export industry. One other critical aspect we believe is significant is the development of OTEC plants for the support of vital overseas military installations.

We see this year as a major turning point for OTEC in Hawaii. The key is the Department of Energy's pilot plant. The pilot plant is presently conceived to be the first OTEC plant of a size of significance to the utility industry. It will be the first plant to interfere with a commercial utility grid; it will prove that OTEC can be operated and maintained to the strict standards of the utility industry. Present plans call for a 40 or 50 megawatt electric plant which could provide 3 to 5 percent of the energy needs of Oahu. If successful the rewards to Hawaii can be substantial.

One, we will have available 3 to 5 percent of Oahu's electricity needs from an indigenous energy source.

Two, we will maintain Hawaii's leadership role in OTEC with the potential for an export industry.

Three, this plant will provide the data and the confidence to justify investment in a 100 to 150 MWe plant in Hawaii.

Four, a Federal expenditure of this size could create State and local tax income of $10 million.

Five, during construction this project could generate 2,100 direct and indirect jobs.

The winning of this contract is a vital element in the development of alternate energy in Hawaii. Likewise, the construction of this pilot plant will be significant development for ocean thermal energy as a supplier of power to the Nation.

We see your proposed Federal legislation as being very supportive of the development of this pilot plant which can lead to the construction of larger commercial plants in Hawaii and elsewhere in the United States. We believe we have demonstrated in Mini-OTEC that the technology is really not a problem. Rather it is the regulatory and financing issues that are more significant than technical problems for the commerical development of OTEC at this time. Therefore, we see the enactment of S. 2492 complementing the OTEC demonstration bills sponsored by Representative Fuqua (H.R. 5796) and Senator Matsunaga (S. 1830) which provides for needed demonstrations. S. 2492 known as the Ocean Thermal Energy Conversion Act of 1980, introduced by Representative Studds in the House as H.R. 6154 and your bill S. 2492 will provide the needed Federal regulatory framework and financing provisions. We believe both of these two pieces of legislation are necessary and that passage of both is needed to insure prompt commerical development of OTEC in Hawaii and for the Nation as a whole.

Senator Inouye, we believe this legislation will make it possible for private enterprise to proceed with the development of this energy resource. Without the legal and administrative provisions of this bill private enterprise cannot proceed to develop the enormous potential of OTEC in a responsible and expeditious manner.

Thank you for the opportunity to be here and to testify in support of the development of an ocean thermal energy industry.

Senator INOUYE. Thank you very much.

Will you elaborate a little bit on the part of your statement that says: "One other critical aspect we believe is significant is the development of OTEC plants for the support of vital overseas military installations."?

Mr. BANKS. In this area, Senator, there is opportunity for renewable power for places such as Guam, the Northern Marianas, areas where the South Seas-Asian is becoming a very vital part of our overall defense of our Nation. We would have the OTEC plants where we would not have to worry about the renewable fossil fuel on a plant that is presently operating in this area.

Guam, for instance, has somewhere between 50 to 70 megawatts of power, and all of their power is derived from fossil fuel.

With an OTEC plant in an area such as Guam, which is very critical to our western defense, we could then have this as an opportunity to provide greater security to the United States.

Senator INOUYE. Thank you very much, sir.

The next witness represents TRW, Inc. of Redondo Beach, Calif., Mr. Robert H. Douglass.

STATEMENT OF ROBERT H. DOUGLASS, TRW, INC., REDONDO BEACH, CALIF.

Mr. DOUGLASS. Thank you, Senator.

My name is Robert Douglass, manager, ocean and energy system projects for TRW, Redondo Beach, Calif.

Passage of S. 2492, or similar legislation, is on the critical path to successful commericalization of OTEC systems. It provides for a favorable institutional and legal climate which must precede formation of capital, and for equitable management of risks within

public and private sectors. Since demand for new base-load energy is increasing, and major restraints on fossil and nuclear systems are operative, it appears desirable to accelerate, where possible, introduction of alternatives in the national energy supply. Ocean Thermal Energy Conversion, or OTEC, appears as a leading candidiate for accelerated development with particular application to island economies such as Hawaii, Guam, Puerto Rico, and the Virgin Islands.

Deployment of OTEC plants at such island sites would serve the dual purpose of alleviating dependence on fossil fuels, and providing potential investors with necessary operational data to evaluate potential for rapid introduction of OTEC to mainland load centers.

Two conditions must be fulfilled for successful commercial development of OTEC. First, successful demonstration of the basic technology, and second, establishment of an institutional climate attractive to investors, utility operators, and other potential owners of OTEC systems. Senator Matsunaga's bill, S. 1830, would bring about multiple demonstrations of OTEC within a time frame which is relevant to the national need for near-term reduction in dependence of foreign oil. S. 2492 is in our view also vital, since it fulfills the second condition of favorable institutional climate.

We believe the bill is necessary at this time since its provisions must be operative prior to any serious consideration of OTEC as a commercial entity. Once enacted, it would also provide major impetus to accelerated development and deployment of large-scale operational OTEC systems.

As perceived by TRW, the major benefits of this bill are in:

RISK REDUCTION AND MANAGEMENT

The bill provides the private sector with assurances that risks will be largely those technical and market risks which face any new commercial development. It would assure availability of financing, enable project scheduling, and guarantee investors rights to operate within reasonable guidelines. It provides the public sector with precautions against risk to environment, life, and property. It provides early visibility installations, and for regulating operations in the public interest.

ALLOCATION OF RESPONSIBILITY AND AUTHORITY

The bill provides for clear-cut responsibility within a single government agency for administration, processing, and regulation of licenses, including the one-stop feature which effectively requires government to integrate its various agencies' requirements and regulations and present a single point of contact to applicants.

OBJECTIVE EVALUATION OF ENVIRONMENTAL ISSUES

By providing for base-line and followup studies and surveys, environmental questions will be responsibly and fairly examined and adjudicated. This provides for confidence in public and private sectors that fairness and objectivity will prevail.

As as engineer, I am principally concerned with development of OTEC technology to meet commercial requirements of capital cost, performance, and service reliability. Because of the scale of OTEC

systems, this work requires Federal research and development funding, and progress in developing and proving the technology is constrained by funds availability. But in the case of S. 2492, it seems that giant steps would be taken on behalf of OTEC with virtually no Federal outlays out of pocket, save for internal administrative costs. It is our impression that the 1-percent fee on loans guaranteed under the act would tend to offset the use of tax revenues for administrative expenses.

It is my understanding, sir, that in the administration of the Merchant Marine Act of 1936, that has been the experience over the 43 years the bill has been in operation. In fact, it has been extraordinarily successful from a financial point of view. This aspect of the bill has particular appeal in view of the rising Federal budget.

There are a number of minor technical suggestions for word changes and the like which I have already conveyed to the committee staff for consideration in future drafts of the bill.

I would like to add parenthetically that I would appreciate it, sir, if my statement before Mr. Studds could be included in the record in support of this legislation.

The CHAIRMAN. Without objection it will be included by reference.

Mr. DOUGLASS. In the interests of time, I have purposefully kept my remarks brief and have foresworn altogether any recitation of TRW's activities in ocean thermal energy. This does not diminish the honor I take on appearing here today, nor my company's enthusiasm for its role in the OTEC-1 project, soon to be deployed here in Hawaii.

This concludes my prepared testimony, and if time remains, I would appreciate the opportunity to answer questions. Thank you.

Senator INOUYE. Thank you very much, sir.

Do you believe that the Department of Energy is enthusiastic about OTEC?

Mr. DOUGLASS. An honest answer would have to be I can't perceive a great deal of enthusiasm. As a matter of fact, a great many informed people, including Dr. Craven and others in Hawaii who have been in the program here now for 6 years, members of the public and private sectors, the environmental community, people from law, from all sectors of our society have unequivocally supported this bill and its objectives, but I would not anticipate the same enthusiasm from the Department of Energy.

Senator INOUYE. Why do you think the Department has been taking that attitude?

Mr. DOUGLASS. I am sorry, sir, that has defied every thought process of which I am capable over the last several years. As a matter of fact, there doesn't appear to be any real reason to be against it. It's not life threatening, it is exportable as an energy supply system. On the other hand, there has been great consideration about nuclear proliferation. If we are going to aid the Third World countries by bringing them nuclear energy, I can understand the concern about providing nuclear power overseas. But you can't turn an ocean thermal energy plant into a bomb. It is impossible. The waste products of a nuclear plant concern many people—and, by the way, I am not speaking as an expert on nuclear energy

or for or against nuclear energy; I am just trying to make some distinctions. I am just saying there are attributes of alternative energy sources that one can understand a reasonable concern about; CO_2 addition to the environment or a concern for extraordinary use of land. But in the case of ocean thermal energy it is very difficult to find out why anybody—assuming it would work—why anyone would be against it or why anyone would wish to delay its introduction in the national energy supply.

Senator INOUYE. I didn't want to embarrass you by asking you these questions, but I figured I would get the right answers from you, sir.

This measure does provide for NOAA as the lead agency. Do you have any comments on that?

Mr. DOUGLASS. From my appreciation of the responsibilities of NOAA, that would appear to be the appropriate agency, since they embrace also the fisheries people, and the Maritime Administration, is a division of the Department of Commerce—so, yes, I think that would appear to be the appropriate agency. They might have more enthusiasm; I don't know.

Senator INOUYE. We have talked to them already.

Thank you, sir.

Our next witness is the manager of the ocean energy programs, Lockheed Missiles & Space Co., Mr. Thomas P. Higgins.

STATEMENT OF THOMAS P. HIGGINS, MANAGER, OCEAN ENERGY PROGRAMS, LOCKHEED MISSILES & SPACE CO.

Mr. HIGGINS. My name is Thomas P. Higgins. I am the manager of the ocean energy systems of Lockheed Missiles & Space Co., and I am responsible for the implementation of new systems to utilize the solar energy which is captured by the oceans.

It is an honor to be invited to present this committee our views on S. 2462, which will provide for the regulation of OTEC plants and make certain financial assistance available. Lockheed's enthusiastic support of the OTEC concept has already been documented in our various recent testimony before similar committees, and we provided supportive testimony in January of this year for H.R. 6154, the companion House bill.

We at Lockheed have given practical evidence of our strong support to OTEC by leading the private venture which, in conjunction with the State of Hawaii, built and operated the mini-OTEC plant last autumn off the shore of Hawaii. As you have heard, this was the first working demonstration of a closed cycle system on a seaborne platform. It would be tempting to talk at length on the implications of 24-hour-a-day electricity derived from a renewable energy source, but the need and the reward are clearly present in the minds of all of you. However, mini-OTEC's demonstration of continuous electricity output has properly served notice of the nearness of large-scale OTEC plants.

Your committee has an opportunity to provide a significant impetus to the attainment of useful power from one of the more promising solar energy conversion systems. These hearings in Hawaii are both timely and appropriate in their recognition of strong efforts being made by Hawaii to provide advocacy for the early implementation of renewable energy systems.

We have carefully studied the text of your proposed bill and regard it as a major and helpful step in the evolution of OTEC to an effective role in the U.S. energy supply inventory.

Enactment of the S. 2492 will provide readily identifiable benefits. Several of these that I feel are worthy of specific comment are:

First, it establishes a single licensing authority for OTEC platforms and ships, and it defines any OTEC platform as a registered U.S. vessel. These actions will obviate a great many legal and jursidictional arguments, and also permit access to Marad title XI financing support, among other sources. The separation of regulatory and advocacy roles, which are recommended as a result of experience in the fields of air transport and nuclear energy, is accomplished by placing the licensing authority outside of the Department of Energy.

Second, the bill confirms the traditional role of the Coast Guard in maritime operations and safety, avoiding the split jurisdiction which allocates fixed offshore oil platforms to the U.S. Geological Survey and moving drill ships to the Coast Guard.

Third, S. 2492 establishes firm and reasonably short-time spans for the approval process, including environmental impact statements, with suitable appeal provisions to protect the rights of all affected parties. OTEC should be able to avoid the agonizing delays and uncertainties which have recently characterized the approval process for land-based energy initiatives.

Fourth, the bill exempts "OTEC demonstration plants," so designated by the Secretary of Energy, from the full-licensing procedures if the early demonstration of commercial feasibility is expedited by such exemption. This must be done to meet the timetable for operable OTEC plants as shown in the OTEC demonstration bill.

Fifth, the recognition that U.S. licensing should proceed forthwith, regardless of the outcome of any law of the sea negotiations, is a refreshing contrast to the delays over the authorization of ocean mining. Of the course, most OTEC plants will be under National/State jurisdiction.

Your bill recognizes the essential capital needs for the initial OTEC plants by providing loan guarantees, such as may be provided by title XI of the Merchant Marine Act of 1936. In our discussions with electrical utilities, we can understand their constraints to incorporate new energy sources until a degree of maturity is demonstrated. Thus, industry is faced with both technological and financial challenges in making OTEC power available. Fortunately, there are actions being taken by the Federal Government, such as increased investment tax credit and Federal Energy Regulatory Commission orders for small power production and cogeneration facilities, which, when combined with the loan guarantees, will encourage an entrepreneurial approach to the construction of serveral OTEC facilities.

The subject bill provides a means for the loan guarantee to be used for demonstration plant but not more than five separate facilities. Frankly, we are concerned that the language as now stated could be interpreted to apply to demonstration plants after the initial Department of Energy pilot plant has been constructed. By making it clear that the risk reduction you propose is applica-

ble to the very first OTEC pilot plant, you could very well advance the timetable for OTEC implementation.

The proposed amount of guaranteed obligations for OTEC demonstration plants should be adequate unless there are further schedule slips to meet the goal in the OTEC demonstation bill of 500 megawatts being on line in 1989, provided on considers current prices. However, it seems desirable to take into account the effect of future inflation on the cost of OTEC plants. For example, should inflation run at an average of 6 percent over the next decade, which is 1 percent lower than was the case during the seventies, approximately 150 percent of the guarantees in the OTEC fund would be required to meet the 1989 goal. Somewhat along the same lines, it would be helpful to have some acknowledgement that inflation will play a role between now and the year 2000.

And last—probably the most important point—the development cycle to proceed from small size to medium size to large size OTEC facilities is not clearly defined at this time. However, we infer that the proposed OTEC fund can support the construction of 400 megawatts of OTEC power. Therefore, in recognition that there may be several small and medium size OTEC facilties before the large plants are constructed, we would recommend that the language in the bill which refers to "not more than five separate ocean thermal energy conversion facilities or plantships" be changed to read "not more than 400 megawatts of ocean thermal energy conversion facilities or plantships." Such a change will permit industry to construct a total power capability within the limitations of the OTEC demonstration fund and yet not be restricted to a small number of facilities.

Thank you for the opportunity to present our views on your proposed legislation. Lockheed will perform in a manner to bring credit to your objectives.

Senator INOUYE. Mr. Higgins, thank you very much. And I think we can work out something on your last recommendation. I will confer with the staff about the possibility of the appropriate language of this. And as to clarification language on demonstration plants and pilot plants, I think that could be easily resolved here.

So, here again, the public hearing has been extremely helpful as we progress.

And may we call upon you for future advice in this area, sir?

Mr. HIGGINS. Please do.

Senator INOUYE. Because we would like to have further clarification on "not more than 400 megawatts" instead of "plants."

Mr. HIGGINS. Very well.

Senator INOUYE. Thank you, sir.

Mr. HIGGINS. Thank you.

Senator INOUYE. Our next witness is the general manager of direct energy conversion programs, General Electric Co., Wilmington, Mass., Mr. Frank T. O'Brien.

Welcome, sir.

STATEMENT OF FRANK T. O'BRIEN, GENERAL MANAGER, DIRECT ENERGY CONVERSION PROGRAMS, GENERAL ELECTRIC CO.

Mr. O'BRIEN. Senator Inouye, members of the staff, my name is Frank O'Brien. I am general manager of the direct energy conversion programs of the General Electric Co.

It has been estimated in studies by the Applied Physics Laboratory of Johns Hopkins University that there are approxiamtely 22 million square miles of ocean area around the world where thermal conditions exist; that is, a 40° F temperature difference between surface and deep water temperatures—which are suitable for ocean thermal energy conversion operation. This area could support an estimated 30,000 325 megawatt OTEC plant ships to produce up to 10,000 gegawatts of electric power; 2,000 of such ships could provide the total projected needs for electric power in the United States in the year 2000. Thus, if the United States can develop the means to exploit only a small fraction of this available renewable resource, it can have a major impact on the energy independence of the Nation.

Unfortunately, with the exception of a small area of coastal waters around Hawaii, Puerto Rico, and some of the gulf States, most of the available resource is sufficiently remote from the U.S. land areas to make it impractical to transmit the power to shore as electrical energy. Therefore, it will be necessary to utilize an alternate energy carrier which can be efficiently produced from the electric power generated on board the plant ship and which can be economically transported and distributed to the use points throughout the United States.

One of the most cost-effective energy carriers which can be used in this type of application is ammonia, produced from hydrogen generated by the electrolysis of water and combined with nitrogen from the air. Ammonia is easily liquified for storage and shipment, and on land may be stored indefinitely at room temperature in pressure containers similar to those used for bottled propane gas. It can be used directly as a chemical feedstock for fertilizer manufacture and other industrial processes, or it can be easily decomposed to release the hydrogen for use in a fuel cell or gas turbine to again produce electrical power.

In order to be economically viable it is important that each step in the process, from the generation of electrical power on the plant ship to electrical power at the use site, be as efficient as possible. The direct energy conversion programs component of the General Electric Co., located in Wilmington, Mass., is currently developing high efficiency water electrolysis and fuel cell systems which can be instrumental in achieving the economic goals established for this program. The high efficiency of this technology results in not only a lower cost per unit of ammonia production, but also results in a relatively compact and lightweight system suitable for either shipboard or stationary applications. General Electric is anxious to have the OTEC program proceed in order to provide a sound basis for the commercialization of these technologically advanced products.

Development of the solid polymer electrolyte water electrolysis technology, a direct spinoff from products developed in the 1960's

for NASA space programs, is currently underway at General Electric under a program jointly sponsored by this company, the Department of Energy, and a number of electric and gas utilities. This unique technology has demonstrated a potential for significant increases in efficiency and reduction in capital costs as compared with conventional commercial electrolyzers. The objectives of this development program are to achieve an electrolysis system efficiency in the range of 85 to 90 percent and a projected capital cost on the order of $170 per kilowatt, and to scale the technology up to a 5-megawatt demonstration system in the 1983–84 time period. This demonstration system is currently planned to be installed in the New York State power grid network of Niagara Mohawk Power Corp., a sponsor of this development program.

Another feature of solid polymer electrolyte electrolyzers is that they will require only a fraction of the floor or deck space required by conventional systems.

In utilizing the ammonia for reconversion to electric power, the most efficient system appears to be a hydrogen-chlorine fuel cell system which combines a hydrogen-chlorine solid polymer electrolyte fuel cell with a hydrogen-chlorine-oxygen catalytic chlorine recovery system. Such a system can possibly achieve efficiencies in the range of 60 to 65 percent as compared with efficiencies around 45 percent for the standard hydrogen air fuel cell. The higher efficiency can make a significant impact in the economics for utilizing the solar OTEC resource.

At the present time the hydrogen-chlorine cells are being developed under a privately funded program as an electrolysis cell for commercial production of chlorine from hydrochloric acid. The feasibility for operating these cells reversibly in the fuel cell mode has been demonstrated and cell efficiencies of 70 to 80 percent were achieved. However, there is no current program to develop either the hydrogen-chlorine fuel cell or the overall redox system for commercial applications. It is recommended that such a development program be initiated in conjunction with the OTEC program with funding support from the Department of Energy.

Both the water electrolysis and the hydrogen-chlorine fuel cell will utilize the solid polymer electrolyte technology developed by the General Electric Co. This unique technology has many years of both Government, company, and industry development support to bring it to its present state-of-the-art. Commercialization of these systems for OTEC applications will provide industrial growth and contribute to the economic feasibility of the OTEC program and its potential contribution to energy independence.

Thank you.

Senator INOUYE. Thank you very much. You have made a very exciting suggestion, that ammonia produced by OTEC can be produced for electricity anywhere in the United States.

Mr. O'BRIEN. Yes, sir.

Senator INOUYE. Because of its being less polluting than other energy-producing sources?

Mr. O'BRIEN. Fuel cells have essentially no pollution, sir.

Senator INOUYE. What I'd like to know is what steps should be taken to accelerate the development of this kind of electricity.

Mr. O'BRIEN. I think two things must be done, Senator. Number one, the current program funded by the Department of Energy and its co-sponsors that I mentioned, the electric utilities, gas utilities, and General Electric Co., is currently scheduled to deliver a 2 to 5 megawatt, demonstration system no earlier than 1984. If that program is not accelerated, then the need to provide an electrolyzer for OTEC in the 1984 to 1986 timeframe—in fact, I believe Dr. Avery said that to meet the OTEC schedule, that they would have to have delivered 40 megawatts of electrolyzer capacity by 1984 for installation by 1986. Unless this program, the water electrolysis program, is accelerated, then this schedule cannot be met.

Second, to produce or to use the ammonia as an alternate energy carrier, then along with the acceleration of the current water electrolysis program to generate the hydrogen, feasibility studies must be made as to the most viable fuel cell technology—whether it is hydrogen-chlorine, hydrogen-oxygen, or carbonate fuel cell, which is a longer term fuel cell. There are three or four different fuel cell technologies which should be studied. And when the most viable one economically and environmentally is selected, then a developmental program initiated, this would not, in my judgment, if we started tomorrow—result in a fuel cell being available by the time the water electrolysis gas generators would be available.

Senator INOUYE. How much would these feasibility studies cost?

Mr. O'BRIEN. Feasibility studies. It would all depend on the depth that the Department of Energy would want. But from a feasibility studies standpoint, I would say half a million dollars perhaps, maybe more depending upon how many fuel cell systems it was designed to investigate. But the studies that have been made by General Electric to date—we have done some initial laboratory exploration work, funded by the Department of Energy in 1977—1976, and 1977, and the hydrogen-chlorine technology looked very good at that time. Since that time we have done additional studies, and there were certain questions to be answered in that system, both—well, primarily thermally. But all of the fuel cell technologies should not be ruled out at this stage. So that when the development program is started, industry and the Government will know that the technology being developed is the most viable.

Senator INOUYE. Has the Department of Energy been an enthusiastic partner of yours in your pilot plant program?

Mr. O'BRIEN. Yes, they have as far as the water electrolysis program is concerned, which is the main effort that we, in partnership with the Department of Energy, have. They have been constrained, however, by the yearly Government fiscal-year funding constraints to move the technology along at a pace that both they, industry, the utilities, and the General Electric Co. would like.

Senator INOUYE. I am not aware of the present status, but can you tell us how much appears available for the fiscal year 1980 for investment?

Mr. O'BRIEN. To the best of my knowledge it is less than $1.5 million for the water electrolysis work.

Senator INOUYE. Is that enough?

Mr. O'BRIEN. That is not enough if it is to be developed in time to meet the OTEC requirements and to produce 40 megawatts of water electrolysis generating equipment by the 1984 timeframe.

Senator INOUYE. What is a reasonable number?

Mr. O'BRIEN. A reasonable number in 1981 is an additional $1.9 million. That is our estimate at this time. But additional funds will have to be provided each additional year so that the equipment, which is the major cost element, could be available by 1984.

Now, these funds would be in addition to the funds that are being contributed by industry and the General Electric Company.

Senator INOUYE. And I presume that the Department of Energy is aware of this?

Mr. O'BRIEN. Yes, sir.

Senator INOUYE. Are they afraid of OMB, or what is it?

Mr. O'BRIEN. I really can't answer that, sir. I think in my judgment one problem is that OTEC is in one part of the Department and the work directed toward the development of water electrolyzers for general bulk gas generation is in another one. Whether they get together or not I can't comment. But I believe that all technology that is directly related to OTEC somehow should be directly tied into OTEC. I believe that is the only way that the Department of Energy is going to be able to obtain the funding required to meet the technology needs of the OTEC program.

Senator INOUYE. Dr. Craven earlier suggested that ammonia can be used to fuel automobiles. Do you think that is feasible?

Mr. O'BRIEN. Ammonia, I can't comment on that, sir. But of course ammonia can be very easily broken down into its two constituents, hydrogen and nitrogen. And the hydrogen, as has been suggested by many others both in the Government and industry, could be a very important future fuel for automotive applications. Now, whether the hydrogen that is obtained from the synthesis of ammonia or not, I don't know. Now, his point may be well taken in that some of the more remote areas of the United States, where there is ready transportation of ammonia to produce fertilizer, some of that ammonia during the off seasons—where the need for fertilizer is much less—perhaps could be reconstituted into hydrogen and the hydrogen used in automotive applications. There is quit a bit of that going on in the United States today, evaluating the use of hydrogen directly in automotive engines. So it is practicable, it is feasible. The economics of it obviously have to be proven.

Senator INOUYE. Mr. O'Brien, you have been extremely helpful, sir, and the staff has just advised me they would like to be in touch with you for further discussions.

Mr. O'BRIEN. Thank you, sir.

Senator INOUYE. Thank you.

And our final witness represents the Chamber of Commerce of Hawaii. He is a member of the energy committee of the chamber of commerce, Mr. Thomas Walter.

STATEMENT OF THOMAS WALTER, MEMBER, ENERGY COMMITTEE, CHAMBER OF COMMERCE OF HAWAII

Mr. WALTER. Bottom of the barrel.

Senator INOUYE. Or the top of the deck.

Mr. WALTER. Thank you, Senator Inouye.

My name is Thomas Walter, and while I am the division manager for marketing in Hawaii for Chevron USA, I speak to you as a

member of the Energy Committee of the Chamber of Commerce of Hawaii, a group of businessmen from a variety of industries who advise the chamber on energy matters.

The Chamber of Commerce of Hawaii is vitally concerned with the ability of this State and the entire Nation to meet our energy requirements in the future.

We speak in support of S. 2492, Ocean Thermal Energy Conversion Act of 1980. OTEC as an alternative energy source has been tested successfully using current technology. It is not a futuristic dream. Its translation from the successful research stage to commercial application is feasible today.

The primary problem in bringing this alternative energy source to reality by the production of power is the large capital costs required by the power producers.

If this bill becomes law, companies with the knowledge and expertise to produce power from ocean temperature differentials can capitalize their projects in partnership with the Federal Government without undue delay.

The ability to move quickly into this new area of energy production will accelerate the development of sophistication in this new industry. Such a benefit cannot be overstated, for the sooner this technology becomes refined to a marketable level, the sooner OTEC plantships can be built and exported to under-developed countries throughout the Pacific and elsewhere, thus providing significant alternative energy sources for nations whose geographic situation permits the production of OTEC power.

Environmental benefits of OTEC production are yet to be realized, but Senator Inouye discussed some of the possible ancillary advantages in his speech of March 27 on the Senate Floor. Ammonia production, aquaculture development and improved water quality are only some of the benefits that are possible.

The chamber is aware of the advantage of a new industry: increased public revenues and increased jobs. Hawaii will benefit if OTEC power becomes a reality here and similar benefits will accrue to other regions where OTEC power is possible.

Mr. Chairman, the Chamber is eager to see Hawaii continue its development of this vital energy resource. The potential to supply nearly all of the electric power requirements of our population of nearly one million people is reason enough, but the opportunity to pave the ways for this industry in other areas is an additional advantage. We have the expertise, the knowledge, and the technology. This legislation provides the financial assistance and the government guidance that forge the final links in a strong chain from a scientific dream of electric power for people.

Thank you for your leadership in bringing OTEC power closer to commercialization.

Senator INOUYE. Mr. Walter, we appreciate your words of support. I would like to assure you we will do everything we can to expedite its passage, sir.

Mr. WALTER. Thank you.

Senator INOUYE. With this I would like to recognize the assistance I have received from Ms. Sharon Maier, who is a member of the staff of the Senate Committee on Commerce, Science, and Transportation, and from Mr. Ken Lutterman, who is presently

serving on my staff. These two persons have done much to bring this hearing to its present state, and I am certain that as a result we will be able to expeditiously pass this bill.

With this the committee hearing will stand in recess subject to the call of the Chair.

[Whereupon, the hearing concluded at 4:35 p.m.]

OCEAN THERMAL ENERGY CONVERSION ACT OF 1980

THURSDAY, MAY 1, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

The committee met at 11:05 a.m. in room 2345, Russell Senate Office Building, Hon. Daniel K. Inouye presiding.

OPENING STATEMENT BY SENATOR INOUYE

Senator INOUYE. Today marks the second day of hearings on S. 2492, the Ocean Thermal Energy Conversion Act. On April 10, this committee met in Honolulu to consider the legislation and to hear from the representatives of the industry that have done much of the technological development necessary for OTEC to go forward.

Today we want to hear from the various agencies within the administration regarding this bill, and other interested groups that have been involved with OTEC.

I understand that there is some reluctance on behalf of the administration toward endorsing this legislation. We in the Congress who have been working diligently to facilitate the commercialization of OTEC are quite concerned with this attitude and its implications for the future of this very promising technology, and we will want to explore that in the hearing today.

Two major barriers to commercialization of OTEC have been identified. The first of these is the need for demonstration of large-scale OTEC systems. This has been addressed in S. 1830, introduced by Senator Matsunaga. That legislation provides for demonstration projects and the setting of national goals for energy generated by OTEC.

The second barrier is the need for a Federal regulatory and siting framework and financial assistance. This bill, S. 2492, provides for one-stop Federal licensing of OTEC facilities and plantships, provides that these facilities be recognized as vessels under the laws of the United States, and makes both commercial and demonstration facilities eligible for Federal loan guarantees under title XI of the Merchant Marine Act.

As a continued reliance on imported oil places an increasing burden on the American economy, and as fossil fuels are being depleted worldwide, the Nation's interest is turning to renewable energy resources. These include synthetic fuels, solar power, and energy derived from the oceans.

I believe that OTEC has immense potential as an alternative, clean, and renewable source of energy. It promises to be a technol-

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ogy capable of fulfilling a significant percentage of our energy needs in the next 20 years.

I have here a statement prepared by Senator Sarbanes of Maryland, a cosponsor of the measure. He wanted to be here personally, but prior commitment keeps him away. Without objection, his statement will be made part of the record at this point.

[The statement follows:]

STATEMENT BY HON. PAUL S. SARBANES, U.S. SENATOR FROM MARYLAND

Mr. Chairman and Members of the Subcommittee: I welcome this opportunity to express my continuing strong support for the Ocean Thermal Energy Conversion program, and, specifically, for the legislation which is being considered today. At a time of uncertainties regarding future energy supplies and dependence on foreign sources of crude oil, I believe that it is essential to rethink our energy policies and put together a combination of coordinated programs to ease our energy problems. The Congress has begun to respond; however, the energy situation does not lend itself to singular solutions. Within the broader context of recent Senate initiatives to develop alternative sources of energy, we must not lose sight of a range of options that can sustain the impetus for developing new energy sources. The Congress can then take appropriate and visible steps toward solving the nation's energy needs. This bill presents such an opportunity.

The attractiveness of OTEC technology as a clean renewable energy technology should be underscored. The President's Council on Environmental Quality projected that OTEC could generate the equivalent of one quadrillion to three quadrillion BTUs (quads) by the year 2000 compared with the three quads that the nation today gets from hydroelectric power. More importantly, OTEC uses solar energy, requiring no oil, natural gas, or coal to generate electricity. It is also one of the few solar technologies under consideration by DOE that can be used in the near term to generate electricity on a large-scale basis. I applaud the efforts of The Johns Hopkins University Applied Physics Laboratory beginning in 1973 in the OTEC field. Their expertise in heat exchange and ocean technology has lead to the development of an OTEC proposal, which presents practical solutions to the effective utilization of solar energy. I would also commend Senator Inouye for his support and understanding of the potential of this technology. I was pleased to join him in co-sponsoring this legislation which I believe will give the needed incentives to encourage further OTEC research and development.

I urge favorable consideration, Mr. Chairman, of this important legislation.

Senator INOUYE. Our first witness this morning is the Acting Deputy Assistant Secretary for Solar Energy, Conservation and Solar Energy, Department of Energy, Mr. Bennet Miller. Mr. Miller.

STATEMENT OF BENNET MILLER, ACTING DEPUTY ASSISTANT SECRETARY FOR SOLAR ENERGY, CONSERVATION AND SOLARY ENERGY, DEPARTMENT OF ENERGY

Mr. MILLER. Mr. Chairman, it is a pleasure to be here to discuss with you not only the OTEC program, but S. 2492.

I would like to, with your permission, submit my statement for the record and in the interest of time and because I know there is a long list of witnesses, summarize my statement, and then answer any questions that you may have.

Senator INOUYE. Without objection, it will be so ordered.

Mr. MILLER. We feel the OTEC program has made a great deal of progress in the past year. We are extremely encouraged by that, and I would like to review with you a few of the accomplishments that have taken place.

First, we are very excited about what the State of Hawaii and a consortium of industry, including Lockheed, Dillingham, and Alfa-Laval, have done in putting to sea the mini-OTEC. I know you are familiar with it, and we are very excited about the results of that

and feel it is an important step in the development of an overall OTEC program.

I would like to add that we in the department will support a second deployment of mini-OTEC, presumably again with some of our partners in this. But we are anxious to see that particular program continue.

We are also very proud of the fact that the OTEC-1 system, a $40 million undertaking that has been under construction for almost 2 years, has now left drydock and is in the final stages of refitting. Sea trials are scheduled for mid-May and deployment for mid-June.

In our view, this is the key element in the OTEC program. We need to get to a size scale that is sufficiently large that we can confidently predict performance at the 10- to 40-megawatt range. So as we have said on many occasions, the deployment and successful operation of OTEC-1 is the key to going forward with any other parts of the OTEC program on anything that looks like an accelerated timeframe.

OTEC-1 will bring together for the first time all of the subsystems of an operating OTEC on a size scale, as I said earlier, sufficiently large that we feel confident about future performance.

In addition, the program has been working very hard on a number of other problems that would be associated with the ultimate commercialization of OTEC. These include the cable that would carry power from a moored system back to the mainland, the problem of cold water pipe, which in a commercial site system is an enormous engineering problem (although one that I feel quite confident we are going to be able to solve), and finally the area of heat exchangers with the ancillary concern of biofouling.

We have accomplished a great deal in the department's program and with the help of industrial contractors in developing heat exchangers we think are going to work in a commercial OTEC.

We have tested nine heat exchanger configurations at our test facility at Argonne, and we plan to test two remaining units during the fiscal year of 1980. All units have met or exceeded heat transfer criteria. Data on cleaning single tubes at Panama City, Fla. has identified several attractive approaches. We are confident we can solve the biofouling problem one way or another, which means that the heat exchangers, which heretofore had been a major uncertainty, are much less of an uncertainty now with respect to future systems.

In the area of cold water pipe testing, we have tested one large at-sea cold water pipe, and we have two model basin tests that have been concluded. They have indicated directions in which we need to go. It continues to be an area of concern, but again I think it is one where solid and aggressive engineering can solve the problems.

In the area of the underwater cable, we have just initiated a contract for testing to provide design data by the end of 1980. The success of the mini-OTEC or anticipated success of OTEC-1 and progress on the cold water pipe and on the cable give us confidence to begin planning an OTEC pilot plant, which is in the range of 10 to 40 megawatts.

To accomplish this, we are about to issue a program opportunity notice leading to the award of contracts for the competitive conceptual design of an OTEC pilot plant. Both sea-based and land-based designs based on OTEC technology will be considered.

We plan to start multiple concept-definition studies in the first quarter of 1981. Preliminary design would commence a year later. Upon the completion of these designs, and if proceeding to the construction of an OTEC pilot plant is approved, one contractor would be selected to proceed with detail design and construction on a cost-sharing basis.

The pilot plant is, as we see it now, a half physical scale test article of a commercial item for mainland applications and a representative commercial plant for island applications. Thus it is, in our view, necessary to continue the program beyond the pilot plant stage and to build a subsequent demonstration plant for mainland applications.

That, Mr. Chairman, is a very brief review of where we are with respect to ocean thermal energy conversion systems. I think the progress has been remarkably good, considering the relatively limited budget that this program has had. I think it has been effectively managed, and I anticipate that continuing.

I would like to turn now to some of the specifics of S. 2492.

First, it should be noted that as we see it, the legislation can be interpreted as being two bills that have been linked for convenience into a single package. The first title of the bill provides for one-step licensing. We believe that one-step licensing may be a useful and expeditious method for dealing with a facility whose operation involves overlapping responsibilities of many agencies.

We recognize the early need to develop licensing and regulatory procedures and to insure that the construction of commercial facilities is not impeded by any one of those issues.

However, since it is our view that commercial facilities are not likely to be available until the late 1980's, we do not see the need for legislation on this issue at the moment.

However, the department is willing to conduct an in-depth assessment of such regulatory programs, and this would, of course, address the appropriate roles of the numerous agencies whose existing authorities would be applicable to OTEC facilities. We would be perfectly agreeable to moving forward on a rapid basis to undertake that study.

With regard to OTEC demonstration plans, we agree with section 402 of the bill that the Department of Energy should require such projects to abide by as many of the substantive requirements of title I as practicable, without damaging the major or unduly delaying such projects.

It is our view that the pilot plant, and perhaps even the system after that, will still have a certain number of R. & D. kinds of characteristics, and we want to insure that we do not saddle them with commercial licensing requirements.

Regarding title II, we believe it is an inappropriate time to establish a new loan guarantee program. As you know, the administration recently announced new actions to restrain Federal credit, including a $4 billion reduction in loan guarantees in fiscal year 1981, and an increase in control of Federal credit activities.

Accordingly, we cannot support a $2 billion expansion of Federal credit at this time.

We also believe that emerging energy technologies like OTEC should be thoroughly evaluated against other competing energy technologies to determine the degree and type of Federal financial assistance which is warranted.

We believe the Department is best suited to making the tradeoffs required between competing energy technologies.

For the preceding reasons, Mr. Chairman, the administration does not support the enactment of S. 2492 at this time. We see no reasons to provide loan guarantee authority prior to 1985, nor do we currently believe such authority should be effective until an OTEC pilot plant has been successfully operated.

Again, however, as part of the assessment I mentioned before that we were willing to undertake on an expeditious basis, we would be prepared to discuss with you the establishment of appropriate mechanisms for initiating loan guarantees for OTEC in the broadest context of the commercialization of that technology.

Mr. Chairman, that concludes my remarks. I am prepared to answer any questions you may have.

Senator INOUYE. Does DOE believe that OTEC is feasible and has a potential of providing us clean alternative source of energy?

Mr. MILLER. There is no question in our mind that it is technically feasible, yes. The question that remains unanswered at the moment is of economic competitiveness. I think the resource is sufficiently large that we want to continue a strong R. & D. program aimed at, as thoroughly as possible, getting an OTEC system in place to provide baseload electricity to the island market, and then ultimately into the mainland market.

I don't think the questions are ones now of technical feasibility so much as they are ones of economic feasibility at a scale large enough to be commercial.

Senator INOUYE. If that is the case, how do you expect to encourage or assure industry to make the large investments necessary, without some sort of guarantee? I am certain you have been around the scene long enough. They are not going to throw money away.

Mr. MILLER. No, that is certainly quite true. There are a number of different mechanisms that are available, obviously. There are cost-sharing kinds of arrangements. Loan guarantees, I think, are an effective way to encourage industry involvement.

Senator INOUYE. Loan guarantees, sir?

Mr. MILLER. Yes, loan guarantees are an effective way of encouraging industry involvement. However, we do feel that to initiate loan guarantees at this point is premature.

Senator INOUYE. You think it's a losing proposition?

Mr. MILLER. No, sir, I do not think it will be a losing proposition.

Senator INOUYE. Do you think it will fail?

Mr. MILLER. The OTEC system?

Senator INOUYE. Yes.

Mr. MILLER. No, sir, I do not think that will fail.

Senator INOUYE. Then why should the guarantees be such a risk?

Mr. MILLER. There is always a risk in anything. I tend to be technically oriented and sometimes my own enthusiasm for high

technology kinds of operations is not borne out by the facts. It would be nice to be able to say that one could be absolutely 100 percent certain that the systems will work. I believe they will work.

On the other hand, one cannot endorse loan guarantees with a zero amount of money in the Treasury to back them up. Ultimately the Congress will have to appropriate funds to back up those loan guarantees based on some default rate, and we feel that it is premature at this time.

Senator INOUYE. If that's the case, why don't you go along with this authorization bill? There is still an appropriation level.

Mr. MILLER. We have supported the authorization bill to the extent we feel that OTEC-1 has to go to sea and operate successfully before there should be any major commitments to follow-on kinds of pilot plants.

At the same time, we are prepared to undertake design studies for those pilot plants, without making the kinds of major dollar commitments that would be required, we think at this time, for a pilot plant.

Senator INOUYE. In other words, you are telling me and the committee that DOE will be most willing to participate if and when industry comes forth and presents to you on a silver platter a perfect program.

Mr. MILLER. No, sir, I do not think we are saying that. What we are saying is that at this stage in the development of OTEC, with the kinds of scale-ups that are required, it is going to be a few years before there is clear indication of the commercial opportunities in OTEC.

The best that we have to date is the very successful, but still very small, mini-OTEC system. That is a 50-kilowatt system. To go to the next step, which is 40 megawatts, is a scale-up of almost 1,000.

I do not know of a single technology where one takes that kind of leap without a fair amount of trepidation, and we think that from the 50-kilowatt mini-OTEC to the one megawatt OTEC-1, and then to a 40-megawatt plant is a sequence which is prudent, and which will take a few years to accomplish.

I am quite confident that they will be successful, that those steps will be consummated successfully, but until we see OTEC-1 at sea, until we begin to really understand how much a pilot plant is going to cost, we do not believe it is prudent to go forward with a financial incentives kind of package.

Senator INOUYE. If that is the case, and if DOE is so concerned about risk-taking, why spending all that money on shale?

Mr. MILLER. Mr. Chairman, it is not for me to comment on that. That is not an area——

Senator INOUYE. Where is the risk greater? Shale or OTEC?

Mr. MILLER. I cannot answer that. That is not an area in which I can offer you a considered judgment.

Senator INOUYE. What about the gasification of coal? Where is the risk greater? OTEC or that?

Mr. MILLER. Mr. Chairman, I just have to beg your indulgence on those kinds of questions. I do not have the technical expertise to

ment on the technical uncertainties of any of the fossil technol- or synfuel technologies versus OTEC.

am very sanguine about OTEC's prospects, but it would be appropriate for me to comment on the others. I am sorry.

Senator INOUYE. I think you have provided us with the answer, am I correct to conclude from your statement that if moneys re available, you would be for this bill?

Mr. MILLER. Pardon me, I'm sorry, sir?

Senator INOUYE. If moneys were available for loan guarantees, ou would not oppose this measure?

Mr. MILLER. If moneys were made available, no, I would not ppose them. If they were made available, that's the law of the nd, and we will certainly carry it out.

I personally do not think it would be a prudent use of money at this time. I think when we get further down the line of development, I think not only would it then be prudent, it would probably be highly advisable, because I think loan guarantees are a good financial mechanism.

Senator INOUYE. Why is it wrong to have a law on the books that would encourage industry at this stage, even without the money, because you always have your final say with the Appropriations Committee? Because this bill without appropriation is a skeleton without meat.

Mr. MILLER. I understand that. On the other hand, he two do go hand in hand, and support for legislation that c ries with it implications of the sort that are carried forward he e do have an effect on the appropriations process. They must.

Therefore, as part of that integral process, we do not feel it is appropriate.

Senator INOUYE. How will the current budget situation affect your OTEC program?

Mr. MILLER. The OTEC program has not been touched in the present budget process. The OTEC program has been under a lot of pressure internally because we are determined to bring the OTEC-1 into operation, and there has been a modest overrun there that we have had to meet from the rest of the program, and so it has been under pressure internally.

But, in fact, the Department has stood staunchly behind that. They have proposed to the Congress a $6 million supplemental that was supperted by the Administration, and which remains here for action by the Congress.

Senator INOUYE. For OTEC alone?

Mr. MILLER. For OTEC alone, and we are very anxious to see that passed.

Senator INOUYE. What was the cause of this overrun?

Mr. MILLER. Basically it involved the nature of the project. First of all, it is an R. & D. project. Second, we decided to use a T22 tanker and convert it as the platform, because we felt that was the most cost-effective way. When we opened and inspected and finally had to refit that tanker, it just cost us more than we had originally planned.

On the other hand, I would note, and I think it is important that the record show this, originally when we estimated the cost of this

project 4 years ago, we estimated it at about $44 million. We are still below that target, and I think that speaks well for the project.

But the overruns were completely, and totally, unavoidable. When you take a ship out of mothballs and you finally pull up the linoleum and you find out there are holes in the decks you can't predict that beforehand. Also, we had an overrun associated with the cold water pipe system. We had to modify the contractors design to enable it to withstand better the ocean forces. It just cost more than we expected to refit.

Senator INOUYE. Mr. Miller, we have several questions here. Most of them are of a highly technological—would require a technological response, so may I just submit this to you for your study and response?

Mr. MILLER. Yes, sir, of course.

Senator INOUYE. Thank you very much.

[The statement follows:]

STATEMENT OF BENNETT MILLER, DEPUTY ASSISTANT SECRETARY FOR SOLAR ENERGY (DESIGNATE), DEPARTMENT OF ENERGY

Mr. Chairman and Members of the Committee: It is a pleasure to be here today to review with the Committee the Ocean Energy Systems program in the Department of Energy and provide DOE comments on S. 2492, the Ocean Thermal Energy Conversion Act of 1980. I shall begin by briefly reviewing the nature and general direction of the OTEC program, including a recap of recent progress in our efforts to develop cost-effective, reliable ocean thermal energy conversion technology.

There is no need to call the energy supply events of 1979 to the Committee's attention; our critical situation with regard to imported petroleum is all too evident. In time, we think that OTEC might play an important role in reducing our dependence on imported oil, first in U.S. islands such as Hawaii and Puerto Rico, which are almost totally dependent on imported oil, and later on the mainland.

We are encouraged by the progress that has been made in ocean thermal systems development during the past year. In particular, we commend the initiative of the State of Hawaii and a consortium of industry including Lockheed, Dillingham and Alfa-Laval in funding and successfully operating the "Mini-OTEC" systems experiment. That experiment demonstrated the OTEC concept by producing net power from a closed-cycle OTEC system operated off the Kona Coast of Hawaii during the fall of 1979.

I am pleased to report that the cornerstone of the DOE OTEC program, the seabased engineering test facility known as OTEC-1, has left drydock and is in the final stages of refitting. Sea trials of OTEC-1 are scheduled for May and testing off Hawaii is expected to begin in early June. This facility will provide essential data on the operation and durability of candidate heat exchangers in an OTEC marine environment. Although data already obtained in small laboratory and ocean experiments are encouraging with regard to the ability to clean tubular heat exchangers in rapidly fouling locations, the OTEC-1 facility will provide definitive proof for large-scale hardware. The acquisition of these performance data will permit us to proceed with preliminary design of the OTEC pilot plant.

I would like to now provide a brief review of DOE's OTEC program. As you know, an OTEC system consists of a power plant, a platform or hull to house the plant equipment, seawater systems for handling warm and cold seawater, energy conversion subsystems, and a method of energy distribution. The power plant design may be either open cycle, where water/steam is used as a working medium, or the closed Rankine thermodynamic cycle, using a working fluid (e.g., ammonia or Freon) that can evaporate and condense over a small temperature range. The closed cycle OTEC system with ammonia as a working fluid was selected as the baseline system for early OTEC development because it represented the best balance of economics, technical risk, and technology adaptation.

In a closed-cycle plant, warm surface seawater is pumped into an evaporator where ammonia liquid is heated and vaporized. The ammonia vapor is fed into a turbo-generator where the thermal energy of the vapor is converted into mechanical and then electrical energy. The vapor leaving the turbine is fed into a condenser where it is cooled and condensed into a liquid again. The condenser receives its cooling water through a long pipe (some 2500 to 3000 feet) reaching down into the

ocean depths. The condensed ammonia is pressurized and returned to the evaporator to complete the cycle.

Appropriate sites for present OTEC plant designs are generally restricted to latitudes between 20 degrees north and south of the equator. Suitable sites for the continental United States, namely those at a reasonable submarine-cable distance from shore, are available in the Gulf of Mexico from Florida to Texas. Islands such as Hawaii and Puerto Rico which are located close to good ocean thermal resources may provide earlier competitive markets than the Gulf for initial commercial OTEC plants, since most of their fuel for electrical generation is imported oil. An alternative utilization of the thermal energy resource would be to use the electric power generated at a sea-based OTEC plant to refine a metal such as aluminum or to produce energy-intensive fuels or chemicals such as hydrogen, ammonia or methanol, which can then be shipped for use elsewhere. In this kind of application, OTEC plants would not be moored but rather would operate well out to sea in order to exploit the greatest available temperature differences. For these plantship applications, submarine cable connections to shore would not be needed.

Critical subsystems and components that currently require further experimental verification or development are the heat exchanger cleaning system, the OTEC-to-shore riser and deep-sea bottom-laid transmission lines capable of carrying large amounts of electrical energy, and the cold water pipe or pipes that must extend some 3,000 feet down into the ocean. The intense exploratory and development work done in the past five-years has brought OTEC systems development to the point where ocean tests can be planned with confidence. To date we have completed testing of nine candidate heat exchanger configurations at the OTEC core-test facility at Argonne National Laboratory, and we plan to test two additional units during the remainder of fiscal year 1980. The thermal performance of several advanced heat exchangers was confirmed in those tests. Single tube testing at Panama City, Florida has identified several attractive cleaning approaches that are likely to be successful for larger hardware. In addition, one large at-sea cold water pipe test and two model basin pipe tests have been concluded. The experimental measurements are being compared with predictions from cold water pipe analytical design models. Preliminary results of these comparisons encourage confidence in the available models. We have also just initiated a contract for electric cable load testing to provide design data by the end of 1980.

As I mentioned before, industry and the State of Hawaii have joined together to deploy an early at-sea experiment of OTEC technology called the Mini-OTEC. No federal funds were used for that deployment. This year, however, we expect to provide DOE support to permit Mini-OTEC to resume operation and provide valuable additional data to the OTEC program. Mini-OTEC demonstrated for the first time the operation of an ocean thermal energy conversion plant generating net power—that is, power remaining after meeting the plant's internal energy requirements.

The success of Mini-OTEC, coupled with the expected results of the OTEC–1 experiments, the progress on the cold water pipe verification program, and the progress on the cable development, give us the confidence to begin planning an OTEC pilot plant. To accomplish this, we are about to issue a Program Opportunity Notice (PON) leading to the award of contracts for the competitive conceptual design of an OTEC pilot plant. Sea-based and land-based designs based on OTEC technology will be considered.

We plan to start multiple concept-definition studies for a pilot plant in the first quarter of fiscal year 1981. Preliminary design would commence a year later. Upon the completion of these designs, and if proceeding to the construction of an OTEC pilot plant is approved, one contractor would be selected to proceed with detail design and construction on a cost-sharing basis. The pilot plant is contemplated as a half physical scale test article of a demonstration or small commercial plant for island applications. Thus, it is a necessary engineering development to demonstrate system integration, verify large subsystem performance, and define costs for larger systems.

I will now turn to the specifics of S. 2492. First, it should be noted that the legislation could be interpreted as being two bills that have been linked for convenience into a single package. The first title of the bill provides for one-stop licensing of commercial OTEC plants. We believe that one-stop licensing may be a useful and expeditious method for dealing with a facility whose operation involves overlapping responsibilities of several agencies of the Federal government. We recognize the early need to develop licensing and regulatory procedures for OTEC plants so that planning for construction of commercial facilities is not impeded by uncertainties relating to legal or regulatory issues.

However, since we do not expect commercial facilities to be available unitl the late 1980's at the earliest, we see no need for a licensing and regulatory program at this time. If warranted, such a program could be established several years hence and still not inhibit commercial development of OTEC facilities. Meanwhile, the Department is willing to make an assessment of the need for and dimensions of such a regulatory program. This would, of course, address the appropriate roles of numerous agencies whose existing authorities would be applicable to OTEC facilities.

With regard to Title II, we believe it is an inappropriate time to establish a new loan guarantee program. As you may know, the Administration recently announced new actions to restrain Federal credit programs, including a $4 billion reduction in federal loan guarantees in fiscal year 1981 and an increase in control of Federal credit activities. Accordingly, we cannot support a $2 billion expansion of Federal credit at this time.

We also believe that emerging energy technologies like OTEC should be thoroughly evaluated against other competing energy technologies to determine the degree and type of Federal financial assistance which is warranted. We believe that DOE is better suited to making the tradeoffs required between competing energy technologies.

For the preceding reasons, the Administration does not support the enactment of S. 2492 at this time. We see no compelling reasons to provide additional loan guarantee authority prior to 1985 nor do we currently believe that such authority should be effective until an OTEC pilot plant has been successfully operated. As part of the assessment I mentioned above, we would be prepared to discuss with you the establishment of appropriate mechanisms for initiating loan guarantees for OTEC.

Mr. Chairman, this concludes my statement. I will be pleased to answer any questions you or the other Members of the Committee may have.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. OTEC is a capital intensive development still in the formative stages. You mention that the Administration does not support loan guarantees for these plantships and facilities. The only real way to move toward commercialization is for private industry to play a large role which includes a large financial commitment. How, then, would you encourage and *assure* industry to make that large initial investment to build OTEC without some sort of loan guarantees?

Answer. In my testimony I mentioned that loan guarantees would probably not be required until after the deployment of a pilot plant in 1985. I believe that, eventually, loan guarantees may very well be effective in commercializing OTEC technology. However, I feel it is important that a pilot plant be built and tested before loan guarantees are offered. A pilot plant will decrease technical uncertainties and demonstrate an integrated system.

Question. In talking about the pilot plant, you mention that a single contractor will be chosen to proceed with construction. We have talked with representatives of dozens of industries that have become involved in some phase of OTEC technology. What happens to these people in the interim while you test the pilot plant? Do they then go out of the business or do you anticipate some sort of offbudget incentive for these companies to maintain their interest towards eventual commercialization?

Answer. There is a tradeoff between money invested for a single industrial consortium to build a single pilot plant, and the investment required for multiple groups building multiple pilot plants. Only one pilot plant is needed to acquire the system integration, operation, maintenance, techncial and cost data required to proceed with a demonstration plant. The cost of additional pilot plants is not justified by the additional technical or operational data which might be obtained. We anticipate that the industries not directly involved in the pilot plant will follow its development with interest while continuing their participation in the subsystem and component development portion of the program.

Question. Are there plans for the redeployment of MINI-OTEC of Hawaii? What is the timeable for this?

Answer. The Department of Energy has received a proposal for the redeployment of Mini-OTEC. Subsequent to receipt of that proposal, the Mini-OTEC cold water pipe was lost. On May 7, 1980 we were informed that the pipe had been located on the ocean bottom. Prior to arriving at a final decision we require a proposal revision to define the cost and technique for furnishing a cold water pipe. We have set aside $150,000 in FY 1980 funds for the design work that is required before a second

deployment. However, providing support is contingent upon a satisfactory proposal revision and evaluation. If these are received, we plan to proceed with installation and deployment in the early part of fiscal year 1981.

Question. Does DOE have an integrated program to develop OTEC which includes (1) the development of the OTEC technology, (2) the development of ammonia, fresh water, aquaculture, and other products, and (3) the development of fuel cells which would use ammonia as the feed stock to generate electricity? How is this effort organized, coordinated and funded within DOE?

Answer. An integrated program plan to develop OTEC technology has been developed which ultimately leads to the 40MWe pilot plant via OTEC-1. Major technology development programs are being conducted in heat exchangers, cold water pipes and electric cables. All critical technical issues are to be addressed in significant experiments by fiscal year 1981?

The OTEC program is proceeding with a land based test facility which could be used to perform aquaculture experiments as an adjunct, provided a modified environmental plan is written. The program is also preoceeding with open cycle systems which can produce fresh water. These systems are being developed on a schedule 2-3 years behind that of the closed cycle system. The energy storage systems program is supporting hydrogen fuel cell development. We expect it to be available by 1985.

The Ocean Energy System Division of the Office of Solar Power Applications is responsible for the development of OTEC technology relevant to the production of electric power and fresh water. The hydrolysis equipment required for ammonia production and fuel cell development is the responsibility of the energy storage systems office. Coordination is performed by periodic division meetings and status reports.

Question. Some people have suggested that the success of Mini-OTEC has largely obviated the need for OTEC-1 and that DOE should be proceeding now with the funding for the design of one or several pilot plants.

Could the design and construction of a 40 megawatt pilot plant proceed at the same time, (concurrently), with the development of DOE's long-range program for OTEC ?

Answer. The purposes of the Mini-OTEC and OTEC-1 programs are significantly different. Mini-OTEC was conceived as an early demonstration of an OTEC system to be operated for a short period of time. The OTEC-1 is to be a power system test facility to test and demonstrate several different heat exchangeers, heat exchanger materials, configurations and cleaning systems. The heat exchanger technology demonstrated on Mini-OTEC is for a titanium plate heat exchanger with a chemical cleaning system. We have no data on the efficacy of any cleaning countermeasures used on Mini-OTEC. No attempt was made to determine optimal materials, configurations or cleaning systems. OTEC-1 is a project intended to demonstrate commercial and advanced state of art power system components that improve cost effectiveness. The second deployment of OTEC-1 is especially intended to evaluate new heat exchanger concepts. The design and construction of a 40 MW pilot plant is an element of DOE's long-range program for OTEC. As part of the fiscal 1981 budget submission, it was recommended that the design effort for the pilot plant be initiated and that the pilot plant program be conducted concurrently with other OTEC activities.

Question. Some have suggested that DOE has yet to appreciate the impact of the doubling of the cost of oil and the risks involved in depending upon foreign oil—that DOE is still in the process of attempting to perfect an alternative energy technology that can be filed away in a filing cabinet and be brought out some time in the future when it is needed rather than actively providing leadership to develop OTEC as an industry which can help us solve our energy problem. Is this is a fair criticism?

Answer. The criticism is not fair. DOE appreciates the impact of escalating oil prices, their impact on our balance of payments and the risks inherent in foreign control of strategic materials. DOE also appreciates the double importance on our economy of replacing imported oil with renewable resources which create new jobs that are not competitive with existing U.S. industries. The Department is developing alternate energy sources that will take their place in the energy supply as soon as they are technically and economically ready. Some of these technologies are now entering the market place. Others still requires more development and demonstrations of operating systems before a competitive industry and market can be fully realized.

Question. You mention starting the preliminary design phase of your pilot plant about 1982. Have you established a timetable for completion and testing of this?

Answer. Yes. The first phase for the OTEC pilot plant is conceptual design to be performed in 1981 and the next phase is preliminary design in 1982. Detail design

and construction will follow in 1983 and 1984. Completion is scheduled for 1985 with a one year period for operational tests and evaluation.

Question. The comment has been made that, for your own prototype OTEC facility, DOE has chosen the most expensive design for the heat exchanger—to be manufactured from titanium, the most expensive metal. What is the rationale for these choices?

Answer. The OTEC–1 first deployment will be used to evaluate a titanium shell and tube power system because titanium has demonstrated corrosion resistance sufficient for a 30 year life, is more easily cleaned and is cost effective for an island application. The second deployment will test aluminum, stainless steel and titanium heat exchangers in several shell-tube and plate configurations. As of this date, titanium or stainless steel are still the most cost-effective choices for OTEC heat exchangers when we consider the lifetime, biofouling and corrosion resistance requirements.

Interest is great in developing an aluminum alloy system with a sufficiently long life to take advantage of its low cost compared to titanium. A great deal of development work is proceeding with aluminum, as well as copper-nickel and other candidate metals for OTEC.

Question. At what level of funding is DOE doing and supporting research and development of the use of fuel cells to generate electricity using ammonia as a feedstock?

Answer. At present, DOE is not supporting any projects on the use of fuel cells which use ammonia as a feedstock. However, reforming ammonia to produce nitrogen and hydrogen is a straightforward process, so the entire DOE fuel cell development program is applicable to systems in which ammonia would be used as feedstock. The fiscal year 1981 budget request for fuel cell research and development is $25 million. The corresponding budget for fiscal year 1980 is $26.5 million.

Question. What actions, in the opinion of the Department, could be taken to accelerate the commercialization of OTEC?

Answer. In the DOE plan we have proposed a pilot plant as an essential element to minimize risk and permit industry to proceed to commercial systems. An alternative proposal would be to eliminate the pilot plant but provide loan guarantees to allow industry to proceed directly to a commercial size plant.

We don't know if industry will proceed with this approach without the operating experience provided by the pilot plant. Another approach would be for the Federal Government to give low interest loans to island governments who would then construct and operate their OTEC plants suited to their specific needs.

The present DOE plan could be shortened by one year by deleting conceptual design for the pilot plant at a significant risk of project cost overrun.

Question. What prevents DOE from funding the design of a pilot plant today? Industry reports that they are ready now, in fact were ready over nine months ago, to design and build a 40 megawatt plant. What could be done to acclerate the schedule outlined in your testimony? How large are the potential risks of moving ahead now with the building of a pilot plant? What are the costs of delaying the building of the pilot plant by one, two or three years?

Answer. DOE is preparing to release a solicitation for the design of a pilot plant. Our plans call for conceptual designs in fiscal year 1981, preliminary designs in fiscal year 1982 and construction in fiscal year 1983 to fiscal year 1985 of a 40 MW pilot plant. A year can be potentially saved in the schedule if conceptual design is deleted. However, we do not recommend this approach since it would probably lead to cost overruns due to incomplete design specifications of the pilot plant. Otherwise it is difficult to see how the construction schedule can be accelerated. Delays in building the pilot plant will ultimately relate to further balance of payments deficits for oil imports. It is estimated that each 100 MW OTEC network will save 3,800 barrels of oil a day. However proceeding with pilot plant construction now, before data from the first deployment of OTEC–1 is available to incorporate into pilot plant design entails a high technical risk and will probably lead to redesign in the middle of the construction phase.

Question. What changes in the scheduling funding and programming of OTEC have occurred as a result of, (a) the recent doubling of the cost of oil and its likely future increases, (b) the successfully demonstration of Mini-OTEC—with its implications for energy and the environment, and (c) OTEC's potential for providing electricity which is pollution free, through fuel cell technology, to locations which have severe problems of pollution from oil, coal, and other sources of pollution?

Answer. Changes in the scheduled funding and programming of OTEC have not occurred because of the items listed. The number of supporters in industry and in the government has been significantly increased by the success of the Mini-OTEC demonstration.

Question. What is the earliest time that the federal treasury would have to assume any fiscal risk, of a monetary kind, from the proposed loan guarantees if this act was enacted?

Answer. Presumably it would be when a company wished to start a construction project and would apply for a loan guarantee. This would be fiscal year 1981 at the earliest. Since there would be a one to two-year design, major dollars to cover construction activities may not be required until fiscal year 1982 or 1983. The time of greatest risk would be near completion of construction or after deployment and operation of the OTEC plant, when there would be potential for significant cost overruns or major component malfunction. This would be around fiscal year 1984 through fiscal year 1986. This risk could be high because technical performance and ability to pay back the loan could not be evaluated without the data base from construction and operation of a pilot plant.

Question. What actions need to be taken to accelerate the development of OTEC for commercial purposes? Your testimony states that you "do not expect commercial facilities to be available until the late 1980's at the earliest." What action would need to be taken to make them available by 1985? In short, what are the alternative development strategies for OTEC?

Answer. Alternative development strategies were discussed in the answer to question 10. These include loan guarantees to industry, low interest loans to island governments and deletion of the conceptual design phase of the pilot plant project.

Question. How does the risk factor of OTEC compare with the risks involved in (a) synfuels, (b) coal gasification, (c) oil shale development, and (d) increased use of coal?

Answer. OTEC has several technical features which are feasibility issues such as the ability of the cold water pipe and electric cables to survive the worst storm in 100 years. Also, until a pilot plant is built and operated, cost-effectiveness will remain an element of risk. The issues associated with the other options mentioned are primarily ones centered around cost effectiveness and environmental impact. OTEC appears to have a lesser number of critical environmental issues associated with it, but a detailed comparison has not been performed.

Question. Is the description of DOE's OTEC program schedule accurately described in the testimony (a copy of that testimony is attached) by Sea Solar Power presented on May 1, 1980?

Answer. DOE's OTEC program schedule to operate a pilot plant by 1985 with conceptual/preliminary designs to be initiated in 1981 is an accurate representation. The technology development program for island systems will actually be completed in fiscal year 1981 rather than by the end of fiscal year 1980, due to the delay in the at-sea cold water pipe test program.

Question. What are the comparative risks, costs, and benefits of building and testing the proposed 100 MW plant vs. Solar Sea Power's proposal that we build one or several 100 MW plants instead of this small pilot plant? What are the relative time factors? What are the costs of imported oil that would be eliminated with the earlier development of 100 MW plants?

Answer. The purpose of the pilot plant is to minimize technical risk, demonstrate integrated performance, and provide a better basis for cost projections. If a scaled-down system is sufficient to demonstrate the above criteria then it is cost effective. DOE is therefore considering a pilot plant where the marine subsystems are one-half physical size of a commercial system. The reason for considering implementation of only one 10 MWe power module is that it also can demonstrate all required technical goals at less cost. If a contractor considers a 40 MW power system more cost effective due to pay back of the electrical power produced then it is a viable option. Until a pilot plant is constructed, the cost and technical risk of building a number of larger commercially oriented systems appears to outweigh the benefits.

The immediate initiation of several 100 MW plants is not likely to speed the energy contribution of the OTEC industry beyond those first few plants because the industry would still wait to observe the operation of those first plants before building any more. The schedules for one 40 MW pilot plant and several 100 MW plants would be approximately the same, with operation probably starting in 1985 or 1986.

A 40 MW pilot plant is estimated to cost $280 million in current year dollars. A 100 MW plant is likely to approach $400 million. Each 100 MW plant would save 3,800 barrels of oil per day, or about 1.4 million barrels per year. At $30 per barrel, the savings are $42 million per year. If several 100 MW plants are built, the savings would be multiplied accordingly. To find the differential savings of this approach over the current program, the savings from the 40 MW pilot, $17 million per year, should be substracted from the total.

Senator INOUYE. Our next witness is Mr. James P. Walsh, the Deputy Administrator of National Oceanic and Atmospheric Administration. Welcome to the committee, sir.

STATEMENT OF JAMES P. WALSH, DEPUTY ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. WALSH. Good morning, Mr. Chairman.

Senator INOUYE. Welcome back to the committee room.

Mr. WALSH. It's a pleasure to be here. I welcome the opportunity to testify before you today on the Department of Commerce's views concerning S. 2492, the Ocean Thermal Energy Conversion Act of 1980.

I will direct my remarks primarily to those aspects of the bill which relate to the regulation and licensing of OTEC facilities and plantships.

In particular, I would like to discuss the potential benefits and potential problems associated with the commercial development of OTEC, and to comment on the OTEC licensing and regulatory scheme proposed in the bill.

I will, however, defer to the Department of Energy for an expression of the administration's position on the bill.

Senator INOUYE. You are against loan guarantees?

Mr. WALSH. Yes, sir; the administration is against loan guarantees.

Senator INOUYE. Oh, the administration is against it. Thank you.

Mr. WALSH. It's a back-door spending item that needs to be brought under control, and we feel that generally this kind of activity needs to be looked in more in depth than we have in the past.

The President in his 1979 environmental message set a national goal of obtaining 20 percent of the Nation's energy from the Sun and other renewable resources by the year 2000.

The development of an OTEC industry represents the potential for a new source of renewable, low-cost energy. Although three technology areas—salinity gradients, waves, and currents—are being pursued as possible sources of energy from the ocean, OTEC is the most advanced at this point.

Furthermore, OTEC has a fundamental advantage over other solar energy systems because the resource is available day and night, any time of the year.

In theory, ocean thermal gradients could be a prodigious source of energy. It has been estimated that OTEC facilities could make a significant contribution to the amount of electric power used in the United States at a cost competitive with coal and nuclear energy.

And, unlike fossil fuel energy sources, OTEC operating costs do not escalate with raw material prices, because OTEC fuel is a free good.

Consequently, ocean thermal energy conversion has the potential, if successful, to displace or augment in part foreign supplies of oil and gas resources, and to reduce our balance-of-payments deficit.

Energy produced at OTEC facilities could be used in several ways. The first plants are likely to operate at sites off islands such

as Puerto Rico and Hawaii, transmitting electric power to the island by underwater cable.

The Department of Energy has estimated that energy from OTEC sources could penetrate the U.S. islands market at a rate of several gigawatts by the year 2000, and about 10 gigawatts by the year 2014.

Other possible sites are found in the gulf coast area.

The electrical energy produced through the OTEC process could be used as well at sea-based plants to refine metals or produce chemicals such as ammonia. In addition, ammonia is beginning to be used in fuel cells for producing electric power.

Overall, the OTEC process appears to be a promising area in the renewable technology area, provided the technology evolves in a cost-effective and environmentally acceptable manner.

Let me now turn to the issues associated with OTEC development.

Unfortunately, there are several unresolved issues which cloud the future of OTEC. These uncertainties are both developmental and environmental.

We first discuss the technological question. The basic OTEC process is quite simple in theory. The process, as you know, uses the thermal difference between warm surface waters and the colder deeper water in the ocean as an energy source to generate electricity.

The electrical energy then can be transmitted ashore or used in processing plants at sea. Although several mini-OTEC demonstration projects have been tested, much is yet to be learned before this technology can be applied to construction of a full size commercial facility.

The basic strategy for OTEC system development at this point is to use state-of-the-art technology, developing using adaptations and innovations as necessary.

Subsystems and components that require further development, include heat exchangers, cold water pipes, electric transmission cables, hull structures and seakeeping systems of the entire system.

NOAA is presently helping to find solutions to these technical problems by working with the Department of Energy as a contractor. Because the legislative authority for OTEC initiatives, especially in large scale development, rests with the Department of Energy, NOAA's main effort in this area has been via reimbursable funding from that department.

Since early 1977, NOAA has managed over $10 million of research activity in conjunction with DOE. Through a series of agreements with DOE, we have provided technical management for design studies on platforms, cold water pipes, and stationkeeping; for analytical computer modeling for OTEC design analyses and validation; and for development of plans for construction and installation of commercial-size OTEC structures.

Through a variety of other contract and reimbursible arrangements, the NOAA Data Buoy Office conducted biofouling and corrosion experiments, and the Environmental Data Information Service has created and is maintaining an OTEC data base, principally related to the best site locations.

In 1980, work by NOAA is planned on the OTEC platform, seawater and seakeeping systems. We believe that completion of our ocean engineering studies will help establish the data base necessary to understand the final requirements of a full-scale commercial OTEC facility.

In addition, there are several environmental questions that remain unanswered concerning the effects of installing, operating, and maintaining a full-scale OTEC facility. Undoubtedly problems will exist with incidental pollution from vessels and construction materials similar to those caused by other kinds of offshore facilities, such as oil drilling platforms.

There may also be environmental impacts unique to OTEC. Because there has not yet been full scale operation of an OTEC facility, the types and extent of these impacts cannot be assessed with certainty but several aspects of OTEC operations might raise environmental concerns.

For example, the potential effect of an OTEC discharge as a thermal plume raises the most significant issue, we believe. In operation, an OTEC plant will pump enormous amounts of warm surface waters and colder waters from depths of about 3,000 feet, which will then be discharged at intermediate depths.

For example, a 400 megawatt OTEC plant will require a rate of flow of about 900,000 gallons per second. This is approximately the same flow rate of water from the Nile River.

Furthermore, to achieve an economically viable operation, the maximum temperature differential possible between cold and warm water must be maintained. The changes wrought on the surface and near-surface environment by such large amounts of water varying substantially in temperature cannot be predicted. Water temperature is an important variable that determines the character of the surface ocean environment and, in fact, will influence local weather conditions and possibly climate. Large temperature changes could possibly alter the environment.

Assuming these potential effects are adverse, the thermal impacts on the ocean might be mitigated somewhat by placing the discharge outlet at some intermediate depth, and I believe this is being considered. However, questions will remain about the consequences of moving and mixing waters from two intake points containing different nutrients and biota, and depositing them at a different location.

In short, several environmental questions do remain. What will be the resulting changes in upper ocean chemistry? What effect will these physical and chemical changes have on the biological aspects of the ecosystem? What will be the nature and extent of effects on ocean circulation and the climate?

Potential adverse impacts, as well as possible mitigating measures, should be reasonably understood before we venture into commercial operation. Further studies of these impacts are under way. We may be able to benefit from the studies we have already undertaken concerning possible deep seabed mining environmental impacts, by applying that data to the OTEC model.

In addition, there are environmental problems related to the biocides that will be used to remove biological growth from the

surface of the heat exchanges and from the inside of pipes, and pollution may occur from discharges around the facility.

These issues all deserve further attention, Mr. Chairman.

In conclusion, in light of the uncertainties surrounding the development and economic feasibility of the OTEC industry, we believe that comprehensive legislation detailing a regulatory and licensing regime is premature. We and other concerned agencies will be keeping abreast of the developments in this area and undertaking the necessary studies, so that when regulation is viewed as timely, the public interest of protecting the environment will be met, while giving the industry a clear picture of the requirements that they will have to deal with.

Mr. Chairman, that concludes my statement, and I will be happy to answer any questions that you may have within the scope of my testimony.

Senator INOUYE. When will this technology pass the premature stage?

Mr. WALSH. That's a very good question.

Senator INOUYE. It is a good question?

Mr. WALSH. I believe that the first phase is not even completed as yet, so one would say we will have a better handle on it at some time in the next 2 or 3 years. As you mentioned with the previous witness, the question of the timing of the legislative framework is one that may or may not be related to the precise stage of development of this industry.

As an example, the deep seabed mining industry has invested several hundreds of millions of dollars although legislation has been under consideration by the Congress for about 9 years now.

It is just hard to say when the time is right. It depends on a number of factors, not only the state of the technology, but also the need for the legislation and other factors.

Senator INOUYE. I was deeply moved and impressed by your concern about the environment and I join you in that. If such be the case, why do we permit offshore drilling, where the risk have been demonstrated? It is not a gamble.

Mr. WALSH. Well, the concerns I expressed with regard to the environment are not conclusory. We do not have any conclusions.

We are saying that these things do need to be studied, and there are uncertainties. With oil and gas drilling, we have had many years of experience, not only good experience, but some bad experience, so we have a better idea of the risks we face.

Senator INOUYE. That's acceptable risk, isn't it?

Mr. WALSH. And it has been deemed to be acceptable risk, yes.

Senator INOUYE. If that is acceptable, I can't see anything wrong with this risk here.

Mr. WALSH. I am not saying that the environmental concerns alone are a reason not to go forward. I didn't mean to give you that impression.

For example, with regard to deep seabed mining, an activity which is likely to be in some ways more polluting and maybe a little more deleterious than OTEC, we have judged that the risks are acceptable. With OTEC we just don't know as much about what happens when this large amount of water comes to the surface. It

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obviously will be a major change to a marine ecosystem. That is all. Consequently, we believe it needs to be studied.

But I am not recommending the legislation be held up because of that uncertainty. It is because of the range of other uncertainties.

Senator INOUYE. What is the major reason for opposing this measure? The loan guarantee?

Mr. WALSH. Well, I believe the witness from the Department of Energy has spelled it out, but it is the feeling that this is not the time to establish a new bureaucratic structure which will require the hiring of new individuals and additional Federal expenditures. There is a feeling that the loan guarantees may or may not be necessary at this time, since we are still at an early stage. Furthermore, the legislation does not have to be enacted today in order for us to proceed in the direction we are currently proceeding with our Federal programs.

Senator INOUYE. What sort of message do you think this will send to industry?

Mr. WALSH. Well, I think the message industry is getting is that the Federal Government is presently investing sizable amounts of its money to investigate the uncertainties in OTEC. Here again, using the analogy of the deep seabed mining industry, that industry simply cannot go forward without the deep seabed mining legislation because of the uncertainty of the international situation.

I don't believe that is the case here in OTEC.

Senator INOUYE. I can tell you that according to my mailbag, it is almost unanimous on the part of industry's feeling that you people are dragging your feet.

Mr. WALSH. Well, dragging your feet or waiting until the right time, I guess is a matter of where you sit. I am not surprised that the industry says we are dragging our feet. The administration's position is that there will be a time for this legislation. It is generally conceded to be needed. But the question is when, and we disagree that now is the time.

Senator INOUYE. Well, Mr. Walsh, I am well aware of the problems you have as a member of the administration, so I thank you very much.

Mr. WALSH. Do you know something I don't?

Senator INOUYE. We would like to submit to you several other questions, if we may.

Mr. WALSH. We would be glad to answer them.

[The statement follows:]

STATEMENT OF JAMES P. WALSH, DEPUTY ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. Chairman, I am pleased to appear before you today to present the Department of Commerce's views on S. 2492, The Ocean Thermal Energy Conversion Act of 1980 (the "bill"). I shall direct my remarks primarily to those aspects of the bill which relate to regulation and licensing of OTEC facilities and plantships. In particular, I would like to discuss the potential benefits of the problems associated with the commercial development of OTEC, and to comment on the OTEC licensing and regulatory scheme proposed in the bill. I will, however, defer to the Department of Energy for an expression of the Administration's position on this legislation.

I. BENEFITS AND USE OF OTEC

President Carter, in his 1979 Environmental Message, set a national goal of obtaining 20 percent of the Nation's energy from the sun and other renewable

resources by the year 2000. The development of an OTEC industry represents the potential for a new source of renewable, low-cost energy. Although three other technology areas—salinity gradients, waves, and currents—are being pursued as possible sources of energy from the ocean, OTEC is the most advanced at this point. Furthermore, OTEC has a fundamental advantage over other solar energy systems because the resource is available day and night, anytime of the year.

In theory, ocean thermal gradients could be a prodigious source of energy. It has been estimated that OTEC facilities could make a significant contribution to the amount of electric power used in the U.S. at a cost competitive with coal and nuclear energy. And, unlike fossil fuel energy sources, OTEC operating costs do not escalate with raw material prices because OTEC "fuel" is a free good, at least when the facility is located in our territorial sea or in international waters. Consequently, ocean thermal energy conversion has the potential, if successful, to displace or augment, in part, foreign supplies of oil and gas resources and to reduce the U.S. balance-of-payments deficit.

Energy produced at OTEC facilities could be used in several ways. The first OTEC plants are likely to operate at sites 2-3 miles off islands such as Puerto Rico and Hawaii, transmitting electric power to the island by under-ocean cable. The Department of Energy has estimated that energy from OTEC sources could penetrate the U.S. islands market at a rate of several gigawatts [1] by the year 2000 and about 10 gigawatts by 2014. Other possible sites are found along the Gulf Coast. As well as reducing dependence on foreign fuel in these areas, an OTEC industry could contribute to local economic development, both in terms of employment and new industrial activity.

The electrical energy produced through the OTEC process could also be used at a sea-based plant to refine metals or produce chemicals such as ammonia (ammonia is used as fertilizer to produce corn and wheat), and as an element of industrial products such as caprolactum (a form of rubber), nylon and acrylon. In addition, ammonia is beginning to be used in fuel cells for producing electric power.

Overall, ocean thermal energy conversion appears to be a promising area in renewable energy technology, provided the technology evolves in a cost-effective and environmentally acceptable manner.

II. ISSUES ASSOCIATED WITH OTEC DEVELOPMENT

Unfortunately, several unresolved issues cloud the future of OTEC. These uncertainties are both developmental and environmental.

A. Technological questions

The basic OTEC process is quite simple in theory. The process uses the thermal difference between the warm surface waters of the ocean and the colder deep water as an energy source to generate electricity. As I mentioned earlier, the electrical energy produced may then either be transmitted ashore or be used in on-board processing. Although several mini-OTEC demonstration projects have been tested, much is yet to be learned before this technology can be applied to construction of a full size commercial facility or plantship. The basic strategy for OTEC system development as this point is to use state-of-the-art technology with adaptations and innovations as necessary. Subsystems and components that require further development include heat exchangers, cold water pipes, electric transmission cables, and hull structure and seakeeping systems.

NOAA presently is helping to find solutions to these technical problems. Because the legislative authority for the OTEC initiatives, especially in the large scale development of nonmineral ocean energy resources, rests with the Department of Energy, NOAA's main efforts in the area have been via reimbursable funding from the Department of Energy. Since early 1977, NOAA has managed over $10 million of research activity in conjunction with DOE. Through a series of Interagency Agreements with DOE, NOAA has provided technical management for design studies on platforms, cold water pipes, and station-keeping; for analytical computer modelling for OTEC design analyses and validation; and for development of plans for construction and installation of commercial size OTEC structures. Through a variety of other contract and reimbursable arrangements, the NOAA Data Buoy Office conducted biofouling and corrosion experiments, and the Environmental Data Information Service (EDIS) created and is maintaining an OTEC data base. In fiscal year 1980 ocean engineering work is planned on the OTEC platform, seawater, and seakeeping systems. However, we believe completion of our ocean engineering work will help establish the data base necessary to understand the requirements for an operational OTEC technology.

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[1] A gigawatt is a thousand megawatts.

B. Environmental uncertainties

Important questions about the environmental effects of installing, operating and maintaining full-scale OTEC facilities still remain. Undoubtedly, problems will exist with incidental pollution from vessels and construction materials similar to those caused by other kinds of offshore facilities, such as oil drilling platforms. There may also, however, be environmental impacts unique to OTEC operations. Because there has not yet been full-scale operation of an OTEC facility, the types and extent of these impacts cannot be assessed with certainty, but several aspects of OTEC operations might raise environmental concerns.

The potential effects of an OTEC plant's discharge as a thermal plume raise the most significant issues. In operation, an OTEC plant will pump enormous amounts of warm surface waters and colder waters from depths of about 3,000 feet, which will then be discharged at intermediate depths. For example, a 400 megawatt OTEC plan will require a 900,000 gallon per second flow rate of surface and deep water, approximating the flow rate of the Nile River. Furthermore, to achieve an economically viable operation, the maximum temperature differential possible between the cold and warm water intakes must be maintained. The changes wrought on the surface and near surface environment by such large amounts of water varying substantially in temperature cannot be predicted, but water temperature is an important variable that determines the character of the surface ocean environment, and large temperature changes will alter the environment.

Assuming the effects are negative, the thermal impacts on the ocean might be mitigated somewhat by placing the discharge outlet at some intermediate depth where the discharge temperature more nearly matches the ambient. However, questions remain about the consequences of moving and mixing waters from the two intake points containing different nutrients and biota and then depositing them at a different location in the ocean.

In short, several questions remain. What will be the resulting changes in upper ocean chemistry? What effect will these physical and chemical changes have on the biological aspects of the ecosystem? What will be the nature and extent of effects on ocean circulation and the climate? Potential adverse impacts, as well as possible mitigating measures, should be reasonably understood before we venture into commercial operation. Further study of these impacts is under way, and we may also be able to benefit from the studies undertaken for assessing possible deep seabed mining environmental impacts.

Environmental problems may also result from the use of biocides to clean marine biological growth from the surface of the heat exchanges and pipes. In addition, pollution could occur from discharges of other substances used in maintenance, such as acids, or from discharge of ions from exposed metal surfaces. The potential for leaks of ammonia when it is used as the working secondary fluid in the OTEC process also exists in an OTEC facility. Finally, OTEC platforms and cold water pipes may act as artificial islands for fish and seabirds. This may prove to have beneficial impacts, but the possibility warrants further examination.

These issues deserve further study before commercial operation goes ahead. We will be working to coordinate our efforts with other agencies with expertise in dealing with discharges of pollutants into the marine environment as the technology for OTEC is developed.

IV. CONCLUSION

In light of the uncertainties surrounding the development and economic feasibility of the OTEC industry, we believe that comprehensive legislation detailing a regulatory and licensing regime is premature. We, and other concerned agencies, will be keeping abreast of developments and undertaking the necessary studies so that when regulation is viewed as timely, the public interest of protecting the environment will be met while giving the industry a clear picture of the requirements which will be imposed upon them.

This concludes may prepared statement. I will be happy to answer any questions you may have.

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. To what extent can the environmental concerns which you identified be ameliorated or avoided by the proper siting and development of OTEC?

Answer. The environmental concerns expressed during tstimony on May 1 were of two types: (1) concerns regarding the effects of discharging large volumes of water of varying temperature at or near the surface of the ocean and the potential impact on ocean chemistry, biology, climate, and circulation; and (2) concerns regarding the discharge of polluting substances, such as biocides used for cleaning or leaks of

working fluids (ammonia), and the impact of such discharges on the environment in the immediate vicinity of the OTEC facility.

Whether either of these concerns would be ameliorated or avoided by changes in siting OTEC facilities cannot be determined on the basis of our current knowledge. The choices for siting OTEC facilities or plantships are generally limited to those areas in which a sufficient temperature differential exists. Any site would be subject to the discharge of large volumes of water, and each site will be affected differently. Therefore, all potential sites currently under consideration must be investigated to determine the immediate and long-term affects associated with the discharge of large volumes of water.

Proper technology development may ameliorate, but not totally avoid, the potential for the release of polluting substances in the immediate vicinity of an OTEC facility. Proper systems design, quality control procedures during construction, and adequate operational and maintenance practices should reduce the potential for inadvertent discharge of polluting substances; however, further study in this area is necessary as well.

Question 2. Can NOAA implement the licensing procedures in the time frame specified in S. 2492?

Answer. S. 2492 requires that final regulations be completed within a year from the date of enactment. NOAA would give the highest practicable priority to meeting any Congressional deadline imposed on the agency, and, provided that necessary resources are available, I believe NOAA could meet a one-year deadline.

Question 3. What changes, if any, would you recommend to facilitate the implementation of the licensing and other provisions of the bill?

Answer. As we have stated on previous occasions, the Administration believes the licensing provisions of the bill to be premature. We are, however, studying these and other provisions of the bill as approved by the Committee on May 8, and will be pleased to have the opportunity of discussing them in greater detail at your convenience.

Question 4. Does NOAA, in your opinion, have the appropriate range and depth of personnel to serve as the Administrator for this program?

Answer. The research, regulation and administrative experience in oceanographic, ocean engineering, climatological and fisheries management areas which would be necessary to implement the OTEC program is all found within NOAA. The agency already has substantial contact with OTEC design systems and has assumed, through various interagency agreements, technical management responsibilities for engineering development of ocean energy systems. Engineering development work for the Department of Energy on OTEC systems on a reimbursable basis has been underway for several years.

It is fair to say, however, that additional personnel would likely be desirable in order to administer properly an OTEC program.

Question 5. Is the amount of $3 million for administrative costs adequate, too high, or too low to accomplish the needed tasks of the bill?

Answer. The figure of $3 million is similar to that found in the Deepwater Port Act of 1974, which authorized $2.5 million for administrative costs. 33 U.S.C. § 1524. Assuming, however, an equal administrative load as that found with the Deepwater Port Act and considering the rate of inflation since its passage in 1974, $3 million may be too low. Assuming 10 percent average inflation since 1974, $2.5 million in 1974 approximates $4.4 million in today's money. Of course, these are very rough estimates. Administrative costs can be expected to vary from year-to-year, with greater outlays for regulatory start-up needed in the first few years.

Question 6. The bill contains a provision giving the Governor of a state with an approved coastal zone management program the opportunity to determine whether an OTEC facility, adjacent to or connected to that state, is consistent with the state's coastal management plan. How does NOAA feel about that provision?

Answer. NOAA agrees with the concept, embodied in sections 101(c)(10) and 105 (b)(1) of the bill, of giving the Governor of an adjacent coastal state with an approved coastal zone management program the opportunity to review an OTEC application for consistency with that state's program. However, states with approved coastal zone management programs are already authorized to perform this very review function pursuant to section 307(c)(3)(A) of the Coastal Zone Management Act and implementing regulations at 15 CFR Part 930, at Subpart D. I would, therefore, recommend that sections 101(c)(10) and 105(b)(1) of the bill be deleted as duplicative of existing law.

Question 7. The bill also contains a provision stating that states without approved CZM plans could not hook up to OTEC facilities. In markup on the House side last week this was deleted. Would you comment on that?

Answer. We are aware that this provision was deleted by the Committee from S. 2492 as well; nevertheless, there is a logical link between the management of impacts from an OTEC facility or plantship and the management regime created by an approved coastal zone management program. The subject provision was similar to one found at section 9(c) of the Deepwater Port Act which requires at least satisfactory progress toward development of an approvable coastal zone management program prior to authorization for a deepwater port. We think such a provision would provide reasonable incentives toward participation in the coastal zone management program.

Question 8. Does S. 2492 provide the Administrator of NOAA sufficient authority to responsibly deal with potential environmental problems which might occur from OTEC?

Answer. The bill grants to the Administrator authority to issue and prescribe the conditions of OTEC licenses (section 101), to issue (section 102) and enforce (Title III, generally) regulations governing the siting, design and operation of facilities; to monitor the operations of licenses (section 110); and, where appropriate, seek the suspension or revocation of licenses (section 111). The bill does not, however, contain a section similar to § 6 of the Deepwater Port Act which establishes environmental review criteria, nor does it grant the Administrator explicit authority to issue environmental regulations be granted to the Administrator.

Question 9. What are the potential economic benefits from OTEC for fishing, aquaculture, etc.?

Answer. OTEC facilities, particularly the large surface platforms and cold water pipes, may act as artificial islands to attract and accommodate fish species not naturally present. OTEC facilities, used as artificial islands, might be a means of increasing particular fish stocks, introducing new food resources, or protecting endangered species through relocation. Investigations should be conducted to determine the attraction of OTEC structure for particular species.

In addition to OTEC facilities acting as an artifical island, cold water brought up from the deep to cool OTEC condensers in rich in nutrients that could significantly enhance fish growth around an OTEC installation. In most tropical regions, where OTEC facilities are likely to be sited, the surface ocean water is depleted of the necessary nutrients to support a food chain. Thus, the possibility of starting and sustaining a food chain near, or downstream of, OTEC plants is a matter for further investigation.

Question 10. What is the export potential for OTEC?

Answer. Assuming successful development and demonstration of commercial sized OTEC facilities and plantships, the export potential is high. A special OTEC report in *Ocean Industry* magazine (November 1978) indicates that Japan and a consortium of European industrial firms have heavy OTEC programs under way, and that several developing nations have shown great interest in exploring OTEC feasibility.

More recently (November 1979), a United Nations Technical Panel on Ocean Energy concluded that developing countries in the tropics are well-endowed with ocean thermal gradient resources and recommended that case studies be made of OTEC applications to a Caribbean island, a Pacific island, and a West African coastal site. In this connection, I should note that the Netherlands and the Federal Republic of Germany, and, to a lesser extent, France and Japan are involved in the development of OTEC technology for export purposes.

Senator INOUYE. Our next witness is the Assistant General Counsel for Ship Finance and Contracts, Department of Commerce, Mr. Richard Knutsen.

Welcome to the committee, sir.

STATEMENT OF RICHARD KNUTSEN, ASSISTANT GENERAL COUNSEL FOR SHIP FINANCE AND CONTRACTS, DEPARTMENT OF COMMERCE; ACCOMPANIED BY GERARD NEWMAN

Mr. KNUTSEN. Thank you, Mr. Chairman. Good morning. I am pleased to be here.

Senator INOUYE. We have received your statement, and without objection it will be made a part of the record.

Mr. KNUTSEN. Thank you, sir. In that case, I will take a little different tack than the other witnesses and elaborate on my statement.

Your counsel has raised several questions which I would like to elaborate on, but with your permission, I have asked Mr. Gerard Newman, who is our Deputy Assistant Administrator for Maritime Aids, to accompany me in case there are any specific questions.

As you saw from my statement, we have a basic concern with respect to using title XI financial aid for financing the demonstration phase of OTEC commercialization program.

Our concern stems basically from the fact that title XI is an existing program that has been in place for approximately 30 years as a viable ship financing program.

One of the basic tenets of title XI is that the Secretary of Commerce find, before issuing a guarantee or commitment to guarantee, that the project is, in his estimation, economically sound.

The demonstration phase of the program presented in your bill would call for 100 percent financing by the title XI fund of projects in which the Secretary of Commerce would not be given a chance to make his normal economic soundness finding.

In our estimation, what this would do would be to greatly increase the risk of failure on an economic basis. On a technical basis, we cannot comment. That is not our particular field, but we do notice that there is no required equity input from industry. A normal title XI transaction requires either 12½ percent in the case of most vessels, or 25 percent in the case of subsidized and certain other vessels, of owners' equity to be furnished in order to qualify for Government guarantee.

Senator INOUYE. I gather from your statement that your prime concern is extending title XI funds to the demonstration phase?

Mr. KNUTSEN. That's correct, Senator.

Senator INOUYE. As far as the commercial phase, your concern is not that great?

Mr. KNUTSEN. We don't have a concern with respect to actually commercially viable projects. Our only concern is where a project will come in and we will be obligated to pledge our ship financing fund against that project and have no say in the approval process as to whether or not we think it is a commercially viable project.

OTEC technology, to the extent it proves commercially viable, will probably find a program of the type of title XI to be a major benefit for providing the industry commercialization impetus.

We have no objection to an OTEC vessel, or any other special kind of vessel which qualifies otherwise for title XI, that can prove itself from a commercial basis taking part in the title XI program.

Senator INOUYE. Well, you have had a pretty good record with the ship loan program, haven't you?

Mr. KNUTSEN. Thank you, sir. Yes, we think we have. We have had virtually 40 years—I believe it is close to 5,000 vessels, and we have had a total of now I believe it is 12 companies that have defaulted.

Unfortunately, two of our recent defaults included multiple vessels. I'm not sure of the exact number of vessels, but our fund, which does not contain appropriated money, now stands at somewhere in the neighborhood of $150 million, including any payments and guarantees that we have made over the last 35 or so years.

Senator INOUYE. So as trustees of this fund, you want to keep it viable?

Mr. KNUTSEN. That is our concern.

Senator INOUYE. Well, I thank you very much, sir. I can understand your concern. We will keep your concern in mind, sir.

Mr. KNUTSEN. Thank you very much, sir.

[The statement follows:]

STATEMENT OF RICHARD P. KNUTSEN, ASSISTANT GENERAL COUNSEL FOR SHIP FINANCING CONTRACTS, MARITIME ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. Chairman, members of the Subcommitte: I am pleased to appear before you today to state the position of the Department of Commerce with respect to Federal financing assistance that could be made available in connection with the eventual commercialization of OTEC technology.

The Maritime Administration views the use of existing financial assistance programs in the Merchant Marine Act, 1936 and implementing regulations, which we administer, as a possible vehicle to promote the commercial application of OTEC technology when commercialization becomes practical. While discussion of specific types of financial assistance is now premature, we might note that even at such later date, we would have great concern about extending Title XI guarantees to obligations for financing demonstration OTEC facilities and plantships, if there were no equity investment required by participants in a project and no required finding of economic soundness by the Secretary of Commerce.

In the event of default, the realizable value of the Government's security, i.e., the OTEC facilities and plantships, with their specialized equipment, would most probably be far less than the guarantees. One default could conceivably wipe out the "parent" Federal Ship Financing Fund, as well as the OTEC Fund sub-account, if payment were made from the parent fund. Such an occurrence would have an adverse impact on future marketing of Title XI guaranteed obligations for merchant vessel construction.

Mr. Chairman, when the commercial application of OTEC technology becomes feasible, we would be pleased to assist you and your staff in considering the integration of OTEC financing into the framework of the programs which we administer. We believe that our staff is well equipped in this regard.

This concludes my statement, Mr. Chairman. I will be pleased to address any questions which you or members of the Subcommittee may have.

Senator INOUYE. Our next witness is the Director of the Office of Marine Science and Technology Affairs of the Department of State, Mr. Norman Wulf.

Mr. Wulf, we have received your statement. Without objection, the full text will be made part of the record, and you may proceed as you wish, sir.

STATEMENT OF NORMAN WULF, DIRECTOR, OFFICE OF MARINE SCIENCE AND TECHNOLOGY AFFAIRS, DEPARTMENT OF STATE; ACCOMPANIED BY HENRY ANDERSON

Mr. WULF. Thank you, Senator. In light of the hour and the number of witnesses, with your permission, I would just briefly summarize my statement.

Senator INOUYE. Fine, sir.

Mr. WULF. I am accompanied this morning by Mr. Henry Anderson, who works in my office.

Senator INOUYE. Mr. Anderson.

Mr. WULF. From a foreign policy perspective, S. 2492 is a carefully drafted proposal. As we have pointed out in our prepared statement, there are some relatively minor modifications we would suggest be made to S. 2492, and perhaps a few others that are not included in our statement. But if those modifications were made, and if this proposal is enacted, in our judgment, this legislation would not create any foreign policy problems.

With that, Mr. Chairman, I would be willing to answer any questions you might have.

Senator INOUYE. Well, with that statement, I have very little to ask of you.

We will consider your suggestions, and I think for the most part we will be able to incorporate all of it.

Mr. WULF. Very good. Thank you, Senator.

Senator INOUYE. Thank you very much.

[The statement follows:]

STATEMENT OF NORMAN A. WULF, DIRECTOR, OFFICE OF MARINE SCIENCE AND TECHNOLOGY AFFAIRS, DEPARTMENT OF STATE

It is a pleasure to appear before you today to testify in regard to the Ocean Thermal Energy Conversion Act of 1980. Mr. Chairman, the development of ocean thermal energy conversion (OTEC) is consistent with our foreign policy objective of reducing our dependence upon foreign sources of energy while at the same time promoting new energy technologies in an increasingly energy short world. However, in my testimony today I will defer to the Department of Energy in regard to the Administration's position on the overall appropriateness and desirability of this particular bill at this particular time. I will instead address only those aspects of the bill of particular concern to the Department of State.

Mr. Chairman, we believe the Act's definition of an "ocean thermal energy conversion facility" as "any facility which is connected to the United States by pipeline or cable and which is designed to use temperature differences in ocean water to produce electricity or another form of energy . . ." adequately protects United States interests within the framework of existing international law. Under existing international law, the United States may exercise jurisdiction over OTEC facilities and plantships documented under its laws, over all OTEC facilities and plantships of any registry operating in our territorial sea, and over all cables or pipelines within our territorial sea used to convey electricity or products from the OTEC facility of any registry operating seaward of our territorial sea. By defining an OTEC facility in terms of being "connected to the United States by pipeline or cable," the Act essentially requires that a foreign operator of an OTEC facility abide by its terms as a precondition for connecting a cable or pipeline to U.S. territory.

In this regard I note, however, that Section 101(c)(7) is deficient in that it refers to only documentation but not cable or pipeline connections. I would suggest it be redrafted as follows:

(7) The proposed ocean thermal energy conversion facility or plantship will not be documented under the laws of the United States, and will be not be connected by cable or pipeline to the United States.

This change would make Section 101(c)(7) consistent with the intention of Section 101(a). I should stress, however, that our recommended change does not represent an endorsement of the legislation.

I would also like to note that Article 56 of the Informal Composite Negotiating Text before the Third United Nations Conference on the Law of the Sea would establish the right of the coastal nation to control the production of energy from the water, currents and wind within a 200-nautical mile exclusive economic zone. This would include jurisdiction over all OTEC facilities and plantships within that zone. Under a treaty containing provisions such as those appearing in the current negotiating text, the operation of OTEC facilities and plantships seaward of the 200-nautical mile exclusive economic zone remains a freedom of the high seas to be exercised with due consideration to the interests of other nations in their exercise of high seas freedoms. The United States has supported these provisions of the Informal Composite Negotiating Text and looks forward to their inclusion in an otherwise acceptable Law of the Sea Convention. Until that time, the Act under consideration today protects U.S. interests by defining an OTEC facility in terms of its documentation under U.S. law or its being connected to the United States by pipeline or cable. In this regard, I would note that it is unlikely that a foreign-flag OTEC facility that does not convey its products to our shores by means of a cable or pipeline would be operated adjacent to our coasts. It would generally be more advantageous for the operator of such a facility to locate it in an area where the thermal resource is more favorable than that adjacent to the United States.

Section 108(d)(1) and 108(d)(2) authorize the Secretary of the department in which the Coast Guard is operating to designate safety zones around OTEC facilities or plantships "(s)ubject to recognized principles of international law." The right of a

coastal nation to designate safety zones around certain offshore installations is set forth in Article 5 of the Convention on the Continental Shelf, but the right is clearly linked in the Convention to the coastal nation's right to explore the continental shelf and exploit its natural resources. Because an OTEC facility or plantship would exploit the thermal resources of the water column above the shelf rather than the resources of the seabed or subsoil of the shelf, the establishment of a safety zone around such a facility raises serious questions under international law.

It is worth noting how the drafters of the Deepwater Port Act of 1974 handled the uncertain status under international law of safety zones around a deepwater port. Section 19(c) of the act provides that "(e)xcept in a situation involving force majeure, a licensee of a deepwater port shall not permit a vessel, registered in or flying the flag of a foreign state, to call at, or otherwise utilize a deepwater port licensed under this Act unless (1) the foreign state involved, by specific agreement with the United States, has agreed to recognize the jurisdiction of the United States over the vessel and its personnel, in accordance with the provisions of this Act, while the vessel is located within the safety zone. . ." Similar language could be used to obtain jurisdiction over vessels calling at OTEC facilities or plantships during the construction or to remove or deliver products, but no jurisdiction could be obtained over vessels not making such calls, just as under the Deepwater Port Act jurisdiction could not be obtained over vessels not calling at the deepwater port.

Mr. Chairman, the meaning of Section 101(c)(8) is unclear to us, and we suspect an error may have occurred in the drafting or printing of this subsection. The Department of State, however, would oppose any requirement that an applicant for a license agree that no vessel will be used for the transportation to the United States of things produced, processed, refined or manufactured at the OTEC facility or plantship unless such vessel is documented under the laws of the United States. We believe such a provision would hinder the ability of the United States to participate in the possible worldwide deployment of OTEC plantships. For economic reasons it appears quite possible that OTEC plantships may be owned and operated by international consortia. The provisions of this paragraph would lessen the attractiveness to international consortia of operating an OTEC plantship under U.S. registry, and thereby potentially restrict entry of the U.S. OTEC industry into aspects of the plantship market.

Finally I would note that paragraph (f) section 108 should include the phrase "subject to recognized principles of international law". Paragraphs (a), (b), and (d) already contain such a reference.

Mr. Chairman, this concludes my testimony. I would be pleased to answer any questions the members of the Committee may wish to ask.

Senator INOUYE. Our next witness is the president of Solaramco Inc., Mr. John Babbitt.

Welcome, Mr. Babbitt.

STATEMENT OF JOHN BABBITT, PRESIDENT, SOLARAMCO, INC., WASHINGTON, D.C.

Mr. BABBITT. Thank you, Senator.

Mr. Chairman and members of the committee, my name is John F. Babbitt. I am also president of Devco International, located in Tulsa, Okla.

It is an honor and pleasure to appear before the committee and offer my testimony on the necessity of the passage of bill S. 2492, the Ocean Thermal Energy Conversion Act, if the United States is going to develop an OTEC program.

I am here today representing Solaramco, which is a joint venture company whose purpose is to represent the collective interests of Devco and a number of ammonia-producing companies in a program to determine the commercial, economical and technical viability of OTEC plantships to produce ammonia and deliver it to the U.S. on a commercially competitive basis.

Mr. Chairman, in your introduction of S. 2492 which appeared in the March 27, 1980 issue of the Congressional Record, you made an excellent case for OTEC and its potential for the production of ammonia. You covered the economic straitjacket that ammonia

producers will wear as their cost of natural gas rises from today's $2 per million Btu average to parity with crude oil.

Such an increase today would mean a cost of about $5 per million Btu's and a production cost in the average U.S. ammonia plant of about $245 per ton of ammonia, and ammonia is actually selling today at about $160 per ton on the U.S. Gulf Coast.

The ammonia industry is also faced with the ultimate requirement to phase out the use of natural gas as its availability decreases and the requirement for gas for higher priority uses, such as home heating, take all of the available supply.

Ammonia producers are reluctant to consider the large capital requirement for new plants in this country under such circumstances, and the use of synthesis gas from coal gasification does not appear to be an economic alternative.

Thus we are faced with the prospect of higher imports of ammonia from offshore areas where the cost of gas is much lower.

This scenario could lead us to the position that U.S. agricultural output, 30 percent of which is attributed to the use of fertilizers, could be dependent upon uncertain sources for ammonia, just as we are today dependent upon the whims of OPEC for crude oil.

I believe our country's agricultural productivity, which is the largest single offset to the cost of oil imports from today's balance of payments standpoint, holds more potential power in a world which has an ever-increasing populace to feed, than any other factor in our Nation's future.

I find it abhorrent to contemplate a scenario where we may deliberately allow excessive future ammonia imports to destroy this power base.

Now all of the foregoing economic, political and demographic issues have fostered the desire of Solaramco participants to push forward to develop a grazing OTEC pilot plantship program which would prove the viability of OTEC as a source of ammonia.

Furthermore, Solaramco is interested in the potential for using ammonia as the energy conduit from the plantships to shore, where fuel cells could be utilized for the production of electrical power.

In this country, the ammonia industry has available to it a massive distribution system, consisting of barges, pipelines, cryogenic storage tanks, railroad tank cars, and tank trucks, pressure storage tanks, and smaller and smaller tanks, so that we can serve the individual American farmer, wherever he may be operating, even in the most remote areas.

This distribution system is fully utilized only twice a year for seasonal movement of ammonia, in the fall and spring. The rest of the year, the system operates at low capacity for fill-up of storage facilities. Utilization is only about 20 percent of the system's delivery capacity, and therefore ammonia could be distributed on an incremental basis through existing facilities at a relatively low cost to fuel cells operating initially on the fringe area of the electric grid system on a very competitive basis.

In high population centers, fuel cells utilizing ammonia could be operated for peak shaving of power and eliminate the necessity for the more expensive installation of generating capacity to meet such peak power demands.

We feel the potential of ammonia as an energy conduit tied to fuel cells is sufficiently interesting that Congress should insist that the Department of Energy immediately institute a more aggressive development program for fuel cells.

Now rather than reiterate the potential for OTEC, let me say that Solaramco is a believer in OTEC. As a potential owner/investor in OTEC, and a marketer of ammonia which we hope will be produced in OTEC plantships, we are extremely interested in a program which will prove OTEC's potential or point out its shortcomings.

Legislation, such as S. 1830, which has already passed the Senate, and H.R. 5796, which is before the House of Representatives, breathe life into OTEC as a definitive program. H.R. 6154 and S. 2492 really provide the muscle, however, whereby OTEC can be realized.

Solaramco believes that essentially all of the technology involved in OTEC is proven, with perhaps the exception of the cold water pipe. And even here, risks have been minimized.

However, in order for OTEC to be commercially viable, we have to determine the capital cost and operating efficiencies of significantly sized units so that we may realistically project such costs on a commercial scale. We believe the 40 megawatt grazing pilot plantship provides an optimum sized OTEC pilot unit. This would produce about 125 tons per day of ammonia.

We feel a 40 megawatt pilot plantship should consider the incorporation of different materials of construction, equipment configuration, power systems and heat exchangers, and thus we would have a true pilot plant which would determine an optimum design basis for future units.

We do not quarrel with the concept that a second pilot plant OTEC facility should be installed on a moored basis, close to Hawaii, Puerto Rico, or some other similar suitable geographic area; nor do we underestimate the value of commercial OTEC facilities operating in such areas. But we do not foresee that the real potential for OTEC lies in moored facilities, but rather in grazing plantships operating in the vast ocean areas available with maximum potential water temperature differentials and high operating efficiencies.

The importance of S. 2492 is that it offers an opportunity for industry to participate on a realistic basis in OTEC development. Industry is willing to assume certain risks with respect to OTEC, but a pilot plantship is presently estimated to cost about one-third of a commercial unit, while it can only produce one-tenth of the amount of ammonia of a commercial unit.

Accordingly, there is no economic payout for a pilot plantship. Use of title XI guarantees to the extent of an economic payout applicable to the pilot plantship, along with an industry equity investment, will allow the OTEC program to proceed more rapidly on a cost-sharing basis, rather than depend upon total DOE financing.

And also if Solaramco or other industry interests assume the responsibility to act as the owner/operator of the pilot plantship, it will insure that the specific objectives of the pilot plant program will be tied to commercial viability, as well as scientific curiosity.

Solaramco has already demonstrated its desire to proceed with OTEC development through submission of an unsolicited proposal for a 40 megawatt grazing pilot plantship to the Department of Energy in August 1979. This proposal was on a cost-sharing basis, but was not accepted.

Solaramco proposes to respond to the Department of Energy's forthcoming project opportunity notice for development of an OTEC program, assuming there is sufficient latitude to incorporate Solaramco's commercial concepts into the proposed pilot plantship program.

I certainly hope that the Department of Energy's PON will be drafted to invite industry participation, since up to now the posture of DOE and its apparent lack of real interest in the potential of OTEC have adversely affected industry interest.

Quite frankly, up to now it has been only the continuing interest of Congress and its support of OTEC through bills such as S. 2492 and other bills mentioned earlier, plus the additional investment tax credit included in the windfall profits tax for two OTEC facilities which have encouraged industry to continue its endeavors to go forward with a program to test OTEC's potential contribution to our energy requirements for the future.

In conclusion, I again wish to state that Solaramco enthusiastically endorses S. 2492 and the program to get OTEC underway through a one-stop clearance program, coupled with MARAD title XI guarantees for financing, and particularly a method of accelerating the first pilot venture while still incorporating required safeguards.

Thank you very much. I would be willing to answer any questions.

Senator INOUYE. Thank you very much, Mr. Babbitt.

Is Mr. Knutsen still here?

Mr. KNUTSEN. Yes, sir.

Senator INOUYE. Mr. Knutsen, can you come up and join Mr. Babbitt?

Mr. KNUTSEN. May I bring Mr. Newman with me?

Senator INOUYE. Oh, please, yes.

Mr. Babbitt has suggested that title XI guarantees be used to the extent of an economic payout applicable to the pilot plantship, along with an industry equity investment. Would that be feasible?

Mr. KNUTSEN. Senator, I think we would have to look on a case-by-case basis. Right now if an OTEC vessel were to meet the definition and our interpretations of it, of vessel, and its trade met our definitions of trade, it would be eligible at this time, if it could prove the economics to us.

I think we could promise no more than we would have to look on a case-by-case basis.

Senator INOUYE. I believe that is what Mr. Babbitt is trying to suggest, that the guarantees apply to the economic payout; isn't that right, Mr. Babbitt?

Mr. BABBITT. Yes, that's right. We have had quite a bit of conversation and stream of correspondence with the Department of Commerce and Maritime Administration, and we were advised by counsel, their counsel, that it was very questionable if OTEC would qualify and meet the requirements under the bill, and therefore it

was their suggestion that a new bill be instituted. That is one aspect.

The other aspect, you are quite right, we are looking for—we are not asking the Government on the loan guarantee under title XI for 100-percent financing of the pilot plantship; only that portion which we feel should be and can be economically justified and repaid.

That does leave a sizable amount of money, and some type of a grant or otherwise from probably the Department of Energy, that we hope would be repaid. But we never can guarantee it and don't see a total payout under the pilot plant program.

Senator INOUYE. How do you feel, Mr. Knutsen?

Mr. KNUTSEN. Well, Senator, as I mentioned earlier, our problem is basically the viability of the fund. If we are presented with a project that meets the legal definitions—and the legal constraints within which we have to operate, that we feel from an economic basis does not present an unacceptable risk to the fund, that is, any greater risk than any other commercial shipping venture, that we would finance under title XI, we would be happy to finance.

Of course, we always have a question of allocation of funds which will arise as a policy decision. What is best for the merchant marine. Ultimately, our main goal is to promote the U.S. merchant marine.

Senator INOUYE. I can assure you, as long as I am chairman of the Merchant Marine Subcommittee, you will get enough money.

Mr. KNUTSEN. Thank you, Senator. We do not feel that there is any great divergence between OTEC plantships, et cetera, and the merchant marine, since they would provide employment for a number of people who are traditionally the type of employees that are employed with the merchant marine. It may also provide work for U.S. shipyards, et cetera.

There may be technical questions at this point without a bill of this particular type as to whether any particular design of OTEC facility or plant may fit within the current definition of vessel, or may fit within the current definitions of commercial use.

That we would have to address again. Without something that specifically would tailor title XI to an OTEC facility or vessel, no matter what its design, we would have to approach it the same as we would the economics, on a case-by-case basis, as we do with any vessel.

Senator INOUYE. I would expect you to do that, sir.

May I request that you get together with the committee staff, committee counsel, and Mr. Babbitt, if he wishes to assign his counsel, and work out some language here that might be acceptable and will not endanger your fund?

Mr. KNUTSEN. We will be glad to do that. You must remember, of course, that one of the administration concerns may go beyond simply adding more money to existing off-budget financing programs.

The administration for several years has been interested in bills that have had as their purpose to bring under control, under administration control, some central control, whether it be the Federal financing bank, et cetera, Government off-balance sheet or off-budget financing programs. We can tell you from a technical

legal standpoint what particular portions of title XI would need to be addressed, but we would still be bound by the parameters of the administration position with respect to extending guarantees to a new area of endeavor, to the extent that these vessels would not already be eligible under the current title XI.

Senator INOUYE. I am aware of your limitations, but within that, I hope you can work with the counsel.

Mr. KNUTSEN. We would be most happy to, Senator.

Mr. BABBITT. Excuse me, Senator. I would like to make a comment. Of course, the first unit we are talking about, our first units are truly pilot plants, and by definition and commercial feasibility is limited, and I commented on that limitation.

We were only interested in getting the guarantees to the extent that that economic viability existed. However, if you try and have language saying that you would meet the qualification at today's commercial risks, obviously a pilot plant does not, and that's the language we need to address in the first units, particularly.

Senator INOUYE. Well, let's see if we can do the impossible. Mr. Babbitt, I thank you very much. You have been extremely helpful. Mr. Knutsen.

Our next witness is the representative of the Ocean Energy Programs Office, Applied Physics Laboratory, Johns Hopkins University, Mr. Evans J. Francis.

STATEMENT OF EVANS J. FRANCIS, OCEAN ENERGY PROGRAMS OFFICE, APPLIED PHYSICS LABORATORY, JOHNS HOPKINS UNIVERSITY, LAUREL, MD.; ACCOMPANIED BY DR. GORDON DUGGER; AND DENNIS RICHARDS

Mr. FRANCIS. I would like to introduce Dr. Gordon L. Dugger on my right, and Mr. Dennis Richards of the laboratory, who will help to answer any questions you may have.

It is a pleasure to appear before the committee to discuss the Applied Physics Laboratory's work on ocean thermal energy conversion or OTEC.

A conceptual design of an OTEC plantship is shown on the monitor.

Our work on OTEC commenced in early 1973 when, after a laboratory-wide review of all the potential options for the United States to solve the coming energy crisis, we concluded that OTEC is one of the most promising alternatives for providing a major improvement in U.S. energy supplies.

In our opinion, OTEC has the potential to provide a significant reduction in U.S. reliance on imported oil before the year 2000, and to be competitive in cost to both coal and nuclear power in the 1990's.

The results of our technical efforts in 1979 and 1980, the success of mini-OTEC, the technical progress on OTEC being made by others, and the passage by the Senate in January of S. 1830, the Ocean Thermal Energy Conversion Research, Development and Demonstration Act, continue to reinforce our opinion.

We would like, at this point, to congratulate the committee and you, Senator Inouye, on the leadership, understanding, and foresight which are embodied in S. 2492, the Ocean Thermal Energy Conversion Act of 1980, which we believe provides vital incentives

that will lead to substantial private cost-sharing, even for the first pilot demonstration OTEC facilities and plantships. We strongly support S. 2492 and urge its early passage.

Our work on OTEC has been funded by the Maritime Administration, NOAA, and the Department of Energy.

In the OTEC effort, the Applied Physics Laboratory has worked and consulted extensively with industrial companies and experts in order to obtain the best advice on design, construction, deployment, costing, and leadtimes.

This practice has led to engineering designs, now termed baseline by the Department of Energy, for both the grazing OTEC plantships to produce an ammonia product on board, and moored OTEC facilities for operation cabled to island utility grids ashore. Because of our continuous work with the industry, we know that these designs can be costed and built.

Briefly, the results of OTEC work from 1973 through mid-1979 are contained in this blue and gray ocean thermal energy pamphlet, a copy of which I understand has been provided to you.

I would like to emphasize one item from that brochure, in paragraph 1, where it states that the OTEC resource is truly enormous. We estimate that OTEC systems, using only a small fraction of the ocean thermal resource where the temperature differential is 40 degrees Fahrenheit or more, could theoretically supply all of our Nation's need for electric power, delivered at costs competitive with power from nuclear or coal-fired plants. It could also supply ammonia for fertilizer and fuel, aluminum refining, liquid hydrogen, and many other energy-intensive products.

Since June of 1979, our OTEC accomplishment, are as follows:

First, preliminary engineering design work has been completed on a baseline 40-megawatt grazing OTEC demonstration plantship with a 43,000 short ton per year ammonia production plant on board.

General arrangement drawings, component and equipment weights, sizes and layouts are in hand. The plantship meets all requirements for 100-year return storm survival in the South Atlantic equatorial ocean.

The results of this design work and funding could be given to several shipyards and construction teams today, and an operating OTEC demonstration plantship could be delivered in 3 years. The estimated costs of this demonstration plantship are presented in column 3 of table 1, which is attached to the testimony.

The total cost for detailed engineering design, construction, and initial deployment with the folded-tube power system, are $140 million, to which should be added 10 percent for contingencies and 10 percent for profit, for a total of $170 million or $4,200 per kilowatt.

This plantship has a concrete hull and a 30-foot diameter, lightweight concrete cold-water-pipe, which is deployed down through the center of the platform in 50-foot lengths. Each 50-foot length is connected with a flexible joint.

Layouts within the hull have been done for installations of both an Alclad aluminum heat exchanger of a folded-tube design and a titanium heat exchanger of the Alfa-Laval Lockheed plate design.

The cost estimates we shall present are based on use of aluminum heat exchangers.

The cost estimates of the OTEC demonstration plantship have been developed in extensive detail by companies which are in the design team and have built or can build platforms, components, and equipment of the size required.

For those elements which are unique, we have also obtained supporting estimates from another construction yard, and from other component and equipment manufacturers. These costs have not changed significantly from those developed a year ago, which are shown in columns 1 and 2 of table 1, and which have been widely published and circulated to others for comment.

Second, comparable design work has been completed on a baseline—nominal—40-megawatt OTEC facility with mooring system and direct cable-to-shore suitable for deployment off selected U.S. islands. This would deliver about 34 megawatts ashore to Puerto Rico or 30 megawatts to Hawaii, or alternatively, delivery of 40 megawatts to Puerto Rico or Hawaii would require an increase in size.

General arrangement drawings, component, and equipment weights, sizes, and layouts are again in hand. The facility appears to meet the more rigorous 100-year return storm survival conditions at the Puerto Rico site.

However, a model at one-thirtieth of scale is being built and tests are planned to start this month to obtain additional substantiation of this fact. Cost data for this moored OTEC demonstration facility appear in column 4 of table 1.

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THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
LAUREL MARYLAND

Table 1 Construction and Deployment Cost Estimates For OTEC Pilot/Demonstration Plants, Millions of Mid-1980 Dollars (No Contingency or Profit)

Type	Grazing Plants at Atlantic-1			Moored at P.R.
Size	10/20 MW_e	40 MW_e Nominal		40 MW_e Nom.
Date of estimate	Dec. 78	June 79	Feb. 80	Feb. 80
Ocean ΔT, °F	43	43	43	40.3
Net power onboard, MW_e	14.1	42.8	42.8	34.8
Thrusters or cable loss	1.3	1.6	1.6	1.0
Net power to NH_3 plant or shore, MW_e	12.8	41.2	41.2	33.8
Platform hull, $/M	15.8	21.1	17.4	17.4
Thrusters or mooring	6.7	8.6	7.6	24.2
Outfitting & misc.	7.7	7.7	9.1	9.4
Seawater system	3.2	11.0	9.8	12.6
CW Pipe system	10.0	10.0	8.2	8.1
Power system[a]	16.2[b]	35.9	45.2	45.2
Deployment & sys. test	6.2	6.3	12.3	20.2[c]
Industrial facilities	1.5	2.0	2.1	3.7
Eng'g & detail design	3.3	3.5	3.3	3.3
Subtotal, OTEC plant	70.6	106.1	115.0	144.1
($/$kW_e$ onboard)	(5010)	(2480)	(2690)	(4260)
NH_3 plant or cable	0.4[d]	19.5	24.7	21.3
Total, $M	71.0	125.6[e]	139.7[e]	165.4

[a] All cases based on folded-tube, Alclad aluminum HX's.

[b] For 14.1 MW_e including increase in HX performance from tests.

[c] Includes deployment of the 4 discharge pipes, mooring system and power cables.

[d] Power dissipation by resistors (no ammonia plant).

[e] The difference between the totals in columns 2 and 3 is due in large part to the inflation rate used to update 1978 and 1979 cost estimates to 1980 dollars, 7%/yr for 6/79 estimate and 12%/yr for 2/80 estimate.

Again, the barge-type hull is concrete, the cold water pipe is lightweight concrete, and both aluminum and titanium heat exchanger layouts have been made.

The total costs for detailed engineering design, construction, and initial deployment, with the power system using aluminum folded-tubes, are $165 million, to which again should be added 10 percent for contingencies and 10 percent for profit, for a total of $200 million in 1980 dollars.

There is somewhat more uncertainty in these costs because of the more severe storm conditions and the site-specific requirements for the mooring system and the A/C power cable to the utility grid ashore.

Third, we consider the large cold water pipe for OTEC plantships and facilities to be the largest engineering challenge. In December 1978, we conducted a test with Offshore Technology Corp., which is a subsidiary of Fluor, in which a 500-foot-long, five-foot diameter steel pipe was suspended from an instrumented experimental drill rig platform off Catalina Island and extensive data files were obtained under varying sea conditions.

Under an unexpectedly severe combination of large wave height and short period—steep waves—this nonhinged pipe broke. Since the stresses existing at the breaking condition were in reasonable agreement with the computer predictions, valuable knowledge was obtained.

A second 380-foot pipe with a joint halfway down was then suspended, and more data were obtained. The joint greatly reduced the loads and moments. Exhaustive analysis of this data has provided greater confidence that the computer programs for predicting loads and moments on the cold water pipe are adequate tools, particularly for those favored designs which have a flexible or jointed pipe.

Where differences exist, the computer codes predict greater stresses than are measured, and thus are on the conservative side.

To verify the structural design of the lightweight concrete cold water pipe, a one-third linear scale, 10-foot diameter, test section, including one of the joints with the flexible neoprene bearing pads that are to be used between sections, has been designed, and built and is today completing testing in Tacoma, Wash.

The lightweight concrete mix, developed and tested for APL over the past 2 years by Portland Cement & Concrete Technology Laboratories, has a net weight of only 20 pounds per cubic foot when submerged in seawater.

The one-third scale section strength and durability tests are to be completed today. The early results provide positive substantiation of this cold water pipe design.

Fourth, highly successful tests of a full-scale core unit of the Alclad aluminum folded-tube heat exchanger as an evaporator were completed last October at Argonne National Laboratory.

These were followed by equally successful tests of the unit as a condenser, completed in February 1980.

In both evaporator and condenser tests, the results exceeded predicted performance by more than 20 percent. The next step is the installation and operation of a complete power system module as part of the demonstration plant acceptance tests.

Fifth, tests of ultrasonic removal of biofouling from full scale sections of heat exchanger tubing have shown favorable and repeatable results, indicating that biofouling can be economically controlled by this method without environmental hazard.

This method of cleaning heat exchangers merits further development to take better advantage of state-of-the-art transducer assemblies and to extend its capabilities to additional heat exchanger types.

Program plans have been developed to do this and to run biofouling cleaning tests continuously for a full year. This work is not funded. Because biofouling has been found to be controllable by other means during mini-OTEC deployment and in other tests, and because further ultrasonic tests can proceed in parallel with design and construction of demonstration plants, we do not believe that demonstration should be delayed while further work goes forward in this area.

These photographs show the side and top of the one-thirtieth scale model of an OTEC plant being constructed at Offshore Technology Corp. for use in verifying the seakeeping and survival characteristics of the demonstration OTEC facility and plantship.

The model is 15 feet long and has a draft slightly over 2 feet. It includes an abbreviated cold water pipe, stillwater ponds onboard over the heat exchangers, and water exit passages out the bottom of the platform to model hydrodynamic performance.

The third picture shows a model of the heat exchanger modules to be inserted in the rectangular waterflow passages. Operations in both the grazing and moored conditions will be tested. These tests are to be conducted in a model tank.

Our last OTEC task is a commercialization task which provides for communication with industrial companies which might build, own, and operate OTEC facilities or plantships. It, too, has produced very encouraging results.

We have initiated and maintained dialogs with a number of companies which could build OTEC plants and with potential owners and operators.

The Puerto Rico Electric Power Authority, as you know, in mid-1979 proposed a cost-sharing plan to the Department of Energy for an OTEC demonstration facility to be sited off their shores. Hawaiian Electric Co. is interested in the potential for an early OTEC demonstration facility, and has testified to that interest before this committee.

In April 1980, we discussed the baseline design for such a facility in the boardrooms of both these island utilities, including our estimates of the potential for cost-sharing. We believe that at least 20 percent, and possibly 50 percent, private participation in a demonstration facility may be obtainable at these sites.

In September 1979, the Solar Ammonia Co., as stated, proposed to provide $25 million in cash and $15 million in matching funds to the Department of Energy for a 40-megawatt, 43,000-ton plantship which they agreed to deliver by February 1983 and to own and operate.

We have maintained a dialog with the ammonia industry since our initial visit in November 1974 to Allied Chemical Corp.'s ammonia plant in Hopewell, Va., to discuss making ammonia from

OTEC. We believe that OTEC ammonia plantships offer the lowest risk and the lowest cost demonstration of OTEC commercial viability.

We have recently been provided with a pro forma balance sheet developed by the Solar Ammonia Co. for the use of its joint venture partners, which indicates another 10- to 13-percent increase over their earlier private cash participation. It is our opinion that 20 percent or greater private participation in the first demonstration OTEC ammonia plantship is obtainable.

The incentive for the ammonia producer companies lies both in their need to develop an alternative source of feedstock to their increasingly higher cost and uncertain supply of natural gas, from which over 95 percent of U.S. amonia is now produced, and in the prospects for a much larger market for OTEC ammonia if used as a fuel, in fuel cells to produce electric power and for transportation.

It is our opinion that the Solar Ammonia Co. proposal was a realistic and viable one. We had developed similar numbers for cost-sharing potential and had presented them to the ammonia industry at the annual conference of the Fertilizer Institute in June 1979.

The members of the team who proposed to perform the design and construction work were also known to us and were, in our opinion, qualified. We believe the proposed deployment date of 1983 could have been met. With approval and funding, a deployment in 1984 could be met, starting today.

The plantship design proposed did not differ radically from the baseline OTEC plantship design, which in turn has kept the same general conceptual approach since it was developed with the active participation of Sun Shipbuilding & Drydock Co., Avondale Shipyards, the Applied Physics Laboratory, and others in August 1975.

This baseline design has also been used by industry for their advanced shell-less OTEC heat exchanger design work.

The proposed construction schedule of 3 years from initiation of detailed design to deployment agrees with the estimates of time required for detailed design and construction which we, with ABAM Engineers, Tokola Offshore and Glosten and Associates, have developed.

The Solar Ammonia Co. included in its proposal a requirement that the Government "facilitate MARAD Title XI mortgage insurance." The Ocean Thermal Energy Conversion Act of 1980, S. 2492, which is now before this committee, would fulfill the requirement for both OTEC facilities and plantships. We believe it provides vital incentives, not only to the Solar Ammonia Co., but to any private individual or corporation, to consider substantial private cost-sharing of OTEC facilities and plantships. We strongly support S. 2492. We urge its early passage.

Let me state for the record that the Applied Physics Laboratory does not claim to have any special qualifications in marine financing. We have never built or sought financing for a commercial ocean vessel, and no one has built or financed a large OTEC facility or plantship.

However, we have been funded by the Department of Energy and the Maritime Administration since 1976 to look into the financing needs for OTEC.

In 1976 and 1977, we were ably supported by a vice president of Commercial Credit Capital Corp., who had had extensive experience in large scale project financings, and who strongly recommended MARAD title XI mortgage insurance for OTEC.

We included this recommendation in our report of December 1977, and have since discussed it with prospective OTEC builders, financial houses, other corporate executives and Government officials, in addition to the U.S. ammonia producers and island electric companies.

Without exception, we have been told that title XI or other Government mortgage guarantees will be essential if OTEC is to obtain substantial private funding.

We believe it is in the best interest of the United States to facilitate substantial and early investment of private funds in OTEC facilities and plantships. The essential condition or bottom line needed to make a viable energy source is low cost.

Our judgment is that lower costs will occur with substantial private industry control over OTEC construction and operation than with only the Government's control. With substantial private cost-sharing, we believe the Government will allow this control by commercial owner/operators. This, of course, is a decision only the Government can make.

The benefits to the American people from OTEC construction are clear. A 43,000 ton per year OTEC ammonia demonstration plantship will release 1½ billion cubic feet of scarce domestic natural gas per year, which would otherwise be required for ammonia production, to be used for other purposes, such as the heating of homes.

If the entire 10,000 megawatts of OTEC electric power or energy product equivalent which would be established as a national goal by 1999 under the Senate bill passed in January 1980 were in the form of OTEC ammonia plantships, this would be 30 commercial sized vessels and would release 360 billion cubic feet of domestic natural gas per year for other uses.

As an example, this is slightly more than 2½ times the total natural gas used annually for residential purposes in New England.

In our opinion, the 10,000 megawatts including 100 megawatts of demonstration plants by 1986, set forth in the Senate and House bills, are practical and, in fact, conservative goals for OTEC.

If used entirely for the production of electricity delivered by direct cable-to-shore, as a substitute for imported crude oil now used for electric power generation, 10,000 megawatts of OTEC electric power would reduce oil imports by 380,000 barrels per day. In this application, as in OTEC ammonia, we believe there is substantial potential for up-front private cost-sharing.

A third benefit is jobs for Americans, particularly in core city areas, where large U.S. shipyards are located. I have attached for the record a letter from Mayor Morial of New Orleans, La., in which he states that the shipyard in New Orleans, Avondale Shipyards, assisted by marine concrete structures, could build 15 production model OTEC plants over a period of just 5 years.

This would create up to 27,600 full-time jobs in Louisiana, and add up to $6.4 billion of new activity in the State's economy.

Additional 5-year, 15-ship OTEC construction programs could be supported by a number of shipyards, such as those at Quincy, Mass., Norfolk, Va., Baltimore, Washington—indeed, at least half a dozen large shipyards around the country.

Ed Hood, president of the Shipbuilders Council of America, stated last October that—

> About 60,000 workers in U.S. shipyards presently face the prospect of unemployment, much of which will apply to minority workers in areas of chronic unemployment. With the usual multiplier, nearly 200,000 workers in equally important supporting industries will be affected. Construction of plantships such as those envisioned by OTEC ammonia would certainly alleviate to a considerable extent the crisis in shipbuilding.

The cost to the U.S. Government of a successful program to develop commercially competitive OTEC facilities and plantships is not large, when you compare it to the benefits.

As I stated earlier, we believe S. 2492 fills an essential need for Government mortgage guarantees of OTEC. We also support the one-stop licensing provisions, procedures to protect the environment, and other elements of the bill which we believe will hasten the process of getting OTEC facilities and plantships built and operating.

We appreciate this opportunity to appear before the chairman. We congratulate you on the Ocean Thermal Energy Conversion Act of 1980, which we believe should become law, and should be a very positive step in bringing the potential benefits of OTEC to our country. Thank you.

Senator INOUYE. Thank you very much, Mr. Francis. You have done a lot in working on the cost aspects of OTEC in this study. Have you made any comparative studies of cost effectiveness of Federal investment in OTEC in contrast to other, solar and nonsolar approaches?

Mr. FRANCIS. No, sir, not in any of the work we have published up to this time. Dr. Avery, who heads the OTEC program with the laboratory, is currently working on such a paper, and we hope that we will have one available in a relatively short period of time.

We have a lot of discussion we would like to do with other people about the contents before we make it a part of the record. We would be glad to supply it when it is ready.

Senator INOUYE. I would like to have it as soon as you can. Can you give us just a hint of how it is going? We hope to have a mark-up by May 8.

Mr. FRANCIS. Yes, sir. It shows that OTEC is right near the top. It is not the top, but it is right near the top of the solar technologies, and it does show that a relatively limited amount of Federal support would be necessary in order to get the commercial viability. Dr. Dugger has been working on some of those figures, and I believe may have stopped by the Department of Energy and discussed it briefly with them earlier. Gordon.

Dr. DUGGER. No, I have not been there to discuss it with them yet, but I would say that where I think the study stands at the moment is that OTEC requires the least Government subsidy to become commercially viable, and I am talking about a matter of a few billion dollars, $1, $2, or $3 billion.

I think on the same kind of basis wind power is slightly higher and photovoltaics maybe 20 times higher. We are trying to get a

better fix on that. This is the amount of Government subsidy that would bring you to the same ability to produce electricity or products and meet the commercial market. We are trying, but we want to get some other people's judgments before we put out the paper.

Senator INOUYE. So the results to date would indicate it is a good investment?

Dr. DUGGER. Yes. Relatively speaking, it is very good.

Mr. FRANCIS. We have, sir, previously testified, on the OTEC plantships, that before the eighth plantship, they should be commercially viable. I think the new results will show that the number is slightly less than that, and I think that they will also show the number is less than that for the island plants.

Senator INOUYE. How reliable do you believe your cost estimates of building a 40 megawatt plant are?

Mr. FRANCIS. Unless there are additional requirements that are put in by the Government as a result of their procurement specification, we think they are quite reliable. I think we used the number of minus 10 percent, plus 20 percent, but I think if pressed, we would feel they are more accurate than that. We feel very comfortable with the $140 million.

We don't feel quite that comfortable with the 10-percent profit, because that is pretty much dependent upon how industry responds. The 10-percent contingency, I think we feel quite comfortable with. Yes, sir.

Senator INOUYE. Do you have to take further steps to develop reliable cost estimates?

Mr. FRANCIS. We think there should be a continuing R. & D. program with a continuing concentration on trying to reduce costs, but we think that, as we say, we feel that those costs have been very thoroughly wrung out now for a period of more than 2 years of intensive work on an actual plant design. With our actual plant design, unless somebody changes the design, we feel comfortable with those cost estimates. Yes, sir.

Senator INOUYE. So if you were to advise MARAD, would you say that the risks are minimal?

Mr. FRANCIS. I think when you are getting into the case of MARAD, you are probably looking at the period of how long you pay back—you use for the payback of the loan, and to say that the risks are minimal, that you are going to attain precisely the expected performance on the first ship, and you will be able to maintain it for 25 years, that is probably an incorrect statement.

We think that you will get quite close to them and would be able to maintain for a minimum of 10, probably 15, and likely 20 years of operation, yes.

Senator INOUYE. Well, I thank you very much, Mr. Francis. You have been extremely helpful. We have many other questions we would like to submit to you. If you would look them over and respond to them, we would appreciate it.

Mr. FRANCIS. We would be glad to. Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. What further steps need to be taken by Congress to speed up the development of OTEC?

Answer: Passage by the Senate of S.1830, the "Ocean Thermal Energy Research, Development and Demonstration Act," January 29, 1980, the favorable markup by the Committee on Commerce, Science and Transportation of S.2492, the "Ocean Thermal Energy Conversion Act of 1980," May 8, 1980, and the inclusion of an additional 15% energy investment tax credit in the Windfall Profits Tax by the Senate Finance Committee for the first two OTEC locations have provided the basis for successful demonstration of OTEC and, in our opinion, for early and successful commercialization. The Senate is to be congratulated for its leadership in this important area. The specific further actions needed are:

(1) Passage of S. 2492.

(2) Appropriation of the additional $40 million in FY 1981 funds in the funding section of S. 1830 which also calls for a capital construction line item for demonstration OTEC facility(ies) and plantship(s).

(3) Comparable action in the House of Representatives and reconciliation of any differences between S.2492 and H.R.6154, and between S.1830 and H.R.5796. Neither of the House bills has yet been passed. H.R.6154 received favorable markup on May 7, 1980.

(4) Continuation of attempts to gain favorable action on OTEC by the Administration. As you know, the official Administration position was non-support of the proposed legislative actions to implement this very promising energy resource.

(5) Limited subsidy by the authorization, appropriation and budget process of the early OTEC demonstration and commercial facilities and plantships. We have estimated that subsidies equivalent to a capital investment of $1–1.5 billion by the Government would bring both moored OTEC facilities and cruising OTEC-ammonia plantships to full commercial competitiveness by 1993. This $1–15. billion estimate is in constant 1980 dollars.

Question 2. What further steps need to be taken by the Administration to speed up the development of OTEC?

Answer. The most significant step required by the Administration and the Department of Energy is to support OTEC as one of the priority initiatives in the development of alternatives to foreign oil imports.

The Council on Environmental Quality was right. We can obtain 20% of our energy needs by the year 2000 from solar technologies. Without building a single new shipyard, only using our existing capacity, we could obtain 5 percent of our national energy needs from OTEC by the close of 1999. Substantially more would be possible with expanded shipbuilding facilities.

Support of the Congressional initiatives embodied in S.1830, S.2492 and the Windfall Profits Tax Act on OTEC will require increased emphasis on OTEC within the Administration's low priority program is to slow the introduction of OTEC into the Nation's energy supply. Private industry and the State of Hawaii together, without Federal funding, demonstrated that a complete OTEC system (Mini-OTEC) could be assembled in fifteen months and operated to produce net power, in complete agreement with engineering predictions. The next step should be a decision to go forward with deliberate speed with the construction and deployment of OTEC demonstration plants. A procurement policy is urgently needed which will encourage and respond positively to proposals to cost-share detailed design and construction of OTEC demonstration plants. This could be done in parallel with the funded "conceptual designs." The Administration's plan to go to a bid process for further "conceptual designs" will delay detailed design and construction of OTEC demonstration plants by at least two years.

Internally to DOE, the OTEC program office should be strengthened. Greater utilization should be made of the extensive talent already under contract to it. We foresee nothing in this need to strengthen the program office which precludes going forward with a priority program under the current working level leadership. The Administration problems relative to OTEC are policy level rather than technology level leadership.

Delay of OTEC and other attractive renewable technologies will force an energy stalemate that can have enormous political and social consequences. Time is running out for developing the solutions that are environmentally acceptable, and, therefore, politically and economically possible.

Question 3. What further steps need to be taken by the industry to speed up the development of OTEC?

Answer. There is a need for greater awareness of and involvement in OTEC by the top level executives in U.S. private shipyards, and marine construction firms.

With completion of the Congressional actions set forth in the answers to questions 1 and 2 above, and a continuing Government sponsored program of OTEC research and development, we foresee no need for further steps by industry other than

development of plans for participation in OTEC construction, which a few key companies are already prepared to take.

Question 4. In your testimony your cost estimates cite the use of aluminum folded tube heat exchangers. In the prototype, DOE has chosen to use titanium shell and tube heat exchangers. We understand that the heat exchanger is by far the costliest component and that titanium is the most expensive of the materials available for use. Can you estimate how using these materials and design would affect your cost estimate for your plant?

Answer. The answer to the statement that, in the prototype, DOE has chosen to use titanium shell and tube heat exchangers, is somewhat complicated. By the prototype, we assume that the statement refers to the 1-MWe size unit built by TRW that is to be tested on the heat exchanger testing facility, "OTEC-1." This existing 1-MWe unit is the only titanium shell-and-tube heat exchanger that has been selected by DOE, so far as we know. This horizontal-tube unit includes both plain titanium tubes and a section with enhanced-surface titanium tubes. The enhanced portion has a material cost approximately 70 percent greater than the plain tube portion. The total subcontacted cost for the heat exchanger is approximately $2,500/kWe. It is possible, but unlikely in our opinion, that a heat exchanger design based upon the enhanced tube portion of the 1-MWe unit would be used in a 40-MWe demonstration facility or plantship for the following reasons:

(a) Another type of titanium heat exchanger that is presently used on Mini-OTEC and, as we understand from some DOE statements, is also to be tested on OTEC-1, is a platetype heat exchanger such as the pressed herringbone plate by Alfa-Laval/Lockheed. This type is far more compact than horizontal shell-and-tube heat exchangers and can be mass-produced at less cost. It can also be scaled to larger sizes at low risk. The pilot/demonstration facility and plantship designs done by APL already include layouts to accomodate these units as an alternate to, or companion to, the aluminum folded tube heat exchangers.

(b) An alternate shell-and-tube, titanium heat exchanger design is the vertical falling-film type designed by TRW. It could be used on either our "baseline" barge-type OTEC platforms or spar-type platforms that may prove to be attractive for moored OTEC facilities.

(c) Even with an alternative heat exchanger selected, it is not easy to make a direct comparison of costs. There are a number of other elements to the OTEC power system which are sized to be compatible with the particular characteristics of the heat exchanger: quantity of working fluid required, water flow, manifolding, fouling prevention, cleaning system, and auxiliaries.

(d) The one clear advantage of titanium heat exchangers over Alclad aluminum heat exchangers is that titanium offers an assured 30-yr life, whereas we assume that Alclad aluminum heat exchangers can be designed for at least 15-yr life, with a high probability of being able to achieve 20-yr life by the time commercial-size plants are built. Thus, we have based our OTEC pilot/demonstration cost estimates on the assumption that 15-20-yr life will be adequate. This assumption is particularly pertinent for commercial OTEC-ammonia plantships, for which initial capital cost is considered to be for greater concern that obtaining 30-yr, rather than 20-yr, life before replacement of the heat exchangers.

Keeping points (a-d) in mind, some approximation to a cost increase for use of titanium heat exchangers can be made. The titanium vertical falling film heat exchanger is estimated by APL after discussion with TRW and reference to documentation, to cost approximately three times that of the Alclad aluminum folded-tube heat exchangers. The titanium herringbone plate heat exchanger is esitmated by APL, after reference to available documentation, to cost approximately 2.3 (or more) times the Alclad aluminum folded-tube cost. Thus, we would anticipate that subsitution of titanium heat exchangers for the aluminum heat exchangers upon which our 40-MWe (nominal) pilot/demonstration plant costs are based, would increase the heat exchanger portion of the cost from $34 M to some cost in the $78-102 M range (in 1980 dollars including 10 percent contingency and 10 percent profit). This would increase the overall cost of the 41-MWe, cruising, OTEC-ammonia plantship from $170 million to $210-240 M, and the overall cost of the 34-M we, moored OTEC facility to $240-270M. Considerable effort and time would be required to obtain more precise estimates.

The APL cost estimates provided for an OTEC 40-MWe (nominal) sized demonstration facility and plantship used the Alclad aluminum heat exchanger design and associated power system equipment for which preliminary engineering designs, layouts, weights and costs have been developed. A model section of the heat exchanger has been tested, first as an evaporator and then as a condenser, using 700-foot, 3 in-O.D. full scale tubes. The Trane Company, which built this "core test" unit, was under contract to develop detailed cost data. In addition, the contract

funded as analysis of the cost to produce OTEC demonstration size modules for installation in the OTEC demonstration facility and plantship designs. The Trane Company also did subsequent work on related improvements in construction facilities and techniques which would result in lower costs for production quantities. This provided a good basis for our cost estimates. The next step would be construction and acceptance testing of 5-MW scale modules as part of construction and deployment of 40-MW-scale plants.

Senator INOUYE. Our final witness represents the Ocean Energy Council, Mr. Myron Nordquist. Welcome, sir.

STATEMENT OF MYRON NORDQUIST, OCEAN ENERGY COUNCIL, WASHINGTON, D.C.

Mr. NORDQUIST. Thank you, Senator. I have a written statement. With your permission, I would like to submit it for the record.

Senator INOUYE. Without objection, your full statement will be made part of the record.

Mr. NORDQUIST. Thank you. I would just like to comment upon several of the administration points. First, let me just quickly say that the Ocean Energy Council is a group of largely industry representatives, mostly from the engineering community, although we do have users as well. The Ocean Energy Council's primary objective is to encourage the development of an OTEC industry.

One of the most encouraging aspects about the statements today is that there does not seem to be any disagreement in principle with the administration. The only disagreement seems to be with respect to timing.

The Ocean Energy Council is of the view that it is necessary to take more risks now because the United States is out of time to develop alternative energy industries. We think the Nation is vulnerable and that OTEC is one of the more promising solar alternatives that could help the problem that we face.

There seem to be two major issues, the first with respect to legal regime, and the second with respect to the loan guarantees.

The administration testified today that the legal regime is premature. My good friend Bud Walsh even referred to deep seabed mining, which I would categorize as a perfect example of the opposite point that he would like to have made. That is, the lack of a domestic legal regime has nearly strangled that industry. There is a prospect the industry may revive now that the administration has apparently, at long last, stopped stalling. But I could not think of a better example to illustrate our point than of that fledgling industry's need for a stable legal regime in advance of the actual time that commercial development began.

This leads me to the conclusion that OMB does not understand the lead time that industry needs in order to get into large scale development. It is very difficult for me to understand any down side to the early establishment of a legal regime.

Very simply put, if boards of directors are aware of the consequences in the future of a particular governmental program, they can make more informed decisions and can make commitments.

It is axiomatic when dealing with hundreds of millions of dollars that boards of directors want to know, especially with new technology, what the legal climate will be; what the Government's attitude is.

With respect to loan guarantees, the Department of Energy representative was obviously restrained by the OMB position. I was encouraged at this hearing to note the upbeat tone of his remarks on the prospects for OTEC. He stated that loan guarantees would be effective; he even stated that he at least, personally, would not oppose the application of loan guarantees if the money were available.

The comments made by the MARAD representative were highly revealing. They again reinforce the conclusion that OMB does not understand the loan guarantee program. He stated that the program was $150 million ahead. It is known that even if some of the potential losses that appear on the horizon were factored in, the program is still ahead. If anything, a budget-conscious individual would say: "This program is making money, let's have more of them."

We are looking at a program that pays for itself by the 1-percent admin. fee that's charged. It has a long history of success. We are not talking about a whole slew of new people. We are talking about a program that is in existence; with a little bit of interagency cooperation, there shouldn't be a need for plugging in a large number of new people.

Again, one gets back to the paranoid election concern with a balanced budget. With that one, it just becomes a judgment call whether or not to continue to strangle the very programs that are the solution to our economic problems; namely, the drain on the U.S. economy from overseas petroleum payments. The concluding statement is that the industry is united. I know of no deviation from the view, that the technology is there. The prospects and the economics are at least encouraging enough that, given the state of affairs, we need to accelerate the program. This bill is a very responsible and timely action.

Thank you.

Senator INOUYE. Well, I think you served as a good wrap-up witness. Your comments on the positions taken by the administration are very important to us, and we will be considering them as we mark this up on May 8.

Since we will be hopefully closing out this matter at that time, those who have other statements and who may wish to submit those statements, may we request that they be submitted no later than next Monday.

I thank you very much, Mr. Nordquist. You have been very helpful, sir.

[The statement follows:]

STATEMENT OF THE OCEAN ENERGY COUNCIL

Mr. Chairman: My name is Myron Nordquist. I am a partner in the Washington, D.C. office of the California-based law firm of Nossaman, Krueger & Marsh. I also serve as legal counsel to the Ocean Energy Council, a non-profit corporation dedicated to the development of an OTEC industry. It is a pleasure to appear before you today to testify on behalf of the Ocean Energy Council on S. 2492, the Ocean Thermal Energy Conversion Act of 1980.

All the industry witnesses who testified at the congressional hearings held on OTEC during the past year agreed that OTEC technology is ready for large-scale demonstration, bearing in mind that some components will undergo testing on the pilot plant(s).

Assuming there is no fundamental disagreement on the state of OTEC technology, industry does not understand why the Department of Energy is only planning to

develop what it refers to as an "option". In contrast, industry believes the U.S. should be actively fostering the creation of a private-sector industrial base. The Japanese, French and others are moving forward on OTEC on this basis. By the time these foreign entities enter their commercial phases and begin exporting, the U.S. will possess the technology, but not the industrial base to carry it forward to commercialization. The responsibility for such a failure must be squarely placed on the present unwillingness of the Federal Government to recognize lost time as a relevant, indeed, decisive, factor in meeting our nation's energy crisis. It is manifestly obvious that the Department of Energy needs to stimulate more than an OTEC "option" by 1985. Our nation can no longer afford a leisurely, sequential approach to OTEC commercialization as if secure foreign sources of petroleum will continue to exist for the United States.

Creating an industrial base is the goal of two similar bills currently pending before the House Science and Technology Committee, S. 1830, sponsored by Senator Matsunaga and passed by the Senate, and H.R. 5796, sponsored by Representative Fuqua. The bills would do this in three ways. Firstly, a series of national goals would be established as guidelines for federal planning. Secondly, the Department of Energy would be mandated to prepare a comprehensive commercialization strategy. Thirdly, at least two demonstration plants would be constructed.

The industrial participants in OTEC look to the Department of Energy to coordinate the creation of the industrial base, a task that industry itself cannot perform. To ensure that competitive sources of supply and support are fostered, as many serious participants as possible must be kept involved. The construction of at least two demonstration plants will keep multiple participation alive through the research and development stage.

For technological reasons also, at least two demonstration pilot plants should be built. This will allow more technological options to be demonstrated and more sites to be evaluated, thereby increasing the chances of success. Industry is on record as willing to share some of the cost of the demonstration plants. The percentage of private financing depends on how many pilot plants would be built, the terms and conditions of the cooperative agreements, and other factors which would be included as part of the solicitation(s). But it must be emphasized that when proposals are made in response to a PON, the proposers will be competing with each other for the lowest overall cost and highest percentage of industry cost sharing. As the precise figures will remain unknown until the proposals are actually submitted and negotiated, S. 1830 and H.R. 5796 merely establish a commercialization strategy without multi-year authorizations. The salient point is that off budget incentives are necessary but not sufficient to accelerate the commercialization of OTEC.

To date, the Administration has been reluctant to give its full support to these bills. Hopefully, the point will be understood that the Department of Energy's current philosophy of creating an "option" requires the concomitant fostering of an industrial base. The Matsunaga and Fuqua bills are expected to create that base and merit support from the Congress and the Carter Administration.

S. 2492, the bill sponsored by Senator Inouye which is the subject of today's hearing, and H.R. 6154 sponsored by Representative Studds are designed to complement the Matsunaga and Fuqua bills. The aim of the Studds and Inouye bills is to encourage the creation of an industrial base by establishing permitting and financial regimes. If their purpose were merely to create an option, and not an industrial base, these bills could be fairly characterized as premature. However, the bills recognize that the justification of large, new investment requires considerable internal lead times to accommodate the corporate and financial decision-making process. The preparation of thoughtful long-range plans, the in-house promotion of the new technology, the development of financing, and the resolution of institutional deficiencies all require extended periods of time. To prepare an internal schedule of technology introduction, many institutional and financial questions must be resolved well in advance of their actual materialization. Moreover, a decision to finance an OTEC plant must be made several years before the actual commitment of funds.

Industry cannot make informed decisions on the demonstration/pilot plant(s) without knowing whether loan guarantees will be available. A clear focus on the benefits of the commercial phase requires knowing whether the loan guarantees will be avaliable at that time. The fact is that loan guarantees will cost the government nothing, unless private industry defaults on a loan. Loan guarantees are merely a method whereby the U.S. Government puts its full faith and credit behind a loan which private industry obtains from private financial sources. They do not affect the Federal budget since only off-budget obligation authority is involved. The idea is to create the program in 1980, provide the opportunity for the guarantees shortly thereafter and, hopefully, never require the expenditure of any

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money from the Federal Treasury. If a default did occur, it is unlikely that there would be a budgetary consequence before 1990.

Constructing an OTEC plant involves major front end costs which are later offset by low operational costs since no fuel is needed. Loan guarantees would ensure that private financing would be available at lower than market interest rates, and indeed, would be critical in industry's decision to proceed at all. But even with loan guarantees, no industrial participant would be able to raise all the capital to build its own pilot plant at this time. The risk/return on investment factor is too inadequate and uncertain. The government must share the risk by contributing directly to the funding of the pre-commercialization stages. In short, loan guarantees will accelerate the commercialization of OTEC at a practically non-existent risk to the Federal Government, if the program is managed as well as it has been in the past.

As for the permitting regime, the bills provide for a "one stop" licensing mechanism. Only two agencies would interface with the industry in the permitting process. The Department of Energy could take an aggressive lead during the demonstration phase while the Department of Commerce could do so for the commercial phase. Here again, the philosophy behind establishing the regime at an early stage, is to create an industry. A common, across-the-board industry concern is that a mass of regulations and jurisdictions is a disincentive to the development of new industries. If these bills pass this session, industry will be assured well in advance that a favorable legal regime will be available. Even with a one-stop licensing scheme, each agency retains its formal permitting authority. The only difference is that the government, not the industry, has to deal with the red tape. As with the financial regime, certainty in legal climate is essential to facilitate planning.

A question of concern to the industry is which agency would administer the loan guarantee program. Many in the industry feel that MARAD is the most appropriate agency since it has a well established program already in place which is working well.

If the Congress and the Administration agree that an industrial base needs to be in place when OTEC technology is ready for commercialization, they should support the immediate passage of the four OTEC bills. Already, industry skepticism of governmental objectives and unwillingness to aid in commercializing a technology that industry regards as entirely viable is causing much concern. The net energy impact and export potential of OTEC baseload and plantship applications is too significant for the government not to upgrade OTEC on the list of national priorities. Translated into concrete terms, this means that the administration should support the financial incentives, both on and off budget, that are reflected in the OTEC bills Congress is presently considering. Unless governmental leadership is manifested meaningfully in the near future, the U.S. will lose not an "option," but also a fledgling solar industry.

Mr. Chairman, the passage of S. 2492 this session is vital to the development of an OTEC industrial base. In my view, the real barriers to OTEC commercialization are not technological, financial or legal—they are attitudinal. The United States is capable of handling the alternative energy crisis if sufficient political will exists in the Congress and the Administration. The OTEC industry has already shown it is ready to play its part.

NOSSAMAN, KRUEGER & MARSH,
Washington, D.C., May 6, 1980.

SENATOR HOWARD CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
Washington, D.C.

DEAR SENATOR CANNON: Thank you for your letter of May 2. The following are the responses to the questions you asked:

Question. "Am I correct in understanding that industry thinks this bill is needed now—that it is not premature?"

Answer. Yes. Industry uninformly has stated on the record that your bill is needed now to facilitate internal corporate planning. The creation of an industrial base as a vehicle for the technology demands that institutional and financial questions be resolved well in advance of their actual materialization. New investment requires considerable lead time to accommodate the corporate and financial decision-making processes. The commitment of capital to projects competing for finite resources must be decided upon years in advance of actual allocation.

The nature of the legal and financial regimes are critical elements in the decision whether to invest capital in OTEC. The enactment of S. 2492 will cost the government nothing now and probably never. If a default ever were to occur, it would be

after 1990. However, S. 2492 will provide industry with the certainty that is critical to planning for new technology.

Question. "What further steps need to be taken by Congress to speed the development of OTEC?"

Answer. There are presently four bills before Congress dealing with OTEC. Two of them, S. 2492 and H.R. 6154, initiated by Senator Inouye and Representative Studds, establish permitting and financial regimes prior to their actual utilization, to provide the advance information necessary for industry to plan ahead. The other two, S. 1830 and H.R. 5796, initiated by Senator Matsunaga and Representative Fuqua, would accelerate the Government's OTEC research and development program by establishing national goals, directing the formulation of a comprehensive commercialization strategy, and mandating the Department of Energy with an aggressive demonstration program.

Congress should pass these bills. The only further action foreseen at this time would be to fund that portion of the cost of the demonstration program which the government would bear.

Question. "What further steps need to be taken by the Administration to speed the development of OTEC?"

The Administration must first acknowledge that OTEC may be able to help our nation meet a small, but significant, portion of our energy needs. The Administration must accept greater risks for, and give greater support to OTEC in order to avoid losing more time. A cautious step-by-step approach to the development of OTEC technology is no longer appropriate. The technology is ready to demonstrate and DOE's proper role should be to encourage, not retard, the movement to commercialization. The Administration's posture to date is apppropriate for an era of secure and plentiful supplies of energy. However, everyone knows that the development of all alternative energy technologies needs to be speeded up. We need to advance the day when this nation is independent of imported oil.

The industry is asking the Administration with respect to S. 2492, to support a bill which provides vital information. The cost of a permitting regime is minimal compared with its advantages. The loan guarantee program involves no subsidies, no grants, no loans. It is a small addition to a highly profitable (for the U.S. Government) assisting program. It is no more than Governmental assistance to industry in helping it to raise investment capital from the banks, not from the U.S. Treasury.

Question. "What further steps need to be taken by industry to speed the development of OTEC?"

Answer. None, except to continue to press the Administration to accept a leadership role in alternative energy development.

Sincerely,

MYRON H. NORDQUIST.

Senator INOUYE. Mr. J. Hilbert Anderson of Sea Solar Power wanted to be here to present a statement, but he has been indisposed, so without objection, his statement will be made part of the record at this point.

[The statement follows:]

STATEMENT OF JAMES H. ANDERSON, JR., VICE PRESIDENT, SEA SOLAR POWER, INC.

Sea Solar Power, Inc, is a small company located in York, Pennsylvania. So far as we know, it is the only company devoted solely to the development and construction of OTEC plants. Its founder, J. Hilbert Anderson, has been researching and developing a system-integrated plant for Sea Thermal Power, now called Ocean Thermal Energy Conversion, or OTEC, since 1962.

We at Sea Solar Power, Inc. believe that the speedy enactment of S. 2492 is essential if we are to bring OTEC into commercial reality, for which it is now technically and economically ready.

The need, the resource and the readiness of OTEC are spelled out in the Department of Energy's Multiyear Plan for Ocean Systems, circulated in November, 1979, and approved by the Assistant Secretary of Energy as appears by memorandum circulated on December 5, 1979. I will hereafter refer to this document as the DOE Plan.

On the need for OTEC, the COE plan points out that baseload incremental electricity needs of U.S. Islands and the U.S. Gulf Coast, where OTEC plants are potential candidates, will total 52,500 megawatts by 1990, and 105,000 megawatts by the year 2000 (p. 4-1 and 4-3). Of these incremental electricity needs, the U.S. Islands will need 750 megawatts by 1985. These incremental electricity needs are in

addition to the need to replace the existing oil-fired plants in these areas to reduce our dependency on imported oil. The DOE report also points out that OTEC production of ammonia will be competitive with ammonia produced from natural gas in 1984, and then goes on to state: "OTEC ammonia, to supply one-half the new demand for fertilizer after 1985, will require thirty 325-megawatt plantships, each producing 1,000 metric tons per day . . . Since much of the continental U.S. fertilizer market is becoming captive to flare-gas fertilizer from Russia and Mexico, failure to develop this option can easily lead to foreign domination of U.S. fertilizer, and thus food prices." (p. 4-7)

On the OTEC resource, the DOE plan reports the following:

The resource available to the U.S. is Tens of Quads.

Under the present grid system, OTEC can supply all the electricity needs of the Gulf States and the U.S. Islands, Puerto Rico, the Virgin Islands, Hawaii, Guam, Micronesia and American Samoa, and

"Electrical power generation from ammonia/fuel cell installations should enable OTEC to distribute baseload power anywhere in the United States." (p. 4-4)

On the readiness of OTEC, DOE's plan flatly states:

"The technology development program for island systems will be completed the end of fiscal year 1980" (p. 2-6).[1,2]

"* * * a preliminary design for a demonstration plant can be reasonably initiated in fiscal year 1981, with subsequent construction and deployment by the end of fiscal year 1985". (p. 1-3)

Now the baffling part of the DOE plan! Notwithstanding DOE's recognition of the need for OTEC, of its immense energy resource, and of the readiness of its technology for a demonstration plant preliminary design with completion of construction in fiscal year 1985, the actual program is that DOE will first build an intervening 10 MW pilot plant on a 40 MW marine platform to start operation in March 1985 (p. 8). Thereafter, according to DOE's tentative schedule, the pilot plant would be tested in sea trials for two years.

Accordingly, under the actual DOE program, a demonstration plant of being in operation in 1985, as first put forth in the DOE plan, will not even begin construction until 1987 and will not come into operation before 1992—a delay of at least seven years.

What is the nature of DOE's proposed 10/40 MW pilot plant?

It seems evident from DOE's schedule (pp. 7-8)[3] that it will have a shell-and-tube heat exchanger made of titanium, using ammonia as the working fluid (A-2). Indeed the pilot plant could be delayed.

"If the performance results of the shell-and-tube heat exchanger falls more than 30 percent below the 55/BTU/hr/F°/FT² heat transfer coefficient derived from prediction results". (p. 2-11)

Everyone knowledgeable about OTEC acknowledges that the principal economic factor in OTEC is the heat exchanger system, which ranges from 20 percent to 45 percent of the total cost of the OTEC plant.[4]

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[1] The cold water pipe for a 100 MW OTEC plant of Sea Solar Power design is 30 feet in diameter.

[2] Mechanical Engineering Journal, December 1979, p. 67— "Undersea Power Cable". We also understand (which we are seeking to confirm) that a 65 MW transmission cable to an oil platform is successfully operating in the North Sea.

[3] DOE states that "Budget restrictions in fiscal year 1980 may limit the number of advanced heat exchanger units for testing in OETC-1 to just one." (p. 2-2.) Further, the schedule spells out:

By October 1980, perform at-sea tests on OTEC-1 to verify feasibility of biofouling cleaning techniques for a 1 MWe size shell-and-tube heat exchanger. If the overall heat transfer coefficient (U) remains over 55 BTU/Hr/°F/FT² with periodic cleanings, the test will be considered successful.

By May 1981, commence testing of potential low-cost heat exchangers on OTEC-1.

By October 1981, complete preliminary design and model tests for the pilot plant(s).

By December 1981, commence detail design and construction of the pilot plant(s). (p. 8.) It is clear that even if the "budget restrictions" do not limit the number of advanced heat exhanger units, testing of low-cost heat exchangers would not commence until May 1981. It would be manifestly impossible, therefore, to include low cost heat exchangers in a preliminary design of the pilot plant that is to be completed by October 1981.

[4] Note figures for heat exchangers v. total plant costs in DOE Report, Figure 4-1, "OTEC Technology Tree". Further, DOE Report states that "Platform configuration and costs are functions of the specific heat exchanger concept being used". (Figure B-1). The diameter of the cold water pipe is also a function of the specific heat exchanger being used. This arises from the fact that "CWP design parameters must be defined through the integration with a specific OTEC system and deployment." (Figure B-1) Note cost of heat exchangers to total plant costs/kw in DOE's "Overview of the U.S. OTEC Development Program" 1978 in which the figures were in costs/kw: Heat exchangers—$450-$650; Total plant costs—$1,750-$1,950.

The shocking fact of the DOE program on the heat exchangers is this: DOE's own forecast tree (in 1978 dollars) projects that the shell-and-tube heat exchanger made of titanium is by far the most expensive heat exchanger. (p. 4-2) There are obvious reasons for this. A shell-and-tube heat exchanger system for a 100 MW plant will require between 800,000 and 900,000 separate tubes, each of which must be fastened at the inlet end and outlet end of the heat exchangers by welding or other expensive process. Titanium is both the most expensive and worst heat conductor of the metals considered for OTEC heat exchangers. In addition it is in short supply.

DOE's forecast tree (p. 4-2) recognizes that the plate heat exchangers are considerably less expensive than shell-and-tube heat exchangers. This has been proved by tests of actual SSP plate heat exchangers which were verified by the General Electric Company and reported by it to DOE. Indeed the projected cost of the SSP plate heat exchanger is far less than for the heat exchangers shown on DOE's forecast tree.[5]

DOE proposes to use ammonia as the working fluid in the pilot plant on the basis that "ammonia as the working fluid has been emphasized by OTEC researchers". (p. A-2) The fact is that ammonia is flammable, explosive, toxic, and when mixed with sea water, highly corrosive. Consider that a 100 MW OTEC plant would contain 3,200 tons or 630,000 gallons of working fluid! Thus the safeguard system required by ammonia imposes substantially additional construction, operation and insurance costs. The refrigerants R-12 and R-22 commonly used in kitchen refrigerators are innocuous working fluids.[6] Further, ammonia is incompatible with copper nickel, and therefore requires titanium as the heat exchanger metal.

There is a far better alternative to this proposed pilot plant producing 10 MW, using the most expensive heat exchanger system, and costing $16,000/kw.

In June 1979 in an interview with Dr. John Deutch, Undersecretary of Energy, and by subsequent correspondence,[7] Sea Solar Power sought to convince the Department of Energy to authorize building now of one or more 100 MW OTEC plants that could be demonstration plants. Let us compare DOE's 10 MW pilot plant on a 40 MW marine platform with a 100 MW demonstration plant.

First—Cost

Undersecretary of Energy John M. Deutch in a letter to Sea Solar Power dated August 24, 1979 estimates the cost of the 10 MW pilot plant at approximately $160 million and the 100 MW plant at approximately $320 million. Thus, the estimated cost of the 10 MW pilot plant is $16,000/kw whereas the estimated cost of the 100 MW plant is $3,200/kw.[8]

Even if the first 100 MW plant were to cost double DOE's estimate—that is $6,400/kw, it would produce power at less cost than an oil-fired plant in Puerto Rico, according to DOE's cost calculations presented to OTEC Contractors on Integration Issues on 30 May 1979.[9] Thus after testing, the 100 MW can be put into

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[5] Phase II—Part II—Technical Proposal under Contract ET-78-R-01-3063 by General Electric Co. to U.S. Department of Energy, June 15, 1979. The SSP plate heat exchanger is mechanically assembled, requiring no welding. It was tested with R-12 and R-22. It can, therefore, use copper-nickel, a metal used successfully for years in heat exchangers in thousands of ships at sea. Its much lower projected cost has been presented to DOE.

[6] Two reports favorable to R-22 (or "Freon" 22) appear in 6 OTEC Conference Reprints, one by a General Electric team; another by a Japanese team. M. C. Olmsted, et al., General Electric Co. "Optimizing Plant Design for Minimum Cost Per Kilowatt With Refrigerant-22 Working Fluid." 6 OTEC Conference Reprints Vol. I, p. 4A-51. Uehara, et al.: "Ocean Thermal Energy Conversion Plant with Freon-22", Ibid, p. 4A-61.

[7] Letters dated July 23, 1979 and September 13, 1979 from Sea Solar Power, Inc. to Dr. John Deutch, Undersecretary of Energy.

[8] In a letter dated September 24, 1979 from Sea Solar Power, Inc. to Dr. Robert S. Cohen, Ocean Systems Branch, Division of Central Solar Technology, U.S. Department of Energy, it is pointed out that using the same cost table as that used by DOE on other aluminum heat exchangers proposed, and using the same assumptions of prices of equipment and material, the cost of a plant of SSP design v. the other designs cost studied by DOE results in a projected cost of $775 to $864 less per kw for an SSP plant. DOE has not disputed these figures. Actually, subsequent improvements in enhancement of the SSP heat exchangers reduces the prospective cost of an SSP plant.

[9] Letter dated 30 May 1979 (with enclosures) from Robert Cohen, Ocean Systems Branch, Division of Central Solar Technology, Department of Energy to OTEC Contractors on Market Integration Issues.

commercial operation and amortize out its total cost-even at double DOE's estimate of its cost.[10] The 10 MW pilot plant can never pay out.

By contrast what will be the cost of having DOE's intervening pilot plant? Is it not self-evident that no new source of energy will establish its annual net capacity and reliability until a commercial size plant is built and tested? And is this not so, no matter how many pilot plants are first built? After the $160 million pilot plant is built, according to DOE's Tentative Development Schedule, it would be tested for several years at a cost of $20 million/year. Thereafter, the demonstration plant would be designed and built. The total expenditure under the DOE pilot plant program to the point when the first demonstration plant starts operating, would be over $500 million.

Secondly, cost in time

The direct expenditure is not the only cost factor favoring a 100 MW plant now. DOE's program means an additional seven years in bringing OTEC into reality. And this loss of invaluable time will be for what—for the building of a 10 MW pilot plant that will be costly, unnecessary and probably counter-productive.[11] It will prove nothing more than that we can produce power by the temperature difference of the ocean's surface and subsurface waters—a fact already established in 1979 by the Mini-OTEC pilot plant in Hawaiian waters, and in 1975 by the portable pilot plant built by Sea Solar Power.

By contrast as many as three 100 MW OTEC plants can be designed and constructed beginning now for less than we are spending in one week for imported oil. And these plants could be in operation by 1985. We must enact S. 2492 if we are to trigger substantial private investment in these first 100 MW plants.

Attached to this statement are tables from the DOE plan showing the projected OTEC market penetration. According to the graph, based on a commercial plant starting operation off the U.S. Gulf Coast in 1994 by the year 2010, over 100,000 megawatts of OTEC power would be generating internationally and over 75,000 megawatts of OTEC power would be generating off the Gulf Coast and in plant ships (p. 4-8).

According to the DOE Plan Puerto Rico imports about 80,000 barrels of oil per day for its annual average use of 2000 megawatts. (p. 4-6) Accordingly, 100,000 megawatts of OTEC power would reduce the need for imported oil by 4 million barrels per day and 75,000 megawatts of OTEC power would reduce the need for imported oil by 3 million barrels per day—a total reduction of 7 million barrels per day. By beginning the building of one or more 100 MW demonstration plants now we can reach this target date seven years earlier and by the year 2010 reduce the oil needs by substantially greater figures.

Implicit in the DOE projections is the great international market for the U.S. shipbuilding, electrical equipment, metal producing and pipe manufacturing industries, providing the U.S. is first with the most cost effective OTEC plant. we can be first and best if we promptly enact S. 2492 to facilitate the funding of the construction of 100 MW demonstration plants without further delay. If, however, we contin-

[10] Sea Solar Power has submitted to DOE a three stage demonstration plant plan: Stage I—design and testing of components of a system integrated plan in order to prepare a preliminary plant design on which quotations can be obtained from manufacturers to fix the cost of construction within reasonable parameters. Stage I contracts could be awarded for each heat exchanger concepts; shell-and-tube; pressed plate and SSP channel plate and based on preliminary designs. Each contractor could then submit a preliminary plant design with costs calculated from manufacturers quotations on which one or more construction contracts could be awarded. (It can also be expected that substantial private capital would be offered for Stage II.) Stage II—Final design, construction, deployment and testing of plant. Stage III—Integration commercially into a power system.

[11] Let us examine the three factors referred to by DOE as the reasons for a 10/40 pilot plant to precede a demonstration plant (p. 2-7), as against a 100 MW pilot-demonstration-commercial plant.

1. Scaling up to plant hardware for a 100 to 400 MW plant from a pilot plant built at a cost of $16,000/kw cannot be quantitatively calculated without unacceptable risk. Scaling up or down from a 100 MW plant would be readily acceptable. Further, a 100 MW plant is large enough to absorb the design and testing of system-integrated components, the tooling, and the extra costs of manufacture in a first plant, so as to be a viable commercial undertaking.

2. A 10/40 MW pilot plant, particularly as conceived and limited by DOE, would not establish market credibility. Only a commercial-size plant, successfully tested and put into commercial operation will establish market credibility. A 100 MW plant is a most appropriate size plant for the purpose. It is also large enough to afford the cost of designing and testing cost-effective innovations that will make the plant far more acceptable in the marketplace.

3. A 100 MW plant would generate practical experience in plant operation and grid interaction phenomena that would be convincing and acceptable. It is doubtful that the experience in operating a pilot plant generating 10 MW would be either convincing or acceptable.

ue to delay, Japan, France, or Eurocean OTEC, a group of European companies, may well be first with OTEC, with consequent loss of the immense OTEC market to U.S. industry, and incalculable loss to the power and prestige of the U.S.

Let us not forget the astronomical rise in the price of oil in the past year and our vulnerability in the Middle East so clearly shown in Iran and Afghanistan. The oil bind threatens the economy and political stability of the entire free world. Can it be disputed that we must use every energy resource that is technically feasible and has an acceptable construction, operation and environmental cost? OTEC is a major solar energy resource that meets that test NOW. With the enactment of S. 2492, OTEC can enter the battle for our energy freedom.[12]

May I ask that this statement and footnotes be made part of the record.

Thank you for the opportunity to testify at this hearing.

Senator INOUYE. The committee will stand in recess, subject to the call of the Chair.

[Whereupon, at 12:40 p.m., the committee was adjourned.]

[12] Indeed our critical energy situation justifies a crash program. Whether the dwindling supply of oil in the world is real or contrived, the fact is that the OPEC nations have used and will continue to use, the sale of an essential commodity as a means of gross profiteering. The fact is that a single OPEC nation—such as Iran—supplying only a small fraction of the world's supply of oil is in a position to use oil as a weapon for embargo, terrorism, or blackmail. The fact is that the impotence imposed upon the U.S. by our dependence on Middle East oil encourages Russia to expand into Afghanistan and be in a position to cut off our Middle East oil supply.

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

SHIPBUILDERS COUNCIL OF AMERICA,
Washington, D.C., April 29, 1980.

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: As you consider S-2492, the "Ocean Thermal Energy Conversion Act of 1980," we want to assure you and the members of your distinguished Committee that U.S. shipbuilders have the capabilities, skilled technical expertise and the desire to participate in this program to provide a major source of U.S. energy supplies.

Several of our shipyards in Louisiana, Massachusetts and Washington have reviewed in detail the baseline OTEC plantship engineering design of the Department of Energy, and we are convinced that these ships can be built in prototype and commercial sizes in existing facilities with existing manpower and on a timely schedule. At least five U.S. shipyards are actively interested in OTEC. One yard has converted the barge for "Mini-OTEC," and another yard is actively working to convert a tanker for OTEC-1.

OTEC plantships will be large vessels with a great number of complex components and equipments, but their construction is well within the capabilities and competence of the U.S. shipbuilding industry. This is evident in the variety of innovative ships—liquid natural gas (LNG) tankers, offshore drilling rigs, lighter aboard ship (LASH) vessels, deep sea drilling platforms, special ships such as the GLOMAR EXPLORER, and highly sophisticated combatant and auxiliary naval ships—which have been, and are at this time being, produced by U.S. shipbuilders.

Because of a variety of factors, including budget restraints affecting the U.S. Navy and the world shipping recession which has severely reduced merchant ship construction opportunities, the U.S. shipbuilding industry faces an uncertain outlook.

The backlog of merchant shipbuilding contracts, placed earlier in this decade, is rapidly diminishing. Of 69 merchant ships now on order, 11 will remain to be delivered after the end of next year. Few new orders are now seen on the horizon. Moreover, since early 1977, the five-year naval shipbuilding plan has been reduced from 157 to 97 ships. The shipyard resources of the country will obviously not be fully utilized.

More than 50,000 U.S. shipyard workers could face the prospect of unemployment, much of which will apply to minority workers in areas of chronic unemployment. With the usual multiplier, more than 175,000 workers in equally important supporting industries would be affected. Construction of OTEC plantships such as those envisioned by OTEC ammonia would certainly alleviate this disturbing situation in a significant way.

With respect of the language of S-2492, Section 101(c)(8), line 14 on page 10, we believe the word "not" has been included erroneously. If our belief is correct, we submit the following additional comment:

"While Sec. 101(c)(7) of the Bill provides that, 'the proposed ocean thermal energy conversion facility or plantship will be documented under the laws of the United States,' and Sec. 101(c)(8) provided that, 'the applicant has agreed to the condition that no vessel may be used for the transportation to the United States of things produced, processed, refined or manufactured at the ocean thermal energy conversion facility or plantship unless such vessel is documented under the laws of the United States,' there is no requirement that such 'ocean thermal energy conversion facilities or plantships,' and 'vessels . . . used for the transportation to the United States of things produced, processed, refined, or manufactured at the ocean thermal energy conversion facility or plantship,' be of United States manufacture. We most respectfully request that such a provision be considered for inclusion in S-2492. With such a change, we heartily endorse the proposed application of provisions of the Merchant Marine Act of 1936, as amended, as appropriate."

We hope this letter be made a part of the record of your hearings on S–2492.
Sincerely,

EDWIN M. HOOD, *President.*

MASTERS, MATES & PILOTS,
New York, N.Y., May 5, 1980.

Hon. DANIEL K. INOUYE,
Chairman, Subcommittee on Merchant Marine and Tourism, Senate Committee on Commerce, Science, and Transportation, Washington, D.C.

DEAR MR. CHAIRMAN: We understand that you are about to mark-up finally S. 2492, a bill enacting the "Ocean Thermal Energy Conversion Act of 1980." This Organization is vitally concerned with that legislation and strongly supports it, with one significant amendment. We would strongly urge that Section 108 of the Act be amended so that subparagraph (e) reads as does that same subparagraph of H.R. 6154 as it was amended by the House Merchant Marine and Fisheries Committee. The House Committee changed that subparagraph so that it would require that any ocean thermal energy conversion facility or plantship meet U.S. manning and documentation standards.

We also strongly urge that Section 101(c)(8) of the bill be retained in the form that is now appears. For your guidance I am enclosing a copy of Section 108(e) of H.R. 6154, as approved by the Merchant Marine and Fisheries Committee.

Best regards.
Sincerely yours,

JULIAN H. SINGMAN,
Washington, Counsel.

U.S. SENATE,
Washington, D.C., May 6, 1980.

Dr. JOHN GIBBONS,
Director, Office of Technology Assessment,
Washington, D.C.

DEAR DR. GIBBONS: I appreciated receiving a copy of "Recent Developments in Ocean Thermal Energy—A Technical Memorandum," [1] which was done to update OTA's earlier study published in May 1978. The review of the major technological accomplishments occurring after the publication of the 1978 report is most helpful and useful. It appropriately cites the very substantial amount of technological progress that has been made in the past two years and is much more realistic about the prospects for OTEC than the earlier report which had a very negative editorial bias added to the technological discussion.

The new report implicitly, but not explicitly, refutes the very negative assessment of OTEC found in Paragraph 4 of the Summary of the earlier report. Unfortunately, this change is not made explicit in the new report.

But what is most difficult to understand is the failure of the update to cite or even reference the fact that the price of oil has doubled in the past year and will likely increase further, in addition to the uncertainty of its availability. Since OTEC uses no fuel, the price of fuel (oil, coal, uranium) is a most relevant factor in assessing the competitiveness of OTEC.

The 1978 report has an extensive discussion of costs, including the costs of fuel. In Hawaii, virtually all electricity is generated from oil and the cost of fuel is most important. Why the current update totally ignores the costs of fuel is most difficult to understand since it was an important part of the earlier report and was called to the attention of your staff prior to the issuance of the update.

In addition to the higher costs of fuel, the demonstration of the feasibility of OTEC by the State of Hawaii and private corporations substantially alters the prospects for the successful development of OTEC. Industry and congressional interests in OTEC also suggest that OTA's assessments of the future role of OTEC needs to be fundamentally reassessed. The amount of progress which has occurred in the past two years is not adequately recognized in the update, except for the technological side.

The Department of Energy has funded the Johns Hopkins Applied Physics Laboratory and the Rand Corporation to make estimates of the costs of varying types of OTEC plants. But their work is not assessed or referenced in the update.

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[1] The publication is available from OTA.

I would, therefore, very much appreciate your review of the OTA work on OTEC.
Aloha,

DANIEL K. INOUYE.

AMERICAN INSTITUTE OF MERCHANT SHIPPING,
Washington, D.C., May 7, 1980.

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: We appreciate this opportunity to comment on S. 2492, legislation which would establish procedures for the location, construction, and operation of ocean thermal energy conversion facilities and plantships to produce electricity and energy-intensive products off the coasts of the United States (OTEC). The American Institute of Merchant Shipping (AIMS) is a national trade association composed of 29 companies, which own, operate and charter 190 American-flag bulk vessels, aggregating over 8 million deadweight tons and serving U.S. foreign and domestic oceanborne commerce.

AIMS supports enactment of S. 2492 and the consequent removal of some of the institutional barriers to commercial development of OTEC. AIMS is in complete accord with this attempt to increase our U.S. energy supply by tapping the ocean thermal energy source which has great potential for supplying a significant share of this nation's energy needs. This innovative energy initiative is especially welcome and necessary in the present energy crisis confronting the United States. OTEC, together with other alternate domestic sources of energy, must be developed as quickly as possible in order to end our debilitating dependence on foreign oil.

There is, however, one aspect of S. 2492 which we believe is worthy of clarification. AIMS is concerned that the traditional U.S. Coast Guard authority to inspect and certify vessels be preserved intact with respect to "ocean thermal energy conversion plantships" as established under S. 2492. As the language now stands in the bill, we feel that Coast Guard inspection and certification authority over these vessels is retained. However, there are some parts of the bill which might lead one to conclude otherwise. In comments similar to these submitted to the Oceanography Subcommittee of the House Merchant Marine and Fisheries Committee during its consideration of OTEC legislation, AIMS recommended several changes to avoid any possible ambiguity.

The resulting committee print of April 3, 1980, which was adopted during subcommittee markup, allays our concern by incorporating sufficient clarifying language under "Section 108. Documentation, Inspection, Safety, and Manning Requirements." Specifically, Section 108(e)(1) provides that the Secretary of the Department in which the Coast Guard is operating shall promulgate and enforce regulations "concerning the documentation, design, construction, alteration, equipment, maintenance, repair, inspection, certification, and manning of ocean thermal energy conversion facilities and plantships." In addition, Section 108 (e)(1) mandates that the Secretary "may require compliance with those vessel documentation, inspection, and manning laws which he determines to be appropriate." AIMS supports these changes made by the House subcommittee in its committee print and accordingly recommends that your Committee adopt these or similar provisions to make clear that ocean thermal plantships and facilities will be inspected and certified by the appropriate Coast Guard authorities.

Thank you for this opportunity to express our views. It would be greatly appreciated if these comments could be included in the hearing record.

Sincerely,

W. M. BENKERT, *President.*

DEVCO INTERNATIONAL, INC.,
May 12, 1980.

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR SENATOR CANNON: Thank you for your letter of May 2, 1980 regarding my testimony on May 1st with respect to S. 2492, The Ocean Thermal Energy Conversion Act.

You asked me to comment on a letter received by Senator Inouye from Dr. Stelson, Assistant Secretary of the Department of Energy, regarding the environ-

mental and safety issues associated with the use of ammonia in a widely disbursed "ammonia fuels" distribution network. I would offer the following:

(1) Certainly I do not wish to discount the fact that there could be environmental and safety problems associated with the use of anhydrous ammonia. However, approximately twenty million tons of ammonia are produced or imported into this country every year and almost 50 percent of this total is transported and handled in existing distribution facilities through the use of barges, rail tank cars, tank trucks, and pipelines. Literally tens of thousands of U.S. farmers pick up ammonia in trailers from retail distribution points and then transfer the ammonia at the farm to smaller tractor-drawn tanks for direct application of the ammonia into the soil. The entire distribution network is under the control of the Department of Transportation and numerous rules and regulations are presently applicable which are enhanced and strongly endorsed by The Fertilizer Institute and all ammonia producers and marketers. To date, our major problem in the distribution of ammonia has been derailment of tank cars where we have had problems with deterioration of railroad beds. Otherwise, the safety record of the industry is excellent.

(2) Ammonia has many of the same temperature/pressure characteristics as propane, but is considered safer to handle, since it does not have the explosive range of propane and any small leak of ammonia is easily detected since it is an irritant.

(3) A large use of ammonia in power generation using fuel cells for peak shaving or similar uses by a utility would present few problems, since the ammonia would be handled by trained personnel under highly controlled situations.

(4) If fuel cells were utilized by individual residences or very small communities, I feel sure the present retail ammonia distributors/retailers would move into this field very much along the lines that propane is distributed so that deliveries to residences would be made under controlled conditions by professionals and the only requirement by the consumer operating an ammonia fuel cell would be to turn the unit on and off. This would make the use of ammonia in such a system even safer than at present where farmers and farm laborers handle the ammonia on the farm as discussed in (1) above.

Summing the situation up, the ammonia industry presently has in place a highly complex, regulated and controlled distribution network with an excellent safety record which could effectively handle the ammonia for power generation in fuel cells. I only wish the fuel cells themselves were in the same state of development and sincerely hope that you and the Senate take appropriate steps to fund the development of fuel cells as an additional source of power for our country's future use.

Thank you for this opportunity to comment on the safety of ammonia in today's U.S. marketplace and I would be happy to help in any way possible to further the development of OTEC fuel cells and the production and use of ammonia.

Yours very truly,

J. F. BABBITT, *President.*

[Telegram]

RCA Global Communications.

U.S. SENATOR D. INOUYE C/O BARBARA SAKAMOTO,
U.S. Senator Inouye's Office, P.O. Box 50123,
Honolulu, Hawaii

We have had a review of this act by Energy (TEO), Economic Development (EDP) and Attorney General (AG) Offices. Based on review of their comments. With Governor Coleman, TEO endorses the purposes of the proposed act. It is our understanding an OTEC facility connected to the land by cable or pipeline and which stands all or partially on the seabed repeat stands all or partially on the seabed, falls under the proposed act. 1. American Samoa has ideal sites along shorelines for an OTEC facility which we believe could be constructed above high tide line or on a platform built at the shoreline partially projecting beyond high tide line. 2. We assume title II, sec. 204 and title III, sec. 301 are misprinted. 3. Please note American Samoa is located on a temperature differential contour of 23 degrees centigrade at 1000 meter depths which appears to be the highest differential of any state or territorial waters with the possible exception of Guam. 4. American Samoa is totally dependent on ocean transported refined fossil fuels for power generation. 5. Developing local industry for production and export of ammonia and fertilizers derived from an OTEC facility is of extreme interest and will assist greatly in developing local revenue for the territory.

MATT T. LEI, *Acting Director.*

PROMISING APPLICATIONS OF OTEC

EVANS J. FRANCIS AND G. L. DUGGER

Presented at
7th ENERGY TECHNOLOGY CONFERENCE
Washington, D.C.
March 24-26, 1980

THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY
Johns Hopkins Road, Laurel, Maryland 20810

7th ENERGY TECHNOLOGY CONFERENCE

PROMISING APPLICATIONS OF OTEC

Evans J. Francis and G. L. Dugger
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ABSTRACT

Several bills now moving through Congress recognize two major use classifications for OTEC: delivery of electricity to shore via undersea cables and production of energy-intensive products (ammonia, aluminum, liquid hydrogen etc.) on cruising plantships for shipment to shore. The legislation would establish national goals leading to deployment of 10,000 MW of OTEC facilities and plantships by 1999 and would provide mortgage guarantees, one-stop licensing and investment tax credits. Benefits of 10,000 MW of OTEC facilities would include reduction of foreign oil imports for electric power generation of 374,000 bbl/day. Benefits of 10,000 MW of OTEC plantships producing ammonia would include the conservation of 409 billion cubic feet/year of natural gas which could be used for residential home heating and other uses. Construction of OTEC facilities and plantships would generate thousands of jobs in shipyards and center city areas of chronic unemployment. Recent work at The Johns Hopkins University Applied Physics Laboratory has included the preliminary engineering design of 40 MW OTEC demonstration plants of both the cruising type (producing ammonia) and the moored, cable-to-shore type. The latter looks very attractive for U.S. islands (e.g., Puerto Rico and Hawaii) which now depend completely on imported oil. But the realization of OTEC's greatest potential can occur only by simultaneous development of cruising plantships. In commercial sizes the latter will produce ammonia for fertilizers at costs competitive with onshore production from natural gas or coal. OTEC ammonia also is the most economical hydrogen carrier and can be decomposed on shore to regenerate this hydrogen for use in fuel cells to produce electricity, forecast to be competitive with electricity from coal-fired or nuclear plants in the 1990's. Production of aluminum, liquid hydrogen (for aircraft fuel), methanol and methane are also discussed.

INTRODUCTION

The two major use classifications of Ocean Thermal Energy Conversion (OTEC) plants are 1) direct delivery of electricity to an onshore utility grid and 2) onboard production of energy-intensive products. Senate Bill S.1830, introduced by Sen. Matsunaga of Hawaii and passed by the Senate in January 1980, and the corresponding House Bill H.R. 5796, introduced by Rep. Fuqua of Florida and in progress as this paper is written, recognize these two primary use classifications. This authorizing legislation, if passed by the Congress and the Administration, will set the following goals for total power generated by OTEC for the two uses:

a) 100-MW_e operating capacity, expandable to 200 MW_e, by 1986;

b) 500 MW_e by 1989;

c) improvements to reach cost competitiveness by 1993; and

d) 10,000 MW_e by 1999.

The writers and many prominent engineers in industry who have investigated OTEC in depth during the past six years consider these goals to be readily achievable insofar as U.S. engineering and construction capabilities are concerned (see e.g., the working group reports in Ref. 1).

Various aspects of the companion legislation that would make these goals achievable in socio-economic terms (1a-d) are also being addressed by the Congress. For example, H.R. 6154, introduced by Rep. Studds of Massachusetts, would provide loan guarantees and one-stop licensing for both classes of OTEC plants, and H.R. 3919, the Windfall Profits Tax Bill, would provide an energy tax credit of 15% for two "locations" in addition to the regular investment tax credit of 10% Thus a federal investment tax credit of 25% will be available for one or more plants at at least two sites if that provision stays in the bill. The DOE (Department of Energy) OTEC program includes the collection of the environmental data needed to select optimal sites for the plants and to forecast their effects on the environment (1e-f). The overall picture for OTEC will include positive aspects such as enhanced seafood growth and fewer hazards than rapid expansions of coal and nuclear power.

William E. Richards, DOE's Ocean Energy Systems Branch Chief, has stated that "up to 2.0 Quads (2×10^{15} Btu/yr $\sim$ 22 GW_e of average OTEC power) by the year 2000 is practically achievable, dependent only on the commercialization strategy employed after the demonstration plant" (1g). The foregoing conversion from fuel energy equivalent in Q_t (thermal energy) to electric power in GW_e is based on the usual 33% thermal efficiency for fossil-fuel power plants.

Thus many members of Congress, industry, government agencies [DOE, Department of Commerce (especially the U.S. Maritime Administration--MarAd--and the National Oceanographic and Atmospheric Administration--NOAA) non-profit R&D organizations (represented, e.g., by the writers) and academia jointly agree that OTEC offers great potential for relieving U S dependency on foreign oil and gas. Because of the essentially complete dependence of our islands--e.g., Puerto Rico, Hawaii, the Virgin Islands and Guam--on imported oil as their energy source, some of the early OTEC plants should be deployed at such islands. In this paper we shall treat this direct-cable-to-shore use of OTEC

for islands, and for Florida and other Gulf Coast states, to the extent needed for comparisons. However, the greater part of this paper is directed to cruising OTEC plantships which can produce ammonia, liquid hydrogen, aluminum, and possibly other products (methane, methanol, magnesium, etc.), because about 95% of the world's highest-grade ocean thermal energy reource lies in tropical oceans too far from shore for use of electric cables Only by early, high-priority development of this OTEC option can our nation and others reap the full benefit of this inexhaustible,around-the-clock, solar energy resource.

The most promising initial product from cruising OTEC plantships is ammonia for several reasons:

a) At present, ammonia is made from natural gas, a limited resource that is valued highly for many residential agri cultural and industrial uses Ammonia can be made at sea by combining hydrogen gas (derived from purified seawater by electrolysis) and nitrogen (separated from air by a partial liquefaction process) in a synthesizer at 2000 psi and 700°F, followed by liquefaction of the ammonia for storage at -28°F at 1 atm (1d,3-5). The air-separation and ammonia plants are "off the shelf" items. Only engineering development and scale-up of the preferred electrolysis system is required. The General Electric Company's SPE (solid polymer electrolyte) cells, which have been operating very successfully for years at bench scale, look best (1d,1h,2-5).

b) The primary use (75%) of ammonia by the U.S. is for fertilizers, which make possible our large yields of corn, wheat and other foodstocks for our own use and for export (2,7). Ammonia also will be used to produce grain for gasohol.

c) Among the candidate OTEC products, ammonia is the most economical carrier of hydrogen. It is readily shipped by tanker, barge, pipeline, truck, or rail at modest cost, to be decomposed at the point of use to regenerate its hydrogen for use in a fuel cell to produce electricity. Our estimates, presented later, indicate that the cost of electricity from OTEC ammonia will be competitive with electricity produced by coal-fired and LWR (light-water-reactor, fission) nuclear plants in the 1990's. Thus, it offers a means for delivering OTEC-derived fuel to all of the U.S. mainland areas that can not be served by cable-to-shore OTEC plants.

d) In contrast to coal-fired and nuclear plants, the economies of scale appear to be relatively unimportant for power generation facilities using fuel cells. Thus, dispersed plants of 5 to 100 MW_e size to serve new communities or industrial installations, especially in remote or previously sparsely populated areas, may prove even more attractive in comparison to small conventional plants. The fuel cell installations also should be better neighbors, without noise, pollution, or radiation hazard. Hence OTEC ammonia appears attractive for dispersed as well as centralized power generation.

For special uses, such as for fueling large transport aircraft, liquid hydrogen (LH_2) made on board OTEC plants (2-4) and shipped in

cryogenic tankers offers promise (2,5). The space shuttle also uses LH_2, for which a 10-yr contract at $26/10^6$ Btu was let by NASA in 1975 (9,10). Although LH_2 is more costly to make than ammonia, we estimate that it can be produced at a cost of $10-15/10^6$ Btu including delivery from a cruising plantship southwest of Acapulco, Mexico to San Diego, California, for example.

Use of OTEC power for the electrolytic step of converting alumina (Al_2O_3) to aluminum also looks very attractive for the 1990's (1i,2,8). We shall also present cost estimates for production of methanol and methane, but as noted in an investigation by the Institute of Gas Technology (IGT) 12), the economics for these organic compounds are not as competitive as those for ammonia and LH_2.

AMMONIA FOR FERTILIZERS AND FOR ELECTRICITY

The OTEC-Ammonia Plantship

The APL concept for cruising plantships producing ammonia has been described in numerous publications (3-6,10,13,14). Since the cost of ammonia transportation by supertankers (3-6) will be modest as noted later, OTEC ammonia should be produced on the high seas in ocean areas within a $\pm$ 15° latitude band where average annual temperature differences (ΔT's) of 40-45°F can be exploited (1j 1k 3-5). This is a very important point because the gross power output of an OTEC plant varies with ΔT raised to a power of 2 or more (1ℓ, 10). The cost estimates made by the writers are based upon a ΔT of 43°F, which is udged from historical records to be attainable by cruising in areas east of Brazil and west of Mexico. Higher ΔT's may be achievable in Micronesia 1k).

The preliminary engineering design of a 40-MW_e, 125-short-ton-per-day, OTEC ammonia pilot/demonstration plantship (Fig. 1) is now nearing completion by APL (1m,10,11). The preliminary engineering design for an earlier 20-MW_e (net) capacity version was completed by the Applied Physics Laboratory in 1979 (10) with support from industry and under funding by both DOE and MarAd, and the revisions to accommodate 40 MW_e and an alternate moored configuration (11) were supported by DOE. The concrete hull is 443 ft long by 141 ft wide with a launch draft of 35 ft (before installation of the cold water pipe) and an operating draft of 65 ft. The cold water pipe (CWP) is made of a lightweight concrete (density $\sim$ 85 lb/ft^3) developed specifically for this purpose by the Portland Cement Association and Construction Technology Laboratories. The CWP is 30 ft in diameter and comprises sixty 50-ft sections connected by joints that include flexible bearing pads. It is connected to the platform by a modified balljoint which allows up to 18° rotation. General arrangement drawings of the plantship are available with both Alclad aluminum folded-tube heat exchangers and titanium plate-type heat exchangers installed. The required platform areas for the two heat exchanger types are approximately the same when the cleaning system requirements and platform ballast requirements are included. The ammonia product plant is shown on the forward end of the ship and is illustrated in Fig. 2.

Estimated construction and deployment costs of grazing plantships in 1980 dollars are shown in the first three columns of Table 1. (The moored facility is discussed later Column 1 shows our estimates as of December 1978 for a 20-MW_e OTEC platform with 14 1 MW_e of the folded-tube Alclad aluminum heat exchangers installed in one half of the platform (12). The plant has an energy dissipation system (re-

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sistor banks) to permit power demonstration but no onboard ammonia plant. The second and third columns give our June 1979 and February 1980 estimates for the nominal 40-MW_e plantship. At the ΔT of 42°F that DOE specified for its Power System Development II (PSD-II) program and for APL's interfaces with PSD-II contractors, the plant delivers 40 MW_e (net) without propulsion. At the annual average ΔT of 43°F that we have estimated for siting area Atlantic-1 while cruising at 0.5-knot speed, the generated power of 42.8 MW_e is reduced by 1.6 MW_e for propulsion. Use of the remaining 41.2 MW_e produces 126 short-tons per day (STPD) of ammonia. Comparison of columns 2 and 3 in Table 1 shows an 11% increase in plantship cost, which was due mainly to increases for the power system, ammonia plant and deployment services, while some other costs declined a little.

The onboard ammonia plant capacity that is judged to be near optimum for a commercial OTEC ammonia plantship is 1100 short tons (1000 metric tons) per day. For this ammonia production we estimate the OTEC net power requirement to be 325 MW_e, based on 90% efficiency for the SPE electrolysis cells and use of waste heat recovery to provide the power requirements for the ammonia plant. In projecting costs for such plantships we have extrapolated from the costs of demonstration-size plants by using reasonable assumptions for economies of scale and more efficient space usage. (The pilot/demonstration plant of Fig. 1 has nearly as much hotel and service systems space as a commercial plant, plus space to facilitate testing/demonstration activities.) The estimated construction and deployment cost for the first commercial

Table 1 Construction and Deployment Cost Estimates for OTEC Pilot/Demonstration Plants Millions of Mid-1980 Dollars (No Contingency or Profit)

Type	Grazing Plants at Atlantic-1			Moored at P.R.
Size	10/20 MW_e	40 MW_e Nominal		40 MW_e Nom.
Date of estimate	Dec. 78	June 79	Feb. 80	Feb. 80
Ocean ΔT, °F	43	43	43	40.3
Net power onboard, MW_e	14.1	42.8	42.8	34.8
Thrusters or cable loss	1.3	1.6	1.6	1.0
Net power to NH_3 plant or shore, MW_e	12.8	41.2	41.2	33.8
Platform hull, $/M	15.8	21.1	17.4	17.4
Thrusters or mooring	6.7	8.6	7.6	24.2
Outfitting & misc.	7.7	7.7	9.1	9.4
Seawater system	3.2	11.0	9.8	12.6
CW Pipe system[a]	10.0[b]	10.0	8.2	8.1
Power system	16.2	35.9	45.2	45.2[c]
Deployment & sys. test	6.2	6.3	12.3	13.1
Industrial facilities	1.5	2.0	1.7	3.7
Eng'g & detail design	3.3	3.5	3.3	3.3
Subtotal, OTEC plant	70.6	106.1	115.0	137.1
($/$kW_e$ onboard)	(5010)	(2480)	(2690)	(3940)
NH_3 plant or cable	0.4[d]	19.5	24.7	21.3
Total, $M	71.0	125.6	139.7	158.4

[a] All cases based on folded-tube, Alclad aluminum HX's.

[b] For 14.1 MW_e including increase in HX performance from tests.

[c] Includes deployment of the 4 discharge pipes.

[d] Power dissipation by resistors (no ammonia plant).

plantship was then extrapolated to the eighth plantship by applying learning curve factors near 0.9. Our June 1979 estimate of the 8th plantship cost in 1980 dollars was $393 M or $1208/kW$_e$ (1d). Since no baseline design for this plantship has yet been developed, this value has been considered the nominal cost with an uncertainty range of -10% to +30%.

Estimated Cost and Market for Ammonia as a Commodity

Using the nominal 8th plantship cost of $1208/kW$_e$ and other assumptions indicated by the footnote to Table 2 the cost (in 1980 dollars) of OTEC ammonia at New Orleans or New York in 1990 is estimated to be $187/ST (short ton) and should be competitive with or lower than the cost of ammonia produced from natural gas or coal in onshore plants. Since no fuel or feedstock is required for OTEC ammonia its cost in 1980 dollars should change very little with time whereas the cost of ammonia made from fossil fuels is expected to increase faster than the general inflation rate. Furthermore, once an OTEC ammonia plant begins operation, about 77% of its cost will be fixed costs, whereas for an onshore plant the variable costs including fuel costs that are subject to inflation will represent 2/3 to 3/4 of total costs Thus, the relative cost for OTEC ammonia will decrease in subsequent operating years (3,4).

The U.S. market for OTEC ammonia by 1995 could be substantial (Table 3). OTEC's onshore competition for new ammonia plants or for existing plants converted from natural gas probably will be plants using coal as the feedstock. Development of land-based coal plant technology to an economically competitive basis, and construction of such plants with EPA approvals and assured coal supplies, will occur no faster than OTEC ammonia plantship development can occur with a "fast track" priority program. Thus, use of natural gas plants probably will remain near present levels until 1990 and then be phased out as OTEC and coal plant production, beginning in 1987-88, is increased. We consider the OTEC expansion rate in Table 3 to be modest; it calls for only five 325-MW$_e$ (net), 1100 short-ton/day plantships per year

Table 2 Estimated Relative Costs of Energy-Intensive Liquid Products from the 8th and Subsequent Plantships in 1980 Dollars

Product	Liquid ammonia	Liquid hydrogen	Methanol	Liquid methane
Plant invest. (PI), $/kW$_e$	1208	1248	1218	1298
Annual cost, kW_e$[a]	200	206	238	243
Annual production, ST/kW$_e$	1.17	0.171	1.068	0.410
Onboard cost, $/ST	171	1205	233	592
Shipping cost, $/ST	16	158	23	44
Delivered to U.S. $/ST	187	1360	246	636
$/10^6 Btu	9.7	11.2	12.6	13.4

[a]Assumed percentage rates: debt, 87.5; equity, 12.5; invest. tax credit, 10; fed. inc. tax, 50; int. on debt, 9; deprec. (20 yr), 5; insurance, 0.5; O&M, 1.8; int. on working capital (120 days), 10; return on equity after taxes, 15. Annual costs and shipping costs for methanol and methane include CO_2 feedstock costs.

Table 3 Projected U.S. Demand for Ammonia, and Possible Market Penetrations for Onshore Coal-Fed Plants and OTEC-Ammonia Plantships (Millions of Short Tons per Year)

Year	1980	88	90	95	2000	05	10
U S Demand[a]	20.5	27.2	29.1	34.7	41.4	49.4	58.9
Production from:							
Natural gas	20.5	22.0	22.0	15.2	8.0	2.0	--
Other or imports	?	4.4	0.9	--	--	--	--
Coal	--	0.4	3.1	8.3	12.5	17.0	19.0
OTEC	--	0.4	3.1	11.4	20.9	30.4	39.9
No. of OTEC Plantships		1	8	30	55	80	105

[a]Growth rate of U.S demand is assumed to be 3.58%/yr based on a 3.1%/yr rate for nitrogen fertilizer use as 75% of the total, and a 5%/yr rate for use to manufacture other chemical products.

beginning in 1996. Although U.S. shipyards have stated they could exceed this pace, our estimates reserved some capacity for production of ammonia as the hydrogen carrier for onshore fuel cells (as addressed next) and some capacity for $\underline{LH_2}$ production, aluminum smelting and other products.

Ammonia for Electricity Production

A flow diagram for the concept of using OTEC ammonia onshore to produce electricity is shown in Fig. 3. The General Electric SPE cells can also be used as H_2-O_2 fuel cells with an efficiency of 60% at a current density of 300 amps/ft^2. The estimated onshore system cost including the fuels cells, power conditioning equipment, and auxiliaries (per Ref. 1h and private communications from Nuttall) plus ammonia decomposition equipment and oxygen generation (from air) equipment is \$480/kW$_e$ of output. Note in Fig. 3 that we assume benefits of waste heat recovery (with heat engines at \$420/kW$_e$ to accomplish it) both on the plantship and ashore. With the assumptions shown in the footnote to Table 2 for the OTEC plantship, and with these same assumptions for the onshore fuel-cell system except for increasing the O&M rate to 2% and adding 1% for local taxes, we estimate an electricity cost in 1980 dollars near 65 mills/kWh at the fuel-cell busbars at a coastal city. In some New England cities prices near 100 mills/kWh are being paid by some customers now. For this reason we believe that even if our estimates are on the optimistic side, the OTEC-ammonia-fuel-cell system will be economically viable in the 1990 s for U S locations that can not be economically served by OTEC-cable-to-shore systems Onshore busbar costs for the OTEC-ammonia OTEC-cable from the Gulf to Tampa Florida, and onshore coal plants will all be in the 40-70 mill/kWh range in 1980 dollars, depending on the assumptions made 13 * Nuclear plants may have costs about 10 mills/kWh lower if regulations and delays in construction do not become significantly more severe than they had been prior to the Three Mile Island

*Dr. Avery of APL presented ammonia and electricity costs (13) slightly lower than in Table 2 and above because his were "cash costs" based on a constant 10% interest on PI with no depreciation and no return on equity.

OTEC PLANTSHIPS FOR ALUMINA REDUCTION

In 1976 APL, aided by aluminum plant engineers, estimated costs of aluminum based on use of the OTEC electricity for the energy-intensive step in which alumina (Al_2O_3) is electrolytically reduced to aluminum metal (2). At 6.7 kWh/lb of aluminum produced in a modern plant with Hall cells, and employing waste heat recovery, it was estimated that the OTEC system could be competitive at costs of $0.35-0.40/lb in 1975 dollars.

At present a team at Reynolds Metals Company's Energy Conversion System headed by Malcolm Jones, with support from J. E. Snyder, III of TRW Systems, is concluding an investigation for DOE of OTEC/aluminum plantships. Their investigation includes the new chloride process for alumina reduction which requires only 5-5.2 kWh/lb (Fig. 4). Mr. Jones kindly provided Figs. 4 and 5. This new process is attractive not only for its 25% lower power requirement but also because of its compactness and insensitivity to ship motions. The cell with 12 bipolar plates requires less than 1/12th the platform space of a Hall cell and can be placed closer to the next cell because there is no problem from magnetic interference, hence platform cost would be much lower. The aluminum is produced by reducing $AlCl_3$ with the fused chloride electrolyte (50% NaCl, 45% LiCl, 5% $AlCl_3$) at 700°C. The aluminum falls off the edges of the cathodes into a pool at the bottom of the cell. They suggest that several offshore OTEC plantships could be served by a common shore support plant to provide the alumina, coke, and necessary services. We have not received production cost estimates from them yet, but the prospects look good to us.

LIQUID HYDROGEN, METHANOL, AND LIQUID METHANE

Table 2, discussed earlier for ammonia, includes estimated relative costs for $\underline{LH}_2$, methanol and liquid methane. On an energy content basis in dollars per million Btu delivered by cryogenic tanker over a 4000-naut. mi. distance, $\underline{LH}_2$ costs only 15% more than ammonia, and as a fuel cell feed for onshore plants at coastal cities it could prove to be just as cost-effective as ammonia. If a terminal facility, Miami or New York, is designed to take advantage of the refrigeration or air-conditioning capacity it can provide as it is vaporized for the fuel cell feed, it will be very attractive. For operation at site Pacific-2, which is 200-300 naut. mi. S.W. of Acapulco, Mexico, and shipment to San Diego, a lower cost will result. Since $\underline{LH}_2$ may become a large-aircraft fuel near the year 2000 (7), use of common terminal facilities for both aircraft fuel and fuel-cell feed would be even more attractive. Finally, within, say a 100-200 mile radius from ports such as Los Angeles, Jacksonville, or New York, vaporized $\underline{GH}_2$, transported through pipelines, could supplant present natural gas use in many applications.

As the source of carbon for the synthesis of methane and methanol onboard OTEC plantships, carbon dioxide, recovered onshore from fossil-fuel burning plants and transported in liquid form to the plantship, can be used. Methanol (CH_3OH) is now used as a fuel in racing cars and could be used in cars, buses and trucks. Its $12.60/million Btu cost in Table 2 is comparable to a cost of gasoline at the refinery of approximately $1.80/gal before distributors' and retailers' costs and profits and federal and state taxes. It is not difficult to imagine that OTEC methanol could be competitive with gasoline or gasohol by 1990, especially if it were given tax breaks like gasohol (gasoline containing 10% ethanol) already receives. Liquid methane produced by OTEC plantships could serve any market for which LNG (liquid natural

gas, essentially methane) is now being imported, or could be used as a fuel for large aircraft. The Lewis Laboratory of NASA studied both LNG and $\underline{LH}_2$ as aircraft fuels in the late 1950's, and industry is now becoming seriously interested in these fuels [see, e.g., (7)].

THE MOORED OTEC DEMONSTRATION FACILITY

The moored, cable-to-shore, OTEC demonstration facility (Fig. 6) for which the preliminary engineering design has been completed (12) is similar in dimensions and construction materials to the 40+ MW_e plantship of Fig. 1. Four pipes are added for cold and warm water discharge below the surface mixing layer. These pipes are considered necessary in the moored application to avoid the possibility of reingesting the water or causing undesirable local changes in the environment. An eight-point moor comprising 2 cables each from the four corners is used. The electric cable connections for the AC transmission system (not shown) are located in the aft area There are four cables to shore, three active AC cables carrying the 3-phase electric power, plus one spare cable. Cables go first to a submerged buoy, to reduce the motions caused by surface waves, winds and currents and down to the ocean bottom and to shore The estimated costs of plant construction and deployment for the latter moored demonstration facility at Puerto Rico are shown in the last column in Table 1. At the 40.3°F annual average ΔT obtainable, the facility would produce approximately 34.8-MW_e (net) of which about 33.8-MW_e (net) would be delivered to the Puerto Rico Electric Power Authority (PREPA) substation ashore.

When the Congressionally-initiated OTEC legislation noted in the Introduction is passed, the legislative and financial barriers to large-scale OTEC demonstration facilities and plantships will mainly have been cleared away, and substantial private cost-sharing for demonstration plants can be expected. As part of our commercialization investigation we are using the costs we had estimated and some selling price projections for OTEC ammonia and OTEC electric power as inputs to a cash-flow analysis that has been programmed. The purpose is to estimate potentials for private cost-sharing. Table 4 shows results for an OTEC demonstration facility located off a U.S. island and delivering 32 8 MW_e ashore. (Specific results would be slightly better for Puerto Rico and slightly poorer for Hawaii.) Case 1 is for 50% government and 50% private funding with a projected 1985 selling price for island electric power of 110 mills/kWh. The inflation rate used is 9%/yr, and the private funding is 10% equity and 90% Title XI bonds. The return, with our assumptions after the first year of operations and taking full advantage of the tax benefits in the legislation, is $\underline{\text{all}}$ of the equity investment plus a return on equity for the risks taken of 88%/year. The additional return from operating the plant another 24 years is $621 million in current-year dollars with the 9% inflation rate assumed.

These examples suggest to us that cost-sharing of 50% or more may be achievable. Over the past month, we presented such examples to industry on the mainland and to interested parties at meetings in Puerto Rico and Hawaii While no company or utility keeps its books or makes its investment decisions using the specific methods and assumptions we have employed, we have succeeded in stimulating dialogues which, if nurtured, can lead to substantial private involvement and the construction--soon--of large-scale OTEC demonstrations.

Table 4 Examples of Returns on Private Funding from 32.8 MW_e (Net to Shore) OTEC Facilities at U.S. Islands. All Cases Are for 9% Inflation Rate and a 10% Equity, 90% Title XI Bonds Split for the Private Portion of Funding.

Case	Tax investment Credit, %	% Private Funding	1985 selling price, mills/kWh	Return on equity, 1st-yr operations	Added return next 24 yrs $M
1	25	50	110	All + 88%/yr	$621M
2	25	100	120	All + 92	401
3	25	100	110	All + 93	165
4	25	75	110	All + 92	476
5	25	50	100	All + 90	497
6	25	20	100	All + 78	638
7	25	20	89	All + 82	506
8	10	50	100	All + 44	497
9	10	20	89	All + 34	506

CONCLUDING REMARKS AND ACKNOWLEDGEMENT

Considerable progress has been made in OTEC development and in initiating industry and state involvements in various investigations of OTEC commercialization prospects and issues An OTEC Utility Users Council and an Ocean Energy Council are active. The Congress is developing needed legislation. Benefits of 10,000 MW of OTEC facilities would include a 374,000 bbl/day reduction of oil imports for electric power generation. Benefits of 10,000 MW of OTEC ammonia plantships (30 ships) would include conservation of 409 billion ft^3/yr of natural gas--2 1/2 times the total used for residential purposes in New England. Mayor Morial of New Orleans, in a recent letter, stated that Avondale Shipyards in New Orleans alone could provide 15 such plantships in a 5-yr building program. Six or seven other major shipyards could produce equal numbers (2,4). Mr. Edwin Hood, President of the Shipbuilders Council of America, stated last October that "60 000 workers in U.S. shipyards presently face the prospect of unemployment, much of which will apply to minority workers in areas of chronic unemployment. With the usual multiplier, nearly 200 000 workers in equally important supporting industries will be affected We believe OTEC merits a priority program to alleviate the U S problems of employment, energy dependence on imports, and adverse balances of payments.

We thank W.H. Avery, D. Richards L.L. Perini and R.W Henderson of JHU/APL for contributing to the cost estimating efforts drawn upon herein, and J.F George and others at APL for the material on pilot/demonstration plant designs. We appreciate the opportunity to use the Material on OTEC aluminum smelting provided by M. Jones of Reynolds metals and J.E. Snyder of TRW. We are grateful for the support for this work provided by W.E. Richards and R. Cohen of DOE's Ocean Systems Branch, and by L. Fink of DOC/MarAd's Office of Commercial Development.

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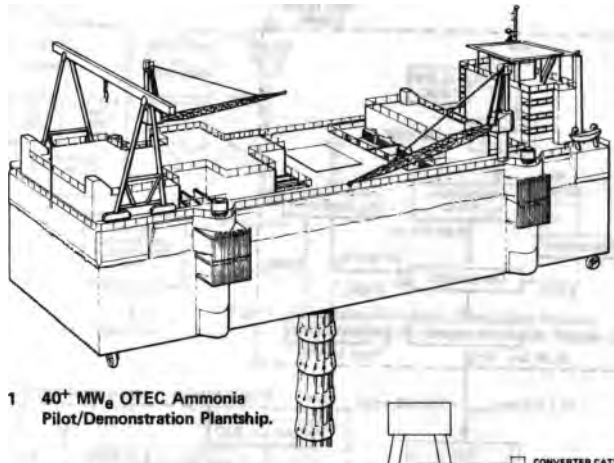


Fig. 1 40^{+} MW_e OTEC Ammonia Pilot/Demonstration Plantship.

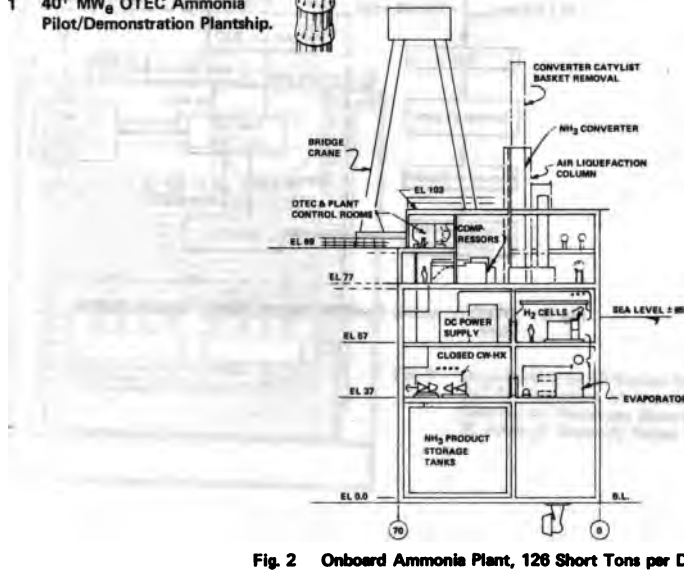


Fig. 2 Onboard Ammonia Plant, 126 Short Tons per Day.

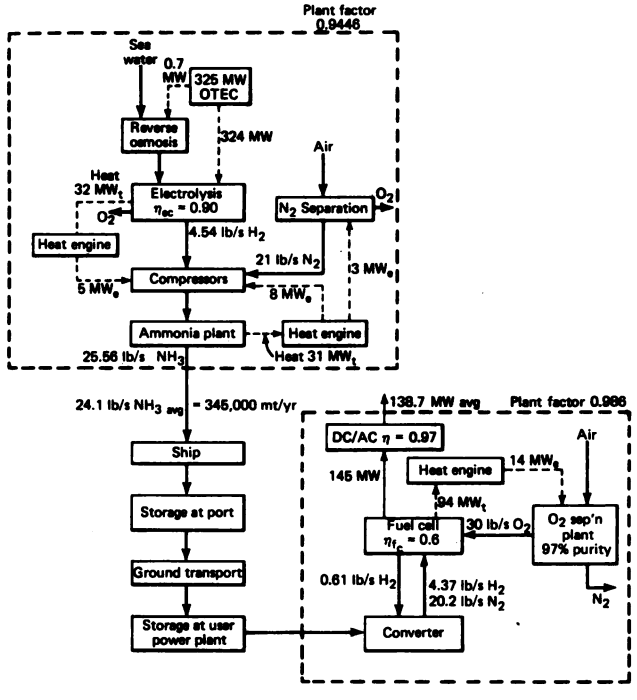


Fig. 3 OTEC/Ammonia Fuel-Cell Electric Power, Baseline Eighth Plant.

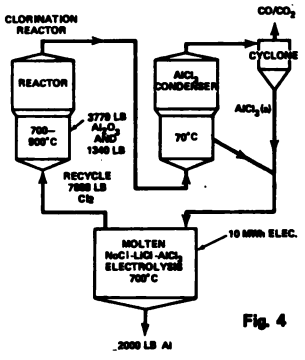


Fig. 4 Onboard Aluminum Reduction Process. (Courtesy of M. Jones, Reynolds Metals Co.).

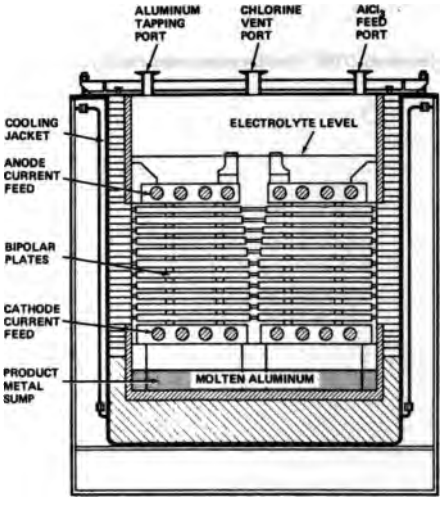


Fig. 5 Cross-Section of 12-Bipolar-Plate Cell for Reduction of Aluminum Chloride to Aluminum (Courtesy of M. Jones of Reynolds Metals Co.).

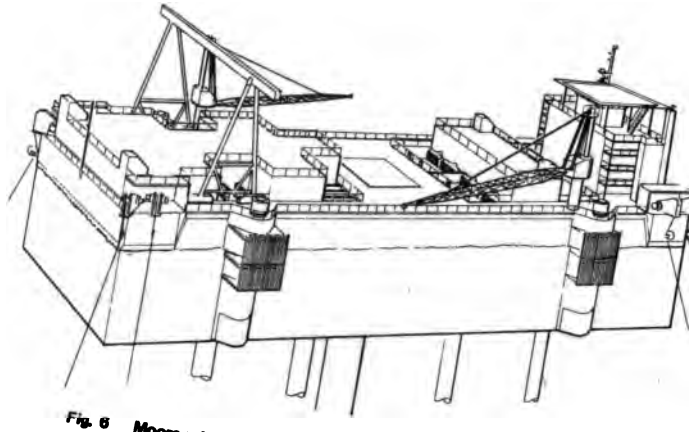
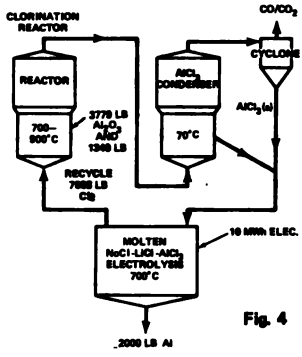


Fig. 6 Moored 40 MW_e (nominal) OTEC Pilot/Demonstration Facility.



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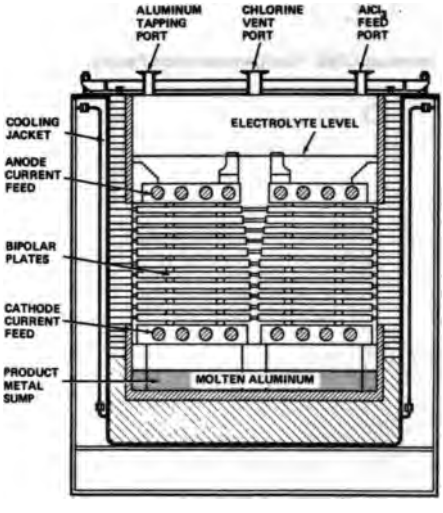

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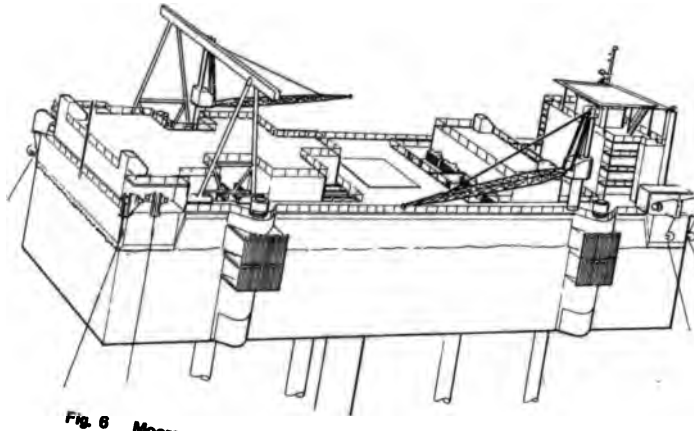

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