Chapter 3

Status of Government Funding

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History of Government Funding

The National Science Foundation (NSF) began funding OTEC research in 1972 when its Research Applied to National Needs program funded **$85,000** worth of OTEC systems studies and workshops. In 1975, the Energy Research and Development Administration (ERDA) became the lead agency in OTEC research with an initial budget of about **$3** million for a variety of tasks on energy utilization, environmental impacts, heat exchangers, and biofouling and corrosion. By 1977, total funding had risen to $14.5 million in ERDA.[1] OTEC funding for 1972 through 1977 is detailed in table 7.

Concept designs have been developed by Lockheed Missiles and Space Company, TRW Systems Inc., and Johns Hopkins University Applied Physics Laboratory.

Government agencies other than NSF and ERDA have also made modest expenditures for researching OTEC concepts, including the Mari-

[1] Energy Research and Development Administration, **Ocean** Thermal Energy Conversion (OTEC) *Programs Summary*, October 1976, and phone conversation with staff member of ERDA, Washington, D. C., Jan. 23, 1978.

Table 7.—OTEC Funding for Fiscal Years 1972-77
(Budgetary Obligations in Thousands of Dollars: ERDA and NSF combined)

Program activity	Fiscal year					
	1972	1973	1974	1975	1976*	1977
Program support				111	**2,062**	2,381
Definition and systems planning						
—Systems studies and workshops	85	230	530	786	**237**	1,440
—Test program requirements					1,091	....
—Mission analysis					360	328
—Energy utilization				360	202	....
—Marine environment					312	10
—Environment impacts				2 : :	457	136
—Thermal resource assessment and siting studies			50	172	....	77
—Legal and institutional studies				61	145	33
Engineering development						
—Heat exchangers					250	1,721
—Electric cables						200
Advanced research and technology						
—Heat exchangers			150	435	1,669	2,834
—Exploratory power cables				27		118
—Submarine electrical cables				50		
—Biofouling and corrosion				207	1,303	2,702
—Ocean engineering				505	497	25
Engineering test and evaluation						1,498
TOTALS	85	230	730	2,955	8,585*	13,500

•Includes funding for Transition Period (July 1, 1976 to Sept. 30, 1976).

Source: Department of Energy.

time Administration and the Office of Sea Grant (both agencies of the Department of Comrierce); the Federal Energy Administration; and the Department of the Navy.

In fiscal year **1978, $36** million is budgeted for OTEC research by the Department of Energy (DOE). The program includes study of biofouling and corrosion rates and cleaning methods, design and testing of heat exchangers, design of cold water pipe and mooring systems, evaluation of platform shapes, and planning for a pilot plant.[2] The 1978 OTEC program schedule (figure 4) sets a target of 1982 for having a 5 MW OTEC plant at sea for tests.

ERDA's choice as the primary OTEC mission had been to develop electrical power generation for transmission to the United States or a U.S. territory by underwater cable from an offshore OTEC plant.[3] With the *1978* funding, however, DOE was ordered by Congress to also pursue development of an OTEC plant ship to manufacture a product such as ammonia, but other possible applications of OTEC, such as desalination, air-conditioning, and cooling of conventional or nuclear powerplants, are receiving little, if any, attention at DOE. In addition, current research is geared toward large-scale OTEC plants, and there is apparently little effort to determine if OTEC plants in the 1 to 5 MW size might have more commercial value than larger plants.

Effect of Government Funding on Status of OTEC

None of the research to date has concluded that an OTEC plant cannot be made to operate. However, the technology for the plants has not yet been proven and many of the components which will be required are considerably larger than similar equipment now in use or otherwise pose difficult design, construction, or development problems.

No OTEC plant has been completely designed and there are critical technical problems. Until these problems are resolved, it is premature to think firm estimates can be made about the cost of OT'EC power or the potential uses of OTEC plants.

Conclusions about the technical and economic success or failure and the environmental impact of OTEC plants should be based on consideration of specific OTEC devices at specific sites, manufacturing and marketing specific products, and transporting raw materials into the device and products out to the users. OTEC has not yet been developed to the level where such an assessment is meaningful,

In the past, many claims for OTEC'S value have been too optimistic for the state of OTEC development. Such claims have assumed quick and economic solutions to all the many technical problems which exist. They have assumed market conditions which make OTEC financially attractive. Thus, it is not difficult to deflate the claims simply by making less optimistic assumptions about the timing and cost of solutions to technical problems or by using less optimistic assumptions to assess the market situation in which OTEC will compete. In addition, private investors and industry are currently unwilling to risk their capital on building OTEC plants, and such reluctance on the part of industries which stand to benefit from OTEC is an argument against over-enthusiastic claims.

It is possible that with sufficient time, money, and effort OTEC could be in the national interest. However, as with many new technologies which offer hope of contributing to the solution of some pressing national problem, the needed time, money, and effort will have to be supplied by the U.S. Government until private industry is convinced OTEC is an economically attractive venture,

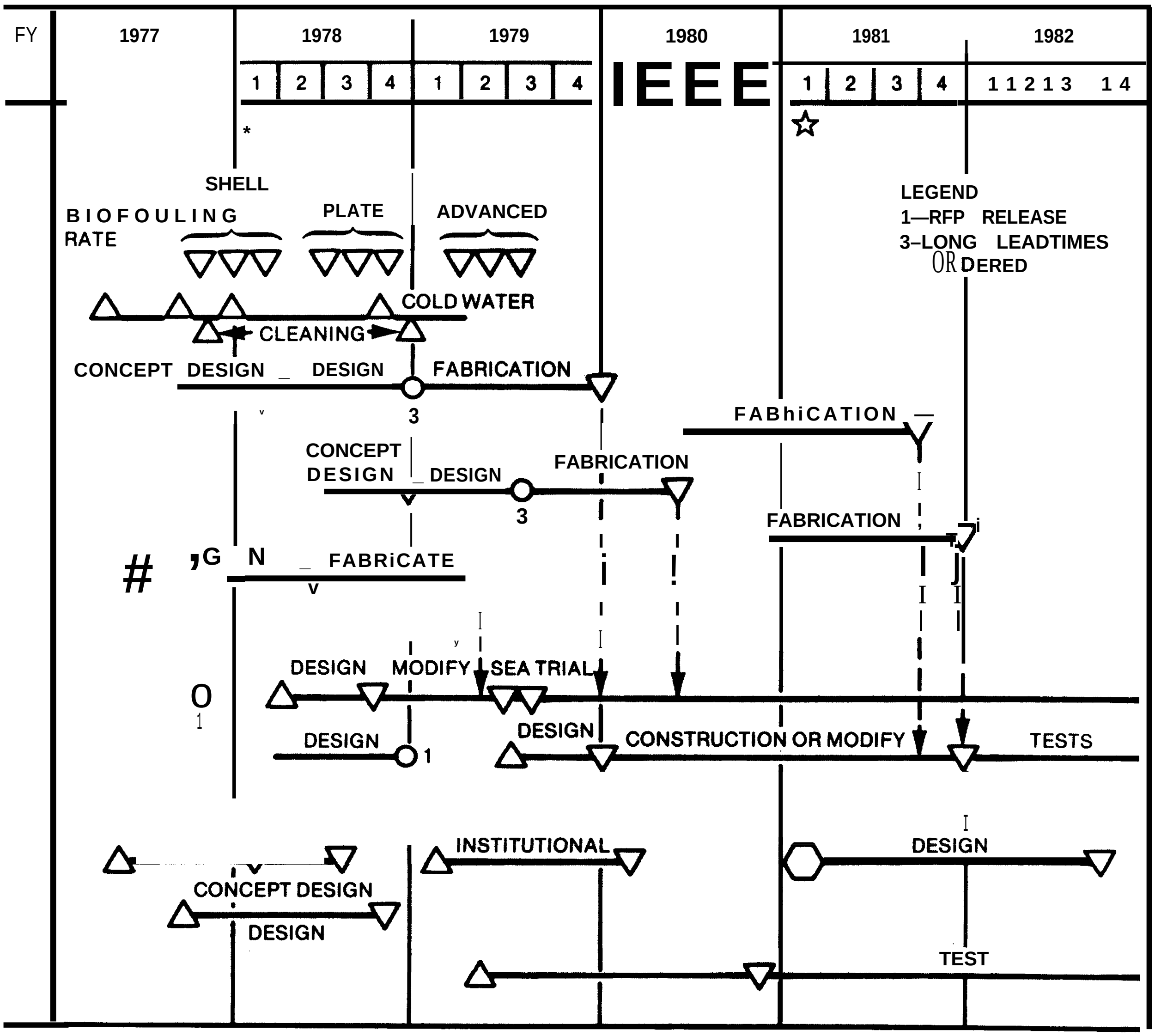
It is still too early to estimate when—or even if —OTEC will achieve that level of development. It is impossible to reliably estimate the total amount of time and money the Federal Government could expect to invest in the long-term development, testing, and commercialization of OTEC. The answers to several unsolved, critical technical problems discussed in this report are necessary before such estimates can be made.

It is also impossible with existing information

[2]Meeting with ERDA staff, Washington, D. C., Sept. 28, 1977.

[3]Letter to W. H. Avery from H. R. Blieden, ERDA, Washington, D. C., Nov. 17, 1976.

Figure 4
OTEC Program Schedule



Programmatic review
Heat exchangers
— Bench scale tests
— Biofouling and corrosion
—Power modules-1 1 MWe
5 MWe
—Power modules-IMMWE
5 MWe
— Early 1 MWe test article

Platforms
—OTEC-I (early ocean test platform)
–OTEC-5 (pilot plant)
Power cable
Demonstrate ion
Open cycle
—Subsystems tests

Source: Department of Energy.

to determine the future value or potential of OTEC in comparison with other energy technologies, such as fusion, the breeder reactor, solar direct heating and cooling, photovoltaics, windmills, tidal power, and others. The best way to judge the desirability of OTEC development is relative to alternative uses of the required technical, financial, and administrative resources.

In 1977, ERDA projected that, within its research budget for solar electric energy projects, it would allocate about **20** percent of the funding to OTEC through **1986.**[4] **That** projection would make OTEC second only to solar thermal in the amount of research money spent. However, the high funding does not reflect a priority or choice of OTEC as the most promising solar electric technology so much as it reflects the fact that OTEC requires massive pieces of equipment which must be operated and maintained in the marine environment.

The present results of Government-funded research suggest that the investment in OTEC is neither clearly foolish nor clearly desirable. They show only that it is unreasonable to expect that OTEC offers a significant source of new and economical energy before the 21st century.

However, in a future when energy becomes increasingly scarce and expensive, an OTEC which successfully feeds electricity into a grid or provides energy for the production of some commodity could be an important component of the mix of energy alternatives. The exact position of OTEC in the energy supply mix then will depend on the development status, cost, and availability of other alternatives.

However, even if it were safe to assume that OTEC would never compete **as a** commercial venture it should not be discarded strictly on that basis. There are numerous examples of industries which are supported by the Federal Government because they have been judged to be in the national interest. In addition, some of the equipment which is being developed for OTEC may be usable by the existing power industry for energy conversion and thermal pollution control purposes.

[4]Michae1 Mulcahy, "Ocean Thermal Energy Conversion is One of ERDA's Exciting New Programs, " *Sea Technology* 18, (August 1977).

Future Funding Possibilities

Considering energy requirements over a long period of time, such as **50** to 100 years, it is evident that some source of renewable energy must be developed. However, it is too early in the development of OTEC technology to say reliably if OTEC can make a significant contribution to the energy production capability of this country or other countries and if it can do so at a price which is acceptable, with or without Government subsidies. For 'that reason, there is no obvious amount of money which should be allocated to OTEC research in the future.

Instead, there are three approaches to funding which Congress may wish to consider before appropriating new money for OTEC research:

- **a** "no funding" approach which implies a pullback of Government involvement, with funding, probably through NSF, of less than a few million dollars a year relegated to basic research and special applications of OTEC principles;
- an "R & D funding" approach which provides funding, in the tens of millions of dollars annually, sufficient to methodically solve all technical problems, prove the feasibility of the concept, and investigate sites, uses of the energy, and impacts;
- a "system development funding" approach which would increase funding rapidly to hundreds of millions of dollars a year with the expressed goal of building an OTEC which would produce a product as soon as possible.

Ideally, funding decisions should be made in the context of an evaluation of the total DOE budget for research on future alternative energy sources. The evaluation should consider for each alternative energy system such factors as:

- the chances that technical problems can be solved;
- the probability that the system will generate net energy;
- the importance of the uses which can be made of the energy;
- the cost of developing a working system;

- the cost of the energy which will be generated; and
- the time required to develop a working system.

No such comparison of alternative energy concepts has been made. Supporters and opponents address each energy concept separately, not relative to each other. Perhaps it is too early in the investigation of most of these alternatives to make meaningful comparisons. However, it is unlikely the Nation can afford system development funding on all the many alternatives which are now being considered. Eventually hard choices will have to be made to determine which alternatives deserve priority funding.

No Funding: If the Congress believes that it is unlikely the technical problems will be solved, that OTEC systems probably will not generate net energy, that the time and cost of solving the problems are excessive, or that OTEC systems will not be competitive, then it may wish to stop program funding for OTEC. If this happens, it is unlikely that OTEC research would stop entirely. Small exploratory projects would probably continue with funding from NSF or private sources. However, it is doubtful that much financial commitment to research would be made by industry if the Government withdrew its support.

A decision to stop program funding for OTEC would mean the elimination of the existing team of OTEC program managers, consultants, and contractors at DOE. It would result in phasing out most current design, testing, and equipment development projects, and additional information about OTEC would be acquired more slowly and principally through industry-sponsored work.

R & D Funding: Since there is currently no evidence that the technical problems relating to OTEC cannot be solved given time and funds, it appears that continued research could lead to development of a workable system. However, it is not known how much money or time would be required to solve the problems. If Congress wishes to attack these problems, funding appropriated at a fairly level amount for the next 5 to 10 years could produce an OTEC program in which solutions to major impeding technical problems are a primary goal and future plans are tied very closely to the outcome of key research tasks.

The philosophy of R & D funding would be to support research and test projects with a goal of developing a feasible system and providing substantial proof of feasibility by working prototype subsystems, engineering designs, and reasonable cost estimates for construction and operation. This approach would not produce working, large-scale machinery in the near future, but would enable program managers to make more informed decisions on the size, location, materials, construction techniques, and uses of OTEC plants.

Level R & D funding for the OTEC program would probably result in continuation of many of the present OTEC research projects. It would, however, delay schedules proposed by some who envision large-scale use of OTEC for generating electricity or power for manufacturing other products in this century. This approach to funding would keep OTEC as a future energy option and would continue to generate needed information about OTEC at a reasonable cost until choices could be made among the many alternative energy technologies in the Federal research program. It would also result in the establishment of a stable management organization within the Federal Government for initiating projects and evaluating results, and a long-range research capability would be built.

The DOE program for OTEC is currently geared to R & D funding. With this philosophy, requests for rapidly increasing funds are inappropriate until the technology has been proven.

With R & D funding, more specific 5- to 15-year research goals could be set to help clarify program objectives and Congress could establish **a** procedure for making funding decisions about OTEC on **a** more informed basis in the future.

More specific research goals could take many forms. Some combination of theoretical analyses, laboratory tests, field surveys and pilot projects would probably be necessary. The following are some examples which have been suggested as short-term goals that could be integrated into an ongoing research program:

c development of scale models of lowtemperature difference machinery which could be tested at nuclear powerplant outfall sites.

- development of small-scale shore-based OTEC systems for testing at a suitable island site;
- development of a small floating pilot plant which could be tested at a site where very large temperature differences are available relatively near the surface; and
- development of a small pilot plant for comparative testing of open and closed cycle systems.

System Development Funding: The cost of proposed OTEC technology is so high that the only way to develop a working prototype plant as soon as possible—that is, to have a large-scale plant at sea producing a product within 10 to **20** years—is to commit large amounts of funds which escalate to hundreds of millions of dollars within a few years.

This is a high-risk approach to funding, not only because it would require billions of dollars, but also because it would probably force a premature choice among several concepts and possible products in order to concentrate on development of one specific system. Although it would include enough testing to gain insights on reliability, cost, maintainability, and online time, this approach could result in skipping long-term testing and environmental studies which would not fit into an accelerated schedule. But it could produce the most rapid demonstration of the one system selected for development. It could also require such a commitment of funds that money would not be allocated to research on other alternative energy sources.

If an OTEC plant were developed quickly, it is possible there would be a significant, though not necessarily large or economically competitive, impact on the Nation's energy production capability sometime well into the 21st century.

Summary of Government Funding

Since 1972, Government funding for OTEC research has grown from *$85,000* a year to the present budget of **$35** million for the fiscal **1978** program in DOE.

To date, no large amount of private money has been invested in OTEC research and development, and it is likely that Government funding will be the major support for any further work in the foreseeable future.

It is too early in the development of OTEC technology to say definitely that OTEC can or cannot make a significant contribution to the energy production capability of this country. For that reason, there is no obvious amount of money which should be appropriated for further research.

In the long term, decisions about funding are ideally made in the context of an evaluation of the total DOE budget for research on future alternative energy sources. In the absence of such a comparison of alternative energy concepts, a "no funding" approach could be used to eliminate the OTEC program and reduce future efforts to basic research and investigation of special applications; an "R & D funding" approach could be used to keep OTEC as a future energy option while generating solutions to important technical problems at a reasonable cost; or a "system development funding" approach could be used to attempt to develop a large-scale working prototype of one specific OTEC system as soon as possible.

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