**STUDY OF DOMESTIC SOCIAL AND ECONOMIC IMPACTS OF
OCEAN THERMAL ENERGY CONVERSION (OTEC) COMMERCIAL DEVELOPMENT**

**Volume I
ECONOMIC IMPACTS**

MASTER

**Submitted to:
DEPARTMENT OF ENERGY
OFFICE OF CONSERVATION AND RENEWABLE ENERGY
DIVISION OF OCEAN SYSTEMS
WASHINGTON, D.C.**

Under Contract DE-AC01-80CS-80002

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December 22, 1981

**Submitted by:
JACK FAUCETT ASSOCIATES, INC.
5454 Wisconsin Avenue
Chevy Chase, Maryland 20015**

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Technical support and analyses, especially in the areas of OTEC construction and operation, were capably and efficiently provided by Barbara Buchleitner and William Kumm of Arctic Enterprises, Inc. William Coleman of Westinghouse provided many helpful comments and support throughout the study. Finally, Pam Brockington and Phyllis Edmonson of JFA accurately typed the draft and final reports.

INTRODUCTION

Ocean Thermal Energy Conversion (OTEC) power plants can provide the United States with a renewable domestic source of energy. Their construction and utilization in the United States could also increase the nation's economic activity. Consequently, it is important to understand the nature and magnitudes of the economic impacts associated with OTEC development. This analysis identifies these economic impacts and quantifies them at the national, regional, and industry levels. It focuses on the effects on the United States' economy of the domestic development and utilization of twenty-five and fifty 400 MWe OTEC power plants by the year 2000.

The methodology employed was characteristic of economic impact analysis (Exhibit 1-1). After conducting a literature review, a likely future OTEC scenario was developed on the basis of technological, siting, and materials requirements parameters. These parameters were used to identify the industries affected by OTEC development; an economic profile was constructed for each of these industries. These profiles established an industrial baseline from which the direct, indirect, and induced economic impacts of OTEC implementation could be estimated. Each stage of this analysis is summarized in Chapter 1; the economic impacts are addressed in Chapter 2. The methodology employed in estimating the impacts is described in Appendix A.

EXHIBIT 1-1
METHODOLOGY

CHAPTER 1

PROJECT OVERVIEW

LITERATURE REVIEW

An extensive overview of OTEC technical and economic literature was conducted, and a bibliography was assembled with citations from a computer search of the following bibliographic data bases:

- National Technical Information Service,
- Smithsonian Scientific Information Exchange,
- Energyline,
- Congressional Information Service,
- Government Printing Office, and
- Oceanic Abstracts

This bibliography is Volume III of this report.

OTEC SCENARIO

A future OTEC scenario was developed on the basis of technological, offshore siting, and construction siting parameters. This scenario was constrained by DOE requirements that two-thirds of the OTEC facilities were to produce electricity for onshore power needs and one-third were to be involved in the production of energy intensive products for both the 25 plant and 50 plant cases. A preliminary OTEC scenario suggested by DOE (Exhibit 1-2) was taken into consideration while the complete scenario was being developed.

EXHIBIT 1-2

**PRELIMINARY OTEC SCENARIO SUGGESTIONS
BY DOE**

TECHNOLOGY: Closed cycle, open cyle

NUMBER: 25 and 50 facilities

USES: One-third plantships, two-thirds electricity

HULL MATERIAL: Steel, Concrete

CWP MATERIAL: Fiberglass, concrete

HEAT EXCHANGER MATERIAL: Titanium, aluminum

ENERGY INTENSIVE PRODUCTS: Aluminum, ammonia

LOCATIONS: U.S. island possessions, U.S. Gulf Coast, plantships in international waters

Technology

The first issue to be resolved was the determination of the most likely technology, open or closed cycle, to be employed in the majority of OTEC plants by the year 2000. Given the government's emphasis on closed cycle systems, plus uncertainties associated with the operation of open cycle systems, the study team concentrated on the closed cycle OTEC. Previous studies of plant design were examined to determine what materials and equipment would be required in the construction and operation of the closed cycle plant.¹ These included steel, concrete, titanium, aluminum, warm and cold water pumps, and heat exchangers. A corresponding list of industries was generated (Exhibit 1-3). Finally, the consideration of energy intensive products to be produced aboard an OTEC plantship was limited to aluminum and ammonia.

Offshore Siting

OTEC plants are usually designed for a nominal ΔT of 20°C to 24°C for performance and economic reasons. This requires an ocean depth in excess of approximately three thousand feet. The depth must not be so great, however, that an electricity generating plant cannot be moored. The distance from shore will also affect the undersea power cable in the electricity generating mode. Finally, for the OTEC concept to succeed as a commercial power plant system, a market for the power must exist.

Given these constraints cabled OTEC power is directly accessible to the United States mainland only in that area along the Gulf of Mexico. This region not only possesses the necessary thermal resources, but is also projected to experience a substantial growth in demand for electricity.²

Cabled OTEC power can also serve Hawaii, Puerto Rico, and the Virgin Islands. However, the economies of these islands do not and will not warrant large numbers of 400 MWe OTEC power plants, even if currently existing fossil fuel fired electricity is replaced.³

The OTEC power can also be used at sea in plantships producing energy intensive commodities. As noted earlier, the two commodities commonly cited are aluminum and

EXHIBIT 1-3: INDUSTRIES DIRECTLY IMPACTED BY OTEC CONSTRUCTION

Industry Title	Standard Industrial Classification (SIC) or Bureau of Labor Statistics (BLS) Economic Growth Sector Number	Short Title as Used in Subse- quent Tables
Blast Furnaces and Basic Steel Products	BLS Sector #71	Steel
Titanium Mill Shapes	SIC 33562	Titanium
Primary Aluminum and Aluminum Products	BLS Sector #74	Aluminum
Cement and Concrete Products	BLS Sector #67	Cement/Concrete
Pumps, Air and Gas Compressors, and Pumping Equipment	SIC 3561	Pumps
Fabricated Structural Metal	BLS Sector #78	Fabricated Metal
Drawing and Insulating of Non-Ferrous Wire	SIC 3357	Cable
Ship Building and Repairing	SIC 3731	Ship Building
Plastic Products	BLS Sector #63	Plastics
Glass Fiber, Textile Type	SIC 32293	Fiberglass
Plastics Materials and Resins	SIC 2821	Resins
Store and Clay Mining and Quarrying	BLS Sector #13	Stone/Clay

ammonia. Several problems exist, however, in the production of aluminum at sea.⁴ Consequently, the combination of a coastal based aluminum plant with a moored OTEC generating electricity seems more feasible. Ammonia appears to be better suited to production at sea, where needed raw materials can be obtained from the air and water, and the final product can be easily transported. Furthermore, a strong market for ammonia exists in the United States, particularly for use in fertilizers. Consequently, the South Atlantic off the northeast coast of Brazil may be a good location for grazing OTEC's producing ammonia.

Construction Siting

A shipyard considered for OTEC construction must be technically capable of building an OTEC plant, and be reasonably close to the intended operating sites in the Atlantic, the Pacific, or the Gulf of Mexico. There are 28 major shipyards in the United States that have building or graving dock facilities in excess of 475 feet in length and of sufficient beam; but 18 are not suitable for OTEC construction under the 25 plant scenario (two are closed, four are on the Great Lakes and 12 either do not have a suitable access channel to deep water, lack an engineering or skilled labor force, or are not financially able to undertake a project of this size).

The ten yards deemed suitable for OTEC construction under the 25 plant scenario were:

- Bethlehem, Sparrow Point, Maryland (BS/SP)
- Newport News S.B., Newport News, Virginia (NNS)
- Tampa Ship Repair, Tampa, Florida (Tampa)
- Ingalls & Litton, Pascagoula, Mississippi (I&L)
- Avondale, New Orleans, Louisiana (Avon.)
- National Steel and S.B., San Diego, California (NASCO)
- Bethlehem, San Francisco, California (BS/SF)
- Lockheed S.B., Seattle, Washington (Lock.)
- General Dynamics, Quincy, Massachusetts
- Triple A, San Francisco, California (AAA)

Of these ten yards, the first eight were selected to actively participate in OTEC construction. Given current information, the General Dynamics yard and Triple A were held in reserve. All of these yards are also forecast to be well below capacity in the 1980's and 1990's.

In the 50 plant scenario, the following three additional shipyards were added to provide sufficient capacity:

- Offshore Power System, Jacksonville, Florida (OPS)
- Bethlehem, Beaumont, Texas (BS/B)
- Sun Shipbuilding, Chester, Pennsylvania (SS)

These yards could be modified to accept OTEC construction, given the need. As a result, only the Triple A yard is held in reserve under the 50 plant scenario.

Conclusion

Given the constraints and requirements identified in the offshore siting and construction siting analyses, Exhibit 1-4 shows the matrix of shipyards, locations, and OTEC plant modes for the twenty-five plant scenario. As can be seen, the majority of OTECs are involved in the production of electricity along the coast of the Gulf of Mexico. Exhibit 1-5 shows a similar matrix for the fifty plant scenario. Again, the majority of OTEC facilities produce electricity along the Gulf Coast.

INDUSTRIAL BASELINE

Economic profiles were developed for each OTEC impacted industry, i.e. steel, titanium, aluminum, cement/concret, pumps, fabricated metal, cale, ship building, plastics, fiberglass, resins, and stone/clay. These profiles detail the impacted industry's history, its financial and economic characteristics, its technological and production traits, and any resource constraints that might impede its operation. Some of the historical data collected include output, value of shipments, number of firms, employment, prices, exports, and imports. This data establishes a baseline from which subsequent economic impact analysis is developed, including the measurement of direct, indirect, and induced impacts. Complete profiles appear in Volume II.

EXHIBIT 1-4

**MATRIX OF SHIPYARD UTILIZED IN CONSTRUCTION OF OTEC FACILITIES
25 OTEC PLANT FACILITIES BY YEAR 2000**

Sites Application	Total OTEC Sites	Atlantic OTEC Sites	Quincy	BS-SP	NNS	Gulf Coast OTEC Sites	Tampa	Ingalls	Avondale	Pacific OTEC Sites	NASCO	Triple A	BS-SP	Lock
ISLAND														
Electric	4	2		2						2				2
Alumina	2	1			1					1				1
Ammonia	2									2	1		1	
COASTAL														
Electric	11					11	3	4	4					
MID-OCEAN														
Ammonia	6	6		3	3									

EXHIBIT 1-5

**MATRIX OF SHIPYARDS UTILIZED IN CONSTRUCTION OF OTEC FACILITIES
50 OTEC PLANT FACILITIES BY YEAR 2000**

Sites Application	Total OTEC Sites	Atlantic OTEC Sites	Quincy	BS-SP	S.S.	NNS	Gulf Coast OTEC Sites	Tampa	OPS	Ingalls	Avondale	BS-B	Pacific OTEC Sites	NASCO	Triple A	BS-SP	Lock
ISLAND																	
Electric	8	5		1	3	1							3				3
Alumina	4	3				3							1				1
Ammonia	4	2	1	1									2	1		1	
COASTAL																	
Electric	22						22	3	5	5	5	4					
MID-OCEAN																	
Ammonia	12	12	3	3	3	3											

In the course of developing these profiles, several problems were identified:

- There is no underwater electrical transmission cable industry in the United States, and it may be difficult to create one.⁵
- There is a concrete aggregate and cement shortage on the Gulf coast that could impede the construction of OTEC hulls there.⁶
- A fiberglass reinforced plastic cold water pipe of the size necessary for an OTEC plant has never been constructed.⁷
- There is insufficient capacity in the titanium industry to support the construction of a large number of titanium heat exchangers, especially if potential defense demand for titanium is considered.⁸
- The offshore service industry, which does not currently exist on the East coast of the United States, is projected to experience a severe manpower shortage that could adversely affect the deployment and operation of OTEC powerplants, hence an accurate forecast of the impact of OTEC development on this industry could not be made.⁹

MATERIALS REQUIREMENTS

Estimates of most of the materials required in the construction of a 400 MWe closed cycle OTEC power plant were developed from design studies done by Westinghouse for a 50 MWe closed cycle-OTEC powerplant, under the assumption that the 400 MWe system would be comprised of eight 50 MWe modules.¹⁰ These requirements are listed in Exhibit 1-6. Estimates for the fiberglass reinforced plastic cold water pipe and the concrete cold water pipe were received from the National Oceanic and Atmospheric Administration and Arctic Enterprises, Inc.¹¹

IMPACT ANALYSIS

Economic impacts generated by the domestic development of OTEC power plants occur at the national, regional, and industry levels. These impacts can further be divided into direct, indirect, and induced effects. Direct impacts are those attributed to the construction, deployment, and operation of OTEC powerplants. Indirect impacts are due to interrelationships between the different sectors of the economy, since industries must purchase the necessary inputs for production from each other. This affects nearly all industries. Finally, induced impacts occur as the expansion in output and

EXHIBIT 1-6

400 MWe CC-OTEC POWERPLANT -- MASS OF MATERIALS
SHORT TONS

Component	Fabricated Steel	Fabricated Titanium	Turbine/ Pump	MHE (1)	Motor/ Generator	Transformer	Switchgear	Other
1. Platform/Ship								
a. Concrete, or								507,416 (2)
b. Steel	107,872							
c. Deck House and Anchor	24,696							
2. Power Module								
a. Condenser	10,904	6,296						
b. Evaporator	7,552	4,072						
c. Turbine/ Generator			656		2,320			
d. Lube Oil System	280							
e. Ammonia Pumps			1,240					
f. Ammonia Pipes and Tanks	9,480							
g. Ammonia Valves	4,760							
h. Sea Pumps			5,400			400		
i. Sea Screens								3,680 (3)
j. Amertap								1,760 (3)
k. Diesel System	40				4,040			
l. Nitrogen Tank	600							
m. Gantry				4,800				
n. Cooling Water	40							
o. Power Conditions							5,320	
p. Wiring								520 (4)
3. Other Components								
a. Ammonia								9,248
b. Nitrogen								1,184
4. TOTAL	166,224	10,368	7,296	4,800	6,360	400	5,320	523,808

(1) Mechanical heavy equipment

(2) Reinforced concrete

(3) Stainless steel

(4) Naval wiring material

employment result in increased personal income among workers, leading to increased spending. This increased spending induces the production of more consumption goods and services in the economy; it is often called the multiplier effect. These impacts are presented and examined in Chapter 2.

Regional impacts, especially on employment, may be the most significant impacts in the development of OTEC powerplants. Most of these effects are expected to flow from increased shipyard activity at construction sites. Other regional impacts could occur if certain areas of the country supply the materials necessary to construct an OTEC plant ship. However, examination of a commodity flow data base to determine if such unequal changes in regional production do occur indicated that they were not of sufficient size to warrant analysis.

NATIONAL BENEFITS

The stimulus of OTEC construction could result in employment and production effects that would reduce unemployment and increase GNP. It should be noted, however, that OTEC construction could replace the construction of other types of power plants, be they coal, nuclear, or oil. Thus, labor and development funds may simply be transferred from one energy project to another, with no net increase resulting from that transference. Such a result is very possible.

Several other benefits could come from OTEC development. A net energy analysis by Westinghouse indicates that a 50-MWe OTEC facility will be highly efficient, with an annual energy output/input ratio of 9.37 for a steel hulled facility and 12.25 for a concrete hulled OTEC (Exhibit 1-7).¹² Furthermore, OTEC power plants producing 10,000 MWe by the year 2000 would produce non-renewable fuel equivalent savings that would not be inconsequential. These savings are shown in Exhibit 1-8. As can be seen, by the year 2001, 25 OTECs could displace the equivalent of 325,950 barrels of petroleum imports per day, saving the nation \$11.4 million per day. Similarly, 50 OTECs could displace 651,900 barrels of petroleum imports per day by 2001, a saving of \$22.8 million per day. Finally, the balance of payments impact of OTEC may be favorable, particularly if one considers the potential export of energy intensive products coupled with reduced oil imports. However, the change in net imports resulting from the increase in industry activity must be included if a complete balance of payments analysis is to be done.

EXHIBIT 1-7
ENERGY CONTRIBUTIONS
WESTINGHOUSE NET ENERGY STUDY

10⁶ BTU

INPUT ENERGY¹

—	Steel Hulled OTEC Power Plant	143,863
—	Concrete Hulled OTEC Power Plant	110,026

OUTPUT ENERGY²

—	Gross	70.0	MWe	
—	Less	19.9	MWe	
—	Net	50.1	MWe	
—	Per Year (90%) ⁶			
	395 x 10 ⁶ kWh or			1,348,000

● **OUTPUT/INPUT RATIO**

—	Steel Hulled OTEC Power Plant	=	9.37
—	Concrete Hulled OTEC Power Plant	=	12.25

¹Includes all energy inputs included in the construction of each major component of an OTEC power plant. Annualized energy inputs were obtained from the total input energy of each major component by dividing the latter by the expected service life of the individual components.

²Net annual output of the OTEC power system, assuming 90 percent availability.

SOURCE: Westinghouse memo — Net Energy Analysis.

EXHIBIT 1-8

**OTEC DISPLACEMENT OF IMPORTED PETROLEUM
(Barrels per Day)**

<u>Year</u>	<u>25 OTEC Scenario</u>			<u>50 OTEC Scenario</u>		
	<u>No. of Vessels</u>	<u>Oil Equiv. bbl/day</u>	<u>Oil Value \$ M/day</u>	<u>No. of Vessels</u>	<u>Oil Equiv. bbl/day</u>	<u>Oil Value \$ M/day</u>
1995	7	91,266	\$ 3,194,310	14	182,532	\$ 6,388,620
2000	22	286,836	\$10,039,260	44	573,672	\$20,078,520
2001	25	325,950	\$11,408,250	50	651,900	\$22,816,500

Values are in 1980 dollars, assuming oil price of \$35 per barrel.

CHAPTER 1

Footnotes

- ¹Gibbs and Cox, Westinghouse, Lockheed.
- ²Quantitative Evaluation of Ocean Thermal Energy Conversion (OTEC). Rand Corporation. Eugene C. Gritton, Richard Y. Pei, Ronald W. Hess; August 1980. Prepared for the U.S. Department of Energy.
- ³Ibid.
- ⁴Study of Integration Issues to Realize the Market Potential of OTEC Energy for the Aluminum Industry. Reynolds Metals Company and TRW, Incorporated. Revised Draft Final Report, November 1980. Prepared for U.S. Department of Energy.
- ⁵See page 88, Volume II.
- ⁶Jack Faucett Associates estimate.
- ⁷Personal communications, Terry McGuiness, National Oceanic and Atmospheric Administration.
- ⁸Jack Faucett Associates estimate.
- ⁹Personal communications and Jack Faucett Associates estimates.
- ¹⁰Westinghouse internal memo: Net Energy Analysis, provided to Jack Faucett Associates by William Coleman, Westinghouse.
- ¹¹Personal communications:

Terry McGuiness, National Oceanic and Atmospheric Administration: final FRP sandwich specifications for CWP - originally 4 inches, revised to 6 inches.

Rick Turkopp, Owens - Corning Fiberglass Corporation: fiberglass and resins requirements in an FRP cold water pipe of the above dimension, plus pricing information.
- ¹²Westinghouse internal memo: Net Energy Analysis.

CHAPTER 2

ECONOMIC IMPACTS

BASELINE FORECASTS

The economic impacts resulting from the domestic development of OTEC power plants appear at the national, regional, and industry levels. In order to properly assess these impacts, it is necessary to develop economic base forecasts from which changes in revenue and employment due to OTEC construction can be estimated. Exhibit 2-1 lists forecasts of gross national product (GNP) for the United States for the period from 1990 to 2000 in constant 1972 dollars. GNP grows at an annual rate of 3.2 percent, increasing from \$2112.8 billion in 1990 to \$2900.3 billion in 2000. This growth rate assumes nominal employment levels throughout the decade. If employment is high during the 1980's and 1990's, GNP can be expected to grow at an annual rate of 3.5 percent from \$2196.2 billion in 1990 to \$3084.7 billion in 2000.¹

Baseline forecasts for growth in the civilian labor force appear in Exhibit 2-2. Three different growth paths are assumed for the period from 1990 to 2000. These are extrapolations of BLS forecasts of labor force growth for the period from 1985 to 1990.² Under the high growth path, the civilian labor force is projected to increase from 125.6 million people in 1990 to 144.3 million in 2000, a rate of 1.4 percent per year. Under the low growth path, however, the civilian labor force will grow at a rate of only 0.8 percent per year, increasing to 122.9 million people by 2000 from a level of 113.5 million in 1990. An intermediate growth rate of 1.1 percent would increase the labor force from 119.4 million in 1990 to 133.2 million in 2000.

Economic base forecasts for industries directly impacted by OTEC construction for the period from 1990 to 2000 are presented in Exhibit 2-3. Forecasts are made of output, employment, and employment/output ratios for each of the twelve industries. All of these industries are forecast to experience increases in output over the period. The greatest growth will be in the fabricated metals industry, which will increase its output

EXHIBIT 2-1
FORECASTS OF GNP
1990 THROUGH 2000

<u>Year</u>	<u>Base</u> <u>\$ billion (1972)</u>	<u>High Employment</u> <u>\$ billion (1972)</u>
1990	2,112.8	2,196.2
1991	2,180.8	2,272.1
1992	2,251.0	2,350.6
1993	2,323.4	2,431.8
1994	2,398.2	2,515.9
1995	2,475.4	2,602.8
1996	2,555.1	2,692.8
1997	2,637.3	2,785.8
1998	2,722.2	2,882.1
1999	2,809.8	2,981.7
2000	2,900.3	3,084.7

Source: Employment Projections for the 1980's, U.S. Department of Labor, Bureau of Labor Statistics, 1979. Bulletin 2030. P. 16, Table 1.

EXHIBIT 2-2
CIVILIAN LABOR FORCE
(in millions)

<u>Year</u>	<u>High Growth</u> <u>Path</u>	<u>Intermediate Growth</u> <u>Path</u>	<u>Low Growth</u> <u>Path</u>
1990	125.6	119.4	113.5
1991	127.4	120.7	114.4
1992	129.1	122.0	115.3
1993	130.9	123.4	116.2
1994	132.8	124.7	117.2
1995	134.6	126.1	118.1
1996	136.5	126.1	119.1
1997	138.4	128.9	120.0
1998	140.4	130.3	121.0
1999	142.3	131.8	121.9
2000	144.3	133.2	122.9

Source: Employment Projections for the 1980's, U.S. Department of Labor, Bureau of Labor Statistics, 1979. Bulletin 2030, p. 2.

EXHIBIT 2-3

**ECONOMIC BASE FORECASTS FOR INDUSTRIES
DIRECTLY IMPACTED BY OTEC CONSTRUCTION
FROM 1990 THROUGH 2000
(Output in Millions of 1972 Dollars; Employment in Thousands of Jobs)**

1990			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	42,785	553.0	0.0000129
Titanium	205	3.1	0.0000151
Aluminum	17,525	171.0	0.0000098
Cement/Concrete	15,368	267.0	0.0000174
Pumps	3,957	99.0	0.0000250
Fabricated Metal	30,816	693.0	0.0000225
Cable	8,563	87.0	0.0000102
Ship Building	7,244	206.0	0.0000284
Plastics	25,241	471.0	0.0000187
Fiberglass	651	11.8	0.0000181
Resins	10,007	69.5	0.0000069
Stone/Clay	5,023	97.0	0.0000193
TOTAL	167,385	2,728.4	0.0000163

1991			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	43,194	546.0	0.0000126
Titanium	210	3.1	0.0000148
Aluminum	18,167	172.0	0.0000095
Cement/Concrete	15,730	267.0	0.0000170
Pumps	4,098	102.0	0.0000249
Fabricated Metal	32,270	707.0	0.0000219
Cable	8,855	88.0	0.0000099
Ship Building	7,490	207.0	0.0000276
Plastics	26,257	479.0	0.0000182
Fiberglass	678	12.0	0.0000177
Resins	10,425	69.7	0.0000067
Stone/Clay	5,136	96.0	0.0000187
TOTAL	172,510	2,748.8	0.0000159

1992			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	43,607	539.0	0.0000124
Titanium	214	3.1	0.0000145
Aluminum	18,833	173.0	0.0000092
Cement/Concrete	16,101	266.0	0.0000165
Pumps	4,245	104.0	0.0000245
Fabricated Metal	33,793	721.0	0.0000213
Cable	9,155	89.0	0.0000097
Ship Building	7,744	208.0	0.0000269
Plastics	27,314	488.0	0.0000179
Fiberglass	707	12.2	0.0000173
Resins	10,854	69.9	0.0000064
Stone/Clay	5,251	95.0	0.0000181
TOTAL	177,818	2,768.2	0.0000156

1993			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	44,024	532.0	0.0000121
Titanium	219	3.1	0.0000142
Aluminum	19,524	174.0	0.0000089
Cement/Concrete	16,481	266.0	0.0000161
Pumps	4,396	106.0	0.0000241
Fabricated Metal	35,388	735.0	0.0000208
Cable	9,464	90.0	0.0000095
Ship Building	8,006	209.0	0.0000261
Plastics	28,413	497.0	0.0000175
Fiberglass	736	12.3	0.0000167
Resins	11,295	70.1	0.0000062
Stone/Clay	5,369	94.0	0.0000175
TOTAL	183,315	2,788.5	0.0000152

EXHIBIT 2-3

**ECONOMIC BASE FORECASTS FOR INDUSTRIES
DIRECTLY IMPACTED BY OTEC CONSTRUCTION
FROM 1990 THROUGH 2000
(Output in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)**

1994

<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	44,445	525.0	0.0000118
Titanium	224	3.1	0.0000138
Aluminum	20,239	175.0	0.0000086
Cement/Concrete	16,869	265.0	0.0000157
Pumps	4,554	109.0	0.0000239
Fabricated Metal	37,057	750.0	0.0000202
Cable	9,782	91.0	0.0000093
Ship Building	8,278	209.0	0.0000252
Plastics	29,557	506.0	0.0000171
Fiberglass	766	12.5	0.0000163
Resins	11,748	70.2	0.0000080
Stone/Clay	5,490	92.0	0.0000168
TOTAL	189,009	2,807.8	0.0000149

1996

<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	45,299	512.0	0.0000113
Titanium	234	3.1	0.0000132
Aluminum	21,751	177.0	0.0000081
Cement/Concrete	17,674	265.0	0.0000150
Pumps	4,885	114.0	0.0000233
Fabricated Metal	40,637	780.0	0.0000192
Cable	10,448	94.0	0.0000090
Ship Building	8,849	211.0	0.0000238
Plastics	31,985	524.0	0.0000164
Fiberglass	829	12.8	0.0000154
Resins	12,684	70.4	0.0000055
Stone/Clay	5,739	90.0	0.0000157
TOTAL	201,024	2,853.3	0.0000142

1995

<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	44,870	518.0	0.0000115
Titanium	229	3.1	0.0000135
Aluminum	20,981	176.0	0.0000084
Cement/Concrete	17,267	265.0	0.0000153
Pumps	4,716	111.0	0.0000235
Fabricated Metal	38,806	765.0	0.0000197
Cable	10,110	93.0	0.0000092
Ship Building	8,559	210.0	0.0000245
Plastics	30,747	515.0	0.0000167
Fiberglass	797	12.7	0.0000159
Resins	12,215	70.4	0.0000058
Stone/Clay	5,613	91.0	0.0000162
TOTAL	194,910	2,830.2	0.0000145

1997

<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	45,732	505.0	0.0000110
Titanium	239	3.1	0.0000130
Aluminum	22,548	178.0	0.0000079
Cement/Concrete	18,090	264.0	0.0000146
Pumps	5,059	117.0	0.0000231
Fabricated Metal	42,555	795.0	0.0000187
Cable	10,796	95.0	0.0000088
Ship Building	9,149	212.0	0.0000232
Plastics	33,272	533.0	0.0000160
Fiberglass	862	13.0	0.0000151
Resins	13,187	70.5	0.0000053
Stone/Clay	5,868	89.2	0.0000152
TOTAL	207,357	2,874.8	0.0000139

EXHIBIT 2-3

**ECONOMIC BASE FORECASTS FOR INDUSTRIES
DIRECTLY IMPACTED BY OTEC CONSTRUCTION
FROM 1990 THROUGH 2000
(Output in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)**

1998			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	46,169	499.0	0.0000108
Titanium	245	3.1	0.0000127
Aluminum	23,374	179.0	0.0000077
Cement/Concrete	18,517	284.0	0.0000143
Pumps	5,240	119.0	0.0000227
Fabricated Metal	44,563	811.0	0.0000182
Cable	11,155	96.0	0.0000086
Ship Building	9,459	213.0	0.0000223
Plastics	34,611	543.0	0.0000157
Fiberglass	896	13.1	0.0000146
Resins	13,693	70.5	0.0000051
Stone/Clay	6,000	86.0	0.0000147
TOTAL	213,922	2,898.7	0.0000136

1999			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	46,611	492.0	0.0000106
Titanium	250	3.0	0.0000120
Aluminum	24,231	180.0	0.0000074
Cement/Concrete	18,953	263.0	0.0000139
Pumps	5,427	122.0	0.0000225
Fabricated Metal	46,666	827.0	0.0000177
Cable	11,524	97.0	0.0000084
Ship Building	9,780	214.0	0.0000219
Plastics	36,005	553.0	0.0000154
Fiberglass	931	13.3	0.0000143
Resins	14,214	70.5	0.0000050
Stone/Clay	6,135	87.0	0.0000142
TOTAL	220,727	2,921.6	0.0000132

2000			
<u>Industry</u>	<u>Output</u>	<u>Employment</u>	<u>Employment/ Output Ratios</u>
Steel	47,056	486.0	0.0000103
Titanium	256	3.0	0.0000117
Aluminum	25,119	181.0	0.0000072
Cement/Concrete	19,400	263.0	0.0000136
Pumps	5,621	125.0	0.0000222
Fabricated Metal	48,868	844.0	0.0000173
Cable	11,904	98.0	0.0000082
Ship Building	10,111	215.0	0.0000213
Plastics	37,454	562.0	0.0000150
Fiberglass	967	13.4	0.0000139
Resins	14,750	70.4	0.0000048
Stone/Clay	6,272	86.0	0.0000137
TOTAL	237,778	2,946.8	0.0000129

by 59 percent. The least growth is expected in the steel industry, which will grow by only 8 percent. Employment will increase in nine of the industries and decrease in three, with the greatest drop occurring in the steel industry, where total employment is forecasted to fall from 539,000 to 486,000. The fabricated metals industry will again experience the greatest increase, with total employment rising from 721,000 in 1990 to 844,000 in 2000. Finally, productivity in these industries is forecasted to rise substantially over the period, as the declining employment/output ratios in each industry indicate. In fact, laborers in these industries are forecasted to be 25 percent more efficient in 2000 than in 1990.

OTEC DESIGN CONFIGURATION IMPACTS

Four 400 MWe OTEC power plant design configurations were selected for analysis. The major design characteristics that were varied to generate the four configurations were the following:

- Purpose - will it be a plantship or an electricity producer;
- Hull - will it be made of steel or concrete;
- Cold Water Pipe (CWP) - will it be made of fiberglass or concrete; and
- Heat Exchanger - will it be made of titanium or aluminum.

Primary Impacts

The configurations selected are listed in Exhibit 2-4. The exhibit also presents the direct revenue impacts, by industry for one 400 MWe OTEC of each basic configuration. Configuration 1 generates the largest total impact on industries directly involved in OTEC construction, \$709.4 million. It is an electricity producer with a steel hull, a fiberglass CWP, and a titanium heat exchanger. The smallest impact, \$309.8 million, is generated by Configuration 4, which is a grazing plantship equipped with a concrete hull, a concrete CWP, and an aluminum heat exchanger. Neither this configuration nor Configuration 3, however, includes any revenue generated as a result of equipping the plantship with the necessary technology to produce either aluminum or ammonia. This estimation was not made due to insufficient design and cost information for these components. Consequently, the impact resulting from any plantship design is probably underestimated.

EXHIBIT 2-4
REVENUE IMPACT BY INDUSTRY FOR ONE 400 MWe OTEC --
FOUR ALTERNATIVE CONFIGURATIONS
(Millions of 1972 Dollars)

Configuration 1		Configuration 2		Configuration 3		Configuration 4	
<ul style="list-style-type: none"> ● electricity producer ● steel hull ● fiberglass CWP ● titanium heat exchanger 		<ul style="list-style-type: none"> ● electricity producer ● steel hull ● concrete CWP ● titanium heat exchanger 		<ul style="list-style-type: none"> ● plantship ● concrete hull ● fiberglass CWP ● aluminum heat exchanger 		<ul style="list-style-type: none"> ● plantship ● concrete hull ● concrete CWP ● aluminum heat exchanger 	
Steel	36.0	Steel	36.0	Steel	12.6	Steel	12.6
Titanium	51.2	Titanium	51.2	Titanium	0.0	Titanium	0.0
Aluminum	0.0	Aluminum	0.0	Aluminum	13.0	Aluminum	13.0
Cement/Concrete	0.0	Cement/Concrete	0.8	Cement/Concrete	5.9	Cement/Concrete	6.7
Pumps	22.6	Pumps	22.6	Pumps	22.6	Pumps	22.6
Fabricated Metal	192.5	Fabricated Metal	192.5	Fabricated Metal	154.3	Fabricated Metal	154.3
Cable	38.8	Cable	38.8	Cable	0.0	Cable	0.0
Ship Building	205.7	Ship Building	205.7	Ship Building	99.9	Ship Building	99.9
Plastics	140.7	Plastics	0.0	Plastics	140.7	Plastics	0.0
Fiberglass	17.6	Fiberglass	0.0	Fiberglass	17.6	Fiberglass	0.0
Resins	3.7	Resins	0.0	Resins	3.7	Resins	0.0
Stone/Clay	0.6	Stone/Clay	0.1	Stone/Clay	1.2	Stone/Clay	0.7
TOTAL	709.4	TOTAL	547.7	TOTAL	471.5	TOTAL	309.8

As can be seen in Exhibit 2-4, the fabricated metal and shipbuilding industries receive major impacts regardless of the design configuration. The size of the impact is more than twice as large for the shipbuilding industry, however, when the OTEC facility is steel hulled. The impacts on the plastics, fiberglass, and resins industries are dependent, as one would expect, on whether the CWP is constructed of fiberglass reinforced plastic. Similarly, the effect on the concrete industry is dependent on whether concrete and cement are used for the hull and/or the cold water pipe.

Other industry level impacts are also based on the chosen design configuration. The effects on the titanium and aluminum industries are determined by the selection of the material for the heat exchanger in the closed cycle system. The impact on the underwater electrical cable industry is directly dependent on whether the facility produces electricity for the onshore power grid or not. If it does, the impact is \$38.8 million³; if it does not, it is zero. The impact on the pump industry, however, is \$22.6 million regardless of the configuration.

Secondary Impacts

Since the design configuration determines the primary inputs into the construction of an OTEC facility, it also determines the secondary revenue impacts resulting from the intermediate demand for materials by the primary industries. Exhibit 2-5 lists these impacts, where quantifiable, for the major inputs into these primary industries. For example, the use of plastic in the fiberglass reinforced plastic cold water pipe of Configurations 1 and 3 results in increased output in the plastic materials and synthetic rubber sector of \$31.9 million. Since these secondary impacts, are generally less than 5 percent of the primary impact (for 83 of 123 industry impacts), they have not been estimated on a year by year basis.

Annual Revenue and Employment Impacts

In order to estimate the annual revenue and employment impacts for industries involved in constructing OTEC plants for the years 1990 to 2000 it was assumed that the actual construction period for one 400 MWe plant was three years, preceeded by a one year preparatory phase and followed by a one year deployment phase. It was then assumed

EXHIBIT 2-5

**SECONDARY REVENUE IMPACTS QUANTIFIABLE MAJOR INPUTS TO PRIMARY IMPACT SECTORS
FOR ONE 400 MWe OTEC; FOUR ALTERNATIVE CONFIGURATIONS
(Millions of 1972 Dollars)**

Primary Industry/ Secondary Industry or Product	Secondary Industry/Product SIC or BLS Sector Number	Configuration 1 Secondary Revenue Impact	Configuration 2 Secondary Revenue Impact	Configuration 3 Secondary Revenue Impact	Configuration 4 Secondary Revenue Impact
Steel					
Iron and Ferroalloy Ores Mining	BLS #8	2.04	2.04	0.71	0.71
Steel	BLS #71	6.57	6.57	2.30	2.30
Wholesale Trade	BLS #129	1.12	1.12	0.39	0.39
Miscellaneous Business Services	BLS #139	1.24	1.24	0.43	0.43
Scrap, Used and Secondhand	BLS #158	1.00	1.00	0.35	0.35
Pumps					
Iron Castings	SIC 332011	1.07	1.07	1.07	1.07
Steel Castings	SIC 332045	0.69	0.69	0.69	0.69
Integral Horsepower Motors and Generators (1 h.p. and over)	SIC 382120	0.84	0.84	0.84	0.84
Fabricated Metal					
Titanium	SIC 33562	51.20	51.20	—	—
Fabricated Metal	BLS #78	4.11	4.11	4.11	4.11
Other Fabricated Metal Products	BLS #82	4.23	4.23	4.23	4.23
Wholesale Trade	BLS #129	4.80	4.80	4.80	4.80
Aluminum	BLS #74	—	—	13.00	13.00
Cable					
Copper and Copper-Base Alloy Wire Bar	SIC 333125	2.67	2.67	—	—
Aluminum and Aluminum-Base Alloy Rods	SIC 335009	1.98	1.98	—	—
Unalloyed Copper Rods	SIC 3335133	6.09	6.09	—	—
Shipbuilding					
Carbon Steel Plates	SIC 331013	11.99	11.99	—	—
Carbon Steel Structural Shapes	SIC 331015	3.16	3.16	—	—
Cement/Concrete	BLS #67	—	—	5.90	5.90

EXHIBIT 2-5

**SECONDARY REVENUE IMPACTS QUANTIFIABLE MAJOR INPUTS TO PRIMARY IMPACT SECTORS
FOR ONE 400 MWe OTEC; FOUR ALTERNATIVE CONFIGURATIONS**
(Millions of 1972 Dollars)
(Continued)

Primary Industry/ Secondary Industry or Product	Secondary Industry/Product SIC or BLS Sector Number	Configuration 1 Secondary Revenue Impact	Configuration 2 Secondary Revenue Impact	Configuration 3 Secondary Revenue Impact	Configuration 4 Secondary Revenue Impact
Plastics					
Plastic Materials and Synthetic Rubber	BLS #55	31.87	—	31.87	—
Miscellaneous Rubber Products	BLS #62	4.39	—	4.39	—
Plastics	BLS #63	4.96	—	4.96	—
Fiberglass	SIC 32293	17.60	—	17.60	—
Resins					
Acrylates and Methacrylates, Monomers	SIC 286925	0.08	—	0.08	—
Ethylene	SIC 291165	0.10	—	0.10	—
Styrene	SIC 286516	0.16	—	0.16	—
Vinyl Chloride, Monomer	SIC 286928	0.10	—	0.10	—
Stone/Clay					
Stone/Clay	BLS #13	0.02	*	0.04	0.02
Petroleum Refining and Related Products	BLS #60	0.02	*	0.04	0.02
Cement/Concrete	BLS #67	0.05	0.01	0.10	0.06
Real Estate	BLS #135	0.02	*	0.05	0.03
Miscellaneous Business Service	BLS #139	0.05	*	0.05	0.03
Cement/Concrete					
Stone/Clay	BLS #13	—	0.07	0.56	0.64
Cement/Concrete	BLS #67	—	0.13	0.93	1.06
Truck Transportation	BLS #119	—	0.05	0.37	0.43
Real Estate	BLS #135	—	0.02	0.15	0.17
Miscellaneous Business Services	BLS #139	—	0.02	0.15	0.18
Aluminum					
Other Nonferrous Ore Mining	BLS #10	—	—	0.55	0.55
Primary Copper and Copper Products	BLS #73	—	—	0.43	0.43
Aluminum	BLS #74	—	—	3.49	3.49
Other Primary Nonferrous Products	BLS #75	—	—	1.05	1.05
Gas Utilities	BLS #127	—	—	0.24	0.24
Wholesale Trade	BLS #129	—	—	0.24	0.24

*Less than 0.005.

that one third of the construction funds were spent each year. This allowed the estimation of Exhibit 2-6, which lists the annual revenue impact, by industry, for the four configurations, per plant. Again, the greatest total impact is generated by Configuration 1; the lowest impact by Configuration 4.

Having determined the annual revenue impact, a timing plan was developed which distributed construction of the appropriate configuration mix among the eligible shipyards for both the 25 plant and the 50 plant scenarios for the period from 1990 to 2000 (see Appendix A). This allowed the estimation of annual increases in employment and revenue over the baseline forecast for each industry for each year from 1990 through 2000. These forecasts are presented in Exhibit 2-7. Again, it is emphasized that these are annual increases over the baseline forecasts for each year, and that they are not to be aggregated over the period.

TWENTY-FIVE PLANT SCENARIO DIRECT IMPACTS

Introduction

In this section, we will examine the direct economic impacts of the 25 plant scenario. First, aggregate direct impacts on GNP and employment will be presented. Second, direct impacts on the revenues of and the employment in the twelve industries will be discussed. Finally, industry level proportional impacts will be examined. A similar presentation will then follow for the 50 plant scenario.

Aggregate Impacts

The aggregate direct impact of OTEC development on the twelve combined industries directly involved in construction or materials supply to construction ranges from a low revenue increase of \$419.0 million in 1990 to a high of \$1,620.8 million in 1998, averaging \$1,200.8 million per year. Aggregate employment is forecasted to experience a minimum increase of 8,998 in 2000 and a maximum increase of 30,316 in 1994.⁴ The average increase in employment throughout the period will be 23,315 jobs per year.

EXHIBIT 2-6

**ANNUAL REVENUE IMPACT BY INDUSTRY FOR
FOUR ALTERNATIVE 400 MWe OTEC CONFIGURATIONS
WITH ONE TO TEN OTEC PLANTS UNDER CONSTRUCTION
(Millions of 1972 Dollars)**

One OTEC Plant Under Construction

<u>Industry</u>	<u>OTEC Configuration Number</u>			
	<u>C #1</u>	<u>C #2</u>	<u>C #3</u>	<u>C #4</u>
Steel	12.00	12.00	4.20	4.20
Titanium	17.07	17.07	0.00	0.00
Aluminum	0.00	0.00	4.33	4.33
Cement/Concrete	0.00	0.27	1.97	2.23
Pumps	7.53	7.53	7.53	7.53
Fabricated Metal	64.17	64.17	51.43	51.43
Cable	12.93	12.93	0.00	0.00
Ship Building	68.57	68.57	33.30	33.30
Plastics	46.90	0.00	46.90	0.00
Fiberglass	5.87	0.00	5.87	0.00
Resins	1.23	0.00	1.23	0.00
Stone/Clay	0.20	0.03	0.40	0.23
TOTAL	236.47	182.57	157.17	103.27

EXHIBIT 2-7

**ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)**

25 OTEC SCENARIO

Industry	1990		
	Revenue	Employment	Proportional Increase
Steel	24.0	0.310	0.00056
Titanium	34.1	0.516	0.16650
Aluminum	0.0	0.000	0.00000
Cement/Concrete	0.3	0.005	0.00002
Pumps	15.1	0.377	0.00381
Fabricated Metal	123.3	2.886	0.00416
Cable	25.9	0.263	0.00302
Ship Building	137.1	3.900	0.01893
Plastics	48.9	0.875	0.00186
Fiberglass	5.9	0.106	0.00901
Resins	1.2	0.009	0.00012
Stone/Clay	0.2	0.005	0.00005
TOTAL	419.0	9.251	0.00250

1991

Industry	1991		
	Revenue	Employment	Proportional Increase
Steel	48.0	0.607	0.00111
Titanium	68.3	1.008	0.32508
Aluminum	0.0	0.000	0.00000
Cement/Concrete	0.5	0.009	0.00003
Pumps	30.1	0.750	0.00735
Fabricated Metal	256.7	5.623	0.00795
Cable	51.7	0.514	0.00584
Ship Building	274.3	7.580	0.03662
Plastics	93.8	1.711	0.00357
Fiberglass	11.7	0.208	0.01731
Resins	2.5	0.016	0.00024
Stone/Clay	0.5	0.009	0.00009
TOTAL	838.1	18.035	0.00486

50 OTEC SCENARIO

Industry	1990		
	Revenue	Employment	Proportional Increase
Steel	32.4	0.419	0.00076
Titanium	34.1	0.516	0.16650
Aluminum	8.7	0.085	0.00049
Cement/Concrete	4.5	0.078	0.00029
Pumps	30.1	0.754	0.00762
Fabricated Metal	231.2	5.199	0.00750
Cable	25.9	0.263	0.00302
Ship Building	203.7	5.794	0.02812
Plastics	93.8	1.750	0.00372
Fiberglass	11.7	0.213	0.01802
Resins	2.5	0.017	0.00025
Stone/Clay	0.9	0.017	0.00017
TOTAL	679.5	15.104	0.00406

1991

Industry	1991		
	Revenue	Employment	Proportional Increase
Steel	72.6	0.918	0.00168
Titanium	85.3	1.260	0.40635
Aluminum	13.0	0.123	0.00072
Cement/Concrete	6.7	0.114	0.00043
Pumps	60.3	1.500	0.01471
Fabricated Metal	475.1	10.410	0.01472
Cable	64.7	0.643	0.00730
Ship Building	442.7	12.236	0.05911
Plastics	234.5	4.278	0.00893
Fiberglass	29.3	0.519	0.04326
Resins	6.2	0.041	0.00059
Stone/Clay	1.7	0.032	0.00033
TOTAL	1,492.1	23.776	0.00865

EXHIBIT 2-7
ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)

25 OTEC SCENARIO

<u>Industry</u>	<u>1992</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	76.2	0.942	0.00175
Titanium	102.4	1.483	0.47850
Aluminum	4.3	0.040	0.00023
Cement/Concrete	2.8	0.046	0.00017
Pumps	52.7	1.292	0.01242
Fabricated Metal	436.4	9.312	0.01291
Cable	77.6	0.754	0.00848
Ship Building	444.7	11.944	0.05743
Plastics	187.6	3.352	0.00687
Fiberglass	23.5	0.405	0.03319
Resins	4.9	0.032	0.00045
Stone/Clay	1.1	0.020	0.00021
TOTAL	1,414.3	29.621	0.00795

1993

<u>Industry</u>	<u>1993</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	68.4	0.827	0.00155
Titanium	85.3	1.208	0.38985
Aluminum	8.7	0.077	0.00044
Cement/Concrete	4.5	0.072	0.00027
Pumps	52.7	1.272	0.01200
Fabricated Metal	423.7	8.800	0.01197
Cable	64.7	0.615	0.00683
Ship Building	409.4	10.688	0.05114
Plastics	234.5	4.103	0.00825
Fiberglass	29.3	0.490	0.03986
Resins	6.2	0.038	0.00055
Stone/Clay	1.5	0.026	0.00027
TOTAL	1,388.9	28.215	0.00758

50 OTEC SCENARIO

<u>Industry</u>	<u>1992</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	121.2	1.498	0.00278
Titanium	136.5	1.978	0.63801
Aluminum	26.0	0.239	0.00138
Cement/Concrete	13.7	0.226	0.00085
Pumps	105.5	2.584	0.02484
Fabricated Metal	821.9	17.537	0.02432
Cable	103.5	1.006	0.01130
Ship Building	748.3	20.100	0.09663
Plastics	328.3	5.866	0.01202
Fiberglass	41.1	0.709	0.05809
Resins	8.6	0.056	0.00080
Stone/Clay	2.8	0.051	0.00054
TOTAL	2,457.4	51.848	0.01382

1993

<u>Industry</u>	<u>1993</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	145.2	1.755	0.00330
Titanium	170.7	2.416	0.77930
Aluminum	26.0	0.232	0.00133
Cement/Concrete	13.9	0.225	0.00085
Pumps	120.5	2.906	0.02742
Fabricated Metal	950.3	19.737	0.02685
Cable	129.3	1.230	0.01367
Ship Building	885.5	23.115	0.11080
Plastics	375.2	6.563	0.01321
Fiberglass	46.9	0.784	0.06377
Resins	9.9	0.061	0.00087
Stone/Clay	3.1	0.054	0.00057
TOTAL	2,876.5	59.078	0.01569

EXHIBIT 2-7

**ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000**
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)

25 OTEC SCENARIO**50 OTEC SCENARIO**

Industry	1994		
	Revenue	Employment	Proportional Increase
Steel	69.0	0.815	0.00155
Titanium	68.3	0.945	0.30476
Aluminum	21.7	0.187	0.00107
Cement/Concrete	10.9	0.171	0.00065
Pumps	67.8	1.623	0.01489
Fabricated Metal	513.8	10.400	0.01387
Cable	51.7	0.481	0.00529
Ship Building	440.8	11.128	0.05325
Plastics	234.5	4.015	0.00793
Fiberglass	29.3	0.479	0.03829
Resins	6.2	0.037	0.00052
Stone/Clay	2.1	0.036	0.00039
TOTAL	1,516.1	30.316	0.00802

Industry	1994		
	Revenue	Employment	Proportional Increase
Steel	157.2	1.857	0.00354
Titanium	187.7	2.598	0.83810
Aluminum	28.0	0.225	0.00128
Cement/Concrete	14.2	0.223	0.00084
Pumps	128.1	3.065	0.02812
Fabricated Metal	1,014.4	20.531	0.02737
Cable	142.3	1.323	0.01454
Ship Building	954.0	24.087	0.11525
Plastics	375.2	6.423	0.01269
Fiberglass	46.9	0.766	0.06127
Resins	9.9	0.059	0.00084
Stone/Clay	3.1	0.052	0.00056
TOTAL	3,059.0	61.210	0.01618

Industry	1995		
	Revenue	Employment	Proportional Increase
Steel	61.2	0.707	0.00136
Titanium	51.2	0.693	0.22358
Aluminum	28.0	0.218	0.00124
Cement/Concrete	12.9	0.197	0.00075
Pumps	67.8	1.596	0.01438
Fabricated Metal	501.1	9.878	0.01291
Cable	38.8	0.357	0.00384
Ship Building	405.5	9.949	0.04738
Plastics	234.5	3.928	0.00763
Fiberglass	29.3	0.467	0.03680
Resins	6.2	0.038	0.00050
Stone/Clay	2.3	0.036	0.00042
TOTAL	1,436.8	28.064	0.00737

Industry	1995		
	Revenue	Employment	Proportional Increase
Steel	169.2	1.953	0.00377
Titanium	204.8	2.772	0.89432
Aluminum	28.0	0.218	0.00124
Cement/Concrete	14.2	0.218	0.00082
Pumps	135.6	3.192	0.02875
Fabricated Metal	1,076.6	21.263	0.02779
Cable	155.2	1.428	0.01535
Ship Building	1,022.6	25.090	0.11948
Plastics	422.1	7.070	0.01373
Fiberglass	52.8	0.841	0.06625
Resins	11.1	0.064	0.00091
Stone/Clay	3.3	0.054	0.00059
TOTAL	3,295.5	64.163	0.01691

EXHIBIT 2-7
ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)

25 OTEC SCENARIO

Industry	1996		
	Revenue	Employment	Proportional Increase
Steel	69.0	0.780	0.00152
Titanium	68.3	0.904	0.29174
Aluminum	21.7	0.176	0.00100
Cement/Concrete	11.2	0.167	0.00063
Pumps	67.8	1.582	0.01388
Fabricated Metal	513.8	9.863	0.01264
Cable	51.7	0.465	0.00495
Ship Building	440.8	10.510	0.04981
Plastics	187.6	3.073	0.00587
Fiberglass	23.5	0.362	0.02831
Resins	4.8	0.027	0.00039
Stone/Clay	2.0	0.031	0.00034
TOTAL	1,462.2	27.842	0.00727

1997

Industry	1997		
	Revenue	Employment	Proportional Increase
Steel	72.6	0.802	0.00159
Titanium	85.3	1.107	0.35704
Aluminum	13.0	0.103	0.00058
Cement/Concrete	6.7	0.098	0.00037
Pumps	60.3	1.394	0.01191
Fabricated Metal	475.1	8.876	0.01117
Cable	64.7	0.569	0.00599
Ship Building	442.7	10.259	0.04839
Plastics	234.5	3.757	0.00705
Fiberglass	29.3	0.442	0.03403
Resins	6.2	0.033	0.00047
Stone/Clay	1.7	0.026	0.00029
TOTAL	1,492.1	27.465	0.00720

50 OTEC SCENARIO

Industry	1996		
	Revenue	Employment	Proportional Increase
Steel	169.2	1.912	0.00374
Titanium	204.8	2.713	0.87521
Aluminum	26.0	0.212	0.00120
Cement/Concrete	14.2	0.213	0.00080
Pumps	135.6	3.164	0.02776
Fabricated Metal	1,078.6	20.703	0.02654
Cable	155.2	1.396	0.01485
Ship Building	1,022.6	24.383	0.11556
Plastics	422.1	6.915	0.01320
Fiberglass	52.8	0.815	0.06369
Resins	11.1	0.062	0.00087
Stone/Clay	3.3	0.052	0.00058
TOTAL	3,295.5	62.541	0.01639

1997

Industry	1997		
	Revenue	Employment	Proportional Increase
Steel	161.4	1.782	0.00353
Titanium	187.7	2.435	0.78550
Aluminum	30.3	0.239	0.00135
Cement/Concrete	16.2	0.236	0.00089
Pumps	135.6	3.136	0.02680
Fabricated Metal	1,065.9	19.912	0.02505
Cable	142.3	1.252	0.01318
Ship Building	987.3	22.878	0.10792
Plastics	422.1	6.762	0.01269
Fiberglass	52.8	0.796	0.06125
Resins	11.1	0.059	0.00084
Stone/Clay	3.5	0.053	0.00060
TOTAL	3,216.2	59.542	0.01551

EXHIBIT 2-7
ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)

25 OTEC SCENARIO

Industry	1998		
	Revenue	Employment	Proportional Increase
Steel	84.6	0.914	0.00183
Titanium	102.4	1.296	0.41796
Aluminum	13.0	0.100	0.00056
Cement/Concrete	7.2	0.103	0.00039
Pumps	87.8	1.540	0.01294
Fabricated Metal	539.3	9.815	0.01210
Cable	77.6	0.668	0.00696
Ship Building	511.3	11.514	0.05405
Plastics	187.6	2.943	0.00542
Fiberglass	23.5	0.343	0.02619
Resins	4.9	0.025	0.00036
Stone/Clay	1.6	0.023	0.00026
TOTAL	1,620.8	29.283	0.00758

1999

Industry	1999		
	Revenue	Employment	Proportional Increase
Steel	56.4	0.595	0.00121
Titanium	68.3	0.819	0.27307
Aluminum	8.7	0.064	0.00036
Cement/Concrete	4.7	0.066	0.00025
Pumps	45.2	1.016	0.00833
Fabricated Metal	359.5	6.372	0.00770
Cable	51.7	0.435	0.00449
Ship Building	340.9	7.459	0.03485
Plastics	140.7	2.161	0.00391
Fiberglass	17.6	0.251	0.01890
Resins	3.7	0.018	0.00026
Stone/Clay	1.1	0.016	0.00018
TOTAL	1,098.5	19.273	0.00498

50 OTEC SCENARIO

Industry	1998		
	Revenue	Employment	Proportional Increase
Steel	153.6	1.660	0.00333
Titanium	170.7	2.159	0.69680
Aluminum	34.7	0.265	0.00148
Cement/Concrete	18.1	0.259	0.00098
Pumps	135.6	3.079	0.02588
Fabricated Metal	1,053.1	19.166	0.02363
Cable	129.3	1.113	0.01159
Ship Building	952.1	21.439	0.10065
Plastics	422.1	6.622	0.01220
Fiberglass	52.8	0.772	0.05893
Resins	11.1	0.057	0.00081
Stone/Clay	3.7	0.054	0.00062
TOTAL	3,136.9	56.646	0.01466

1999

Industry	1999		
	Revenue	Employment	Proportional Increase
Steel	97.2	1.026	0.00209
Titanium	102.4	1.229	0.40960
Aluminum	26.0	0.193	0.00107
Cement/Concrete	13.4	0.186	0.00071
Pumps	90.4	2.032	0.01666
Fabricated Metal	693.6	12.292	0.01486
Cable	77.6	0.653	0.00673
Ship Building	611.2	13.374	0.06249
Plastics	281.4	4.322	0.00782
Fiberglass	35.2	0.503	0.03781
Resins	7.4	0.037	0.00052
Stone/Clay	2.6	0.037	0.00042
TOTAL	2,038.4	35.883	0.00923

EXHIBIT 2-7

**ECONOMIC IMPACT BY INDUSTRY FOR
25 AND 50 OTEC SCENARIOS UNDER
THE EXAMPLE CONFIGURATION MIX, 1990-2000
(Revenue in Millions of 1972 Dollars; Employment in Thousands of Jobs)
(Continued)**

25 OTEC SCENARIO

<u>Industry</u>	<u>2000</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	28.2	0.291	0.00060
Titanium	34.1	0.400	0.13333
Aluminum	4.3	0.031	0.00017
Cement/Concrete	2.5	0.034	0.00013
Pumps	22.6	0.503	0.00402
Fabricated Metal	179.8	3.105	0.00368
Cable	25.9	0.213	0.00217
Ship Building	170.4	3.624	0.01686
Plastics	46.9	0.704	0.00125
Fiberglass	5.9	0.081	0.00607
Resins	1.2	0.006	0.00008
Stone/Clay	0.5	0.006	0.00007
TOTAL	522.3	8.998	0.00229

50 OTEC SCENARIO

<u>Industry</u>	<u>2000</u>		
	<u>Revenue</u>	<u>Employment</u>	<u>Proportional Increase</u>
Steel	48.6	0.502	0.00103
Titanium	51.2	0.600	0.20000
Aluminum	13.0	0.094	0.00052
Cement/Concrete	6.7	0.091	0.00035
Pumps	45.2	1.005	0.00804
Fabricated Metal	346.8	5.990	0.00710
Cable	38.8	0.319	0.00326
Ship Building	305.6	6.498	0.03022
Plastics	140.7	2.111	0.00376
Fiberglass	17.6	0.244	0.01820
Resins	3.7	0.018	0.00025
Stone/Clay	1.3	0.018	0.00021
TOTAL	1,019.2	17.489	0.00447

The proportional increase due to OTEC construction over the aggregate baseline forecasts for these twelve industries combined is less than 1 percent of their total output in each year. The lowest percentage increase is 0.23 percent in 2000; the highest is 0.80 percent in 1994. A similar comparison of the yearly aggregate increases to baseline GNP forecasts for the period yields even lower proportions (Exhibit 2-8). In fact, under the 25 plant scenario, the increase in GNP never exceeds 0.063 percent (1992 and 1994), and is as low as 0.018 percent (2000). Thus, the impact of the OTEC development program on GNP is small.

Exhibit 2-9 summarizes the impact of the 25 plant scenario on each of the twelve industries for the period from 1990 through 2000. This exhibit presents for each industry the total dollar revenue impact over the period and the average annual increase in employment. It also lists the maximum annual proportional increase in each industry's revenues. These industry level impacts are described in detail in the next two sections.

Industry Level Absolute Impacts

The industries impacted most heavily in absolute terms are the shipbuilding and fabricated metals industries. Increases in the shipbuilding industry range from \$137.1 million in 1990 to \$511.3 million in 1998. In the fabricated metals industry, annual revenue increases range from \$128.3 million in 1990 to \$539.3 million in 1998. Employment also increases greatly in these two industries, ranging from an additional 3,900 jobs in shipbuilding in 1990 to 11,944 in 1992; and, in fabricated metals, from 2,886 in 1990 to 10,400 in 1994.

Revenue and employment in the plastics industry increases moderately over baseline forecasts as a result of domestic OTEC development. Revenue increases range from \$46.9 million in 1990 and 2000 to \$234.5 million in 1993, 1994, 1995, and 1997. Increases in employment in the industry reach a high of 4,102 in 1993, with a low of 704 in 2000. The low increase occurs in 2000 because of reduced activity and increased productivity in the industry over previous years.

Another industry that experiences moderate absolute increases in revenue and employment is the titanium industry. Revenue will increase by a minimum of \$34.1 million in

EXHIBIT 2-8
PROPORTIONAL INCREASE OVER FORECAST GNP

<u>YEAR</u>	<u>25 OTEC SCENARIO</u>	<u>50 OTEC SCENARIO</u>
1990	.00020	.00032
1991	.00038	.00068
1992	.00063	.00109
1993	.00060	.00124
1994	.00063	.00128
1995	.00058	.00133
1996	.00057	.00129
1997	.00057	.00122
1998	.00060	.00115
1999	.00039	.00072
2000	.00018	.00035

EXHIBIT 2-9

25 OTEC

<u>Industry</u>	<u>Total Revenue Impact \$ M (1972)</u>	<u>Average Annual Increase in Jobs Jobs</u>	<u>Maximum Annual Proportional Input</u>
Steel	\$ 657.6	690	.00183
Titanium	768.0	944	.47850
Aluminum	121.4	91	.00124
Cement/Concrete	64.2	88	.00075
Pumps	549.9	1,177	.01489
Fabricated Metal	4,327.5	7,721	.01387
Cable	582.0	485	.00848
Ship Building	4,017.9	8,960	.05743
Plastics	1,829.1	2,784	.00825
Fiberglass	228.8	330	.03986
Resins	48.1	25	.00055
Stone/Clay	14.6	21	.00042
TOTAL	13,209.1	23,315	—

50 OTEC

<u>Industry</u>	<u>Total Revenue Impact \$ M (1972)</u>	<u>Average Annual Increase in Jobs Jobs</u>	<u>Maximum Annual Proportional Input</u>
Steel	\$1,327.8	1,389	.00377
Titanium	1,535.9	1,880	.89432
Aluminum	255.7	193	.00148
Cement/Concrete	135.8	188	.00098
Pumps	1,122.5	2,402	.02875
Fabricated Metal	8,809.5	15,704	.02779
Cable	1,164.1	966	.01535
Ship Building	8,135.6	18,090	.11948
Plastics	3,517.5	5,335	.01269
Fiberglass	439.9	633	.06625
Resins	92.6	48	.00091
Stone/Clay	29.3	43	.00062
TOTAL	26,566.2	46,116	—

1990 and by a maximum of \$102.4 million in 1992 and 1998. The largest increase in employment is realized in 1992, when 1,483 additional jobs are projected; the smallest increase occurs in 2000, when only 400 more laborers are required.

Very minor absolute impacts can be expected in several of these industries. In the resins industry, the largest increase in revenue is expected to be only \$6.2 million in 1993, 1994, 1995, and 1997; the largest employment increase will be only 38 people in 1993. The aluminum industry can expect a revenue peak of \$26.0 million in 1995, providing an additional 218 jobs. The cement and concrete industry will experience a maximum revenue impact of only \$12.9 million in 1995, accompanying a maximum increase in employment of only 197. Finally, maximum increases of \$2.3 million and 38 jobs will occur in the stone/clay industry in 1995.

Maximum increases in revenues and employment in the remaining industries are as follows:

- Steel - \$84.6 million in 1998, and 942 jobs in 1992.
- Fiberglass - \$29.3 million in each year from 1993 through 1995 and in 1997, and 490 jobs in 1993.
- Cable - \$77.6 million in 1992 and 1998, and 754 jobs in 1992.
- Pumps - \$67.8 million in each year from 1994 through 1996 and in 1998, and 1,623 jobs in 1994.

Industry Level Proportional Impacts

The titanium industry experiences the largest proportional increases in revenues and employment over baseline forecasts in each year from 1990 to 2000. These proportional increases range from 13.33 percent in 2000 to 47.85 percent in 1992. The magnitudes of these increases are due not only to the large amount of titanium required in a heat exchanger and the scheduling of production, but also to the limited capacity projected for the titanium industry in the next twenty years. This industry, consequently, may prove to be a bottleneck in OTEC development, especially if national defense needs result in increased demand for titanium for military purposes. Another potential

bottleneck is the undersea electrical cable industry, which does not exist in the United States, although a sector that could support it has been identified.

The remaining industries directly affected by OTEC construction are projected to experience substantially smaller proportional increases in output than the titanium industry. The next highest proportional increase is only 5.74 percent, projected for shipbuilding in 1992; a low of 1.69 percent is expected for this industry in 2000. In fact, seven of the twelve industries will not achieve an annual increase in excess of 1 percent in any year of the period. These industries are steel, aluminum, cement/concrete, cable, plastics, resins, and stone/clay. For example, the highest proportional increase in the steel industry is only 0.18 percent in 1998, while the lowest is 0.056 percent in 1990. The lowest proportional increase experienced by any industry occurs in aluminum in 1990 and 1991, when no additional aluminum is scheduled to be provided. The highest proportional increase for aluminum is only 0.124 percent in 1995. Highest proportional increases in output for the remaining five industries in this group are the following:

- Cement/concrete - 0.075 percent in 1995
- Cable - 0.848 percent in 1992
- Plastics - 0.825 percent in 1993
- Resins - 0.055 percent in 1993
- Stone/clay - 0.042 percent in 1995

Industries with maximum proportional increases in excess of one percent (other than titanium and shipbuilding) are the following:

- Pumps - high of 1.5 percent in 1994, low of 0.4 percent in 1990.
- Fabricated Metal - high of 1.4 percent in 1994, low of 0.4 percent in 2000.
- Fiberglass - high of 4.0 percent in 1993, low of 0.6 percent in 2000.

FIFTY PLANT SCENARIO DIRECT IMPACTS

Aggregate Impacts

The aggregate direct impacts of producing 50 OTEC power plants on the twelve combined industries directly involved in construction or the supply of materials is not simply twice the level estimated under the 25 plant scenario. This is due to scheduling

differences required to meet the necessary level of construction for this scenario. Similar reasoning applies to comparisons of industry level impacts on an annual basis.

Aggregate revenue impacts range from a low increase of \$679.5 million in 1990 to a high of \$3,295.5 million in 1995 and 1996, averaging \$2,418.1 million per year. Aggregate employment will experience a minimum increase of 15,104 in 1990 and a maximum increase of 64,163 in 1995. The average increase in direct employment throughout the period will be 46,116 jobs per year.

The proportional increase due to OTEC construction over the aggregate baseline forecasts for the twelve industries is larger under the 50 plant scenario than under the 25 plant scenario. The highest percentage increase in a given year is 1.69 percent in 1995. In fact, the impact exceeds one percent in each year from 1992 to 1998. The lowest percentage increase occurs in 1990, when output rises by only 0.41 percent. A similar comparison of the yearly aggregate increases to baseline GNP forecasts for the period shows that the impact on GNP exceeds one-tenth of one percent over the period from 1992 to 1998, peaking at 0.133 percent in 1995 (See Exhibit 2-8). The lowest percentage increase is in 1990, when increased output due to OTEC only constitutes 0.032 percent of GNP. Again, the total impact of the OTEC program is small in comparison to baseline forecasts of GNP for the period.

Exhibit 2-9 summarizes the impact of the 50 plant scenario on each of the twelve industries for the period from 1990 through 2000, presenting the total dollar revenue impact, the average annual increase in employment, and the maximum annual proportional increase in each industry's revenues. These industry level impacts are described in detail in the next two sections.

Industry Level Absolute Impacts

The industries most heavily impacted under this scenario are again the shipbuilding and fabricated metal industries. Increases in annual revenue in shipbuilding range from a low of \$203.7 million in 1990 to a high of \$1,022.6 million in 1995 and 1996. Revenue increases in fabricated metals are at their lowest in 1990 at \$231.2 million and at their highest at \$1,078.6 million in 1995 and 1996. Employment will also increase substan-

tially in the two industries, with low increases occurring in 1990 (5,794 in shipbuilding and 5,199 in fabricated metals) and high increases in 1995 (25,090 in shipbuilding and 21,263 in fabricated metals).

Other industries that can expect sizeable increases in activity include:

- **Plastics** - Revenue impacts will range from a low of \$93.8 million in 1990 to a high of \$422.1 million in each year from 1995 to 1998. Employment will peak at 7,070 in 1995 from a low of 1,750 in 1990.
- **Titanium** - Increases in revenue will be at their lowest in 1990 at \$34.1 million and at their highest in 1995 and 1996 at \$204.8 million. The minimum increase in employment will occur in 1990 when 516 additional jobs are expected; the maximum will be in 1995 when 2,772 workers will be added.

In the remaining industries, the maximum increases in revenues and employment are as follows:

- **Steel** - \$169.2 million in 1995 and 1996, and 1,953 jobs in 1995.
- **Aluminum** - \$34.7 million and 265 jobs in 1998.
- **Cement/Concrete** - \$18.1 million and 259 jobs in 1998.
- **Pumps** - \$135.6 million in each year from 1995 to 1998, and 3,192 jobs in 1995.
- **Cable** - \$155.2 million in 1995 and 1996, and 1,428 jobs in 1995.
- **Fiberglass** - \$52.8 million in each year from 1995 to 1998, and 841 jobs in 1995.
- **Resins** - \$11.1 million in each year from 1995 to 1998 and 64 jobs in 1995.
- **Stone/Clay** - \$3.7 million in 1998, and 54 jobs in 1995 and 1998.

Industry Level Proportional Impacts

The titanium industry again experiences the largest proportional increase over baseline forecasts in each year of the period from 1990 to 2000. These proportional increases

range from 16.65 percent in 1990 to an extremely high 89.43 percent in 1995. Again, it is doubtful that capacity in the titanium industry will be large enough to supply this additional amount of titanium without massive investment, especially if defense requirements for titanium greatly expand and if aluminum is found to be inappropriate for heat exchangers.

The remaining industries directly affected by OTEC construction will not experience such large proportional increases. High and low proportional impacts for each of these industries follow:

- Steel - high of 0.377 percent in 1995, low of 0.076 percent in 1990.
- Aluminum - high of 0.148 percent in 1998, low of 0.049 percent in 1990.
- Cement/Concrete - high of 0.098 percent in 1998, low of 0.029 percent in 1990.
- Pumps - high of 2.875 percent in 1995, low of 0.762 percent in 1990.
- Fabricated Metal - high of 2.779 percent in 1995, low of 0.710 percent in 2000.
- Cable - high of 1.535 percent in 1995, low of 0.302 percent in 1990.
- Shipbuilding - high of 11.948 percent in 1995, low of 2.812 percent in 1990.
- Plastics - high of 1.269 percent in 1994, low of 0.372 percent in 1990.
- Fiberglass - high of 6.625 percent in 1995, low of 1.802 percent in 1990.
- Resins - high of 0.091 percent in 1995, low of 0.025 percent in 1990 and 2000.
- Stone/Clay - high of 0.062 percent in 1998, low of 0.017 percent in 1990.

As can be seen, five of the remaining eleven industries never achieve an increase in excess of one percent in a given year; and only four have a highest percentage increase in excess of two percent. Again it must be noted that an underwater electrical transmission cable industry, per se, does not now exist in the United States, and may be difficult to create.

OTHER IMPACTS

OTEC Manning Levels

After the construction of an OTEC facility is completed, what manning levels are necessary to operate the power plant in each of three modes:

- electricity production;
- ammonia production; and
- aluminum production?

Current literature regarding OTEC plants connected by an electrical cable to the shore suggests an average berthing capacity of 50 people.⁵ In addition to the Coast Guard required personnel and the hotel steward's department, totaling about 22 individuals, an estimated 12 to 25 technicians would require housing on an OTEC plant. These technicians would serve a monitoring function in one specific facet of the total OTEC operation and would handle minor repairs when necessary. However, if a major systems problem arose, they could delineate this problem and call for a repair crew. This procedure would alleviate the necessity for housing a complete repair crew on each OTEC plant ship. Furthermore, since the on-board technicians would work a 12 hour shift, only 2 shifts of 10 to 12 workers would be necessary. Since individuals required by the Coast Guard could also fulfill OTEC functions, a crew of 50 for an electricity producing OTEC is reasonable.

For an aluminum reduction plantship, a recent DOE study suggests that approximately 100 people are necessary under a two shift scenario.⁶ Since about half of this number would be involved in aluminum reduction, the 50 people hypothesized to run an electricity OTEC seems reasonable. Finally, it is hypothesized that since ammonia production is less labor intensive than the processing of aluminum, approximately 80 people would be needed to staff such an OTEC facility.

Since the OTEC plant must be operated continuously at sea, a double crew system is required under which each individual would work a two week duty, with a two week rotation to shore after that time. Consequently, the total staffing required to run one OTEC is twice the level of the on-board crew. Allowing for uncertainty, this places per plant OTEC staffing requirements in the following ranges:

- Electricity production - 90 to 120 per plant;
- Aluminum production - 180 to 220 per plant; and
- Ammonia production - 140 to 180 per plant.

Therefore, in the 25 and 50 OTEC plant scenarios, the manning levels would be as shown in Exhibit 2-10, given the assumed mode distribution. Consequently, the total manpower requirement would range between 2,830 and 3,680 people in the 25 plant scenario; and between 5,660 and 7,360 in the 50 plant scenario.

Offshore Support Industry

The need for logistical support in the deployment and operation of OTEC power plants is an uncertain topic. Technical problems related to the actual deployment and operation of OTEC facilities make it difficult to estimate the types of vessels and manpower necessary to support a large number of these facilities. The possibility that new craft would be developed to service OTEC facilities further clouds the issue. Consequently, the level of employment that would result from an offshore service industry dedicated to OTEC service was not estimated.

Tax Revenues

Domestic OTEC development will generate increased business tax revenues to federal, state, and local governments by stimulating increased economic activity. These increased business tax revenues, however, are quite small at the aggregate industry level (See Exhibit 2-11). In fact, if the historical relationship between federal corporate income taxes and total corporate revenues in the manufacturing sector is maintained in the period from 1990 to 2000, increases in federal corporate income taxes:

- will peak at \$43.8 million in 1998 and only average \$32.4 million per year under the 25 plant scenario; and
- will peak at \$89.0 million in 1995 and 1996 and average \$65.2 million per year under the 50 plant scenario.

Since approximately the same historical relationship exists between state and local business taxes and total business revenues, approximately the same impact can be expected on state and local business tax revenues.

EXHIBIT 2-10
OTEC MANNING

25 PLANTS

<u>TYPE</u>	<u>Plants</u>	<u>Manning</u>
Electric	15	1350 - 1800
Aluminum	2	360 - 440
<u>Ammonia</u>	<u>8</u>	<u>1120 - 1440</u>
TOTAL	25	2830 - 3680

50 PLANTS

<u>TYPE</u>	<u>Plants</u>	<u>Manning</u>
Electric	30	2700 - 3600
Aluminum	4	720 - 880
<u>Ammonia</u>	<u>16</u>	<u>2240 - 2880</u>
TOTAL	50	5660 - 7360

EXHIBIT 2-11

ESTIMATED FEDERAL AND STATE AND LOCAL CORPORATE TAXES

<u>25 OTEC SCENARIO</u>				<u>50 OTEC SCENARIO</u>		
<u>Year</u>	<u>Revenue</u>	<u>Federal Tax</u>	<u>State and Local Tax</u>	<u>Revenue</u>	<u>Federal Tax</u>	<u>State and Local Tax</u>
1990	419.0	11.3	11.3	679.5	18.3	18.3
1991	838.1	22.6	22.6	1492.1	40.3	40.3
1992	1414.3	38.2	38.2	2457.4	66.3	66.3
1993	1388.9	37.5	37.5	2876.5	77.7	77.7
1994	1516.1	40.9	40.9	3059.0	82.6	82.6
1995	1436.8	38.8	38.8	3295.5	89.0	89.0
1996	1462.2	39.5	39.5	3295.5	89.0	89.0
1997	1492.1	40.3	40.3	3216.2	86.8	86.8
1998	1620.8	43.8	43.8	3136.9	84.7	84.7
1999	1098.5	29.7	29.7	2038.4	55.0	55.0
2000	522.3	14.1	14.1	1019.2	27.5	27.5

REGIONAL IMPACTS

Primary

Most of the regional impacts from OTEC construction will flow from increased shipyard activity. This is especially true about regional impacts on employment and revenue. Other regional impacts will result from the increased demand for concrete, cement, stone, and clay required in the construction of OTEC hulls and cold water pipes. This is because these materials are difficult to transport long distances and must therefore be locally available. Regional impacts resulting from increased activity in these industries, however, are small when compared to shipbuilding.

Exhibits 2-12 and 2-13 list the direct impacts on local industry revenues and employment resulting from OTEC construction in local shipyards. Under the 25 plant scenario (Exhibit 2-12), the maximum regional increases in revenues and employment are the following:

- Baltimore - \$104.0 million and 2,529 jobs in 1995.
- Norfolk-Virginia Beach - \$71.5 million in 1995 and 1996, and 1,752 jobs in 1994.
- Tampa-St. Petersburg - \$137.1 million in 1997 and 1998, and 3,181 jobs in 1997.
- Pascagoula, Miss. - \$137.7 million in 1996 and 1998, and 3,273 jobs in 1996.
- New Orleans - \$137.4 million in 1997, 1998, and 1999 and 3,186 jobs in 1997.
- San Diego - \$35.5 million in each year from 1994 to 1996 and 874 jobs in 1994.
- San Francisco - \$35.8 million in each year from 1993 to 1995, and 909 jobs in 1993.
- Seattle - \$137.7 million and 3,699 jobs in 1992.

EXHIBIT 2-12

REGIONAL ECONOMIC IMPACT UNDER THE 25 OTEC SCENARIO (Revenue in Millions of 1972 Dollars, Employment in Thousands of Jobs)

County 3A (or city) Shipyard	Baltimore County Baltimore Bethlehem-Sparrows Pt.		Norfolk-Va. Beach-Portsmouth Newport News		Hillsborough County Tampa-St. Petersburg Tampa Ship Repair		Jackson County Pascagoula Ingalls Litton	
	Revenue	Employment	Revenue	Employment	Revenue	Employment	Revenue	Employment
(Total)	68.57	1.947						
ment/Concrete	0.00	0.000						
pbuiding	68.57	1.947						
ne/Clay	0.00	0.000						
(Total)	68.57	1.892			68.57	1.892	68.87	1.898
ment/Concrete	0.00	0.000			0.00	0.000	0.27	0.005
pbuiding	68.57	1.892			68.57	1.892	68.57	1.892
ne/Clay	0.00	0.000			0.00	0.000	0.03	0.001
(Total)	68.57	1.844	35.47	0.932	68.57	1.844	68.87	1.849
ment/Concrete	0.00	0.000	1.97	0.032	0.00	0.000	0.27	0.004
pbuiding	68.57	1.844	33.30	0.896	68.57	1.844	68.57	1.844
ne/Clay	0.00	0.000	0.20	0.004	0.00	0.000	0.03	0.001
(Total)	68.57	1.790	35.47	0.904	68.57	1.790	68.87	1.795
ment/Concrete	0.00	0.000	1.97	0.032	0.00	0.000	0.27	0.004
pbuiding	68.57	1.790	33.30	0.869	68.57	1.790	68.57	1.790
ne/Clay	0.00	0.000	0.20	0.003	0.00	0.000	0.03	0.001
(Total)	68.57	1.728	71.23	1.752			68.87	1.733
ment/Concrete	0.00	0.000	4.20	0.066			0.27	0.004
pbuiding	68.57	1.728	66.60	1.678			68.57	1.728
ne/Clay	0.00	0.000	0.43	0.007			0.03	0.001
(Total)	104.03	2.529	71.53	1.708			68.87	1.685
ment/Concrete	1.97	0.030	4.47	0.068			0.27	0.004
pbuiding	101.87	2.496	66.60	1.632			68.57	1.680
ne/Clay	0.20	0.003	0.47	0.008			0.03	0.001
(Total)	71.23	1.655	71.53	1.659	68.57	1.632	137.73	3.273
ment/Concrete	4.20	0.063	4.47	0.067	0.00	0.000	0.53	0.008
pbuiding	66.60	1.585	66.60	1.585	68.57	1.632	137.13	3.264
ne/Clay	0.43	0.007	0.47	0.007	0.00	0.000	0.07	0.001
(Total)	71.23	1.613	71.23	1.613	137.13	3.181	68.87	1.595
ment/Concrete	4.20	0.061	4.20	0.061	0.00	0.000	0.27	0.004
pbuiding	66.60	1.545	66.60	1.545	137.13	3.181	68.57	1.591
ne/Clay	0.43	0.007	0.43	0.007	0.00	0.000	0.03	0.001
(Total)	71.53	1.569	35.47	0.780	137.13	3.086	137.73	3.094
ment/Concrete	4.47	0.064	1.97	0.028	0.00	0.000	0.53	0.008
pbuiding	66.60	1.499	33.30	0.749	137.13	3.086	137.13	3.085
ne/Clay	0.47	0.007	0.20	0.003	0.00	0.000	0.07	0.001
(Total)	35.77	0.764	35.47	0.759	68.57	1.502	68.87	1.506
ment/Concrete	2.23	0.031	1.97	0.027	0.00	0.000	0.27	0.004
pbuiding	33.30	0.729	33.30	0.729	68.57	1.502	68.57	1.502
ne/Clay	0.23	0.003	0.20	0.003	0.00	0.000	0.03	0.000
(Total)	35.77	0.743					68.87	1.465
ment/Concrete	2.23	0.030					0.27	0.004
pbuiding	33.30	0.709					68.57	1.461
ne/Clay	0.23	0.003					0.03	0.000

EXHIBIT 2-12

REGIONAL ECONOMIC IMPACT UNDER THE 25 OTEC SCENARIO (Revenue in Millions of 1972 Dollars, Employment in Thousands of Jobs) (Continued)

County MSA (or city) Shipyard	Orleans Parish New Orleans Avondale		San Diego County San Diego NASCO		San Francisco County San Francisco-Oakland Beth.-San Francisco		King County Seattle-Everett Lockheed	
	Revenue	Employment	Revenue	Employment	Revenue	Employment	Revenue	Employment
(Total)							68.87	1.953
ement/Concrete							0.27	0.005
ipbuilding							68.57	1.947
one/Clay							0.03	0.001
(Total)							68.87	1.898
ement/Concrete							0.27	0.005
ipbuilding							68.57	1.892
one/Clay							0.03	0.001
2 (Total)	68.57	1.844					137.73	3.699
ement/Concrete	0.00	0.000					0.53	0.009
ipbuilding	68.57	1.844					137.13	3.689
one/Clay	0.00	0.000					0.07	0.001
3 (Total)	68.57	1.790			35.77	0.909	104.33	2.699
ement/Concrete	0.00	0.000			2.23	0.036	2.23	0.036
ipbuilding	68.57	1.790			33.30	0.869	101.87	2.659
one/Clay	0.00	0.000			0.23	0.004	0.23	0.004
4 (Total)	68.57	1.728	35.47	0.874	35.77	0.878	104.33	2.606
ement/Concrete	0.00	0.000	1.97	0.031	2.23	0.035	2.23	0.035
ipbuilding	68.57	1.728	33.30	0.839	33.30	0.839	101.87	2.567
one/Clay	0.00	0.000	0.20	0.003	0.23	0.004	0.23	0.004
5 (Total)	68.57	1.680	35.47	0.849	35.77	0.854	35.47	0.849
ement/Concrete	0.00	0.000	1.97	0.030	2.23	0.034	1.97	0.030
ipbuilding	68.57	1.680	33.30	0.816	33.30	0.816	33.30	0.816
one/Clay	0.00	0.000	0.20	0.003	0.23	0.004	0.20	0.003
6 (Total)	68.57	1.632	35.47	0.825				
ement/Concrete	0.00	0.000	1.97	0.029				
ipbuilding	68.57	1.632	33.30	0.793				
one/Clay	0.00	0.000	0.20	0.003				
7 (Total)	137.43	3.186						
ement/Concrete	0.27	0.004						
ipbuilding	137.13	3.181						
one/Clay	0.03	0.001						
8 (Total)	137.43	3.090						
ement/Concrete	0.27	0.004						
ipbuilding	137.13	3.086						
one/Clay	0.03	0.000						
9 (Total)	137.43	3.007						
ement/Concrete	0.27	0.004						
ipbuilding	137.13	3.003						
one/Clay	0.03	0.000						
0 (Total)	68.57	1.460						
ement/Concrete	0.00	0.000						
ipbuilding	68.57	1.460						
one/Clay	0.00	0.000						

EXHIBIT 2-13

REGIONAL ECONOMIC IMPACT UNDER THE 50 OTEC SCENARIO
(Revenue in Millions of 1972 Dollars, Employment in Thousands of Jobs)

SMSA (or city) Shipyard	Boston General Dynamics		Baltimore Bethlehem-Sparrows Pt.		Chester, Pa. Sun Shipbuilding		Norfolk-Va. Beach-Portsmouth Newport News	
	Revenue	Employment	Revenue	Employment	Revenue	Employment	Revenue	Employment
1 (Total)	35.47	0.984			35.77	0.989		
ement/Concrete	1.97	0.034			2.23	0.039		
hipbuilding	33.30	0.946			33.30	0.946		
tone/Clay	0.20	0.004			0.23	0.004		
2 (Total)	71.23	1.918			35.77	0.961	68.57	1.947
ement/Concrete	4.20	0.071			2.23	0.038	0.00	0.000
hipbuilding	66.60	1.838			33.30	0.919	68.57	1.947
tone/Clay	0.43	0.008			0.23	0.004	0.00	0.000
3 (Total)	71.23	1.869	35.47	0.932	104.63	2.786	104.33	2.781
ement/Concrete	4.20	0.069	1.97	0.032	2.50	0.041	2.23	0.037
hipbuilding	66.60	1.792	33.30	0.896	101.87	2.740	101.87	2.740
tone/Clay	0.43	0.008	0.20	0.004	0.27	0.005	0.23	0.004
4 (Total)	35.77	0.909	35.47	0.904	68.87	1.794	139.80	3.603
ement/Concrete	2.23	0.036	1.97	0.032	0.27	0.004	4.20	0.068
hipbuilding	33.30	0.869	33.30	0.869	68.57	1.790	135.17	3.528
tone/Clay	0.23	0.004	0.20	0.003	0.03	0.000	0.43	0.007
5 (Total)	35.47	0.874	71.23	1.752	137.73	3.465	71.23	1.752
ement/Concrete	1.97	0.031	4.20	0.066	0.53	0.008	4.20	0.066
hipbuilding	33.30	0.839	66.60	1.678	137.13	3.456	66.60	1.678
tone/Clay	0.20	0.003	0.43	0.007	0.07	0.001	0.43	0.007
6 (Total)	35.47	0.849	35.77	0.854	68.87	1.685	106.70	2.552
ement/Concrete	1.97	0.030	2.23	0.034	0.27	0.004	6.17	0.094
hipbuilding	33.30	0.816	33.30	0.816	68.57	1.680	99.90	2.448
tone/Clay	0.20	0.003	0.23	0.004	0.03	0.001	0.63	0.010
7 (Total)	71.23	1.655	71.23	1.655	137.73	3.273	71.23	1.655
ement/Concrete	4.20	0.063	4.20	0.063	0.53	0.008	4.20	0.063
hipbuilding	66.60	1.585	66.60	1.585	137.13	3.264	66.60	1.585
tone/Clay	0.43	0.007	0.43	0.007	0.07	0.001	0.43	0.007
8 (Total)	35.77	0.809	71.23	1.613	68.87	1.595	142.17	3.222
ement/Concrete	2.23	0.033	4.20	0.061	0.27	0.004	8.13	0.119
hipbuilding	33.30	0.773	66.60	1.545	68.57	1.591	133.20	3.090
tone/Clay	0.23	0.003	0.43	0.007	0.03	0.001	0.83	0.013
9 (Total)	35.77	0.785	139.80	3.108	104.33	2.327	70.93	1.561
ement/Concrete	2.23	0.032	4.20	0.060	2.23	0.032	3.93	0.056
hipbuilding	33.30	0.749	135.17	3.041	101.87	2.292	66.60	1.499
tone/Clay	0.23	0.004	0.43	0.006	0.23	0.003	0.40	0.006
10 (Total)			104.33	2.265	35.47	0.759	70.93	1.519
ement/Concrete			2.23	0.031	1.97	0.027	3.93	0.055
hipbuilding			101.87	2.231	33.30	0.729	66.60	1.458
tone/Clay			0.23	0.003	0.20	0.003	0.40	0.006
11 (Total)			68.57	1.460	35.47	0.739		
ement/Concrete			0.00	0.000	1.97	0.267		
hipbuilding			68.57	1.460	33.30	0.709		
tone/Clay			0.00	0.000	0.20	0.003		

EXHIBIT 2-13

REGIONAL ECONOMIC IMPACT UNDER THE 50 OTEC SCENARIO
(Revenue in Millions of 1972 Dollars, Employment in Thousands of Jobs)
(Continued)

MSA (or city) Shipyard	Tampa-St. Petersburg Tampa Ship Repair and Dry Dock		Jacksonville Offshore Power Systems		Pascagoula Ingalls-Litton		New Orleans Avondale Shipbuilding	
	Revenue	Employment	Revenue	Employment	Revenue	Employment	Revenue	Employment
(Total)			68.57	1.947			68.87	1.953
ment/Concrete			0.00	0.000			0.27	0.005
ipbuilding			68.57	1.947			68.57	1.947
one/Clay			0.00	0.000			0.03	0.001
(Total)	68.87	1.898	68.57	1.892			68.87	1.898
ment/Concrete	0.27	0.005	0.00	0.000			0.27	0.005
ipbuilding	68.57	1.892	68.57	1.892			68.57	1.892
one/Clay	0.03	0.001	0.00	0.000			0.03	0.001
(Total)	68.87	1.849	137.13	3.689	68.87	1.849	68.87	1.849
ment/Concrete	0.27	0.004	0.00	0.000	0.27	0.004	0.27	0.004
ipbuilding	68.57	1.844	137.13	3.689	68.57	1.844	68.57	1.844
one/Clay	0.03	0.001	0.00	0.000	0.03	0.001	0.03	0.001
(Total)	137.73	3.589	68.57	1.790	137.43	3.584	68.87	1.794
ment/Concrete	0.53	0.009	0.00	0.000	0.27	0.004	0.27	0.004
ipbuilding	137.13	3.579	68.57	1.790	137.13	3.579	68.57	1.790
one/Clay	0.07	0.001	0.00	0.000	0.03	0.001	0.03	0.000
(Total)	68.87	1.733	137.13	3.456	137.43	3.461	137.73	3.465
ment/Concrete	0.27	0.004	0.00	0.000	0.27	0.004	0.53	0.008
ipbuilding	68.57	1.728	137.13	3.456	137.13	3.456	137.13	3.456
one/Clay	0.03	0.001	0.00	0.000	0.03	0.001	0.07	0.001
(Total)	137.73	3.369	68.57	1.680	137.13	3.360	137.73	3.369
ment/Concrete	0.53	0.008	0.00	0.000	0.00	0.000	0.53	0.008
ipbuilding	137.13	3.360	68.57	1.680	137.13	3.360	137.13	3.360
one/Clay	0.07	0.001	0.00	0.000	0.00	0.000	0.07	0.001
(Total)	68.87	1.636	137.13	3.264	137.13	3.264	137.73	3.273
ment/Concrete	0.27	0.004	0.00	0.000	0.00	0.000	0.53	0.008
ipbuilding	68.57	1.632	137.13	3.264	137.13	3.264	137.13	3.264
one/Clay	0.03	0.000	0.00	0.000	0.00	0.000	0.07	0.001
(Total)	68.87	1.595	137.13	3.181	137.13	3.181	137.73	3.190
ment/Concrete	0.27	0.004	0.00	0.000	0.00	0.000	0.07	0.001
ipbuilding	68.57	1.591	137.13	3.181	137.13	3.181	137.13	3.181
one/Clay	0.03	0.000	0.00	0.000	0.00	0.000	0.53	0.008
(Total)			137.13	3.086	137.43	3.090	137.73	3.094
ment/Concrete			0.00	0.000	0.27	0.004	0.53	0.008
ipbuilding			137.13	3.086	137.13	3.086	137.13	3.085
one/Clay			0.00	0.000	0.03	0.000	0.07	0.001
(Total)			68.57	1.502	68.87	1.506	68.87	1.506
ment/Concrete			0.00	0.000	0.27	0.004	0.27	0.004
ipbuilding			68.57	1.502	68.57	1.502	68.57	1.502
one/Clay			0.00	0.000	0.03	0.000	0.03	0.000
(Total)					68.87	1.465		
ment/Concrete					0.27	0.004		
ipbuilding					68.57	1.461		
one/Clay					0.03	0.000		

EXHIBIT 2-13

REGIONAL ECONOMIC IMPACT UNDER THE 50 OTEC SCENARIO (Revenue in Millions of 1972 Dollars, Employment in Thousands of Jobs) (Continued)

SMSA (or city) Shipyard	Beaumont-Port Arthur Orange Bethlehem Shipbuilding		San Diego National Steel & Shipbuilding		San Francisco Bethlehem Shipbuilding		Seattle-Everett Lockheed	
	Revenue	Employment	Revenue	Employment	Revenue	Employment	Revenue	Employment
1 (Total)								
ement/Concrete								
hipbuilding								
tone/Clay								
2 (Total)					35.47	0.956	68.57	1.892
ement/Concrete					1.97	0.033	0.00	0.000
hipbuilding					33.30	0.919	68.57	1.892
tone/Clay					0.20	0.004	0.00	0.000
3 (Total)					33.30	0.896	68.57	1.844
ement/Concrete					1.97	0.032	0.00	0.000
hipbuilding					35.47	0.932	68.57	1.844
tone/Clay					0.20	0.004	0.00	0.000
4 (Total)					35.47	0.904	172.90	4.488
ement/Concrete					1.97	0.032	2.23	0.036
hipbuilding					33.30	0.869	170.43	4.448
tone/Clay					0.20	0.003	0.23	0.004
5 (Total)	68.57	17.28					104.33	2.606
ement/Concrete	0.00	0.000					2.23	0.035
hipbuilding	68.57	1.728					101.87	2.567
tone/Clay	0.00	0.000					0.23	0.004
6 (Total)	137.43	3.364					172.90	4.214
ement/Concrete	0.27	0.004					2.23	0.034
hipbuilding	137.13	3.360					170.43	4.176
tone/Clay	0.03	0.000					0.23	0.004
7 (Total)	137.43	3.268					68.57	1.632
ement/Concrete	0.27	0.004					0.00	0.000
hipbuilding	137.13	3.264					68.57	1.632
tone/Clay	0.03	0.000					0.00	0.000
8 (Total)	137.73	3.190					68.57	1.591
ement/Concrete	0.53	0.008					0.00	0.000
hipbuilding	137.13	3.181					68.57	1.591
tone/Clay	0.07	0.001					0.00	0.000
9 (Total)	137.43	3.090	35.77	0.785				
ement/Concrete	0.27	0.004	2.23	0.032				
hipbuilding	137.13	3.086	33.30	0.749				
tone/Clay	0.03	0.000	0.23	0.003				
10 (Total)	137.43	3.007	35.77	0.764				
ement/Concrete	0.27	0.004	2.23	0.031				
hipbuilding	137.13	3.003	33.30	0.729				
tone/Clay	0.03	0.000	0.23	0.003				
11 (Total)	68.57	1.460	35.77	0.743				
ement/Concrete	0.00	0.000	2.23	0.030				
hipbuilding	68.57	1.460	33.30	0.709				
tone/Clay	0.00	0.000	0.23	0.003				

Under the 50 plant scenario (Exhibit 2-13), the following maximum impacts are realized:

- Boston - \$71.2 million in 1991, 1992, and 1996, and 1,918 jobs in 1991.
- Baltimore - \$139.8 million and 3,108 jobs in 1998.
- Chester, Pa. - \$137.7 million in 1994 and 1996, and 3,465 jobs in 1994.
- Norfolk-Virginia Beach - \$142. million in 1997, and 3,603 jobs in 1993.
- Tampa-St. Petersburg - \$137.7 million in 1993 and 1995, and 3,589 jobs in 1993.
- Jacksonville - \$137.1 million in 1992 and 1994, and in each year from 1996 to 1998, and 3,689 jobs in 1992.
- Pascagoula, Miss. - \$137.4 million in 1993, 1994, and 1998, and 3,584 jobs in 1993.
- New Orleans - \$137.7 million in each year from 1994 through 1998, and 3,465 jobs in 1994.
- Beaumont, Tx. - \$137.7 million in 1997 and 3,364 jobs in 1995.
- San Diego - \$35.8 million in each year from 1998 to 2000, and 785 jobs in 1998.
- San Francisco - \$35.5 million in each year from 1991 to 1993, and 956 jobs in 1991.
- Seattle - \$172.9 million in 1993 and 1995, and 4,488 jobs in 1993.

Secondary Employment

Earnings of workers engaged in the construction of OTEC facilities will be mostly spent for goods and services in the region in which they are employed. This stimulates an increase in secondary and induced employment in that region, resulting in further growth in total regional employment. Annual estimates of the total regional employment impact arising from OTEC construction appear for each region in Exhibits 2-14 and 2-15. Under the 25 plant scenario, the following ranges for total annual impacts on regional employment are estimated:

- Baltimore - 2,229 in 2000 to 7,587 in 1995.
- Norfolk - 2,960 in 1999 to 6,833 in 1994.
- Tampa - 6,008 in 1999 to 12,724 in 1997.
- Pascagoula, Miss. - 3,370 in 2000 to 7,528 in 1996.

EXHIBIT 2-14
REGIONAL TOTAL EMPLOYMENT IMPACTS
25 OTEC SCENARIO
(1000's Jobs)

<u>Year</u>	<u>Baltimore</u>	<u>Norfolk</u>	<u>Tampa</u>	<u>Pascagoula</u>	<u>New Orleans</u>	<u>San Diego</u>	<u>San Francisco</u>	<u>Seattle</u>
1990	5.841							7.617
1991	5.676		7.568	4.385				7.402
1992	5.532	3.635	7.376	4.253	8.669			14.426
1993	5.370	3.526	7.160	4.129	8.413		4.727	10.526
1994	5.184	6.833		3.986	8.122	4.020	4.566	10.163
1995	7.587	6.661		3.876	7.896	3.905	4.441	3.311
1996	4.965	6.470	6.528	7.528	7.670	3.795		
1997	4.839	6.291	12.724	3.669	14.974			
1998	4.707	3.042	12.344	7.116	14.523			
1999	2.292	2.960	6.008	3.464	14.131			
2000	2.229			3.370	6.862			

EXHIBIT 2-15

REGIONAL TOTAL EMPLOYMENT IMPACTS 50 OTEC SCENARIO (1000's Jobs)

<u>1990</u>	<u>Boston</u>	<u>Baltimore</u>	<u>Chester</u>	<u>Norfolk</u>	<u>Tampa</u>	<u>Jackson- ville</u>	<u>Pascagoula</u>	<u>New Orleans</u>	<u>Beaumont</u>	<u>San Diego</u>	<u>San Francisco</u>	<u>Seattle</u>
1990	4.231		3.462			8.567		9.179				
1991	8.247		3.364	7.593	7.592	8.325		8.921			4.971	7.379
1992	8.037	2.796	9.751	10.616	7.396	16.232	4.253	8.690			4.846	7.192
1993	3.909	2.712	6.279	14.052	14.356	7.876	8.243	8.432			4.701	17.503
1994	3.758	5.256	12.128	6.833	6.932	15.206	7.980	16.286	5.530			10.163
1995	3.651	2.562	5.898	9.953	13.476	7.392	7.728	15.834	10.765			16.435
1996	7.117	4.965	11.456	6.455	6.544	14.362	7.507	15.383	10.458			6.385
1997	3.479	4.839	5.583	12.566	6.380	13.996	7.316	14.993	10.208			6.205
1998	3.376	9.324	8.145	6.088		13.578	7.107	14.542	9.888	3.611		
1999		6.795	2.657	5.824		6.609	3.464	7.078	9.622	3.514		
2000		4.360	2.587				3.370		4.672	3.418		

- New Orleans - 6,826 in 2000 to 14,974 in 1997.
- San Diego - 3,795 in 1966 to 4,020 in 1994.
- San Francisco - 4,441 in 1995 to 4,727 in 1993.
- Seattle - 3,311 in 1995 to 14,426 in 1992.

Under the 50 plant scenario, the following employment ranges are realized for each region:

- Boston - 3,376 in 1998 to 8,247 in 1991.
- Baltimore - 2,562 in 1995 to 9,324 in 1998.
- Chester, Pa. - 2,587 in 2000 to 12,128 in 1994.
- Norfolk - 5,924 in 1999 to 14,052 in 1993.
- Tampa - 6,380 in 1997 to 14,356 in 1993.
- Jacksonville - 6,609 in 1999 to 16,232 in 1992.
- Pascagoula, Miss. - 3,370 in 2000 to 8,243 in 1993.
- New Orleans - 7,078 in 1999 to 16,286 in 1994.
- Beaumont, Tx. - 4,672 in 2000 to 10,765 in 1995.
- San Diego - 3,418 in 2000 to 3,611 in 1998.
- San Francisco - 4,701 in 1993 to 4,971 in 1991.
- Seattle - 6,205 in 1997 to 17,503 in 1993.

Finally, it is interesting to compare the projected yearly increases in employment in each region with the current level of unemployment in the same region. Exhibit 2-16 lists the June 1980 and June 1981 unemployment figures for the regions potentially affected by OTEC construction. The conclusion one draws from comparing these figures with the total regional employment numbers in Exhibits 2-14 and 2-15 is that an OTEC construction program could significantly reduce unemployment in these regions if current unemployment levels persist into the 1990's.

Exhibit 2-16 also allows one to ascertain which potential OTEC construction regions could most benefit from the extra employment generated by OTEC construction. For example, one could rank these regions by their unemployment rates so as to designate

EXHIBIT 2-16
UNEMPLOYMENT SITUATION IN
REGIONS POTENTIALLY IMPACTED
BY OTEC CONSTRUCTION:
June 1980 and 1981

<u>Region</u>	<u>Number Unemployed (Thousands)</u>		<u>Unemployed Percentage of the Labor Force</u>	
	<u>June 1980</u>	<u>June 1981*</u>	<u>June 1980</u>	<u>June 1981*</u>
Boston (SMSA)	83.0	85.5	5.9	5.8
Baltimore (SMSA)	86.7	86.6	8.1	8.1
Philadelphia (SMSA)	156.1	183.6	7.3	8.5
Norfolk-Va. Beach- Portsmouth (SMSA)	23.1	22.9	6.9	6.7
Tampa-St. Petersburg (SMSA)	35.8	36.2	5.9	5.7
Jacksonville (SMSA)	19.6	19.6	6.4	6.2
Mississippi	93.4	87.7	8.9	8.6
New Orleans (SMSA)	28.8	36.7	6.0	7.6
Beaumont-Port Arthur- Orange (SMSA)	13.4	17.9	8.0	10.2
San Diego (SMSA)	54.3	49.6	7.3	6.5
San Francisco- Oakland (SMSA)	93.1	90.3	5.8	5.5
Seattle-Everett (SMSA)	54.2	70.4	6.3	8.3

*Data for June 1981 are preliminary.

priority areas for action. If this were done, Beaumont, Pascagoula, Philadelphia (Chester), and Baltimore would be the first four regions that would be given OTEC projects. The last region would be the San Francisco - Oakland area.

TOTAL EMPLOYMENT IMPACT

Under the 25 plant scenario, the peak year for total employment is 1994, when an additional 61,891 jobs will be created due to OTEC construction (Exhibit 2-17). The average through the period from 1990 to 2000 is 47,674 additional jobs per year. Under the 50 plant scenario, the peak year for OTEC related employment is 1995, when 132,561 additional jobs are created (Exhibit 2-17). The average over the period is 96,082 additional jobs per year.

EXHIBIT 2-17
TOTAL EMPLOYMENT IMPACT

<u>YEAR</u>	<u>25 OTEC TOTAL</u>	<u>50 OTEC TOTAL</u>
1990	18,809	34,670
1991	35,466	66,806
1992	61,500	111,507
1993	60,389	123,782
1994	61,891	126,916
1995	55,587	132,561
1996	54,222	128,578
1997	58,774	121,940
1998	59,396	111,379
1999	40,590	68,718
2000	17,791	30,049
Average	47,674	96,082

CHAPTER 2

Footnotes

¹Dollar terms through the chapter will refer to 1972 constant dollars.

²Employment Projections for the 1980's. U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2030, 1979.

³Assumes 148 nautical miles of bottom cable and 21,700 feet of riser cable.

⁴It should be noted that the methodology explicitly assumes that only 25 or 50 plants are constructed between 1990 and 2000, and that the program stops at that point. Consequently, the analysis forecasts a slowing of incremental economic activity in the later years of the decade. If this assumption is removed, and it is assumed that OTEC construction continues, a leveling rather than a decrease in incremental economic activity would result.

⁵Previous DOE studies as reviewed and reported by Arctic Enterprises, Inc. (William Kumm and Barbara Buchleitner).

⁶Study of Integration Issues to Realize the Market Potential of OTEC Energy In the Aluminum Industry. Reynolds Metals Company and TRW, Incorporated. Revised Draft Final Report, November 1980. Prepared for U.S. Department of Energy.

Selected References

- 1) Westinghouse Electric corporation internal report: Net Energy Analysis, provided by William Coleman.
- 2) Study of Integration Issues to Realize the Market Potential of OTEC Energy In the Aluminum Industry. Reynolds Metals Company and TRW, Incorporated. Revised Draft Final Report, November 1980. Prepared for DOE.
- 3) E.C.Gritton, et al A Quantitative Evaluation of Closed-Cycle Ocean Thermal Energy Conversion (OTEC) Technology in Central Station Applications. Rand Corporation. May 1980.
- 4) J.R. Roney, Employment and Economic Impacts of OTEC Commercialization. Princeton Energy and Environmental Research Company, March 1981.
- 5) R.Y. Pei, Resource Estimate for Ocean Thermal Energy Conversion (OTEC) in the Gulf of Mexico. The Rand Corporation, September 1980.
- 6) E.C. Gritton, et al, Quantitative Evaluation of Ocean Thermal Energy Conversion (OTEC). Executive briefing. The Rand Corporation, August 1980.
- 7) E.J. Stenehjem and J.E. Metyger, A Framework for Projecting Employment and Population Changes Accompanying Energy Development. Argonne National Laboratory, May 1980.
- 8) Employment Projections for the 1980's. Department of Labor, Bureau of Labor Statistics, Bulletin 2030, 1979.
- 9) J.R. Roney, OTEC Data Inputs for Utility System Modeling. November, 1979.

APPENDIX A

THE OTEC ECONOMIC IMPACT SIMULATION MODEL

INTRODUCTION

The primary objective of this project was to quantify the economic impacts of constructing 25 or 50 400 MWe OTEC plants by the year 2000. However, the technological components of an OTEC power plant or plantship are by no means fixed and are subject to change as new knowledge is acquired through laboratory and pilot plant studies. Thus, new configurations other than the four utilized in this report may be proposed in the future. In addition, the mix of configurations to be constructed can also be expected to change. Finally, the distribution of OTEC configurations among individual shipyards may be altered as their capabilities are studied in greater depth. Given the possibility of varying one or more of these parameters, an economic simulation model has been developed that quantifies the economic impact of any configuration and/or configuration mix proposed, including that assumed for this study.

OVERVIEW OF DATA DEVELOPMENT FOR THE MODEL

Introduction

In this section, the data sources and methodologies employed in the development of the data base components of the model are presented. The sources and methods are discussed in connection with the major data tables presented in the main body of the report as follows:

- Economic base forecasts;
- Total direct revenue impact by industry by OTEC configuration type;
- Secondary revenue impacts by industry by OTEC configuration type;
- Annualized direct economic impacts by industry, 1990-2000; and
- Regional economic impacts, 1990-2000.

Economic Base Forecasts

The objective of this task was to forecast output and employment for each industry directly affected by OTEC construction for the years 1990 through 2000. These forecasts were either based directly on forecasts from the Bureau of Labor Statistics (BLS) Economic Growth Model or adjusted to be consistent with those forecasts. They provide a baseline from which estimates of OTEC revenue, employment, and impacts are generated.

The logic behind the sectoring plan is as follows. Where a single impacted industry or a group of industries (identified in Volume II of this report) comprised the major part of a BLS Economic Growth sector, the BLS sector was used. Where a single impacted sector comprised only a small part of a BLS sector, or if the remainder of the BLS sector represented a very different sort of business (e.g. ship building and repair plus boat building and repair equals BLS Sector # 105), then a more specific Standard Industrial Classification (SIC) industry code was used in order to better represent the impact on the industry identified in Volume II.

The first stage of this task was to forecast base output by industry through 2000. For the impacted BLS sectors, output forecasts for 1985 and 1990 (in constant 1972 dollars) were obtained directly from the BLS publication, Employment Projections for the 1980's (Bulletin 2030; 1979). The compound annual growth rate from 1985 through 1990 was then used to estimate output for the years 1991 through 2000.

For SIC coded industries, relationships between these industries and their parent BLS producing industry, or an appropriate group of BLS consuming industries, were identified by using linear regression and/or ratio analysis. The relationships identified were between the historical value of shipments data for the impacted SIC coded industries and the historical output data for the related BLS industries, all in constant 1972 dollars. The SIC coded data were obtained or derived from the following Commerce Department sources:

- Bureau of Industrial Economics, 1981 U.S. Industrial Outlook for 200 Industries with Projections for 1985.

- Bureau of the Census, Census of Manufactures (1977, 1972, 1967), Industry Series volumes.
- Bureau of the Census, Current Industrial Reports, "Fibrous Glass".

The historical BLS industry data were obtained from a BLS computer printout entitled: "Time Series Data for Input-Output Industries -- Output, Price, and Employment" (June 1979).

Once the relationships were established between SIC coded industries and related BLS industry sectors, the value of shipments for the affected SIC coded industries could be estimated using a two stage approach. The first stage involved estimating output for each related BLS industry (or group of BLS industries) for the period from 1991 through 2000 by using the compound annual growth rate for 1985 through 1990.¹ In the second stage, the values of shipments (in 1972 dollars) for affected SIC coded industries were estimated in one of two ways.

- For industries related through linear regression analysis, the forecasted BLS sector output data points were used in the regression equations as independent variables, yielding a value for the dependent variable, the value of shipments, for each year from 1990 through 2000.
- The value of shipments for SIC coded industries related to parent BLS industries through ratio analysis were estimated for 1990 through 2000 by multiplying the average ratio of the value of shipments value for the SIC industry to the BLS parent sector's historical output by forecasted values of the BLS parent sector's output for the years 1990 through 2000. In both cases, the forecasts of the value of shipments are identified in Exhibit 2-3 in Chapter 2 as industry output.

The second major step in the Economic Base Forecast task was to estimate industry level employment through the year 2000. As with output for the impacted BLS sectors, employment forecasts for the same sectors for 1985 and 1990 were collected from Employment Projections for the 1980's and then extrapolated to 1991 through 2000 by using the compound annual growth rate for the period from 1985 through 1990.

Estimating employment for the SIC coded industries was more difficult. After calculating ratios of employment to output (value of shipments in 1972 dollars) for the historical period, hypotheses about future trends in productivity in the impacted SIC industries were developed. Next employment to output ratios were estimated for the years 1990 through 2000. These were then multiplied by forecasted output to obtain preliminary forecasts of SIC coded industry employment. These preliminary employment forecasts were then checked for consistency with forecast employment in the BLS parent sector.² If the employment forecast for the SIC coded industry was not consistent with that of the BLS parent, then the forecast of employment to output ratio was re-estimated using an iterative process until reasonable consistency was obtained. This procedure was necessary since BLS tends to assume relatively high growth rates in labor productivity. The historical employment data for the SIC coded industries used in the preceding analysis, were obtained from Bureau of the Census, Census of Manufactures (1977, 1972, 1967), Industry Series volumes.

With a complete set of data on future employment and output for each OTEC impacted industry, final employment to output ratios were computed for each industry in each forecast year. These were later used in estimating annualized direct employment impacts.

Total Direct Revenue Impact by OTEC Configuration Type

The purpose of this task was to identify the major hardware components and materials required in the construction of four alternative OTEC configurations, and to then develop estimates of the revenues that would accrue to the affected supplier industries.

The primary source of data on the tonnage of materials required for a 400MWe OTEC plant was the Westinghouse Corporation.³ Most of these data are presented in Exhibit A-1. Westinghouse also supplied data on the materials required for aluminum heat exchangers. Additional sources of data include:

EXHIBIT A-1
400 MWe CC-OTEC POWERPLANT — MASS OF MATERIALS
SHORT TONS

Component	Fabricated Steel	Fabricated Titanium	Turbine/ Pump	MHE (1)	Motor/ Generator	Transformer	Switchgear	Other
1. Platform/Ship								
a. Concrete, or								507,416 (2)
b. Steel	107,872							
c. Deck House and Anchor	24,696							
2. Power Module								
a. Condenser	10,904	6,296						
b. Evaporator	7,552	4,072						
c. Turbine/ Generator			656		2,320			
d. Lube Oil System	280							
e. Ammonia Pumps			1,240					
f. Ammonia Pipes and Tanks	9,480							
g. Ammonia Valves	4,760							
h. Sea Pumps			5,400			400		
i. Sea Screens								3,680 (3)
j. Amertap								1,760 (3)
k. Diesel System	40				4,040			
l. Nitrogen Tank	600							
m. Gantry				4,800				
n. Cooling Water	40							
o. Power Conditions							5,320	
p. Wiring								520 (4)
3. Other Components								
a. Ammonia								9,248
b. Nitrogen								1,184
4. TOTAL	166,224	10,368	7,296	4,800	6,360	400	5,320	523,808

- (1) Mechanical heavy equipment
(2) Reinforced concrete
(3) Stainless steel
(4) Naval wiring material

- Arctic Enterprises, Inc. - concrete requirement for OTEC cold water pipe.
- National Oceanic and Atmospheric Administration (NOAA) - final Fiber-glass Reinforced Plastic (FRP) sandwich specifications for cold water pipe. Personal communications with Terry McGuiness.
- Owens-Corning Fiberglass Corporation - fiberglass and resins requirements in an FRP cold water pipe. Personal Communications with Rick Turkopp.
- Industry Profiles (Volume II of this report) - concrete input requirements; glass sand input to fiberglass manufacture.

After the material requirements data had been collected in physical units, expenditures were estimated by multiplying the physical unit data by the appropriate 1972 dollar prices. Price data were obtained or derived from the following sources:

- Bureau of the Census, 1972 Census of Manufactures, Industry Series — prices for titanium mill shapes, cement and concrete.
- Bureau of the Census, 1972 Census of Mineral Industries, Industry Series — prices for glass sand, construction sand and crushed stone.
- Bureau of the Census, Current Industrial Reports, "Fibrous Glass" — price for glass fiber, textile type (fiberglass).
- U.S. Department of Commerce, Domestic and International Business Administration, U.S. Industrial Outlook 1977 With Projections To 1985 — steel price.
- U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles, "Aluminum" — aluminum price.
- Owens-Corning Fiberglass Corporation — first quarter 1981 price for resins, deflated to 1972 average annual price using BLS Producer Price Indexes

The last step was to assign the 1972 dollar values of the materials to their appropriate industry (note: glass sand, construction sand, and crushed stone are all assigned to the Stone/Clay industry).

The remainder of the direct revenue impacts resulting from OTEC construction were derived from cost data for major OTEC plant components that were collected from two OTEC research reports. A substantial portion of these data were obtained from the Rand Corporation report to DOE entitled A Quantitative Evaluation of Closed-Cycle Ocean Thermal Energy Conversion (OTEC) Technology in Central Station Applications (May 1980). Cost data in 1978 dollars per kilowatt were obtained for the following components:

- Heat Exchangers (evaporators and condensers made from titanium).
- Pumps (working fluid, cold sea water, warm sea water).
- Platform (hull structure, etcetera; concrete or steel).
- Transmission Cables (riser cable, bottom cable).

Most of the Rand cost data were deflated to 1972 dollars using various BLS Producer Price Indexes, with the exception of the platform cost, which was converted to 1972 dollars using an implicit "value of work completed" deflator derived from 1978 current and constant dollar data for SIC 3731, obtained from the Bureau of the Census, Bureau of Industrial Economics, 1981 U.S. Industrial Outlook for 200 Industries with Projections for 1985.

The sector assignments for these components are as follows:

- heat exchangers to the Fabricated Metal industry;
- pumps to the Pumps industry;
- platform to the Ship Building industry; and
- transmission cables to the Cable industry.

The revenue impacts for the Fabricated Metal industry under Configuration 3 and Configuration 4 were adjusted downward to reflect the lower material cost for aluminum versus titanium.

Data on the total cost of the FRP cold water pipe in 1980 dollars per foot were collected from the McDermott Incorporated report to NOAA entitled Conceptual Design Study - Cold Water Pipe Systems for Shelf-Mounted OTEC Powerplants (February, 1981). These data were adjusted to account for the difference in thickness of FRP and core material between this study and more recent NOAA data supplied to Jack Faucett Associates. The 1980 dollars were deflated to 1972 dollars using the BLS Producer Price Index for Plastic Construction Products.

Secondary Revenue Impacts by OTEC Configuration Type

In addition to the direct (or primary) revenue impacts that accrue to economic sectors from OTEC construction, there are subsequent transactions called secondary impacts, which take place between the establishments in these industries and other business establishments that provide them with the inputs to their production processes. It is important to note that if these secondary impact are measured at a fairly high level of industry aggregation, one of the largest inputs to an establishment in a given industry can come from establishments within the same industry. Another interesting aspect of secondary impacts is that some of these impacts (identified in Exhibit 2-5 in the main body of the report) are also direct (primary) impacts in other sectors in this study. For example, the direct revenue impacts on the titanium and aluminum industries also appear as secondary impacts in the fabricated metal industry. Other examples of this phenomenon include inputs of fiberglass to the Plastics industry, inputs from the Cement/Concrete industry to the Shipbuilding industry, and inputs of glass sand from the Stone/Clay industry to the Fiberglass industry. The development of the secondary revenue impacts, other than those which are also primary impacts, is described below.

As with the direct (primary) impacts, different data sources were used for impacted BLS Economic Growth industries than for the impacted SIC coded industries. Using a projected 1980 BLS Input-Output Matrix ("Matrix AXC1980") in 1972 dollars, the major inputs to OTEC - impacted BLS industries from the BLS industries (and typically the same BLS industry as well) were identified. These data were then divided by the outputs of the primary impacted industries to form the proportions of primary impact shown in Exhibit 2-5 in the main body of the report. These proportions were multiplied by the primary impacts to obtain the secondary impacts in 1972 dollars.

For the directly impacted SIC coded industries, values of major inputs in 1972 dollars were identified in the "materials consumed" data in Bureau of the Census, 1972 Census of Manufactures, Industry Series volumes. These data were then divided by the value of shipments for the directly impacted industry, yielding proportions which were then multiplied by the primary OTEC impacts to obtain the secondary impacts in 1972 dollars.

Annualized Direct Economic Impacts, 1990 - 2000

The purpose of this task was to estimate annual direct impacts from OTEC construction activity by industry for the years 1990 through 2000, under the 25 and 50 OTEC scenarios. The subcomponents of this task are as follows:

- Preparing Construction Schedules for 1990 through 2000
- Computing the Number of OTEC Plants Under Construction in each year from 1990 through 2000 by Configuration Type
- Computing the Annual Revenue Impact by Industry by Configuration Type, with One to Ten OTEC Plants Under Construction
- Computing the Annual Aggregate Revenue Impact by Industry for the years 1990 through 2000
- Computing the Annual Aggregate Employment Impact by Industry for the years 1990 through 2000

The first step was to prepare construction schedules. A five year set up, construction, and deployment period was assumed on the basis of a report by J.R. Roney entitled OTEC Data Inputs for Utility System Modeling (November 1, 1979). A breakdown of the level of effort expended in each year, developed for this report, follows:

- Prior to the starting year, 5% of total cost in planning and longer lead items.
- First year, 10% of total cost on set up and procurement.
- 2nd year, first construction year, 25% of total cost.

- 3rd year, second construction year, 25% of total cost.
- 4th year, third construction year, 25% of total cost.
- 5th year, deployment 10%.

Within the five year period, the revenue impacts for the three construction years are developed in this report. However, the full five year period was considered in setting up the construction schedule. In Exhibit A-2, the following items are identified:

- Five Year Set Up, Construction, and Deployment Periods
- Three Year Construction Periods
- The total number of OTEC plants to be produced and deployed during each period

The reason for computing the number of OTEC plants completed per period was to distribute them evenly over the available periods. As this is not mathematically possible, the distribution is skewed toward later periods so that learning curve benefits can be applied to the majority of OTEC plants.

Another component of the construction scheduling process was the assumption about the mix of OTEC configurations. The DOE scenarios provided for either 15 OTEC power plants (electricity producers) and 10 OTEC plantships totalling 25 OTEC plants, or 30 OTEC power plants and 20 OTEC plantships totalling 50 OTEC plants. Consequently, OTEC power plants were allocated between Configuration 1 and Configuration 2, while OTEC plantships were allocated to Configuration 3 and Configuration 4. These plant configurations are identified in Exhibit A-3 along with the total number of each to be produced and deployed under the two scenarios.

By combining Exhibit A-2 and Exhibit A-3, a construction schedule by OTEC configuration types is produced; this is presented in Exhibit A-4. The total number of OTEC plants by configuration type are distributed across the available construction periods, with the sum of OTEC plants during each construction period being equal to the totals presented in Exhibit A-2.

The next step involved the preparation of a table showing the number of OTEC plants, by configuration type, that would be under construction in each year from 1990 through 2000. These data are presented in Exhibit A-5. A simple program was devised to

EXHIBIT A-2

OTEC AGGREGATE CONSTRUCTION SCHEDULE, 1989-2001

<u>Five Year Set Up, Construction, and Deployment Periods</u>	<u>Three Year Construction Periods</u>	<u>Number of OTEC Plants Produced and Deployed Per Period</u>	
		<u>25 OTEC Scenario</u>	<u>50 OTEC Scenario</u>
1989-1993	1990-1992	2	4
1990-1994	1991-1993	2	5
1991-1995	1992-1994	3	5
1992-1996	1993-1995	3	6
1993-1997	1994-1996	3	6
1994-1998	1995-1997	3	6
1995-1999	1996-1998	3	6
1996-2000	1997-1999	3	6
1997-2001	1998-2000	3	6

EXHIBIT A-3
EXAMPLE MIX OF OTEC CONFIGURATIONS

Configuration Number and Description	<u>Number of OTEC Plants to be Constructed</u>	
	<u>25 OTEC Scenario</u>	<u>50 OTEC Scenario</u>
Configuration #1	8	15
<ul style="list-style-type: none"> ● electricity producer ● steel hull ● fiberglass CWP ● titanium heat exchanger 		
Configuration #2	7	15
<ul style="list-style-type: none"> ● electricity producer ● steel hull ● concrete CWP ● titanium heat exchanger 		
Configuraton #3	5	10
<ul style="list-style-type: none"> ● plantship ● concrete hull ● fiberglass CWP ● aluminum heat exchanger 		
Configuration #4	5	10
<ul style="list-style-type: none"> ● plantship ● concrete hull ● concrete CWP ● aluminum heat exchanger 		

EXHIBIT A-4**EXAMPLE CONSTRUCTION SCHEDULE BY OTEC
CONFIGURATION TYPES: 25 and 50 OTEC SCENARIOS****NUMBER OF OTEC PLANTS TO BE CONSTRUCTED**

Construction Period	<u>25 OTEC Scenario</u>				<u>50 OTEC Scenario</u>			
	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>
1) 1990-1992	1	1	0	0	1	1	1	1
2) 1991-1993	1	1	0	0	2	1	1	1
3) 1992-1994	1	1	1	0	1	2	1	1
4) 1993-1995	1	0	1	1	2	2	1	1
5) 1994-1996	0	1	1	1	2	2	1	1
6) 1995-1997	1	0	1	1	2	2	1	1
7) 1996-1998	1	1	0	1	2	2	1	1
8) 1997-1999	1	1	1	0	1	2	2	1
9) 1998-2000	1	1	0	1	2	1	1	2
TOTALS	8	7	5	5	15	15	10	10

EXHIBIT A-5

NUMBER OF OTEC PLANTS UNDER CONSTRUCTION
PER YEAR BY CONFIGURATION TYPE, 1990-2000

25 OTEC SCENARIO

50 OTEC SCENARIO

<u>OTEC Configuration Number</u>				
<u>Year</u>	<u>C#1</u>	<u>C#2</u>	<u>C#3</u>	<u>C#4</u>
1990	1	1	0	0
1991	2	2	0	0
1992	3	3	1	0
1993	3	2	2	1
1994	2	2	3	2
1995	2	1	3	3
1996	2	2	2	3
1997	3	2	2	2
1998	3	3	1	2
1999	2	2	1	1
2000	1	1	0	1

<u>OTEC Configuration Number</u>				
<u>Year</u>	<u>C#1</u>	<u>C#2</u>	<u>C#3</u>	<u>C#4</u>
1990	1	1	1	1
1991	3	2	2	2
1992	4	4	3	3
1993	5	5	3	3
1994	5	6	3	3
1995	6	6	3	3
1996	6	6	3	3
1997	5	6	4	3
1998	5	5	4	4
1999	3	3	3	3
2000	2	1	1	2

compute the number under construction each year, using the data from Exhibit A-4 as inputs. Data registers are used as accumulators for the sum of OTEC plants under construction for a single configuration type in each year. The number of plants under construction during a construction period is entered and summed into three consecutive data registers. Then the program backs up to the second of the three data registers for the next entry. This process is repeated until the data for all the construction periods has been entered; the result being 11 consecutive data registers containing the sum of OTEC plants under construction in each year for the configuration type processed. A copy of the program is provided in the second major section of Appendix A, Instructions for Running the Model.

An additional matrix had to be developed prior to generating the annual aggregate revenue impacts by industry: the revenue impact by industry by configuration, given that anywhere from one to ten OTEC plants are under construction during a single year. Under our example mix of configurations, the maximum number under construction is six; revenues for up to ten plants are provided here for the purpose of rerunning the model under an alternative configuration mix. These data were generated as follows:

- Assemble the data on direct revenue impacts by industry by configuration type for one 400 MWe OTEC (from Exhibit 2-4 in the main body of the report).
- Given our previous assumption that there is an equal level of effort expended in each of the three construction years, divide the above data set by three to obtain the revenue impact for one OTEC plant under construction during a single year.
- Multiply the revenue impact vector for one OTEC under construction by the numbers two through ten to provide revenue impact vectors for two to ten OTEC plants under construction.

The annual revenue impacts by industry by configuration type, with one to ten OTEC plants under construction, are presented in Exhibit 2-6 in Chapter 2 of the report.

Annual aggregate revenue impacts by industry for the years 1990 through 2000 are now calculated by using data from Exhibit 2-6 of Chapter 2 with the data in Exhibit A-5, as follows. The vectors of revenue data in Exhibit 2-6 that correspond to the number of OTEC plants under construction by configuration type during a given year in Exhibit A-5 are assembled in a matrix. The industry rows are then summed to obtain the total direct revenue impact by industry in the given year. Dividing these vectors of direct revenue impacts by industry from Exhibit 2-7 by the vectors of projected industry output from Exhibit 2-3 yielded the proportional increase in output. Due to the methodology employed in generating the employment impacts, the proportional increases in output and employment are the same.

The last step in the development of annualized direct economic impacts of OTEC construction was to generate the employment impacts. Annualized employment impacts by industry were obtained by first multiplying the revenue impacts in Exhibit 2-7 by 1,000 and then multiplying the resulting file by the employment/output ratios in Exhibit 2-3. This step completed the data development process for the annualized direct economic impacts.

Regional Economic Impacts

The industries in which significant regional impacts from OTEC construction will occur are the Shipbuilding, Cement/Concrete, and Stone/Clay⁴ industries. The annual direct revenue and employment impacts by region for these industries are presented in Exhibits 2-12 and 2-13 in Chapter 2. These impacts will induce further employment impacts in the general regional economies through what is called the "multiplier" effect. Total direct plus induced employment impacts are presented in Exhibits 2-14 and 2-15. The methods employed in developing the regional impacts are described below.

The process of computing annual direct revenue and employment impacts by region is almost identical to the process used at the national level; the only differences are that there are only three industries involved and that individual shipyards are assigned to the construction schedule that shows the number of OTEC plants to be constructed by

configuration type per construction period (Exhibit A-4). The basis for assigning shipyards to the construction schedule comes from the matrices of shipyards utilized for constructing 25 or 50 OTEC plants by the year 2000, which appear as Figures 2 through 4 in the "Assessment of U.S. Shipyards" chapter of Volume II of this report. These are reproduced here as Exhibits A-6, A-7 and A-8 (note: a small adjustment was made to the distribution of OTEC plants produced at Sparrows Point in the 50 OTEC Scenario). The sum of electricity producing OTEC plants for each shipyard was allocated to the construction schedule for Configuration 1 and Configuration 2. The sum of OTEC plantships (alumina and ammonia producers) for each shipyard was allocated to the construction schedule for Configuration 3 and Configuration 4. The result of this procedure is shown in Exhibit A-9. It is important that the shipyards be spread as evenly as possible over the construction periods (especially under the 50 OTEC scenario), as there is a finite limit to the number of graving docks that a shipyard will have available for OTEC construction.

Once the construction schedule by configuration type by shipyard is in place, the direct output and employment impacts by industry by region can be calculated using the same techniques as at the national level. The only difference is that the steps are repeated for each region. Note that each region is simply the city or Standard Metropolitan Statistical Area (SMSA) in which the shipyard is located. In summary, the calculation steps are as follows:

- Compute the number of OTEC plants by configuration type under construction during each year for each region.
- Use the data from Exhibit 2-6 on the revenue impact by configuration type by industry with one to ten OTEC plants under construction to compute the revenue impact by industry by region for each year.
- Multiply the revenue impact by industry by region for each year by 1,000 and then apply the employment/output ratios by industry and year from Exhibit 2-3 to obtain the employment impacts.

The details of the above steps are found in the previous section, "Annualized Economic Impacts, 1990-2000."

EXHIBIT A-6

SHIPYARD SCENARIO LEGEND

QUINCY	GENERAL DYNAMICS, QUINCY MASS.
S.S.	SUN SHIPBUILDING, CHESTER, PA.
BS-SP	BETHLEHEM SHIPBUILDING, SPARROWS POINT, MD.
NNS	NEWPORT NEWS, VA.
TAMPA	TAMPA SHIP REPAIR & DRY DOCK
OPS	OFFSHORE POWER SYSTEMS, JACKSONVILLE, FLA.
INGALLS	INGALLS LITTON, MISS.
AVONDALE	AVONDALE SHIPBUILDING, NEW ORLEANS, LA.
BS-B	BETHLEHEM BEAUMONT, TX.
NASCO	NATIONAL STEEL AND SHIPBUILDING SAN DIEGO, CALIF.
TRIPLE A	TRIPLE A SAN FRANCISCO
BS-SF	BETHLEHEM SHIPBUILDING, SAN FRANCISCO
LOCKHEED	LOCKHEED SEATTLE, WASH.

EXHIBIT A-7

MATRIX OF SHIPYARD UTILIZED IN CONSTRUCTION OF OTEC FACILITIES 25 OTEC PLANT FACILITIES BY YEAR 2000

Sites Application	Total OTEC Sites	Atlantic OTEC Sites	Quincy	BS-SP	NNS	Gulf Coast OTEC Sites	Tampa	Ingalls	Avondale	Pacific OTEC Sites	NASCO	Triple A	BS-SP	Lock
<u>ISLAND</u>														
Electric	4	2		2						2				2
Alumina	2	1			1					1				1
Ammonia	2									2	1		1	
<u>COASTAL</u>														
Electric	11					11	3	4	4					
<u>MID-OCEAN</u>														
Ammonia	6	6		3	3									

EXHIBIT A-8

MATRIX OF SHIPYARDS UTILIZED IN CONSTRUCTION OF OTEC FACILITIES 50 OTEC PLANT FACILITIES BY YEAR 2000

Sites Application	Total OTEC Sites	Atlantic OTEC Sites	Quincy	BS-SP	S.S.	NNS	Gulf Coast OTEC Sites	Tampa	OPS	Ingalls	Avondale	BS-B	Pacific OTEC Sites	NASCO	Triple A	BS-SP	Lock
ISLAND																	
Electric	8	5		1	3	1							3				3
Alumina	4	3				3							1				1
Ammonia	4	2	1	1									2	1		1	
COASTAL																	
Electric	22						22	3	5	5	5	4					
MID-OCEAN																	
Ammonia	12	12	3	3	3	3											

EXHIBIT A-9
EXAMPLE CONSTRUCTION SCHEDULE BY OTEC
CONFIGURATION TYPES BY SHIPYARD: 25 and 50 OTEC SCENARIOS

NUMBER OF OTEC's TO BE CONSTRUCTED (AND SHIPYARD)

Construction Period	25 OTEC Scenario				50 OTEC Scenario			
	Configuration #1	Configuration #2	Configuration #3	Configuration #4	Configuration #1	Configuration #2	Configuration #3	Configuration #4
1) 1990-1992	1 (BS-SP)	1 (Lock)	0	0	1 (OPS)	1 (Avon)	1 (Q)	1 (S.S.)
2) 1991-1993	1 (Tampa)	1 (Ingalls)	0	0	2 (NNS/Lock)	1 (Tampa)	1 (BS-SP)	1 (Q)
3) 1992-1994	1 (Avon)	1 (Lock)	1 (NNS)	0	1 (OPS)	2 (S.S./Ing.)	1 (BS-SP)	1 (NNS)
4) 1993-1995	1 (BS-SP)	0	1 (Lock)	1 (BS-SP)	2 (Lock/Ing.)	2 (Tam./Av.)	1 (NNS)	1 (Lock)
5) 1994-1996	0	1 (Ingalls)	1 (NASCO)	1 (NNS)	2 (OPS/BS-B)	2 (S.S./Av.)	1 (Q)	1 (BS-SP)
6) 1995-1997	1 (Avon)	0	1 (BS-SP)	1 (NNS)	2 (Lock/Ing.)	2 (Tam./BS-B)	1 (NNS)	1 (NNS)
7) 1996-1998	1 (Tampa)	1 (Ingalls)	0	1 (BS-SP)	2 (OPS/Ing.)	2 (Av./S.S.)	1 (BS-SP)	1 (Q)
8) 1997-1999	1 (Tampa)	1 (Avon)	1 (NNS)	0	1 (OPS)	2 (Av./BS-B)	2 (NNS/NNS)	1 (BS-SP)
9) 1998-2000	1 (Avon)	1 (Ingalls)	0	1 (BS-SP)	2 (BS-SP/BS-B)	1 (Ingalls)	1 (S.S.)	2 (S.S./NASCO)
TOTALS	8	7	5	5	15	15	10	10

Estimates of total direct plus induced employment were developed separately for each region by applying employment multipliers to the total direct employment impact on the region. These multipliers were obtained from Argonne National Laboratory's A Framework for Projecting Employment and Population Changes Accompanying Energy Development, except for the multiplier for Norfolk/Newport News which is the average of all the other multipliers used. These multipliers are listed in Exhibit A-10.

INSTRUCTIONS FOR RUNNING THE MODEL

Introduction

As stated in the introduction to this appendix, the economic impact of OTEC construction can change for the following reasons:

- New OTEC configurations may be developed that could either replace or augment existing configurations.
- A different mix of OTEC configurations may be selected for construction.
- The distribution of OTEC plants by configuration type to individual shipyards might be altered.

The purpose of this section is to provide the reader with a summary checklist of instructions to be used in rerunning the model to obtain revised economic impact data, reflecting changes in any of the above mentioned variables. The steps are presented in brief, summary form and are only intended to serve as a checklist; it is important that the previous sections on "Total Direct Revenue Impact by OTEC Configuration Type," "Secondary Revenue Impacts by OTEC Configuration Type", "Annualized Direct Economic Impacts, 1990-2000", and "Regional Economic Impacts" also be read in conjunction with the instructions presented below.

Providing for New OTEC Configurations

To the extent that new OTEC configurations are just a new combination of the subcomponents for which impact estimates have already been made, total direct revenue impacts can be easily calculated by using the data from Exhibit 2-4. For

EXHIBIT A-10
REGIONAL EMPLOYMENT MULTIPLIERS

<u>Region</u>	<u>Multiplier</u>
Boston	4.3
Baltimore	3.0
Chester, Pa.	3.5
Norfolk/Newport News	3.9
Tampa	4.0
Jacksonville	4.4
Pascagoula, Miss.	2.3
New Orleans	4.7
Beaumont, TX	3.2
San Diego	4.6
San Francisco	5.2
Seattle	3.9

Source: A Framework for Projecting Employment and
Population Changes Accompanying Energy
Development, Argonne National Laboratory.
Norfolk/Newport News is the average of the
other multipliers.

example, if aluminum heat exchangers are not cost effective due to more frequent replacement necessitated by bio-fouling, then Configurations 3 and 4 could be altered to include titanium heat exchangers instead of aluminum. The Titanium industry revenue impact would be substituted for that of Aluminum, and the higher Fabricated Metal industry impact of Configurations 1 and 2 would be used. However, if a new OTEC configurations require subcomponents and industries not covered by this study, additional research would be required.

If the total direct revenue impact of a new OTEC configuration can be developed by reassembling data from Exhibit 2-4, then the corresponding secondary revenue impact can be developed by reassembling data from Exhibit 2-5. Continuing our example of substituting titanium heat exchangers for aluminum ones in Configurations 2 and 4, the secondary impacts associated with the primary industry, titanium, are substituted for those associated with the Aluminum industry, and the secondary impacts associated with the primary industry. Fabricated Metal in Configurations 1 and 2 replace those used for Configurations 3 and 4.

Once the total direct and secondary impacts for a new OTEC configuration have been estimated, the next step is to develop the direct annual revenue impacts given that one to "n" OTEC plants of the new configuration are under construction in a single year. The steps required to generate these data are the following:

- Divide the vector of total direct revenue impacts by three, yielding the annual revenue impact with one OTEC of the new configuration under construction during a given year.
- Multiply the annual revenue impact vector of one OTEC under construction by the numbers 2 through "n" to obtain revenue impact vectors for two through "n" OTEC plants under construction during a given year.

Providing for an Alternative Mix of OTEC Configurations

If an alternative mix of configurations (as they exist in this report) is desired, the steps described below must be followed to re-estimate the economic impacts; likewise, if a new configuration has been introduced (see previous section), the configuration mix is

also changed. The following instructions refer to worksheets; corresponding blank worksheet "shells" are provided for reference or actual use.

1. Prepare Configuration Mix Worksheet (Worksheet #1) -- this worksheet lists configuration characteristics and the number of each configuration to be constructed under the 25 and 50 OTEC scenarios.
2. Allocate the number of OTEC plants to be constructed by configuration type across the construction periods on the Construction Schedule Worksheet (Worksheet #2).
3. Compute the number of OTEC plants under construction during each year, 1990-2000, for each configuration type given that each plant is under construction for three years. If desired, the following program for the Texas Instruments 59 calculator may be used.

000	R/S
001	PRT
002	SM*
003	OO
004	OP
005	20
006	SM*
007	00
008	OP
009	20
010	SM*
011	00
012	OP
013	30
014	RST

The program is run as follows:

WORKSHEET #1
CONFIGURATION MIX SHEET

Number of OTEC Plants to be Constructed

**Configuration Number
and Description**

25 OTEC Scenario

50 OTEC Scenario

Configuration #1

- _____
- _____
- _____
- _____

Configuration #2

- _____
- _____
- _____
- _____

Configuration #3

- _____
- _____
- _____
- _____

Configuration #4

- _____
- _____
- _____
- _____

WORKSHEET #2
CONSTRUCTION SCHEDULE WORKSHEET

NUMBER OF OTEC PLANTS TO BE CONSTRUCTED

Construction Period	<u>25 OTEC Scenario</u>				<u>50 OTEC Scenario</u>			
	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>
1) 1990-1992								
2) 1991-1993								
3) 1992-1994								
4) 1993-1995								
5) 1994-1996								
6) 1995-1997								
7) 1996-1998								
8) 1997-1999								
9) 1998-2000								
TOTALS								

The program is run as follows:

1. CMS
2. 1 STO 00
3. Key in number of OTEC plants under construction during a construction period for a configuration type (from Worksheet #2) and press R/S.
4. Press R/S again, then repeat step 3 only for each additional data element in a configuration type column of Worksheet #2 before proceeding to step 5.
5. Collect results:
 - a. with printer -- press 1 INV list
 - b. without printer -- RCL 01, RCL 02, RCL 11.
6. Return to Step 1 to process each additional column of data on Worksheet #2.

To process the data without the Texas Instruments 59 calculator, refer to the subsection from "Annualized Direct Economic Impacts, 1990-2000" on "computing the number of OTEC plants under construction in each year from 1990 through 2000 by configuration type for the description of the arithmetic involved. The results generated in this section can then be tabulated onto Worksheet #3.

The next step (#4) is to develop data on annual aggregate revenue impacts by industry for the period from 1990 to 2000. This is done by using the data on annual revenue impacts by industry by configuration with one to "n" plants under construction with the data in Worksheet #3, as follows:

1. Assemble the revenue vectors from the "one to n plants" matrix that correspond to the number of plants under construction by configuration in each year from Worksheet #3.

WORKSHEET #3

**NUMBER OF OTEC PLANTS UNDER CONSTRUCTION
PER YEAR BY CONFIGURATION TYPE, 1990-2000**

25 OTEC SCENARIO

OTEC Configuration Number

<u>Year</u>	<u>C#1</u>	<u>C#2</u>	<u>C#3</u>	<u>C#4</u>
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				

50 OTEC SCENARIO

OTEC Configuration Number

<u>Year</u>	<u>C#1</u>	<u>C#2</u>	<u>C#3</u>	<u>C#4</u>
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000

WORKSHEET #4
CONSTRUCTION SCHEDULE BY OTEC
CONFIGURATION TYPES BY SHIPYARD

NUMBER OF OTEC's TO BE CONSTRUCTED (AND SHIPYARD)

<u>Construction Period</u>	<u>25 OTEC Scenario</u>				<u>50 OTEC Scenario</u>			
	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>	<u>Configuration #1</u>	<u>Configuration #2</u>	<u>Configuration #3</u>	<u>Configuration #4</u>
1) 1990-1992								
2) 1991-1993								
3) 1992-1994								
4) 1993-1995								
5) 1994-1996								
6) 1995-1997								
7) 1996-1998								
8) 1997-1999								
9) 1998-2000								
TOTALS								

2. Sum the industry rows in the revenue impacts matrix formed in substep 1 to obtain total annual direct revenue impacts by industry for 1990-2000.
3. If desired, divide the revenue impacts developed in substep 2 by the projected industry output in Exhibit 2-3 to obtain the proportional increase in output due to OTEC construction.

Step 5 involves the development of the annual employment impacts by industry. These are estimated by multiplying the revenue impacts developed in substep 4-2 by 1,000 and then multiplying by the employment/output ratios in Exhibit 2-3. This completes the development of the annualized economic impacts.

Providing for an Alternative Distribution of OTEC Plants
to Individual Shipyards

Since a new OTEC configuration and/or changing the configuration mix automatically alters the distribution of OTEC plants among shipyards, new regional impacts must be estimated. The procedures for rerunning the model for revised regional economic impacts are as follows:

1. Prepare a "Construction Schedule by Configuration Type by Shipyard" (Worksheet #4).
2. Compute the number of OTEC plants by configuration type under construction during each year for each region (same procedure as Step 3 in the previous section).
3. Use the data on the annual revenue impact by configuration type with one to "n" plants under construction to compute the aggregate annual revenue impact by region for the Shipbuilding, Cement/Concrete and Stone/Clay⁵ industries.

4. Multiply the aggregate annual revenue impact (by industry by region) by 1,000 and then apply the employment/output ratios by industry from Exhibit 2-3 to obtain the direct regional employment impacts by industry. Sum the industries to get the total direct employment impact for each region.
5. Apply the multipliers from Exhibit A-10 to the total direct employment impacts developed in Step 4 to obtain total direct plus induced employment impacts by region.

APPENDIX - A

Footnotes

¹1985 and 1990 output data were collected from BLS, Employment Projections for the 1980's.

²Employment in the BLS parent sector was extrapolated from 1990 to the years 1991 through 2000 using the same technique described in the preceding paragraph.

³Westinghouse memo: Net Energy Analysis.

⁴Excluding the impacts accruing to producers of glass sand. Only the impacts for construction sand and crushed stone producers are included here.

⁵For configurations which use both concrete and a cold water pipe of FRP, be sure to subtract out the glass sand revenues from the vector at a rate of \$0.2 MM per year.