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Volume 2, Number 11 (November 1978)

The OTEC Liaison

AN INTERNATIONAL NEWSLETTER ENGAGED AS LIAISON FOR THE COMMUNITY OF OCEAN THERMAL ENERGY CONVERSION

DOE'S IN-HOUSE ASSESSMENT OF OTEC:

"Summary of Principal Findings, OTEC Cost and Efficiency"

The following report of a Department of Energy in-house assessment of OTEC is presented in its entirety. It is authored by A. S. Clorfeine, Division of Planning and Technology Transfer, ETS; James R. Roney of the Franklin Research Laboratories; Gay Heit Lavi of ERDI Incorporated, Pittsburgh, Pennsylvania; and Abrahim Lavi of the Ocean Systems Branch of DOE's Division of Solar Technology. The report is dated August 14th, 1978.

Readers are cautioned to also digest the letter, reproduced in this issue, from DOE's F. G. Blake, dated October 3rd, which accompanied the forwarding of this report to The OTEC Liaison, regarding its content.

Readers' comments are both invited and encouraged.

(Note: Words and sentences are shown in bold type exactly as they were underlined in the original report.)

The OTEC Liaison

VOLUME 2, NUMBER 11
November 1978

DOE'S IN-HOUSE REPORT ENTITLED: SUMMARY OF PRINCIPAL FINDINGS, OTEC COST AND EFFICIENCY

Summary of Principal Findings

Ocean Thermal Energy Conversion (OTEC) is surrounded by more than its share of misunderstanding and controversy. The conflicting statements regarding OTEC, the wide and differing ranges of cost estimates, and the various programmatic and market options have precipitated a degree of confusion which this study has attempted to reduce. The study has addressed most of the major OTEC issues, particularly those dealing with cost, efficiency, and potential market. Principal findings are summarized below.

Market Potential

The nearest-term customer would be the oil-dependent island utility seeking additions or replacements of 10 to 100 megawatts capacity. A total installed island capacity of three gigawatts by the year 2000 appears feasible. Puerto Rico, Hawaii, and Guam have expressed strong interest in OTEC. Economic, social, and political factors appear favorable for the development of an island market. **Technology for these small plants appears to be at hand.**

OTEC penetration of the US mainland power market is unlikely before 2000. By 2020 a 20-to-40-gigawatt OTEC installed capacity — a small fraction of the required baseload capacity for the Southeast — seems plausible. This conclusion is based on a moderately-low growth scenario and on expected coal and nuclear-power costs as derived in recent studies. **The mainland market hinges on the successful development of high-voltage, high-power, underwater bottom and riser cable technology.**

Eventual penetration beyond the Southeastern Region is possible if the cost of transmission to the interior is not prohibitive.

The ability of plant-ship products to compete in the ammonia fertilizer market is dependent on the generation of on-board electricity at costs below those we believe to be obtainable. Thus, while continued study of the plant-ship concept — especially the potential value of products in

(continued on Page 3)

SOLAR OCEAN ENERGY

OUTLINE OF DEEP OIL TECHNOLOGY'S COLD-WATER-PIPE RESEARCH

In a reply to a request by this publication to DOE, W. G. Sherwood, Program Manager of the Division of Solar Energy's Ocean Systems Branch, advises the following briefing of the current efforts of Deep Oil Technology Incorporated of Long Beach, California:

Deep Oil Technology's effort on the cold-water pipe is a verification test. A five-foot diameter steel pipe, 800 feet in length, will be installed on the Deep Oil Technology tension leg X-1 platform for tests offshore of San Clemente Island, California. The pipe will be instrumented to monitor pipe stresses under actual sea conditions. Data collected will be used to verify analytical models, giving confidence to the design and deployment of larger cold-water pipes.

Deep Oil Technology is also making the primary effort on a feasibility design study to develop the design parameters, schedules, and budgets to install 10-MWe OTEC plants and a 40-MWe land-based OTEC plant at specific sites in Hawaii (Keahole Point) and Puerto Rico (Punta Tuna).

Federal Options

Risk Level	Description	FY80 Budget $ (Millions)	FY80-85 Budget Accumulated $ (Millions)	Year Of Island Entry	Year Of U.S. Entry
Low	Serial: OTEC-1 (Including Turbine-Generator) Test In FY 80-81 10MW Modular Experiment Design To Follow	36	300	1991-1995*	2001-2010*
Medium	Modular Experiment Design Initiated Prior To OTEC-1 Testing	42	300	1990	2000
High	Designs For 2 Modular Experiments Initiated Prior To OTEC-1 Testing Long Lead-Time Items Ordered Before Design Is Completed	50	420	1987	1995

*Depends On Budgetary Decisions Made In Subsequent Years

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SUBSCRIPTION RATE INCREASE IN 1979

Due to inflationary increases in the cost of paper, printing, postage, and mailing, subscription rates for The OTEC Liaison will be raised to $95 annually on all new subscription orders and renewals received after January 1st, 1979. Until then the current published rates will be in effect: $80 for one year (12 issues), $140 for two years (24 issues)—a saving of $20. Colleges and universities: $70 for one year (12 issues), $120 for two years (24 issues)—a saving of $20.

NOAA AWARDS RESEARCH CONTRACTS FOR COLD-WATER PIPE

October 30th, 1978: Two contracts totaling almost $1.2 million have been awarded to develop preliminary designs for a cold-water-pipe (CWP) system of proposed Ocean Thermal Energy Conversion (OTEC) plants, the National Oceanic and Atmospheric Administration (NOAA) has announced.

The awards by the Commerce Department agency were made to a team consisting of personnel from TRW Incorporated and Global Marine Development Incorporated of Los Angeles for $573,918, and to a team consisting of personnel from Science Applications Incorporated of Los Angeles and Brown and Root Incorporated of Houston for $593,080.

The contracts will result in detailed engineering designs of the CWP system concept. The two contractors will carry out parallel development and design, each preparing three preliminary designs of CWPs 30 feet in diameter and 3,000 in length.

NOAA's Office of Ocean Engineering is administering the contracts as part of a multi-million-dollar Department of Energy program aimed at perfecting OTEC plants.

According to NOAA, the cold-water pipe is one of the last major engineering problems to be solved to prove the thermal conversion system technically successful.

DOE AWARDS FOUR POTENTIAL MARKET ASSESSMENT CONTRACTS

The Department of Energy has awarded one-year contracts to four firms to assess potential markets for electricity generated by large floating "ocean thermal energy conversion" power plants.

The four firms (and contract amounts) are Fairchild Industries, Stratos Division, Manhattan Beach, California ($294,000); General Electric/Tempo, Washington DC and Santa Barbara, California ($193,000); Reynolds Metals Company, Richmond, Virginia ($303,000); and Consultores Technicos Asociados, Puerto Rico ($106,000).

Reynolds will focus on the potential of using OTEC power for the production of aluminum. The other companies will concentrate on the requirements necessary for OTEC to be an acceptable power source for public utilities.

Fairchild has subcontracts with Florida Power and Light and Hawaiian Electric; General Electric with Florida Power and Light and Middle South Services Company; and Consultores Technicos Asociados with the University of Puerto Rico's Center for Energy and Environment Research and the Puerto Rico Water Resources Authority (the local electric utility). These contracts will help the Government structure future development efforts to move the OTEC concept into commercial reality in the 1990s.

ON HAWAII'S SEACOAST TEST FACILITY

(The following story appeared in the October 14th issue of DOE's publication *Energy Insider.*)

The Argonne National Laboratory has awarded a DOE-supported $480,000 contract to the Research Corporation of the University of Hawaii to design a facility for the testing of components and materials for Ocean Thermal Energy Conversion (OTEC) plants.

The huge floating power plants of the future will use the temperature difference between sun-warmed tropical surface water and cold deep-ocean water to create electricity. The process will involve pumping tons of seawater through miles of heat-exchanger tubing.

The Hawaii project is funded by DOE's Office of Energy Technology.

The new facility, called the Seacoast Test Facility, will be used for experiments to learn the effects of seawater and microscopic marine life on materials and components proposed for OTEC plants. The mineral content of the seawater could prove corrosive, while microscopic marine life could form insulating layers of growth inside the tubes of OTEC heat exchangers, limiting the plants' ability to draw heat from warm water.

Components to be tested at the facility will include reduced versions of OTEC heat exchangers which draw the energy from the sea. Several new heat-exchanger designs have been tested at Argonne using fresh water to determine their efficiencies, but they have not yet been tested in seawater.

If the Research Corporation design is approved for construction, the cost is expected to total about $6 million, with the University contributing about 40%.

The Seacoast Test Facility will occupy about 20 acres of lava bed on Keahole Point on the west side of the island of Hawaii.

CORRECTION

In the October issue of TOL extensive coverage was given to a feature article on OTEC and ocean energy that appeared in the August issue of *Sea Technology.* In our condensation of the *Sea Technology* article, we erred in crediting Byron Washom quotes to the much-criticized Office of Technology Assessment (OTA) report on ocean energy. In fact, Washom, Manager of Advanced Products Technology and Policy for the Stratos Division of Fairchild Industries, Manhattan Beach, California, had given testimony in Congress on this report, and it is from that testimony that his quotes are taken.

TOL apologizes to Mr. Washom, *Sea Technology,* and TOL readers for the error.

(continued from Page 1)

future applications (such as H_2 and NH_3 in fuel cells)—is called for, high priority for OTEC plant-ships vis-a-vis cabled electricity is not justified at this time.

Technical Feasibility

OTEC plants are characterized by low efficiency (2 to 2.5%), huge equipment, and high flow rates. Major technical concerns are: (a) the implications of low efficiency, (b) manageability of biofouling, (c) the underwater cable, (d) the cold-water pipe, (e) capacity factor, and (f) sensitivity of performance to design uncertainties.

Arguments stating that low efficiency by itself implies prohibitive costs are specious. They are based on extrapolations from conventional power-plant technology. However OTEC operates in a relatively benign environment (low temperatures and pressures) which favors reasonable component costs in spite of the large size.

Reasonable control of biofouling is vital to preservation of high heat transfer. Early ocean tests have been encouraging. Biofouling rates in the open ocean appear to be less than those in coastal regions; mechanical and chemical cleaning are likely to be effective. However, **considerable experimental evidence is necessary before this encouraging trend is confirmed.**

Substantial advances in cable technology are crucial to the success of the mainland power mission. Thus **the cable effort should receive higher priority.** Acceleration of cable development should reduce cost uncertainty, possibly greater for this component than for any other in the program.

The cold-water pipe—its fabrication, deployment, and coupling to the platform—will require a concerted engineering effort to produce advances beyond the state-of-the-art. For small plants (10 to 40 megawatts), the problems are not likely to be show-stoppers. For large plants, considerable effort is necessary.

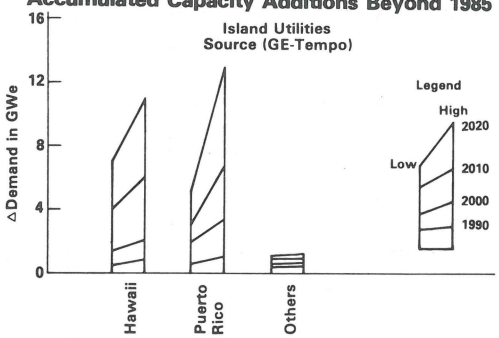
An 85 to 90% **availability**—referring to that portion of the time when the system is capable of operating—seems realistic. High availability will be aided by modularity and on-line cleaning, though conditions peculiar to ocean operation introduce some uncertainty. Note, however, that it is the **capacity factor**—the product of availability and a second factor related to the seasonal variation of the surface-to-bottom temperature difference, delta T—that determines power cost. For the Gulf region, capacity factors of 75 to 80% appear realizable.

Uncertainties in biofouling, overall heat-transfer coefficient (U), parasitic losses, and delta T should not, even under the worst case assumptions, lead to a zero net-power condition, though of course overall power reductions could become prohibitive. Sensitivity to uncertainties in delta T—a 10% reduction in this quantity leading to about a 30% loss in output—exceeds that for other parameters. For the heat exchanger, in one specific design studied, a 50%-lower-than-anticipated U would result in 25% less power.

OTEC Penetration Scenario (Choice of Medium Risk FY 1980 Budget Option Assumed)

FY1980 10 MW Modular Experiment (M.E.) Preliminary Design Initiated.
1981 OTEC-1 Testing Of Heat Exchanger Successful.
1981 M.E. Detailed Design Initiated.
1981 Construction Of M.E. Initiated (About 3 Months After Initiation Of Detailed Design, The Latter Continuing During Construction Phase).
1983 M.E. Testing Initiated.
1985 Construction Of Additional 30 MW (Presumably Advanced-Technology) Heat Exchangers Completed And Installed On M.E. Testing Initiated At 40 MW Level.
1986 Design Of Island OTEC Initiated (Size Of 40-100 MW TBD).
1987 Construction Of Island OTEC Initiated.
1990 OTEC Power Delivered To Island.
2000 OTEC Power Delivered To Southeast U.S.
2005 About 30 Graving Docks Completed By This Time. If Titanium Used, Huge Expansion Of That Industry Required.

Table 1
Low-High Island Electricity Projections
Accumulated Capacity Additions Beyond 1985



NOTES FOR TABLE 1 SOURCE: GE TEMPO P. III-25

DEFINITION OF OTHERS: VIRGIN ISLANDS, GUAM, MICRONESIA

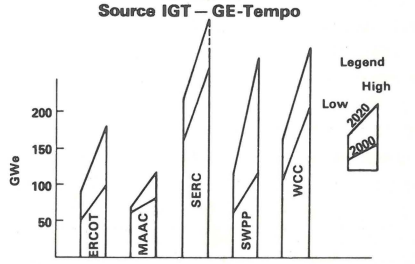
GROWTH OF ELECTRICITY REQUIREMENTS (PERCENT INCREASE, COMPOUNDED ANNUALLY)

HAWAII	4-5
PUERTO RICO	3-4
ISLANDS, OTHERS	3

CURRENT INSTALLED CAPACITY

HAWAII	1.4 GW
PUERTO RICO	4.5 GW
OTHERS	0.3 GW

Table 2
Additional Base Load Capacity Required
All USA
Source IGT—GE-Tempo



ASSUMPTIONS: TABLE 2

1975	TOTAL GENERATING CAPACITY	GWe
ERCOT	ELECTRIC RELIABILITY COUNCIL OF TEXAS	32
MAAC	MID AMERICA AREA COUNCIL	42
SERC	S. E. ELECTRIC RELIABILITY COUNCIL (INCLUDES FLORIDA)	110
SWPP	SOUTH WEST POWER POOL (INCLUDES ALABAMA & MISSISSIPPI)	40
WSCC	WESTERN SYSTEM COORDINATING COUNCIL	89

HIGH GROWTH: 1975 - 2000 = 6.1% COMPOUNDED ANNUALLY
2000 - 2020 = 3.8%
LOW GROWTH: 1975 - 2020 = 2.9%

BASE LOAD ADDITION IS 60% OF ADDED CAPACITY
REF: G.E./IGT REPORT P. 29

Economic Feasibility

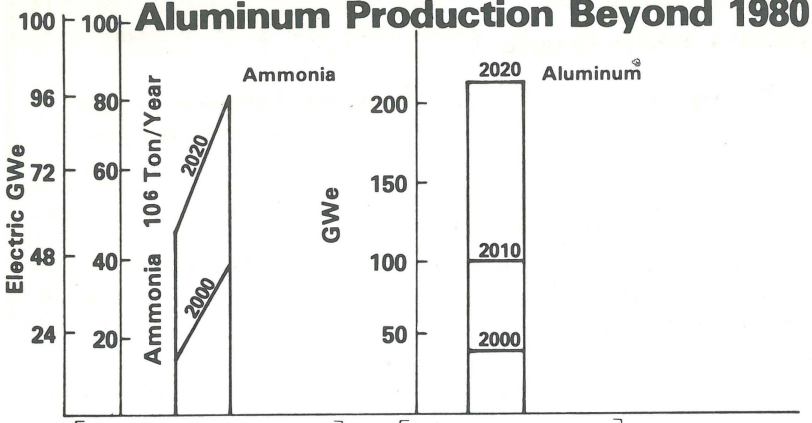
Quoted energy costs below 30 mills/KWh are, in our judgment, too optimistic. Questions of economic feasibility are related first to component cost ($/KW) and ultimately to energy cost (mills/KWh). Plant costs ($/KW) estimated by various contractors range over a factor of four. If one disregards the most optimistic and, in our opinion, indefensible estimates, the range reduces to $1500-2700/KW (sum-of-component costs in 1978$)—a projection that appears credible. The heat-exchanger costs account for nearly half of the above totals.

These capital costs lead to unsubsidized energy costs of 35 to 70 mills/KWh if capacity factors, interest during construction, installation costs, and other financial assumptions are properly accounted for.

The uncertainty in power costs can be reduced by (a) standardized costing procedures, (b) integrated site-specific designs, (c) continued component development,

(continued on Page 5)

Table 3
Additional Capacity Required for NH3 & Aluminum Production Beyond 1980



Source GE-Tempo (p. IV-8) and 1977 OTEC p. III-77

Source 1977 OTEC (p. III-77)

Table 4
Electricity Cost Assumptions for Islands in 1978 $ Mills/kwh

Oil			OTEC			OTEC $/kw	
Year	Hawaii	Puerto Rico	Size MW	Hawaii	Puerto Rico	Hawaii	Puerto Rico
1980	59	56					
1990	61	57	40	104	95	4560	4000
2000	68	66	100	78	76	4560	3000
2020	76	74	100/250	53	49	2280	2000

Source GE-Tempo p. XV
Mitre p.25
Lavi See Attached

Table 4
(Continued)
OTEC Penetration in Islands in GWe

Year	Hawaii	Puerto Rico
1990	.25	.25
2000	1.5	1.5
2010	2.5	2.5
2020	4	4 (4.7) *

Source GE-Temp. P. III-25
* Mitre
See Notes Atached

NOTES TO TABLE 4

	PUERTO RICO	HAWAII	
CAPACITY FACTOR	0.8	0.83	
1980 O&M CHARGES	4	4	MILLS/KWH
1990 O&M CHARGES	3	3	" "
FIXED CHARGE RATE (%)	16	18	
ΔT (°F)	41	38	

NOTES:

1. LOW DEMAND SCENARIO ASSUMED
2. ALL ADDITIONAL CAPACITY SUPPLIED BY OTEC UNTIL 40% LEVEL IS REACHED
3. THEREAFTER, OTEC PENETRATION MAINTAINED AT 40%
4. FIXED CHARGE RATE EXPLANATION:

	PRIVATE	PUBLIC
COST OF MONEY	10%	8%
INSURANCE	4	4
TAXES	3	0
ADMINISTRATION	1	2
EQUALIZATION OF INTEREST RATE	0	2
	18%	16%

BUSBAR COST PARAMETERS FOR GULF-COAST UTILITY:

OTEC — SOURCE: MITRE

INVESTMENT TAX CREDIT	10%
FEDERAL TAX RATE	48%
STATE TAX RATE	4%
FINANCIAL LIFE	30 YRS
TAX LIFE	23 YRS
DISCOUNT RATE	10.16%
EQUITY FRACTION	35/12%
DEBT FRACTION	53%
EQUITY RATE	14/8.5%
DEBT RATE	8%
PROPERTY TAX/INSURANCE RATE	1.4%
CONSTRUCTION PERIOD	5 YRS
O&M COST	$35/KW/YR
O&M ESCALATION	5%
GENERAL INFLATION RATE	5%
GROSS RECEIPTS TAX RATE	2%
FIXED CHARGE RATE	14.918%

ASSUMPTIONS USED FOR GULF-COAST OTEC OPERATION

OTEC COST TO DROP TO $1800/KW BY THE TIME 20 GWE ARE INSTALLED.

INVESTMENT TAX CREDIT: 10%

FIXED CHARGE RATES: PUBLIC 10.9% PRIVATE 14.9%

CAPACITY FACTORS (CORRECTED FOR ΔT VARIATION):

FLORIDA	0.83
ALABAMA-MISSISSIPPI	0.75
TEXAS-LOUISIANA	0.73

PLANT AVAILABILITY: 0.9

DESIGN ΔT: 40°F; SIZE: 400 MWE; CONCRETE SPAR, TITANIUM HEAT EXCHANGER; AMMONIA WORKING FLUID, RUBBER COLD WATER PIPE, STATIC MOORING

SUCCESSFUL ENTRY INTO ISLAND MARKET IN 1990 (10-40 MW), 1995 (100 MW)

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ranklin Institute Research Lab- ("Franklin" or "FIRL") is a esearch organization whose prod- the solution of problems and the ent of useful technology. Ser- performed for business, industry, rnment by a staff of several hun- ntists, engineers, and support per- mploying the most sophisticated t and techniques available.

arent organization, The Franklin was founded in 1824 to promote d sciences. After greatly expand- cilities at the request of the US ent during the Second World War, ute established the Laboratories s a separate division. Although it to serve the Federal Govern- anklin also devotes a large part orts to the problems of private and society in general, with in- emphasis on programs directed e solution of the critical techno- es facing the world today.

is located in modern, efficient, tile quarters near the Institute's and Planetarium building in mid- ladelphia. A field-test facility is the nearby suburb of Elverson. fices in Washington DC, Munich, o facilitate technological inter- d provide local points of liaison ernment and industrial clients.

PRESENTATIVE BREAUX LS MODEST OTEC FUNDING AS "ABSURD"

ing at the American Oceanic Or- n luncheon of October 19th, Rep- e John Breaux (D-LA), Chairman ouse Subcommittee on Oceanog- id that ocean resources are being by the Federal Government. He absurd that so much money is nt by DOE on geothermal energy st to the $34 million annual bud- ean energy, $32 million of which EC.

IGER;

Table 5

Range of Electricity Cost for South East U.S. in 1976 $ Mills/kwh

Based on National Energy Act Scenario 10% ITC

	Year of Entry 1995			Year of Entry 2000		
Year	OTEC	Coal	Nuclear	OTEC	Coal	Nuclear
2000	37-70	38-50	25-45	40-70	38-50	25-45
2010	32-56	42-53	25-50	35-60	42-53	25-50
2020	32-63	43-60	30-58	40-63	43-60	30-58

Source Mitre
See Notes for Assumptions

Table 5 (Continued)

Levalized Modal Bus Bar Cost (1976 $ Mills/kwh): 2020

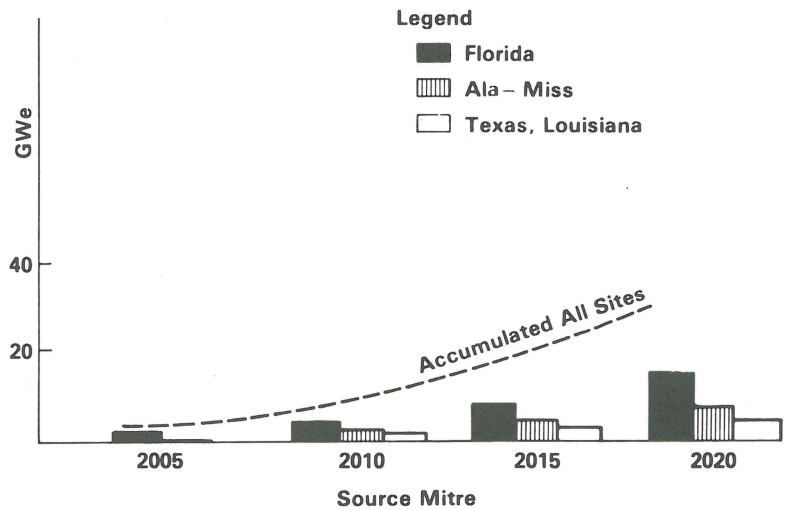
Market Entry of OTEC 1995

Region	OTEC	Coal	Nuclear
Florida	42	57	44
Alabama-Miss	45	53	44
Texas	47	49	44

Source Mitre

Table 5 (Continued)

OTEC Cumulative Capacity Market Entry to U.S. in Year 2000



Source Mitre

(continued from Page 3)

and (d) system experiments.

Note that our projections for OTEC power costs overlap those made for coal and nuclear plants.

Resources, Environmental, and Institutional Issues; Spinoffs

Issues can be identified relating to the thermal resources (magnitude and renewability) and environmental effects (local and global). Institutional issues concern regulation and licensing, legal (US and international), financing, and constraints imposed by utility business practices.

While gross data (such as the monthly variation of delta T) suitable for plant design exist, detailed data (terrain, short-range fluctuations in delta T) are insufficient. Environmentally, effects of local temperature changes are not known; chlorination — if required for biofouling control — may be a problem; damage to marine life cannot be ascertained at present.

Power companies in particular are loath to take unnecessarily large risks. However oil-dependent island utilities may more readily plan for technology that has not been fully confirmed. Financing could present a major problem for both small and large utilities. Further problem definition and remedial actions are required concerning safety and regulation, taxation, licensing, and law-of-the-sea issues. Tighter coupling of utilities to DOE efforts, a total system design, and other studies could clarify many of the institutional issues.

Spinoffs from the development of a viable OTEC industry could include improved heat exchangers, improved efficiency of conventional power plants via waste-heat recovery, lower-cost desalination, mariculture farms, and a rejuvenation of the US shipbuilding industry.

Federal Options

The entry of OTEC into a US mainland market is unlikely unless and until small OTEC plants have been successfully demonstrated in the more benign and closer-to-shore island environment.

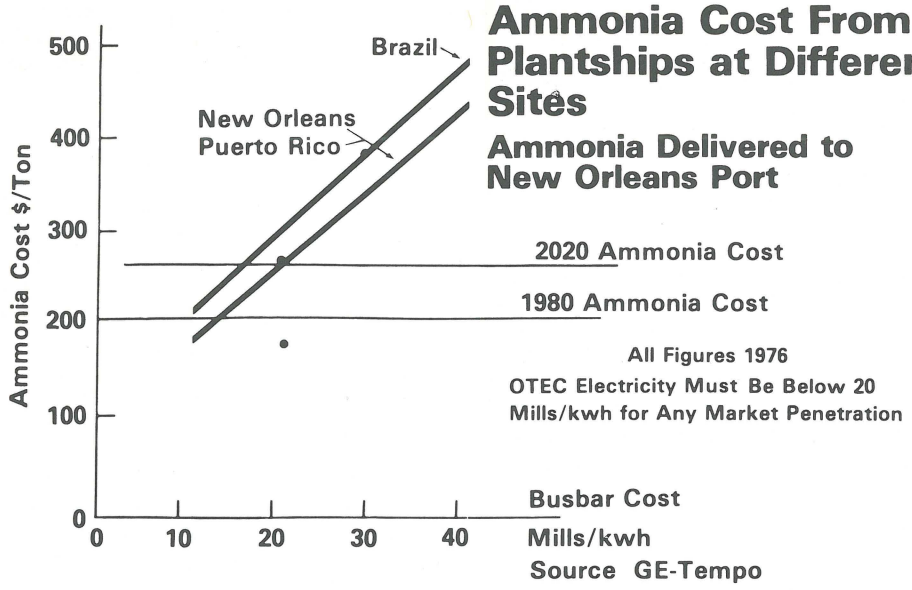
OTEC could deliver power competitively to US islands by 1990 if technical and economic feasibility are proven by the mid-1980s. Proof of technology will require successful completion of one or more modular experiments each costing approximately $100 million. Cost-effective modular experiments will require a **sufficiently early and integrated industry-led** design approach to problems of performance, siting, environment, and grid interaction.

Multiple design efforts for multiple sites will improve the probability of constructing and conducting an effective modular experiment.

A spectrum of three federal options — their brief descriptions, cost, and implications — are summarized in the attached table. The additional risk inherent in the "medium risk" option — stemming from

(continued on Page 6)

Table 6
Ammonia Cost From Plantships at Different Sites
Ammonia Delivered to New Orleans Port



Component Cost Range Estimation in 1978$ $/kw
$\Delta T = 40°F$

Subsystem	High	Low
Power (Ti Shell-Tube Hx)	1,360	850
Platform (Ship)	400	120
CW Pipe (Rubber)	200	200
Mooring (Static)	130	38
Others Incl. Eng.	150	85
Cable 100 Miles	400	200
Total	2,640	1,495

ASSUMPTIONS REGARDING COMPETITION

NUCLEAR

THE FOLLOWING TECHNOLOGIES ARE CONSIDERED:

- CANDU (HEAVY WATER REACTOR - CANADIAN)
- HTGR (HIGH TEMPERATURE GAS-COOLED REACTOR)
- LMFBR (LIQUID METAL FAST BREEDER REACTOR)
- LWBR (LIGHT WATER BREEDER REACTOR

COSTS

- PROJECTED CAPITAL COSTS ARE FROM $750/kW TO $1200/kW
- PROJECTED O&M COSTS ARE FROM $17/kW/YR TO $25/kW/YR
- PROJECTED FUEL COSTS ARE FROM 3 TO 8 MILLS/kWe

AVAILABILITY

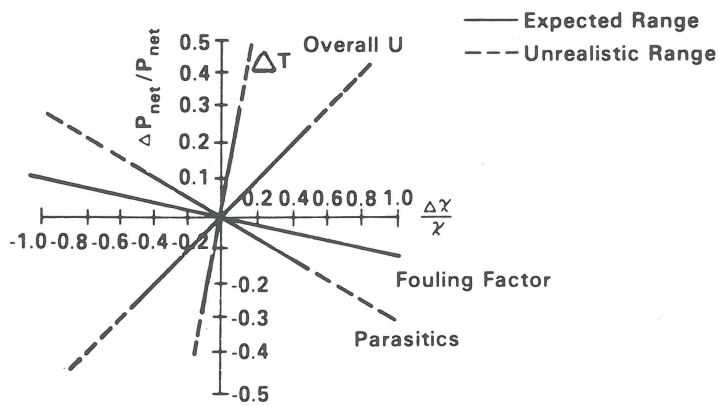
- CANDU - 1990
- HTGR, LMFBR, LWBR - 2000

REJECTION OF LWR

- INADEQUATE URANIUM SUPPLY TO SUPPORT CONSTRUCTION BEYOND 2000
- NOT COMPETITIVE WITH CANDU DUE TO POOR FUEL EFFICIENCY

SOURCE: MITRE

Performance Sensitivity to Design Uncertainty in Key Variables



Baseline Conditions

$P_{net} = 12.5$ MWe
Parasitic = 3.5 MWe (Only Variable Portion Included)
$P_{gross} = 16.0$ MWe

Fouling Factor $= 3 \times 10^{-3}$ (Btu/hr ft^2°F)$^{-1}$
Overall U = 1100 (Btu/hr ft^2°F) Double Fluted Tubes
$\Delta T = 40°F$

ASSUMPTIONS REGARDING COMPETITION (CONTINUED)

COAL

THE FOLLOWING TECHNOLOGIES ARE CONSIDERED:

- FGD (FLUE GAS DESULPHURIZATION)
- AFBC (ATMOSPHERIC FLUIDIZED BED COMBUSTION)
- PFBC (PRESSURIZED FLUIDIZED BED COMBUSTION)
- IGCC (INTEGRATED GASIFIED COMBINED CYCLE)

COSTS

- PROJECTED CAPITAL COSTS ARE FROM $475/kW TO $650/kW
- PROJECTED O&M COSTS ARE FROM $16/kW/YR TO $24/kW/YR
- PROJECTED FUEL COSTS ARE FROM 10 MILLS/kWH TO 25 MILLS/kWH

AVAILABILITY

- FGD - 1980
- AFBC - 1990
- PFBC - 1995
- IGCC - 1995

OTHER FACTORS

- COAL COSTS ARE RELATIVELY HIGH IN THE GULF REGION

SOURCE: MITRE

ASSUMPTIONS REGARDING COMPETITION (CONCLUDED)

ADVANCED TECHNOLOGIES REJECTED

- BIOMASS COMBUSTION - ECONOMIC BUT LIMITED SUPPLIES
- GEOPRESSURED - LIKELY TO BE USED FOR PIPELINE GAS
- MAGNETOHYDRODYNAMICS - NOT BEFORE 2020
- FUSION (MAGNETIC/LASER) - NOT BEFORE 2020
- SPACE BASED POWER - NOT BEFORE 2020
- HYDRO - SITE-LIMITED
- LOW HEAD HYDRO - NOT BASE LOAD
- OIL/GAS - NOT AVAILABLE FOR BASE LOAD
- LIGNITE - USED INTERCHANGEABLY WITH COAL
- PEAT - NOT AVAILABLE IN SOUTHEAST
- SOLAR WITH STORAGE - NOT ECONOMIC

SOURCE: MITRE

(continued from Page 5)

the initiation of preliminary modular experiment design prior to the confirmation of acceptable performance of the state-of-the-art titanium heat exchangers—is judged to be slight. The attached OTEC Penetration Scenario is consistent with the adoption of the medium-risk option.

Department of Energy
Washington, D.C. 20545

October 3, 1978

Mr. Richard Arlen Meyer
The OTEC Liaison
1910 N. Elston Avenue
Chicago, Illinois 60622

Dear Mr. Meyer:

In response to your inquiry of September 13, 1978, addressed to Dr. Bennett Miller, concerning a recent in-house assessment of OTEC, I am enclosing a copy of the "Summary of Principal Findings, OTEC Cost and Efficiency", dated August 14, 1978, together with some back-up tables and graphs. This constitutes the only "report" that has been prepared and it represents the opinions of the authors, not an official Departmental position.

Like any forecast or "scenario", the findings depend, in some instances critically, upon the assumptions on which they are based. These assumptions and their sources, are provided. You will note that there are divergences of opinion, so that at least to that extent, the findings are tentative.

A final caveat concerns the table labeled "Federal Options." The budget numbers shown are only examples postulated for the purpose of developing alternative scenarios. They do not in any sense represent actual or approved proposals or plans. I am sure you are aware we are still in the process of preparing proposals for the President's Budget for FY 80, to be presented to the Congress next January, and no decisions have yet been reached.

Once again, we thank you for your continuing interest and support of OTEC, one of our major solar energy programs.

Sincerely,

F. G. Blake
Special Assistant
Office of the Program Director
for Solar, Geothermal, Electric
and Storage Systems

Attachments:
As stated

● Dr. Abrahim Lavi left his position at DOE in late August, returning to his academic duties at Carnegie-Mellon University. Dr. Lavi has advised TOL that he is also associated with a new firm called ERDI—Energy Research and Development International Incorporated of Pittsburgh.

● The article on OTEC to appear in *Ocean Industry* magazine will be in the November 1978 issue as a featured story accompanied by full-color illustrations.

● *The Saturday Review* is planning to feature the oceans in its January 1979 issue, with special attention to ocean resources. An extensive article on OTEC will be included.

● Famed science-fiction author Dr. Isaac Asimov has written an article titled "Ocean Energy" appearing in the October issue of *American Way,* distributed to passengers of American Airlines. It is a rough outline of the basic concepts of ocean thermal-energy conversion, but no mention whatsoever of OTEC or any of its history or current state of development is included.

TOL spoke with Dr. Asimov and was told that he was not aware of current research and development; however he later said that he had based the article on his general recollection of what he had read or heard about it.

US GOVERNMENT PROCUREMENT INVITATIONS AND CONTRACT AWARDS

Listed below are procurement invitations and contract awards related to OTEC in particular and ocean resources in general culled from the *Commerce Business Daily*. This is not to be construed, however, as a complete list.

Oct 16: Pace Energy and Petrochemical Outlook to 2000: Negotiations are being conducted with Pace Company, Houston TX 77052, for Contract EI-78-C-01-6467. Contract specialist is Peter Braun.

● **Oct 16: Integration Issues to Realize OTEC Market Potential:** Part A: Contract ET-78-C-02-5090.A000, for $294,254, awarded to the Fairchild Stratos Division, 1800 Rosecrans Avenue, Manhattan Beach CA 90266.

Oct 17: Water and Land Availability for Energy Farming: Contract ET-78-C-01-3142 (unsolicited proposal), $163,120, awarded to RI International, Menlo Park CA 94025.

Oct 17: Environmental Assessment for the Hydrogen Energy storage Program: Contract ET-78-C-01-3403 (no RFP), for $97,251, awarded to Aerospace Corporation, Los Angeles 10009.

Oct 17: Evaluation of Technical Material and Information for Potential Desalting Demonstration Plants: Contract 14-34-0001-8705, for $132,107, awarded to Boyle Engineering Corporation, 4525 Mission George Place, San Diego CA 92120. US Department of the Interior, Office of Water Research and Technology, 18th and C Streets NW, Washington DC 20240.

Oct 17: Appropriate Technology: Renewable resource utilization: Contract DSAN-C-0061, $58,000, for an eleven-month period, awarded to the Center for Development Technology, Washington University, St. Louis MO 63130. Department of State, Agency for International Development, Washington DC 20523.

Oct 17: Data Collection and Information Processing Services for Energy Technology: Contract ET-78-C-01-3187 (sole source), for $255,800, awarded to Opportunity Systems, Washington DC 20005.

Oct 17: Technical Support Services for the Division of Power Supply and Reliability: Contract EB-78-C-01-6380 (RFP EB-78-C-01-6380), $77,696, awarded to Temple, Barker, and Sloane, Wellesley Hills MA.

Oct 18: Engineering Services for Advanced Ocean Systems Including System and Product Documentation, Advanced Systems Technical Support, and System Engineering and Analysis: It is the intent of the Government to enter into a cost-plus-fixed-fee indefinite-delivery contract for CY 79. RFP N00604-79-R-0004. Closing 1 Nov 78. Requests for solicitation should be received at the issuing office prior to 20 Oct 78. Telephone (808) 471-0811, RCA Telex 7238645 NSC PH. Regional Procurement Department, Naval Supply Center, Box 300, Pearl Harbor, Hawaii 96860.

Oct 18: Data Analysis and Reduction for Upper Ocean Analysis: Contract N00014-78-C-0879, 28 Sep 78 (no RFP), for $98,772, awarded to Jaycor (S), 1401 Camino del Mar, Del Mar CA 92014.

Oct 18: Research in Numerical Techniques for Ocean Forecasting: Contract N00014-78-C-0706, 28 Sep 78 (no RFP) $68,800, awarded to the Regents of the University of Colorado, Graduate School, Office of Contracts and Grants, Boulder CO 80309.

● **Oct 18: Aquaculture Technology Development:** Contract AID/DSANC-0053, $116,000, awarded to Auburn University International Center for Aquaculture, Auburn AL 36830, 29 Sep 78. Department of State, Agency for International Development, Washington DC 20523.

● **Oct 20: Development, Design, Fabrication, and Testing of Ocean Thermal Energy Conversion:** Contract ET-78-C-01-3407, $901,297, awarded to Lockheed Missiles and Space Company, Inc., PO Box 504, Sunnysdale CA 94098.

● **Oct 20: Development, Design, Fabrication, and Testing of Ocean Thermal Energy Conversion (OTEC) Power Systems Development:** Contract ET-78-C-01-3408, for $836,289, awarded to TRW Inc., One Space Park, Redondo Beach CA 90278.

● **Oct 20: Development, Design, Fabrication, and Testing of Ocean Thermal Energy Conversion (OTEC) Power Systems Development (PSD):** Contract ET-78-C-01-3063, $994,503, awarded to General Electric Company, Schenectady NY.

Oct 20: Survey of Worldwide Market for Critical Energy Equipment: Contract EH-78-C-01-6414, $117,538, awarded to Gordian Associates, New York NY 10017.

Oct 20: Planning and Analysis Support to Divisions of Energy Technology: Contract EG-77-C-01-4024 (contract modification), for $168,176, awarded to PRC Energy Analysis Company, McLean VA 22101.

Oct 20: Planning and Analysis Support to Divisions of Energy Technology: Contract EG-77-C-01-4024/A004 (contract modification), $168,176, awarded to PRC Energy Analysis Company, McLean VA 22101.

Oct 23: Design, Fabrication, and Field Testing of a Solar-Powered Electrodialysis System for Desalting Remote Brackish Water Sources: Contract 14-34-0001-8576, $137,109, awarded to Ionics Inc., Watertown MA.

Oct 23: Development of a Large Spiral Module for Seawater Desalination by Reverse Osmosis: Contract 14-34-0001-8573, $298,248, awarded to Fluid Systems Division, UOP, Inc., San Diego CA $298,248.

Oct 23: Design, Fabrication, and Field Evaluation of an Energy Recovery Device To Be Used With Reverse Osmosis Systems: Contract 14-34-0001-8554, for $125,772, awarded to Polymetrics Inc., SAnta Clara CA. US Office of Water Research and Technology, Washington DC 20240.

Oct 23: Program Support Services: Contract EG-77-C-03-1446, $328,051, awarded to TRW Inc., 7600 Colshire Dr., McLean VA 22101.

● **Oct 30: Study in Oceanography on Mesoscale Circulation Using Satellite Data:** Contract N00014-75-C-0152, 29 Sep 78 (no RFP), for $85,559, awarded to the University of California at San Diego, La Jolla CA 92093.

Oct 30: Further Research on Vertical Transport of Materials in the Ocean: Contract N00014-74-C-0262, 29 Sep 78 (no RFP), $84,476, awarded to Woods Hole Oceanographic Institution, Woods Hole MA 02543.