CEER-55

PROPOSED FIVE YEAR PLAN

ENERGY AND ENVIRONMENT PROGRAMS

FY 1982-86

DRAFT NO. 1

DECEMBER 1979

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO — U.S. DEPARTMENT OF ENERGY

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CEER

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PREFACE

As the result of a negotiating process begun in 1975 between the Energy Research and Development Administration and the University of Puerto Rico, the Administrator of ERDA (now DOE) and the President of the University approved an Action Memorandum dated April 11, 1976, providing for the creation of a Center for Energy and Environment Research (CEER) to supersede the Puerto Rico Nuclear Center (PRNC) which had been operated under contract with the Atomic Energy Commission since 1957. The Council on Higher Education of Puerto Rico authorized the establishment of CEER effective July 1, 1976. Appendix A contains a copy of the Action Memorandum of April 11, 1976 mentioned above.

To help CEER achieve the transition from a nuclear Center to one focusing on ERDA's (DOE) national energy goals and Puerto Rico's own energy needs, ERDA (DOE) established an Oversight Committee. The Committee held its first meeting with representatives of CEER and the University System in November, 1976, to review the transitional measures taken up to that time and to refine plans for the future. There was full agreement that CEER's success would require continuous and close communication and collaboration between the Center, ORO, ERDA (DOE) technical program directors and the Oversight Committee, as well as continuous interaction between the Center and the University System as a whole.

A five year plan (FY-1977-82) dated February 1977 was prepared for the second meeting of the Oversight Committee in March 1977. This plan has served as a general guide with some modifications, for CEER's present programs.

The Action Memorandum dated April 11, 1976 (Appendix A) considered the possibility of three options for changing the old Puerto Rico Nuclear Center (PRNC)-GOCO operations to new CEER administrative set-ups ad follows:

1. Continue the PRNC-GOCO arrangements with UPR-making certain management and funding modifications.
2. Develop a mixed ERDA (DOE) GOCO and non-GOCO arrangement with the UPR.
3. Discontinue the ERDA (DOE) GOCO operations, transferring the facilities to the UPR, or others, or close them if appropriate and executing ERDA (DOE) programs under other contractual bases.

Option number 3 above was the recommended one. This option involved the gradual reduction of funding (until complete elimination) for support of facilities. The present inability of the UPR to financially support CEER requires a revision of funding, and previous set plans by DOE in its relations with CEER, unless the forced closure of CEER is the selected alternative. There are now several valid reasons for continuing DOE support that were mostly unknown or undefined by 1976. They have grown out of the on-going work at CEER, and are coupled to the changing energy situation. These reasons are listed below.

REASONS WHY DOE SHOULD CONTINUE CEER SUPPORT:

1. International Programs

CEER represents a useful instrument to DOE International Relations in the Caribbean and Latin America. Because of Puerto Rico's Spanish and English cultural background uniqueness and the bilingual Spanish and English speaking population, geographical location in the Caribbean,

and established scientific and technical interactions with Latin America and the Caribbean, CEER represents an ideal institution for DOE international interface in energy assessment of LDC countries and technology transfer in the indicated areas. CEER is presently involved in energy related future programs with Venezuela, Panama, and Ecuador. Dominican Republic officials have already contacted the CEER Director for possible future interactions.

During the past few years CEER Scientists have taken an active participation in energy related meetings and symposia held in Venezuela, Colombia, Chile, Dominican Republic, Jamaica, and Barbados. These meetings were sponsored by US-AID and other USA or international organizations.

2. Sooner Demonstration of Economic Competitiveness

Puerto Rico Represents one of the very few areas under the US flag where economic competitiveness of various energy alternatives could be proven sooner, which will accelerate the commercialization of these energy alternatives. Among such energy alternatives are: a) OTEC, b) Biomass, c) Direct Solar Conversion technologies.

Puerto Rico has one of the best sites, if not the best, for the location of an OTEC plant which can result in minimum project investment costs. Only the sites of Punta Tuna in southern Puerto Rico and the site of Keyhole West of Hawaii main island offers 1000 meters ocean water depths close to land (8000 ft. for Hawaii and 9000 ft. for Puerto Rico), where temperature differentials of (20-24°F) between surface and deep waters are found. Such temperature differentials are required for an OTEC facility. The closeness of such ocean site areas to land minimizes

costly electrical cable connections and deployment costs for first generation facilities.

The Puerto Rico Electric Power Authority (PREPA) has extensive experience in installing, conserving and operating transmission submarine cables. P. R. has been interconnected with two offshore islands, Vieques and Culebras, with over 20 miles of undersea (46kv, 14 MVA three phase) transmission cables. The operating experience of PREPA for these cables extends over 15 years. The Puerto Rico site has the added advantage over the Hawaii site in the sense that the electrical power system of Puerto Rico can absorb the power of a 100-500 MW OTEC plant. The total generating capacity of the Puerto Rico system exceeds 4000 MW and its peak generation exceeds 2000 MW. The electric power system of Hawaii has a peak demand of approximately 90 MW. A large OTEC plant (100 MW) in which economic feasibility can be achieved should be proven in a large power system with sufficient electrical stability.

In Biomass, the impressive production records of tropical grasses and napier grass, demonstrated under the CEER/DOE sponsored Biomass programs, have already indicated the possibility of biomass fuel costs of the order of $1.70 per million BTU delivered vs present $4.00 per million BTU oil fuel costs. Biomass energy alternatives could probably be demonstrated through the CEER programs to be one of the first commercially viable economic energy alternatives sponsored by DOE.

In the area of direct conversion of solar energy such as photovoltaics and direct conversion of solar heat to steam for prime mover applications to electrically driven generators, the insolation rates are of paramount importance in determining economic competitiveness. Recent

data obtained at Ponce, P. R. (south coast), at 18 degrees latitude, indicate an average daily total isolation of approximately 1900 BTU/sq. ft-day on a horizontal surface. The relatively small change in day length (P.R. being close to the equator) from summer to winter, enhances the utilization factor of solar energy throughout the entire year. The high isolation rates of tropical Puerto Rico is a very important factor to sooner demonstrate the economic competitiveness by DOE sooner than in many other areas.

3. Component Testing in Tropical Environment

Puerto Rico's tropical weather offers an adequate and suitable environment to study the effects of a tropical environment on solar technology components such as photovoltaics cells, ferroelectric converters, solar concentrators, etc. The discontinuance of CEER will impact adversely on such important energy-environment related programs.

4. Unique Tropical Ecological System

The only tropical forest owned by the U.S. Dept. of the Interior is in Puerto Rico - the Luquillo Rain Forest. It offers the only true tropical ecological system under the US flag where the interaction between ecology and energy systems or components are presently being studied. CEER data acquisition laboratory and field station in addition to a 200 acre Use Permit in El Verde Forest (which is part of the Luquillo Rain Forest) forms an important part of the program. In addition Puerto Rico is unique in that it contains six different ecological zones ranging from desert to rain forest.

5. Affirmative Action Policy

Of approximately 43 research and development facilities, including CEER, owned and supported by DOE, CEER is the only facility located in an

environment which constitutes a predominant minority group. The continuous support and funding of CEER will enhance the good will and spirit of DOE as a strong supporter of the Affirmative Action U.S. Government Policy.

6. Baseline Data

Important energy and environment baseline information developed during the last three years of CEER/DOE programs represent significant assets in the time schedule and program definition of viable energy and environment development and demonstration projects which might bring earlier commercialization in the Caribbean as well as the southern part of the USA.

During the period of 1976 to present, the aforementioned reasons for continued DOE support, grew out of the world energy situation and research occuring over the last few years. CEER's original objectives were somewhat modified as per the changing energy situation in relation to the needs of both the Mainland USA and P.R. As such, in review and observation of these trends, it is felt that review and modification of the original Action Memorandum should be carried out in accordance with the benefits to DOE in continuing support of CEER.

PURPOSE OF DOCUMENT

The main purpose of this documentation is to project programs and budget requirements for the 5 year period (FY-1982-86) beyond the current 5 year (1977-81) contractual relationship with the Department of Energy (DOE) in order to contribute in meeting the President's National Plan for Energy Research and Development Needs and serve as the basis for a proposed new contract with DOE.

The principal CEER objective is to support the effort of achieving national energy independence while contributing to Puerto Rico's own effort to obtain the same goal for itself. Puerto Rico's economy at present time depends entirely (99 percent) on energy derived from imported petroleum. Total petroleum fuel domestic consumption in Puerto Rico is approximately 70 million barrels per year. Table 1, "Estimates of P. R. Energy Requirements to the year 2000", indicates rough predictions made by CEER energy analysis studies. Puerto Rico's total fuel bill for the rest of the century is predicted to exceed $155,000,000,000 if no energy alternatives are considered.

To implement the timely development of alternative sources, CEER efforts should be substantially increased from the level of funding sustained during the current five year (1976-81) contractual plan with DOE. The programs presented herein address this subject in detail.

TABLE 1

ESTIMATES OF PUERTO RICO'S ENERGY REQUIREMENTS TO THE YEAR 2000 UNDER PRESENT SOCIO-ECONOMIC STRUCTURES AND ABSENCE OF STRONG R AND D PROGRAM ON ALTERNATE ENERGY SOURCES

	(1)	(2)	(3)	(4)	(5)	(6)
	MILLION BARRELS OF OIL IMPORTS FOR					
YEAR	ELECTRICAL ENERGY (1)	GASOLINE & DIESEL(2)	INDUSTRY & OTHER(3)	TOTAL	ESTIMATED UNIT PRICE (4) $/BBL	TOTAL COST ($ Millions)
1976	21.7	17.6	26.3	64.7		
1977	23.0	18.2	21.5	62.7		
1978	24.5	16.5	23.9	65.0		
1979	26.0	17.0	25.1	68.1	14.70	1001.
1980	27.5	17.9	26.3	71.7	16.78	1203
1981	29.0	18.5	27.7	75.2	19.17	1442
1982	29.7	19.0	29.1	77.8	21.30	1704
1983	31.9	19.8	30.5	82.2	25.00	2055
1984	33.6	20.5	32.0	86.1	28.55	2458
1985	35.3	21.0	33.6	89.9	32.70	2939
1986	36.7	21.4	35.3	93.4	36.29	3390
1987	37.9	21.9	37.1	96.9	40.28	3903
1988	42.2	22.5	38.9	103.6	44.72	4633
1989	44.8	23.1	40.9	108.8	49.60	5396
1990	47.4	23.6	42.9	113.9	55.00	6266
1991	50.8	24.0	45.1	119.9	58.75	7044
1992	53.4	24.5	47.3	125.2	62.75	7856
1993	56.0	25.1	49.7	130.8	67.00	9295
1994	59.1	25.7	52.2	137.0	71.50	9796
1995	62.0	26.0	54.8	142.8	76.50	10924
1996	65.0	26.4	57.5	148.9	81.12	12078
1997	68.1	26.7	60.4	155.2	86.00	13347
1998	71.5	27.4	63.4	162.3	91.15	14793
1999	74.1	27.9	66.6	168.6	96.62	16290
2000	77.6	28.1	69.9	175.6	102.6	18016
TOTAL						$155,829

(1) Statistical Correlations between population and GNP and between GNP and Electrical Energy Generation. Correlation 99%.

(2) Gasoline Consumption growth projected conservatively between 2 1/2 - 3% per year vs. 6.6% actual. More accurate predictions to be included in CEER Energy Studies.

(3) Industrial needs projected at 5% per year growth. More accurate predictions to be included in CEER Energy Studies.

(4) Fuel oil proces escalation indicated is approximately 1980-85: 14.3%/year; 1985-90: 11% year; 1990-95: 6.8%/year and 1995-2000: 6% year.

UNIQUENESS AND CAPABILITY OF P.R. AND CEER FOR R & D IN ENERGY AND ENVIRONMENT

CEER is the only significant research and development facility in Puerto Rico and one of the few within the U.S. that focus on both energy and environment problems and the interrelated impact upon each other. It is on of the largest one in the Caribbean. Puerto Rico is also probably the most technologically advanced region of the Caribbean. Many technically advanced projects were developed in P.R. prior to even consideration given by other Latin American or Caribbean islands for such projects. The result of this technological advancement has provided Puerto Rico with local scientific and technical personnel capable of handling sophisticated R & D projects in both energy and environment. A few of the technically advanced projects are:

1. The BONUS (Boiling Nuclear Superheat) Nuclear Plant - Only one of two research boiling water reactors with integral nuclear steam superheating built in the USA. This facility of 50,000 KWth, 16,300KWe was constructed on the west coast of Puerto Rico at Rincón, and operated by the local power utility during the period 1960-68. Facility personnel were trained at PRNC (CEER). Several BONUS related experiemnts and measurements were carried out at PRNC (CEER). Among one of the reasons for selecting Puerto Rico by the USAEC (now DOE) was the technical capability of PREPA and the University (PRNC) to carry out the program.

2. Nuclear Research Reactor

   A swimming pool 1 MW research reactor built in 1959 and later

replaced (1970) by a Triga Type reactor (2MW) which served as an R & D and training facility for nearly 18 years of PRNC (now CEER) operations.

3. Controlled Flash Evaporator Desalinization Pilot Plant, 10 GMP at Palo Seco Power Plant.

   This has been the only desalinization pilot plant ever built using a power plant condenser waste heat for water desalting. The project was a success but water costs had to compete with other desalting schemes using $1.50/bbl oil at that time (1965). Today the information developed in this project is an asset for future consideration of water desalting due to the high fuel costs.

4. The Arecibo Ionospheric Laboratory, owned and operated by Cornell University, has the world's most powerful radio telescope in the field of astronomical investigations. This has added specialized radio communication technicians and scientists to the scientific population of Puerto Rico.

5. The 200 KW DOE-NASA/PREPA wind mill erected on the island of Culebra, located to the east of Puerto Rico. Important operating data is being accumulated at present. This represents another energy alternative technological advancement.

6. Rum Pilot Plant

   A special law of the Legislature of Puerto Rico established the Rum Pilot Plant in 1952. It is owned and operated by the UPR Agricultural Experiment Station. It is located at Rio Piedras a short distance from the main CEER-UPR facilities. Its operations

are organized in a number of divisions dealing with analytical chemistry, fermentation chemistry and technology, rum waste utilization, and technical services.

A collection of superior yeast strains is also available. Laboratories are well equipped for investigation in all aspects of the manufacture of rum and allied products. Information derived from these studies is transmitted to the P.R. Rum Industry through publications and technical meetings. Special reports are issued periodically to the rum industry and various interested institutions.

In addition to above projects, Puerto Rico has a very sophisticated and advanced electric power system. It is the second largest public utility within the USA, being second only to the city of Los Angeles Water and Power System. The Puerto Rico electric generating system is equipped with fully automated remote controlled and supervised hydroelectric power stations (approx. 80 MW in 8 automatic stations); modern high pressure (2400 psi), high temperature 1000°F superheat, 1000°F reheat steam stations with digital computer supervision in all stations above 82.5 MW capacity (4-82.5 MW units, 4-100 MW units, 2-225 MW units and 4-450 MW units). The Palo Seco Steam Station computer installation was a pioneer in the field being placed in operation in 1960. The generating transmission system is economically dispatched with an economic-dispatch in line computer which sends digital signals to generator governor for minimum fuel consumption systemwise, and in addition, it provides security programs system operations.

The main transmission network is 230 KV. The distribution system is equipped with remote control and electrically supervised stations. System planning is performed with very sophisticated computer programs for load flow, loss of load probability analysis, transient stability, load modelling, etc. The technology involved in planning, constructing and operating the power system requires a high caliber of engineering expertise and provide a challenge to the educational institutions.

Island industries are also highly sophisticated and advanced. There are many computer oriented and electronic industries, petrochemical refineries, an aircraft factory, a large electrical industry, chemical factories, pharmaceutical industries, etc.

In the education field, Ph.D degrees in Chemistry, Physics, Marine Sciences and MS in all engineering programs are offered by the University of Puerto Rico. There are three schools of medicine in addition to that of the University of Puerto Rico. In addition to the University of Puerto Rico, three large private Universities offer degrees in Sciences, Business Administration and other professional fields.

All of these activities provide an adequate and suitable background for the development of R & D projects on energy and environment in Puerto Rico.

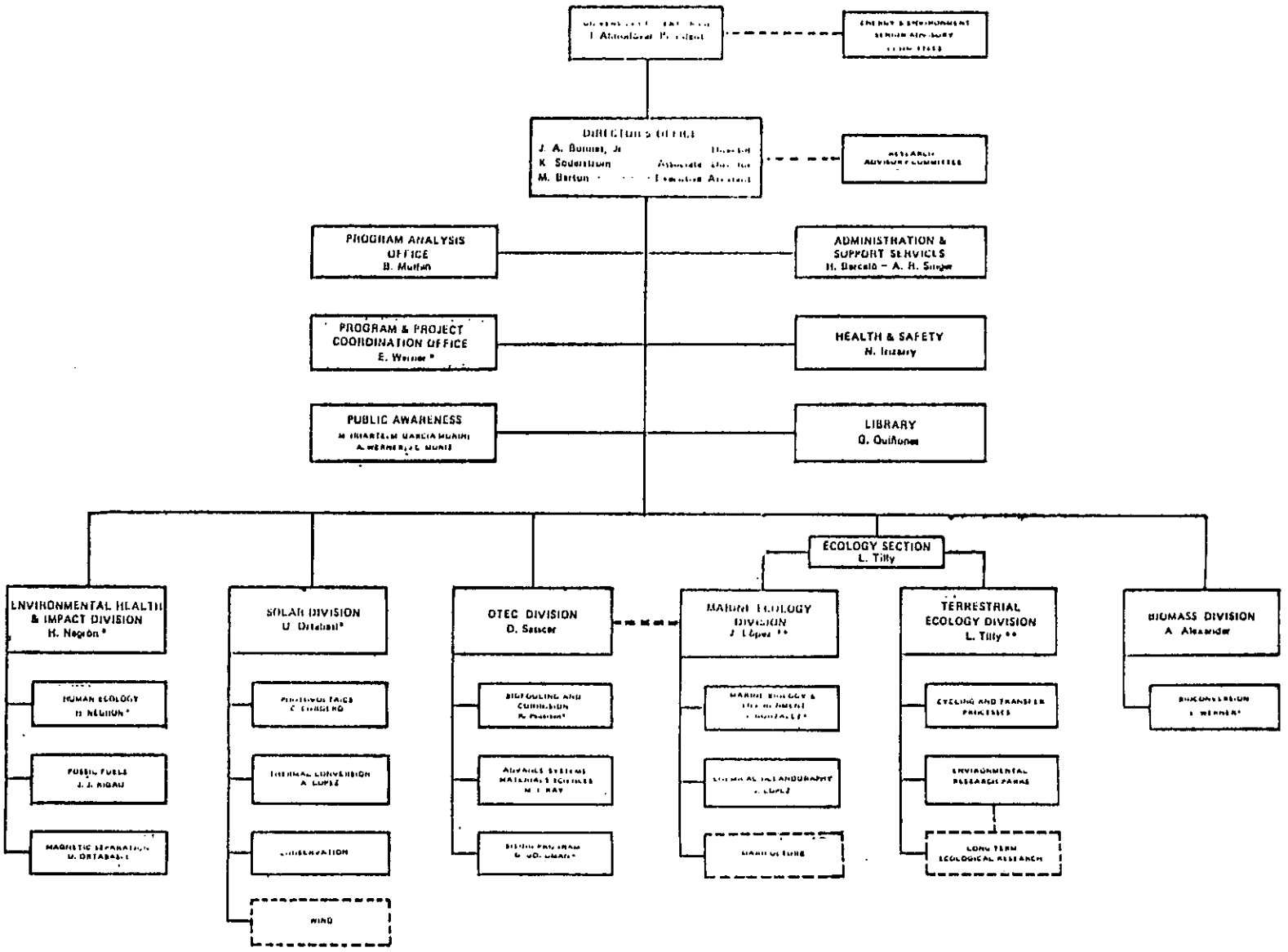
CEER AND ITS ACCOMPLISHMENTS

CEER Organization

The Center for Energy and Environment Research, previously known as the Puerto Rico Nuclear Center, operates as a single unit within the University of Puerto Rico system, reporting directly to the President of the

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

UNIVERSITY OF PUERTO RICO



Contractor : University of Puerto Rico
Location : Puerto Rico
Operations : Oak Ridge
Contract No : DE AC05-76OR01833
Total Personnel : 164
Date : November 1979

* DUAL FUNCTION

** ACTING

Figure 1

University. UPR is an island wide university with over 60,000 students concentrated in three large campuses, three four year university colleges, and five community colleges and includes an agricultural research network and cooperative extension service. The organizational structure of CEER is illustrated in Figure 1.

DOE facilities associated with CEER have an acquisition value of approximately $12 million and are located on four main sites: (1) Rio Piedras site, adjacent to the UPR School of Medicine, (2) Mayaguez site (20 acres), adjacent to the UPR Campus in Mayaguez, (3) Cornelia Hill site (20 acres) south of Mayaguez and adjacent to the ocean which houses the marine ecology program, (4) Luquillo National Forest El Verde Facility in the Luquillo Rain Forest which houses data acquisition laboratory field station and has a 200 acre Use Permit.

A new site has been added recently consisting of a 15 acre lot within the municipality of Toa Baja in the Ward of Palo Seco and not far from the north coast. This site recently acquired by the UPR System has been assigned to CEER for the development of a future Experimental Station for field testing and demonstration of alternative energy sources such as solar, wind, and biomass-bioconversion.

Accomplishments, Past

During the 19 year (1957-1976) period in which the CEER predecessor, the Puerto Rico Nuclear Center (PRNC), operated a nuclear energy program, one of its main accomplishments was the training of students in nuclear science and technology, nuclear medicine and health physis. A total of 3560 students and scientists from 41 different countries participated in the various

training and research programs. The participants were from countries throughout the entire globe, representing India, Great Britain, Spain, Greece, Israel, Korea, Lebanon, Liberia, Kenya, Philippines, Germany, Hungary, Indonesia, Thailand, United Arab Republic, Turkey, South Africa, Malay, Formosa and Japan. However, the largest number of participants were from Latin American countries, including Argentia, Bolivia, Brasil, Chile, Colombia (largest representation), Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haití, Honduras, Jamaica, Mexocp. Nicaragua, Panamá, Paraguay, and Venezuela. Many of the participants that were students traine in these programs, today held importan positions in both government and private industry in their respective countries in the fields of energy and environment. The good will and ambassadorship together with the intelectual and know-how accomplishments gained through these training programs is probably the major accomplishment of the CEER predecessor.

Accomplishments, Present

The major accomplishment of CEER during the last three years of operation has been the establishment of a base for research and development programs for alternative energy sources and the solution of environmental problems associated with them. Baseline information has been collected, analyzed and reported for such important program as the siting of an Ocean

includes biofouling corrosion and materials studies, measurements of oceanographic environmental studies parameters, seawater surfactant systems and variability relationships to an open cycle FOAM OTEC System and OTEC Parameter Ocean Spatial Variability.

Due to Puerto Rico's geographical location in a high insolation region with sufficient rainfall, good agricultural land and the availability of facilities and agricultural research scientists, biomass for energy research programs has been under development at CEER and the Agriculture Experiment Station of UPR. Baseline information in relation to Biomass includes the development of agricultural technologies and optimization for harvesting large columns of biomass and their economic and agricultural feasibility.

Bioconversion projects producing methane from wastes have been developed. Wastes biologically digested together with biomass in an optimized mix, can represent an atractive project from the point of view of integrated energy and environment research in Puerto Rico as well as other areas, including the USA mainland. A demonstration project (waste digestion only) for the US Army at Fort Buchanan has been developed by CEER and is in operation. Important information has been gathered for the design of larger systems. Various methane generators including newly designed systems to digest rum distilling has produced important baseline information.

A solar research program can not be logically developed unless a baseline solar radiation data is developed for the area under consideration. Solar radiation data has been under continuous monitoring by a series of CEER measuring stations located in Mayaguez, Cabo Rojo, Lajas, Rio Piedras, Ponce and Cataño. These data, both global and diffuse, are taken on an hour by hour basis, stored in a computer, and have been mathematically modeled for practical use for research and design applications. Reports have been issued containing this important and vital information. Additional measuring stations are planned to generate more detailed information. An evacuated tube CPC concentrator for producing steam for industrial requirements has been developed by CEER which will form the base of future industrial solar steam programs. In addition, CEER has participated in the design phase of solar demonstration projects (photovoltaics and solar-thermal.

The design, testing, and evaluation of a solid dessicant air conditioning machine using silica gel has provided basic information for the further study and consideration of this important system in the tropics. Air conditioning is a significant electrical load in Puerto Rico, especially in the commercial sector.

In the ecology area, salient accomplishments are the establishment of baseline information for future ecological studies and assessment related to planned energy production and utilization. This has been accomplished through El Verde Project and the Tallaboa-Guayanilla Bay ecosystem studies, research of several years duration that carries over from PRNC programs.

In addition, the ecology section presently has a large role in the ecosystem study for the OTEC site and in new siting considerations for a coal fired plant.

Health programs form an important part of CEER programs. The main efforts in the past has been in controlling water quality and tropical disease transmission through aquatic systems (schistosomiasis). As a result of CEER's efforts, schistosomiasis in P. R. has been nearly erradicated. Ongoing programs are establishing baseline information required in connection with correlation of respiratory diseases, cancer and air quality as well as the correlation between gastrointestinal disorders and water quality are common in Puerto Rico.

Materials programs have developed basic information related to improvements and optimization of fuel cell electrodes, determination of properties of several solar selective surfaces and material degradation on solar collectors and water heaters in the tropics. A base already exists in the area of materials research in terms of availability of scientists and laboratories.

On integrated technological assessment, energy analysis of various alternative energy sources has been made, providing basic economic information and period of competitiveness for the timely selection and development of alternative energy sources. The studies indicate that nuclear energy, on a cost basis only, is the lowest cost energy for the rest of the century and beyond. Biomass and OTEC are strong contenders with costs lower than coal fired power plants. Photovoltaic economics looks highly

promising. The engineering economic analysis of alternatives is a very important aspect in an energy environment programand CEER is not overlooking this aspect.

Public Awareness or Training and Education Programs have received very little funding. However, CEER has conducted several significant programs in this area including an International three weeks energy seminar in which scientists from Latin America participated. In addition, several summer energy-environment oriented training courses for local high school teachers and students have been conducted. Base information has been accumulated for future programs. CEER also sponsors and participates in many professional level seminars each year in the areas of energy and environment.

In the Transportation and Conservation Sector, significant economic and policy studies have been and are presently being conducted. Base data has been established for important future policy and decision making considerations. Over twenty five (25)% of P.R. net petroleum imports are spent in the transportation sector.

Present studies and experimentation is focused toward the feasibility of utilizing electric or hybrid electric vehicles. Both of these vehicles show promises for substantial reduction in gasoline usage due to the predominant high density traffic in the metropolitan areas.

To keep abreast of the latest developments in energy and environment research, CEER has sent their scientists to visit various research laboratories for discussion of special projects and current research in the

areas of prime interest to CEER. Some of these laboratories visited have been: ORNL, JPL, SERI, ANL, KMS, SRL, BNL, Sandia, and LBL. In addition, visits to major university research laboratories have also been carried out, among some of which are: MIT, U of Colo., Colo State U., U. of Fla., Cal Tech, UCLA, U. of Cal-Berkeley and U. of Mich.

Additional programs and accomplishments at CEER during the last four years include the success of the magnetic separation program (removal of pollutants from aqueous waste discharges); tertiary treatment of waste water with water hyacinths; use of sludge and hyacinth compost to produce methane; joint efforts with the Venezuelan Government in the research required to establish the practicability of using a microbial oil stimulation method in marginal wells producing extra heavy crudes and biodegration of heavy crudes by means of selected microorganisms.

Extremely careful planning was necessary in making periodic all the above CEER accomplishments through very limited funding, an average total on the order of $3 million per year for all programs.

Figure 2 "Institutional and Developmental Programs FY-1980 Projections and FY-1979 Allocations" illustrate the actual funding distribution of the various programs.

Table 2 "Institutional and Development Funding by Project Areas FY-79 and FY-80 indicates the present funding distribution by institutional program classification.

Appendix B "CEER Programs" gives a detailed listing of "CEER Institutional and Development Programs: FY-77 through FY-70". The specific ongoing projects funding, project location, and leaders are indicated. Also included within Appendix B are the sponsored and Competitive Research Programs.

FIGURE 2 INSTITUTIONAL AND DEVELOPMENTAL PROGRAMS FY-1980 PROJECTIONS AND FY-1979 ALLOCATIONS

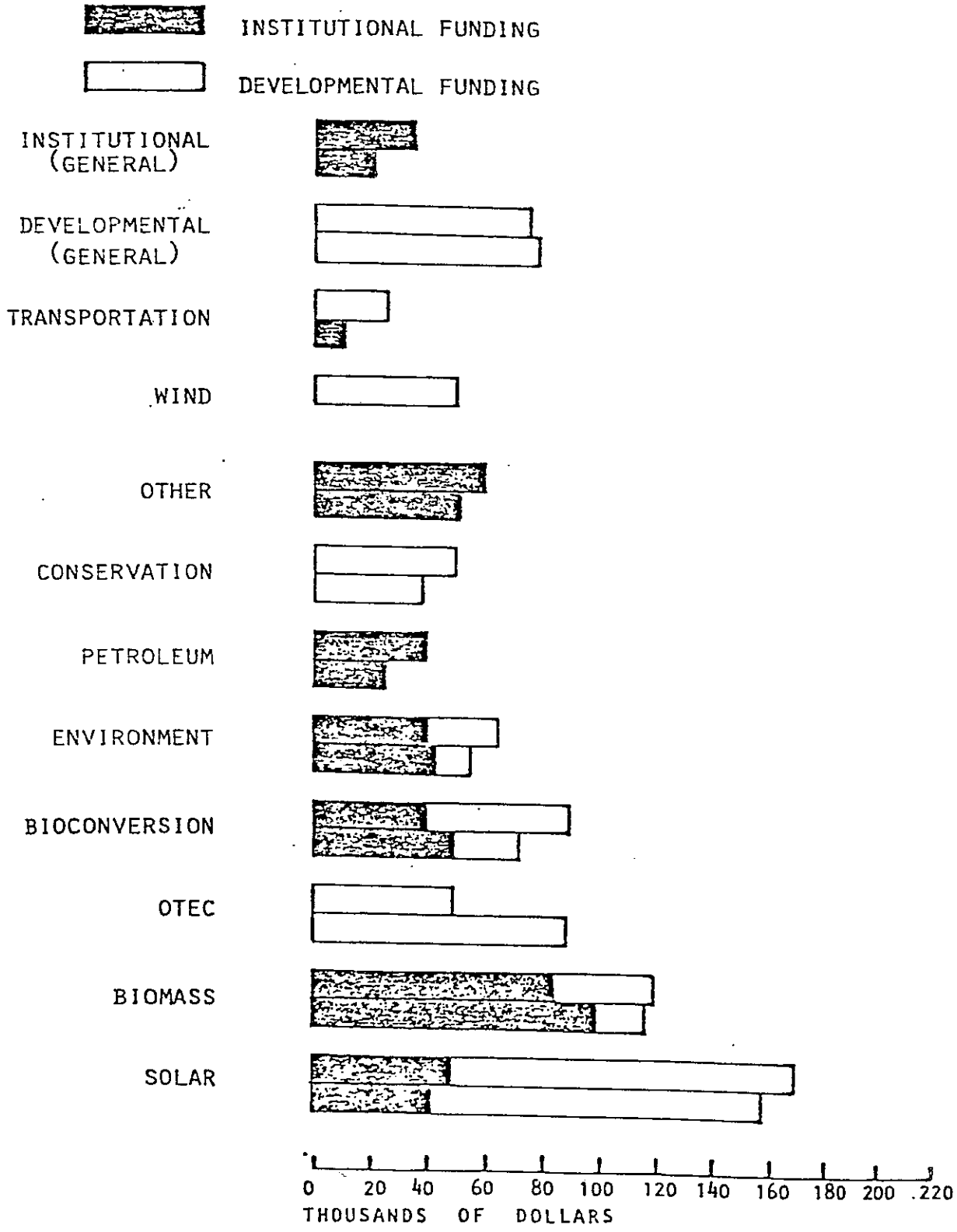


TABLE 2 - INSTITUTIONAL AND DEVELOPMENTAL FUNDING BY PROJECT AREAS: FY 79 AND FY 80

	PROGRAM	FY '79 INST	FY '79 DEV	FY '79 TOT	FY '80 INST	FY '80 DEV	FY '80 TOT
1.	Petroleum	25,300	---	25,300	40,000	---	40,000
2.	Biomass	100,050	18,400	118,450	85,000	35,000	120,000
3.	Bioconversion	49,795	23,000	72,795	40,000	50,000	90,000
4.	Solar	42,780	115,000	157,780	50,000	140,000	190,000
5.	Environment	42,780	11,500	54,280	40,000	25,000	65,000
6.	Other	51,750	---	51,750	60,000	---	60,000
7.	OTEC	---	89,999	89,999	---	50,000	50,000
8.	Conservation	---	39,095	39,095	---	50,000	50,000
9.	Inst. Prog.	26,505	---	26,505	35,000	---	35,000
10.	Dev. Accnt.	---	78,006	78,006	---	75,000	75,000
11.	Wind	---	---	---	---	50,000	50,000
12.	Transportation	11,040	---	11,040	---	25,000	25,000
	TOTALS	$350,000	$375,000	$725,000	$350,000	$500,000	$850,000

PROPOSED FIVE YEAR (1982-86) PLAN

SUMMARY

The proposed five year plan (1982-86) for the development of alternative energy sources is subdivided into thirteen (13) main subject areas:

I. OTEC
II. Biomass
III. Bioconversion
IV. Fossil Fuels Research
V. Solar Program
VI. Ecology Programs
VII. Environmental Health
VIII. Materials Development
IX. Integrated Technological Assessment
X. Nuclear Program
XI. Transportation and Conservation
XII. Public Awareness
XIII. International Programs

Summary Table S-1 "Total Funding Requirements for Proposed Five Year Plan" illustrates the funding level requirements for each subject program. Total funding requirements average out approximately $13.7 million per year. This is approximately 3-4 times the average level of CEER funding existing during the last two or three years. One of the

TABLE S-1

CEER - YEAR PLAN
TOTAL BUDGET REQUIREMENTS
Thousands $

	Program	82	83	84	85	86	TOTAL	% of Total
I.	OTEC	2,200	2,800	3,200	3,200	3,400	14,800	21.5
II.	Biomass	4,150	2,130	2,380	2,380	2,280	13,320	19.4
III.	Bioconversion	1,131	784	789	800	485	3,989	5.8
IV.	Fossil Fuels	1,124	1,049	1,072	926	826	4,997	7.3
V.	Solar	828	995	1,235	1,507	1,710	6,275	9.1
VI.	Ecology (excluding OTEC)	2,850	2,475	2,300	2,500	2,650	12,775	18.6
VII.	Environmental Health	600	605	760	850	940	3,755	5.5
VIII.	Materials	250	455	655	780	790	2,930	4.3
IX.	Integrated Ass.	155	170	185	255	285	1,050	1.5
X.	Nuclear	65	80	80	105	105	435	0.6
XI.	Transp. & Conserv.							
	a) Hybr. V.	475	202.5	445	370	167.5	1,659	2.4
	b) Policies	150	165	188	200	220	923	1.3
XII.	Public Awareness	667	245	280	311	334	1,837	2.7
XIII.	International	---	---	---	---	---	---	---
	TOTALS	14,645	12,155.5	13,569	14,184	14,192.5	68,746	100%

main reasons of the increase is that the proposed program budget reflects costlier development and demonstration programs as compared with previous less expensive programs addressed to develop baseline information data. 42% of the total budget goes toward "Development" and only 30% to Basic Research. This last requirement is badly needed for development of additional baseline information. Demonstration programs account for 22% of the Budget while training and education accounts for less than 6%. No meaningfull energy program could be developed without a funding comparable to the indicated in Summary Table S-1. OTEC is the largest budgeted program (21.5%) followed by Biomass (19.4%). Ecology which interfaces with several of the energy programs ranks third in budgeting (18.6%) followed by Solar (9.1%).

Summary Table S-2 "Total Program Personnel Distribution" illustrates the total manpower requirements, by classifications for all programs. For detail information on manpower requirements, per program see the corresponding Table 2 under the respective program section.

The total maximum projected personnel requirements for the program varies between 297-335. Present CEER total personnel is slightly under 200, hence this indicates an approximate growth of 77% to handle all programs. CEER feels that enough physical facilities are available. After decontamination of the nuclear reactor facilities in Mayaguez, that additional available space in addition to that available at the Rio Piedras facility should be able to accomodate the projected expansion.

Summary Table S-3 "Total Program Budget Distribution by Type of Research, Development, Demonstration and Education and Training. The largest component as previously pointed out is "Development". For details of Budget classification of a particular program refer to the corresponding Table 3 in the respective section program.

TABLE S-2

CEER 5-YEAR PLAN
TOTAL PERSONNEL DISTRIBUTION

Category/Year	82	83	84	85	86
Scientific Staff	94.25	92.15	101.55	104.8	106.6
Technical Staff	116.9	121.9	134.5	141.4	145.1
Administrative Staff	40.25	42.9	45.05	48.05	47.45
All Staff	251.4	256.95	281.1	294.25	299.15
Overhead Staff(1)	46	48	51	53	56
TOTAL	297.4	304.95	332.1	347.25	355.15

(1) Includes all classification (Adm. Tech. and Sc.). Figures reflect 5%/year increase from existing overhead staff.

TABLE S-3

CEER 5-YEAR PLAN
TOTAL BUDGET DISTRIBUTION
Thousands $

Category	82	83	84	85	86	TOTALS	% of Total
Basic Research	4,537	4,395	4,012	4,208	3,560	20,712	30.1
Development	4,567.5	4,947	6,599.5	6,622.5	6,644.5	29,381	42.7
Demonstration	4,527.5	2,227.5	2,327.5	2,612.5	3,192	14,887	21.7
Education & Training	1,013	586	630	741	796	3,766	5.5
TOTALS	14,645	12,155.5	13,569	14,184	14,192.5	68,746	100%

Summary Table S-4 "Total Program Budget Distribution Classified" illustrates the total budget classification distribution by personnel, equipment and materials, and services (contracts). Personnel Budget estimates of 50% of total indicates an adequate and appropriate use of the budget dollars. For details of the budget distribution for a particular program, refer to the corresponding Table 4 of the respective section program.

Figure 3 illustrates graphically the Budget distributions. The budget, as presented, does not reflect inflation but includes overhead and fringe benefits. Dollars indicated are early 1980 dollars.

Not included within the budget is the program on Energy Assessment Studies of Underdeveloped countries and Technology Transfer in the International Program. This can contribute substantially to the U.S. efforts. However it is rather difficult to estimate Budget requirements for this program. This will depend mainly on the role played by U.S. agencies and the degree of interaction and involvement of CEER in each program.

A detailed description with budget analysis for each program follows.

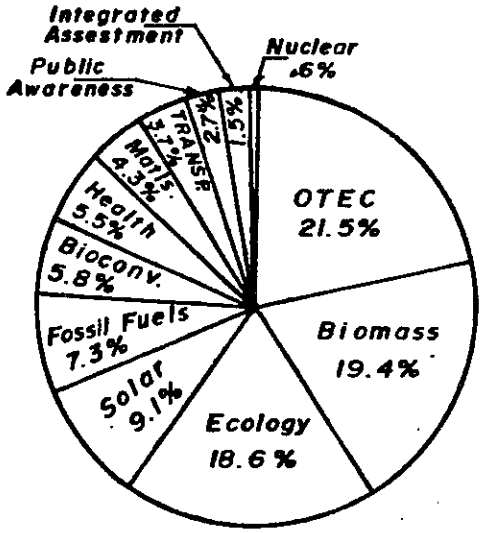
TABLE S-4

CEER 5-YEAR PLAN
TOTAL BUDGET DISTRIBUTION-CLASSIFIED
Thousands $

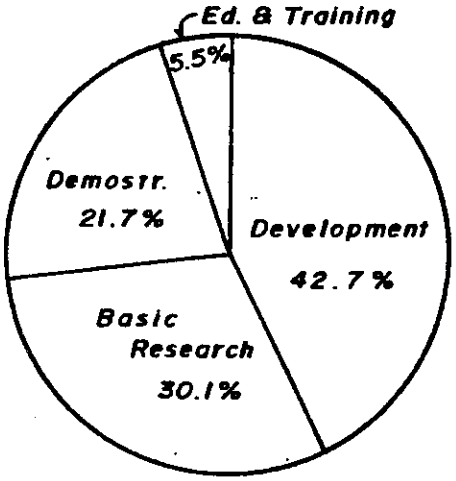
	82	83	84	85	86	Totals	% of Totals
Personnel	6,227	6,341.5	7,000	7,320	7,449.5	34,338	50.0
Equipment & Materials	5,166	2,618	2,869	3,045	3,157	16,855	24.5
Services	3,252	3,196	3,700	3,819	3,586	17,553	25.5
TOTALS	14,645	12,155.5	13,569	14,184	14,192.5	68,746	100%

FIG. 3. CEER 5 YEAR PLAN (1982-86)

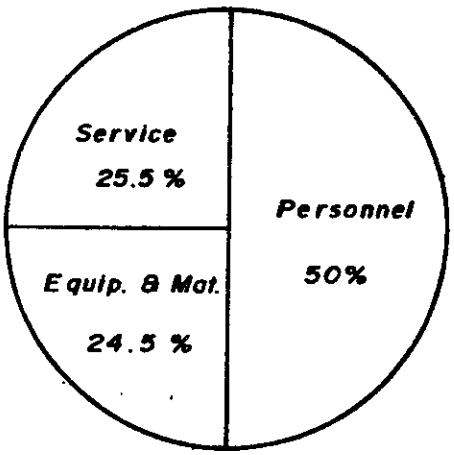
BUDGET AND PERSONNEL DISTRIBUTIONS



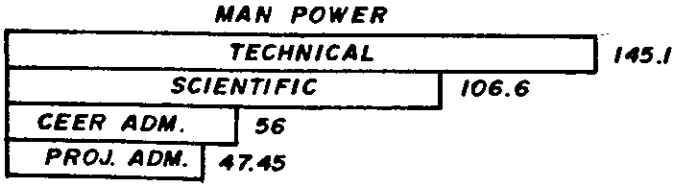
Budget Distr. by Programs



Budget Distr. by Type of Research



Budget Distr. by Services



Total Personnel Dist. for 1986 in number of Men

PROPOSED
FIVE YEAR PLAN PROGRAMS

1982-86

OTEC PROGRAM

I. OTEC PROGRAM

OTEC Studies - Integrated Engineering and Environmental Program

Puerto Rico is blessed with one of the best sites in the world for demonstrating technical and economic feasibility of an OTEC power plant sooner than any other USA mainland site. Efforts in OTEC Studies in Puerto Rico go as far back as 1966 when the local electric utility performed a study for the Punta Tuna site in South Puerto Rico and described a research program and the funding requirements.

In its normal operation an OTEC plant may be considered to be drawing up water from two depths and discharging it at a third depth as a mixed plume potentially containing a variety of adulterants. The discharge may be regarded as a point source subject to dispersion in whatever the prevailing currents may be in accordance with the myriad of factors which may influence that process. Intake and structural integrity questions are of greatest importance in the vicinity of the structure and diminish in importance with distance; whereas discharge questions may be regarded as increasing in importance to a maximum at some as yet unspecifiable but discrete distance "downstream" beyond which plant influences can no longer be differentiated from background.

The environmental information required for predicting the probable impact of the environment upon the plant overlaps broadly with the information needed to describe the environmental effects of an OTEC unit. It is mainly the details, emphasis and applications of the data which differ. Knowledge of currents, temperature structure, water mass chemistry, and dominant biota is required for different reasons

both near the plant site and "downstream". The CEER research plan for OTEC is designed to develop the above information with the appropriate emphasis on a field study which starts at the specific OTEC site off Punta Tuna and radiates broadly and with decreasing spatial resolution to encompass an area expected to intercept a plume arising at the OTEC discharge. Figure I-1 shows the grid of stations lying in a 60 degree arc having its main axis in a NE/SW (approximately 241° TN) direction originating at the OTEC site where a Landing Craft Utility (LCU) vessel will be moored for biofouling, corrosion and heat transfer studies. Figure I-2 locates Punta Tuna in Puerto Rico.

Periodic replicated measurements of current velocity and direction in relation to depth will be made at an array of stations within the grid and always at the LCU. Temperature, salinity, nutrients, dissolved oxygen, chlorophyll and phytoplankton profiles will likewise be measured across the grid. Zooplankton will be collected on the same synoptic cruises providing the other biological, physical and chemical data. On a schedule complementary to planned cruises similar data will be developed at the LCU, but with more detail to resolve patterns of vertical distribution and short term temporal variation (day-to-day and hour-to-hour). These data will be applied in the interpretation of the synoptic cruise data in which spatial and short term temporal variation will necessarily be confounded. LCU sampling will also emphasize entrainment/impingement potential, the potential for physical stress to structures due to currents and waves and an evaluation of the thermal resource. LCU studies will further provide a backdrop of potential

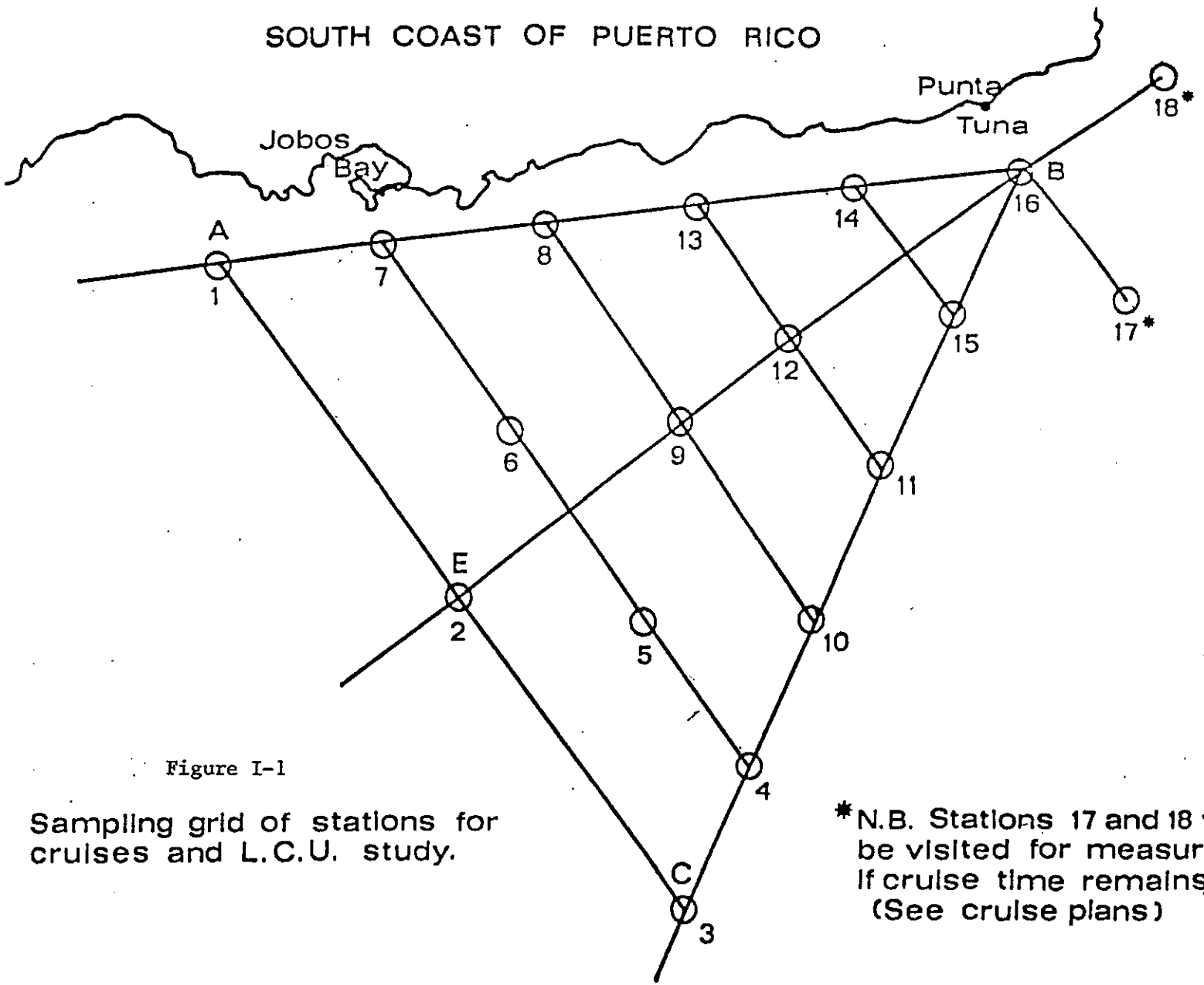


Figure I-1

Sampling grid of stations for cruises and L.C.U. study.

*N.B. Stations 17 and 18 will be visited for measurement if cruise time remains. (See cruise plans)

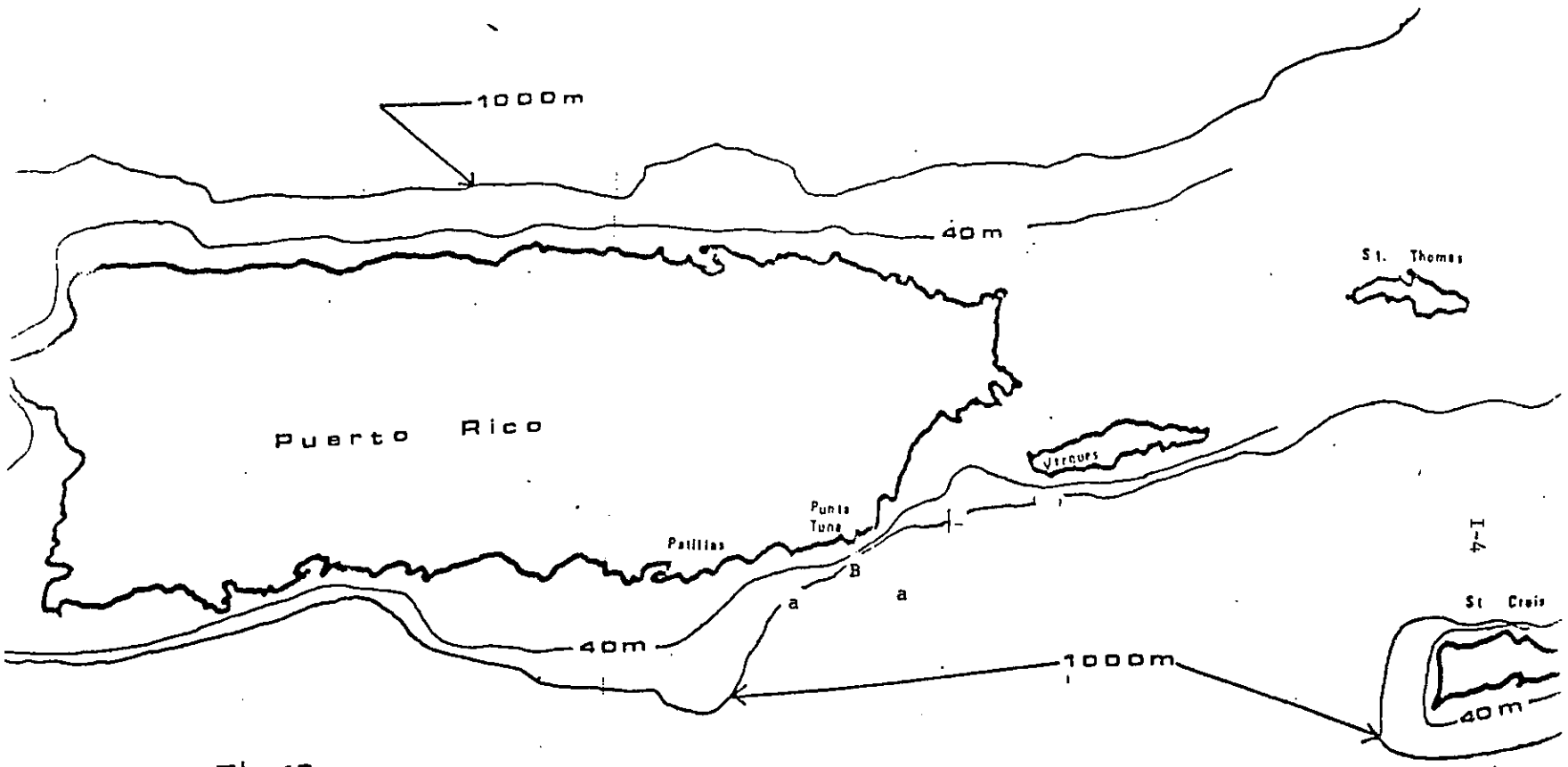


Figure I-2

Proposed Station Locations
"B"--Benchmark, Augmented, & Ancillary
"A"--Augmented, & Ancillary
"a"--Ancillary only

physical, chemical and biological correlates for the biofouling, heat transfer and corrosion measurements concurrently being made there. Studies are planned which will define water masses in the vicinity, and by the use of drogues define a "most probable plume" for purposes of determining which areas and ecological communities most need to be studied downstream.

Data from the first year of study will be used along with the latest design information to refine estimates of a most probable plume and of the most likely environmental impacts for further study. The later studies will focus on the effects of biocides on model heat exchanger biofouling, corrosion and heat transfer and within the most probable plume area on the effects of biocides, heavy metals and working fluid on organisms residing there.

TABLE I-1

PROGRAM OVERALL BUDGET
(Thous. of Dollars)

Program Titles	82	83	84	85	86*
OTEC					
A. Evaporator (Biofouling, Corrosion, Materials, Cleaning and Enhanced Heat Transfer)	250	300	350	250	150
B. Condensor (Inorganic Fouling, Corrosion, Materials, Cleaning and Enhanced Heat Transfer)	450	500	550	450	350
C. Site Characteristic and Ecological Effects (Current Waves, Nutrients, Entrainment, Biocides)	1,200	1,650	1,900	2,050	2,400
D. Miscellaneous (Raiser Cable, CWP, Mariculture, Advanced Systems)	300	350	400	450	500
TOTALS	2,200	2,800	3,200	3,200	3,400

*Approximately 400K/yr will be used through 85 for operation of the research facility. Budget assumes OTEC 10-100 platform will be available in FY-86, thus research facility operation is reduced to 100K/yr.

TABLE I-2

PROGRAM PERSONNEL DISTRIBUTION
(Man-Years)

Program Titles	82	83	84	85*	86
OTEC					
A. Evaporator					
Scientific Staff	1.0	1.2	1.5	1	.5
Tech. Staff	2.0	2.4	3.3	1.4	1.0
Adm. Staff	.3	.3	.3	.3	.3
B. Condensor					
Scientific Staff	2.0	2.3	2.7	2.0	1.6
Tech. Staff	4.3	4.9	5.7	4.3	3.7
Adm. Staff	.3	.3	.3	.3	.3
C. Site Characterization and Ecological Effects					
Scientific Staff	6	7.2	8.2	9.0	12.5
Tech. Staff	7	9.2	10.9	12.2	16.6
Adm. Staff	1	1	1	1	1
D. Miscellaneous					
Scientific Staff	1	1.3	1.6	2.0	2.5
Tech. Staff	2.7	3.5	4.1	4.7	6.0
Adm. Staff	.4	.4	.4	.4	.4
TOTALS					
Scientific Staff	10	12.0	14	14	17.1
Technical Staff	16	20	24	22.6	27.3
Adm. Staff	2	2	2	2	2
ALL STAFF	28	34	40	38.6	46.4

*9 man-yrs/yr will be subcontracts for research platform operation and do not show in this table.

TABLE I-3

PROGRAM BUDGET DISTRIBUTION BY TYPE OF RESEARCH
(Thous. of Dollars)

Program Titles	82	83	84	85	86	Totals
OTEC						
A. Evaporator						
Basic Research	50	50	0	0	50	
Development	200	250	250	125	100	
Demonstration	0	0	0	0	0	
Educ. & Training	0	0	0	0	0	
B. Condensor						
Basic Research	100	100	50	0	100	
Development	350	400	400	350	250	
Demonstration	0	0	100	100	0	
Educ. & Training	0	0	0	0	0	
C. Site Characterization and Ecological Effects						
Basic Research	200	200	200	200	200	
Development	1,000	1,450	1,700	1,800	2,150	
Demonstration	0	0	0	50	50	
Educ. & Training	0	0	0	0	0	
D. Miscellaneous						
Basic Research	200	250	250	250	250	
Development	100	100	150	200	250	
Demonstration	0	0	0	0	0	
Educ. & Training	0	0	0	0	0	
TOTALS						
Basic Research	550	600	500	450	600	2,700
Development	1,650	2,200	2,500	2,475	2,750	11,575
Demonstration	0	0	200	275	50	525
Educ. & Training	0	0	0	0	0	0
TOTALS	2,200	2,800	3,200	3,200	3,400	14,800

BIOMASS PROGRAM

II. BIOMASS PROGRAM

A. Existing Programs

Biomass production research studies on tropical grasses and sugarcane were initiated in 1976 the UPR Center for Energy and Environment Research (CEER). Sugarcane, tropical grasses related to sugarcane, and other tropical grasses have large growth potentials on a year-round basis in Puerto Rico due to the high insolation rates and appropriate soils. This, together with the available scientific and technical personnel and agronomical laboratories makes biomass research an attractive possibility to help in the solution of energy problems. It is estimated that the ailing sugar industry presently using over 70,000 acres of land could be replaced by an economically viable biomass for energy and higher-test molasses (to supply the rum industry agricultural program. The important rum industry in Puerto Rico imported last year 90% of its molasses. The basic R&D information resulting from this program is useful to many Caribbean Islands, Latin America nation as well as mainland USA.

The basic premise is that such plant materials can be produced as a renewable, domestic source of fuels and chemical feedstocks that will substitute for imported fossil fuels. Two annual reports dated 1977-78 and 1978-79 to DOE presents the results of two years of research efforts. Fuel costs of the order of $1.70 per million BTU have been predicted with year round production of tropical grasses.

The Project Objectives of this Program have been (a) determination of the agronomic and economic feasibility of mechanized, year-round production of solar-dried biomass, through the intensive management of sugarcane and napier grass as tropical forages, and (b), examination of alternate tropical grasses as potential sources for intensive biomass production. A secondary objective concerns the selection and breeding of new sugarcane progeny having superior biomass productivity as their principal attribute.

It is estimated that this Program needs to be continued at the present level of funding of approximately $400,000 per year up to the Year 1984-85.

New Programs:

B. Hydrocarbon Producing Plants

While tropical grasses (sugar cane-S. Officinarum x s. spontaneum) and napier grass (Pennisetum purpureum) have impressive production records in Puerto Rico they require larger water demands than hydrocarbon bearing plants of the Euphorbias, Asclepiais and Guayale families. Fresh water requirements for the tropical grasses require water within

probably less than 500 ppm salts content while the indicated hydrocarbon producing plants might thrive with water as much as 2000 ppm salt content. They are very rugged type plants and might adapt hetter to the more hostile environment of southwestern Puerto Rico and southwestern U.S. desertic areas. They also can grow better in steep slopes.

The chemical components extracted from the hydrocarbon producing plants of the families indicated abovr are more valuable than the heat content of the fibers. Even after the hydrocarbons, which are mainly Polymers of isoprene, are extracted, the resultant fiber still can be used as biomass fuel with 7000-7500 BTU per dry pound. About 20% by wieght of isoprene polymers can be extracted from the indicated plants.

Puerto Rico has about 65 species of 10 families of such hydrocarbon producing plants and import can also be made from Brasil, other South American countries, and the western USA mainly California.

The principal objectives of the project will be (a) the identification of the most promising candidates for detailed studies of selection and breeding of switable hydrocarbon bearing plants progeny having superior isoprene polymers productivity as their principal attribute. Included within this objectives are laboratory studies for characterization of the isoprene polymers and evaluation of their conversion

into useful motor fuels and chemical feedstocks. (b) determination of the agronomic and economic feasibility through intensive management of hydrocarbon bearing plant plantation.

Some effort is presently being performed at CEER in this area. Samples are being collected from local hydrocarbons producing plant and analyzed.

The level of funding is estimated as follows:

82	83	84	85	86
150K	200K	400K	500K	500K

It is estimated that a technical staff of seven agronomists and one organic (hydrocarbon) chemist will be involved in this project.

C. Seaweed, Farming and Harvesting

Although land used for uneconomical agricultural programs such as sugar cane could be made economically productive in a combined biomass for energy programs as previously indicated, harvesting the seas make more sense for Puerto Rico and many others small caribbean islands than land biomass.

This research study will address itself also to the possibility of developing and harvesting tropical marine algaes including sargassum. From using available data and from direct simple observation a very preliminary assessment will be made. Two factors are important for the development of a marine farm:

1. Water depth
2. Water currents
3. Available nutrients

Water depth above 200 ft. results unsuitable for development of any type of marine algae. Marine kelp, a red algae can thrive in depths up to 150 ft. They require relatively slow water motion. Abrupt water current changes produce serious obstacles to the thriving of these algaes. The study will try to identify any appropriate marine areas which could be used for detailed studies and further definition and roughly estimate its potential values.

It is estimated that a technical staff of 3-4 scientists will be involved.

The level of funding is estimated as follows:

82	83	84	85	86
100K	150K	200K	300K	400K

D. Direct Firing of Biomass (Tropical Grasses and/Sugarcane

Solar dried biomass is contemplated for direct firing in conventional waterwall steam boilers in central electric power plants. The BTU content of dried (15%) sordan is approximately 7500 BTU/lb or 15 millions BTU per ton. It is estimated that one single 450MW generating unit operating at 75% capacity factor can supply by the year 1987, 13% of the electrical energy needs of Puerto Rico and displace approximately 5 million barrels of Bunker C oil. This will require 55,000-60,000 acres of land. By contrast, the ailing sugar cane industry in Puerto Rico has over 70,00 acres of sugar cane plantation. Sugarcane production in Puerto Rico is uneconomical at present

and was government subsidized last year to the approximate figure of $500 per acre of sugar cane plantation.

Economic analysis indicate that direct biomass firing can be economically more attractive than oil, coal and OTEC plants in the Puerto Rico Scenario. For the year 1990, CEER energy studies analysis indicate that direct firing of biomass in Puerto Rico in 450MW units can produce electricity with a levelized cost of 9 cents per kwhr including 8% compounded inflation up to 1985 and 5% per year compounded inflation thereafter. For the same escalation assumptions and year, a 450MW coal fired plants can produce electricity at the lowest estimated cost of 12 cents per kwhr levelized cost, while a 250MW OTEC Plant will be over 14 cents per kwhr levelized cost. An oil fired plant is estimated to produce energy at a levelized cost of 46 cents per kwhr assuming 9% per year inflation in oil costs.

Program D Objectives:

The principal objective of the direct firing program is to convert an existing sugar mill to handle 1000 tons of biomass oer day, and determine the logistics of production, drying, transportation, storing and burning of biomass, and technical modifications and improvements to boiler handling and burning equipment and particulate and gaseous emissions characteristics. Electric power utilities will therefore be able to incorporate is steam boiler bids specifications,

enough technical data for specifying steam boilers to burn biomass and design other items such as storage and handling equipment accordingly.

The project will be divided into four principal phases as follows:

(a) Installation and testing of a biomass dryer phase

The Stearn-Roger Company of Denver has previously installed rotary dehydrator in sugar mills on the US mainland and Hawaii. This unit will be a rotary dehydrator utilizing waste heat from the mill stacks. It must be capable of drying large daily tonnages to 40% moisture and lesser amounts to 15-25% moisture. The atmospheric emissions produced from such plant will be compared to those from more conventional plants.

(b) Biomass Storage Facility Phase

A biomass complex must be constructed to accomodate both solar dried and mechanically dried biomass fuels. A structure, aluminum roofed, open-sided, 12 ft. deep, and total 120,000 sq.ft. area with bituminous-crushed stone floor designed for biomass carrying vehicles is envisioned as a typical biomass storage structure for the 100 tons per day project. This will provide 60 day-storage. Construction cost is estimated at $7.00/sq.ft. The unit must be suitably designed so

that fuel can flow to the boiler with minimum handling costs and ease of operations.

(c) Agricultural Field Operations Phase

Optimization of land use (8000 acres) for full year operation of the project:

1) already planted land for 1st. year operation
2) replantation
3) mix of different species, cane, napier and sordan.

(d) Environmental Assessment

Examination of the impact of such harvest and culture operations upon surface and ground water quantity and quality. The extent to which culture techniques to achieve maximum biomass require fossil fuels in terms of fertilizer and biocides applications which may also have environmental costs, and increase total operational costs, should be assesed.

(e) Mill Engineering Phase

Modifications to the existing mill and performance evaluation.

D. DIRECT FIRING OF BIOMASS

Project D Estimate (Thousands)

Item	82	83	84	85	86
Salaries and wages	180,	180,	180,	180,	180,
Equipment	2,000,	80,	80,	80,	80,
Field Operations	650,	650,	650,	650,	650,
Travel & Per Diem	10,	10,	10,	10,	10,
Additional Direct Costs (Maint.) and Others	36,	150,	150,	150,	150,
Total Direct Costs	2876	1070	1070	1070	1070
Indirect Cost 45% of Salaries and Wates	81	81	81	81	81
Sub-Total	2957	1151	1151	1151	1151
20% Contingency	591	230	230	230	230
TOTAL	3548	1381	1381	1381	1381

5 Yr. Total = $9072

TABLE II-1

TOTAL BIOMASS BUDGET (Thousands $)

	Project	82	83	84	85	86
A-	Tropical Grasses Agronomic Studies (Continued)	400	400	400	200	-
B-	Hydrocarbon Bearing Plants	150	200	400	500	500
C-	Seaweed	100	150	200	300	400
D-	Direct Firing of Biomass	3,500	1,380	1,380	1,380	1,380
	TOTALS	4,150	2,130	2,380	2,380	2,280

TABLE II-2

BIOMASS PROGRAM PERSONNEL DISTRIBUTION

(Man-Years)

		82	83	84	85	86
A.	Existing Tropical Grasses Biomass Program					
	Scientific Staff	4	4	4	2	-
	Technical Staff	3	3	3	1.5	-
	Administrative Staff	1	1	1	1	-
B.	Hydrocarbon Bearing Plants					
	Scientific Staff	2	3	4	4	4
	Technical Staff	1	2	3	3	3
	Administrative Staff	1	1	1	1	1
C.	Seaweed Farming and Harvesting					
	Scientific Staff	2	2	2	3	3
	Technical Staff	1	2	2	2	4
	Administrative Staff	0	1	1	1	1
D.	Direct Firing of Biomass					
	Scientific Staff	4.5	4.5	4.5	4.5	4.5
	Technical Staff	3.0	3.0	3.0	3.0	3.0
	Administrative Staff	1.0	1.0	1.0	1.0	1.0
	TOTALS					
	Scientific Staff	12.5	13.5	14.5	13.5	11.5
	Technical Staff	8.0	10.0	11.0	9.5	10.0
	Administrative Staff	3.0	4.0	4.0	4.0	3.0
	ALL STAFF	23.5	27.5	29.5	27.0	24.5

TABLE II-3

PROGRAM BUDGET DISTRIBUTION BY TYPE OF RESEARCH

A. Existing Tropical Grasses Biomass Program

	82	83	84	85	86	Totals
Basic Research	200	200	200	100	-	
Development	200	200	200	100	-	
Demonstration	0	0	0	0	-	
Education & Training	0	0	0	0	-	

B. Hydrocarbon Bearing Plants

Basic Research	150	200	200	300	300	
Development	0	0	200	200	200	
Demonstration	0	0	0	0	0	
Education & Training	0	0	0	0	0	

C. Seaweed Farming and Harvesting

Basic Research	100	150	150	150	250	
Development	0	0	50	150	150	
Demonstration	0	0	0	0	0	
Education & Training	0	0	0	0	0	

D. Direct Firing of Biomass

Basic Research	-	-	-	-	-	
Development	-	-	-	-	-	
Demonstration	3,500	1,380	1,380	1,380	1,380	
Education & Training	-	-	-	-	-	

TOTALS

Basic Research	450	550	550	550	550	2,650
Development	200	200	450	450	350	1,650
Demonstration	3,500	1,380	1,380	1,380	1,380	9,020
Education & Training	0	0	0	0	0	0
TOTALS	4,150	2,130	2,380	2,380	2,280	13,320

TABLE II-4

BIOMASS PROGRAM BUDGET DISTRIBUTION-CLASSIFIED
(Thousands $)

		82	83	84	85	86	Totals
A.	Existing Tropical Grasses Biomass Program						
	Personnel	200	200	200	100	-	
	Equipment and Materials	150	150	150	75	-	
	Services	50	50	50	25	-	
B.	Hydrocarbon Bearing Plants						
	Personnel	75	125	200	200	200	
	Equipment and Materials	50	50	100	200	200	
	Services	25	25	100	100	100	
C.	Seaweed Farming and Harvesting						
	Personnel	60	100	100	135	200	
	Equipment and Materials	30	35	50	100	100	
	Services	10	15	50	65	100	
D.	Direct Firing of Biomass						
	Personnel	313	313	313	313	313	
	Equipment and Materials	2200	96	96	96	96	
	Services	987	971	971	971	971	
	TOTALS						
	Personnel	648	738	813	748	713	3660
	Equipment and Materials	2430	331	396	471	396	4024
	Services	1072	1061	1171	1161	1171	5636
	TOTALS	4150	2130	2380	2380	2280	13,320

BIOCONVERSION PROGRAM

III. BIOCONVERSION PROGRAM
METHANE

It is rapidly becoming apparent that Bioconversion may be one of the key components in the resolution of the critical energy problems facing the world at present. In addition, judicious choices of the operational parameters of this process can contribute to no small extent to the amelioration of the agricultural and protein shortfalls in many parts of the world. Although the basic elements of bioconversion are well known, and in fact have been successfully employed for centuries, it is necessary to study and develop techniques and devices which can be integrated into modern mass production methods to produce simple, low cost systems. These must be compatible with the technological and economic constraints of the Third World and developing countries, and those sectors of the industrialized nations where isolated appropriete technology concepts are still apllicable.

Present research at this Institution has been following as much as possible these guidelines in the design and prototype testing of anaerobic digestion systems for a variety of substrates. After a comprehensive survey of the literature and an assessment of the low level decentrailized energy needs of Puerto Rico and other less developed areas of the Caribbean, designs were developed for a series of bioconverters, some of which have already been constructed and are operational.

The primary consideration was in maximizing the conversion of

the most commonly available biomass and each bioconverter was designed for a specific substrate. The systems tested and shown to produce usable methane (and other valuable by-products) used as substrates water hyacinths, agricultural waste, animal (poultry ans swine) waste; cafeteria refuse and rum slops.

At present, continuously operating bioconverters are those using water hyacinths, rum waste and cafeteria refuse. The first two units are operating at CEER and the cafeteria waste converter is in operation at the Ft. Buchanan Army Base in cooperation with the Army's Environmental Research Program.

Preliminary assessment is under way of the potential of the marine algae Sargassum as a bioconversion substrate. With the cooperation of the Goddard Space Laboratories (Bethesda) of NASA, a series of satellite photographs of Sargasso sea were made available and are currently being examined.

Another area which is currently being explored is potential of the municipal refuse deposits as a source of naturally generated methane in appreciable quantities. Designs have been for an experimental methane tapping system and it is expected that this will be functional early in 1980.

In addition to the experimental work, the staff of the Bioconversion Program has been active in a number of conferences, locally and on the mainland, relating to Bioconversion. Presentations were made of the Division's project and concepts. At the present number, there are also a number of proposals to various agencies now under

consideration for future funding of continuing efforts in all areas of bioconversion.

Preliminary studies have been initiated in other areas of bioconversion such as biophotolysis, hydrogen production and assessment of hydrocarbon plants as fuel producers. After completion of literature studies experimental operations, as indicated in the following pages, will be initiated.

The specific objectives of the Bioconversion Program are:

1. Produce, use and demonstrate the technical and economic feasibility of fermentative biogas production from locally available biomass in decentralized, low technology operations.
2. Instrument and monitor existing or newly constructed biogas production facilities.
3. Develop alternate uses for anaerobically fermented waste residue and effluent.
4. Work with local industry to help reduce environmental pollution and petroleum derived energy dependence by biological converting wastes into biogas and secondary products.
5. Design, and monitor biological energy production systems for incorporation into existing agricultural or industrial facilities in Puerto Rico.
6. Optomize and demonstrate hydrogen production by biophotolysis.
7. Design, construct and demonstrate the feasibility of using the marine ecosystem as a source of biomass for biogas production.
8. Act as a central technology data source for tropical biogas

production information and expertise.

9. Develop and demonstrate the construction of a functional and useful biological analogue of the photovoltaic cell using halophylic bacteria.

10. Preliminary screening of other general bioconversion processes for energy or environment conservation.

The following is proposed as the Experimental Program to meet Bioconversion objectives:

A. Biogas demonstration program

Design, construct and demonstrate the biogas production potential of locally available biomass sources. Program duration 5 years, approximately 10 person years required.

B. Commercial monitoring program

Instrumentation and monitoring commercial scale biogas production facilities; program duration 4-8 years, approximately 8 persons years required.

C. Alternative waste utilization program

Develop alternative uses for anaerobically fermented waste residue and effluent. Program duration 6 years, approximately 14 person years required.

D. Industrial energy production and waste utilization program

Work with local industry to help reduce environmental pollution and dependence upon petroleum derived energy resources. Program duration 5 years, approximately 12 person years required.

E. Biophotolysis program

Optomize and demonstrate biophotolysis potential. Program duration 4 years, approximately 10 person years required.

F. Marine biomass program

Demonstrate the marine environment as a biomass and biogas production resource. Program duration 8 years, approximately 18 person years required.

G. Information transfer program

Transfer appropiate technology information to local personnel. Continual program, approximately 1.5 years required yearly.

H. Light activated biological proton pumping program

Investigate the feasibility of utilizing the light activated protein pumping characteristics of the purple membrane segment from halophilic bacteria in the construction of a functional and useful biological analogue of the photo-voltaic cell. Program duration 5 years, approximately 10 person years required.

I. Bioconversion screening program

Evaluate various bioconversion processes for energy or environment conservation. Program duration 6 years, approximately 13 person years required.

Tables III-4 indicates the budget distribution for these above programs.

III.b BIOCONVERSION
ETHANOL

Puerto Rico, and particularly the University of Puerto Rico is well suited for conducting fermentation ethanol studies with sugarcane. The Island has a long history of conventional cane production in support of the sugar-refining and distillery industries. There is a natural capability for year-round harvesting of sugarcane, which would provide a continual influx of raw juice and eliminate the need to produce and store molasses for off-season fermentation.

Several divisions within the UPR framework are ideally qualified for specific contributions to ethanol research. The Agricultural Experiment Station can readily supply the input cane from both conventional and energy-plantation growth regimes. The Experiment Station's Rum Pilot Plant has a range of fermentation facilities and technical personnel long acquainted with fermentation research. Other personnel from the UPR Department of Chemical Engineering are also available to support ethanol studies. Puerto Rico's Sugar Corporation, a unit of the local Department of Agriculture, can also contribute to sugar production and fermentation studies.

ETHANOL PROJECT

The Ethanol project would evaluate ethanol production costs utilizing sugarcane juice and high-test molasses as direct sources of fermentable solids. Emphasis would be directed toward minimizing producting costs by utilizing a one or two-step milling operation, reduced fermentation time, and distillation-extraction modifications. Cost reduction studies would center on reduced milling expenditures, direct fermentation of raw juice, improved fermentation efficiency through superior yeast selection and process modification, and improved distillation processes.

The economic assessment of processes using crude juice as a direct source of fermentable solids, as opposed to the more costly preparation of stable high-test molasses, is regarded as an important phase of the proposed project. For this purpose the Vogelbusch approach is ideally suited since the fermentors are closed systems working with yeast recycling. This assures that alcohol losses are negligible and contamination is minimized. By evaporating the clarified juice to a stable syrup, a substantial cost factor is added to the process which could render the ethanol produced too expensive for its use as a motor fuel and for most industrial applications. For rum production, the added cost impact may be marginal. In the latter instance the molasses is ordinarily transported to a rum distillery site, and hence the increased shipping charges for raw juice would offset some of the savings expected from direct fermentation of the juice.

For practical purposes it will be better to perform the ethanol production operations directly at the milling site. This will minimize transportation and storage costs and the need for storage facilities.

Distillilation process: The conventional distillation has as its object the purificaton and concentration of ethyl alcohol by using a system comprised of three columns. These are the "beer", purification, and rectification columns. Waste streams, termed "slops", consist of water or water containing solids in solution or suspension. In thc usual distillation process for rum, by-product streams include "fusel oils" (mixtures of alcohols with substances having more than two carbon atoms per molecule), and "heads" (mixtures of aldehydes, ketones, esters, acids, and amines). The separation of these components from ethanol is a cost factor which probably is not necessary in a fuel-production process. An important feature of the proposed project is the evaluation of means whereby this step can be minimized or eliminated.

Project Objectives

The primary objective of this project is to evaluate the direct production of ethanol from surgarcane fermentable solids in an integrated system, with emphasis on modified technologies and economization of the integrated processes.

Project Approach

The necessary tasks to achieve this goal are:

a. A pre-milling preparation of cane, followed by one or two milling steps aimed at the extraction of maximum recoverable fermentable solids.

b. An economic evaluation of the suitability of crude juice as a fermentation substrate, as opposed to high test-molasses.

c. A short time fermentation technology based on continuous fermentation and the development of economical techniques to extract the ethanol product.

d. To perform an economic analysis of the various steps, including an assessment of the major implications of the integrated processes, and to make recommendations applicable to industrial-scale production of ethanol.

TABLE III-1a

BIOCONVERSION PROGRAM TOTAL BUDGET
($ Thousands)

		82	83	84	85	86
A.	Biogas Demonstration	85	50	50	45	45
B.	Commercial Monitoring	85	55	40	40	40
C.	Alternative Waste Utilization	112	75	80	70	65
D.	Industrial Energy Production	90	60	65	70	75
E.	Biophotolosys	114	75	75	70	-
F.	Marine Biomass	250	160	165	165	160
G.	Information Transfer	35	25	25	30	30
H.	Light Activated Biological Pumping	60	32	32	34	34
I.	Bioconversion Screening	80	32	32	36	36
	TOTALS	911	564	564	560	485

TABLE III-2a

BIOCONVERSION-BUDGET BY PERSONNEL DISTRIBUTION

	82	83	84	85	86
Project A - Biogas Demonstration					
Scientific Staff	.5	.5	.5	.5	.5
Technical Staff	.7	.9	.9	1.0	1.0
Administrative Staff	0	0	0	0	0
Project B - Commercial Monitoring					
Scientific Staff	.5	.5	.5	.5	.5
Technical Staff	.5	.5	.6	.7	.7
Administrative Staff	.3	.3	.3	.3	.3
Project C - Alternative Waste					
Scientific Staff	.5	.5	.5	.5	.5
Technical Staff	.7	.8	.9	1.0	1.1
Administrative Staff	.3	.3	.3	.3	.3
Project D - Industrial Energy Production					
Scientific Staff	.4	.4	.4	.4	.4
Technical Staff	.9	1.1	1.1	1.2	1.2
Administrative Staff	0	0	0	0	0
Project E - Biophotolysis					
Scientific Staff	.5	.5	.5	.5	0
Technical Staff	.7	.8	.9	1.0	0
Administrative Staff	0	0	0	0	0
Project F - Marine Biomass Conversion					
Scientific Staff	.5	.5	.5	.5	.5
Technical Staff	1.3	1.4	1.5	1.6	1.7
Administrative Staff	0	0	0	0	0
Project G - Information Transfer					
Scientific Staff	.2	.2	.2	.2	.2
Technical Staff	.2	.2	.3	.3	.4
Administrative Staff	.4	.4	.4	.4	.4

TABLE III-2a(Continuation)

	82	83	84	85	86
Project H - Light Activated Biological Proton Pumping					
Scientific Staff	.4	.4	.4	.4	.4
Technical Staff	.5	.6	.7	.8	.9
Administrative Staff	0	0	0	0	0
Project I - Bioconversion					
Scientific Staff	.1	.1	.1	.1	.1
Technical Staff	1.2	1.2	1.3	1.3	1.4
Administrative Staff	0	0	0	0	0
TOTALS					
Scientific Staff	3.6	3.6	3.6	3.6	3.1
Technical Staff	6.7	7.5	8.3	9.0	8.5
Administrative Staff	1.0	1.0	1.0	1.0	1.0
Total Staff	11.3	12.1	12.9	13.6	12.6

TABLE III-3a

BUDGET DISTRIBUTION BY TYPE OF RESEARCH

	FY ($1000.00)				
	82	83	84	85	86
Project A - Biogas Demonstration					
Basic Research	0	0	0	0	0
Development	0	0	0	0	0
Demonstration	85	50	50	45	45
Education & Training	0	0	0	0	0
Project B - Commercial Monitoring					
Basic Research	40	45	25	25	25
Development	0	0	0	0	0
Demonstration	45	10	15	15	15
Education & Training	0	0	0	0	0
Project C - Alternate Waste Utilization					
Basic Research	100	50	70	50	50
Development	12	25	10	20	15
Demonstration	0	0	0	0	0
Education & Training	0	0	0	0	0
Project D - Industrial Energy Production					
Basic Research	90	50	50	50	50
Development	0	10	15	20	25
Demonstration	0	0	0	0	0
Education & Training	0	0	0	0	0
Project E - Biophotolysis					
Basic Research	114	75	70	10	-
Development	0	0	5	60	-
Demonstration	0	0	0	0	-
Education & Training	0	0	0	0	-
Project F - Marine Biomass					
Basic Research	200	110	110	50	50
Development	50	50	55	50	50
Demonstration	0	0	0	0	0
Education & Training	0	0	0	0	0

TABLE III-3a (Cont.)

	82	83	84	85	86	
Project G - Information Transfer						
Basic Research	0	0	0	0	0	
Development	0	0	0	0	0	
Demonstration	0	0	0	0	0	
Education & Training	35	25	25	30	30	
Project H - Light Activated Biological Pumping						
Basic Research	60	32	32	34	34	
Development	0	0	0	0	0	
Demonstration	0	0	0	0	0	
Education & Training	0	0	0	0	0	
Project I - Bioconversion Screening Program						
Basic Research	50	15	15	18	18	
Development	30	17	17	18	18	
Demonstration	0	0	0	0	0	
Education & Training	0	0	0	0	0	
TOTALS ($ Thousands)						
Basic Research	654	377	372	237	227	1867
Development	92	102	102	168	108	572
Demonstration	130	60	65	125	120	500
Education & Training	35	25	25	30	30	145
TOTALS	911	564	564	560	485	3084

TABLE III-4[a]

BIOCONVERSION PROGRAM BUDGET BY CLASSIFICATION

	82	83	84	85	86
Program A - Biogas Demonstration					
Personnel	30	33	34	35	35
Equipment & Materials	55	17	16	10	10
Services	0	0	0	0	0
Program B - Commercial Monitoring					
Personnel	30	31	32	33	34
Equipment & Materials	55	24	8	7	6
Services	0	0	0	0	0
Program C - Alternative Waste Utilization					
Personnel	35	37	39	41	43
Equipment & Materials	77	38	41	29	22
Services	0	0	0	0	0
Program D - Industrial Energy Production					
Personnel	30	33	34	35	36
Equipment & Materials	60	27	31	35	39
Services	0	0	0	0	0
Program E - Biophotolysis					
Personnel	30	32	34	36	-
Equipment & Materials	84	43	41	34	-
Services	0	0	0	0	-
Program F - Marine Biomass					
Personnel	40	42	44	46	48
Equipment & Materials	210	118	121	119	112
Services	0	0	0	0	0
Program G - Information Transfer					
Personnel	17	18	19	20	21
Equipment & Materials	18	5	5	8	9
Services	0	2	1	2	2

TABLE III-4 a(Cont.)

	82	83	84	85	86	
Program H - Light Activated Biological Pumping						
Personnel	22	24	26	28	30	
Equipment & Materials	38	8	6	6	4	
Services	0	0	0	0	0	
Program I - Bioconversion Screening						
Personnel	25	26	27	28	29	
Equipment & Materials	55	6	5	8	5	
Services	0	0	0	0	0	
TOTALS (Thousand dollars)						Totals
Personnel	259	276	289	302	276	1402
Equipment & Materials	652	286	274	256	207	1675
Services	0	2	1	2	2	7
TOTALS	911	564	564	560	485	3084

BIOCONVERSION

CEER 5 YEAR PLAN

ETHANOL PROJECT

TABLE IIIb-1

	82	83	84	85	86	Total
TOTALS	220	220	225	240	-	905

TABLE IIIb-2

Personnel Distribution

Scientific Staff	1.3	1.3	1.3	1.3	-	
Technical Staff	4.1	4.1	4.1	4.1	-	
Administrative Staff	.5	.5	.5	.5	-	

Table IIIb-3

Budget Distribution by Class of Research

Basic Research	120	120	125	140	-	505
Development	100	100	100	100	-	400
Demonstration	-	-	-	-	-	-
Education & Training	-	-	-	-	-	-
TOTALS	220	220	225	240	-	905

TABLE IIIb-4

Budget Distriubtion - Classified

Personnel	185	185	185	185	-	740
Equipment & Materials	15	15	19	20	-	69
Services	20	20	21	35.0	-	96
TOTALS	220	220	225	24.0	-	905

FOSSIL FUELS RESEARCH

IV. FOSSIL FUELS RESEARCH PROGRAM

Puerto Rico is fully dependent on fossil fuels as an energy source. Traditionally Venezuelan crudes have been a major source of supply for local refineries. Consequently, we need to fully understand all the associated problems related to the production and consumption of petroleum and other fossil sources in a tropical environment. CEER for the last two years has initiated a program in fossil fuels oriented to explore the biodegradation of non-conventional hydrocarbon mixtures under aerobic and anaerobic conditions. Duly motivated scientific personnel, laboratory facilities, base line data, and intimate personal and professional links with scientists from government laboratories, universities, and decision-makers interested in the development of non-traditional sources of hydrocarbons is available. In addition, Puerto Rico now faces the attractive possibility of finding petroleum on the north coast as a result of basic and detailed geophysical studies making a fossil fuels research program a venture well exploring.

The Fossil Fuels Research Program mission, goals, and objectives are:

The Mission: Improve our understanding of the environmental impacts and the technology associated with the production, upgrading, and consumption of fossil fuels, knowledge of the potentially serious risks that these fuels present to the public health and the environment and the possible technological alternatives to improve their production upgrading and consumption.

The Goals: Develop a systems perspective of the health and environmental aspects which could result from research work associated with the production, upgrading and consumption of fossil fuels and to take the necessary steps required to increase the availability of hydrocarbon sources to protect public health and the natural environment.

The Objectives:

1. To explore the chemical and physical nature of fossil fuels with an orientation to improve their production, upgrading, and consumption.
2. To explore the technological aspects associated with the production, upgrading, processing and consumption of non-conventional fossil fuels.
3. To investigate the microbial biochemistry associated with the biodegradation of hydrocarbons and their heterocompounds in nature, to improve this process under controlled conditions, and to look for potential applications in the areas of enhanced oil recovery and in the disposition of fossil fuels derivatives in a tropical environment.

4. To predict and control toxic substances associated with the production upgrading and consumption of fossil fuels.

5. To integrate molecular, biochemical, structural and physiologic data in order to understand the essential nature of environmental disease as a result of the continuous and increasing use of fossil fuels.

Project A. Desulfurization of Organosulfur Compounds and Petroleum Fractions by Microorganisms and its Application to Enhanced Heavy Oil Recovery

The production and upgrading of heavy and extra-heavy crude oils today represents a technological problem and a strategically invaluable source of energy. To help reduce the environmental impacts involved in the commercialization of such new energy sources and to define its full potential in the enhancement of oil recovery it is proposed to continue exploring the biodegradation of sulfur compounds and heavy petroleum fractions by selected groups of microorganisms. Microorganisms from two sites in Puerto Rico (CORCO and Gulf Refineries) and impregnated soils from heavy petroleum producing fields in Venezuela (Orinoco Petroleum Belt and Lake Guanoco) are presently under study, with routine sampling for hydrocarbonoclastic microorganisms by direct plating and enrichment culture. A salts medium supplemented with yeast extract is used to provide conditions for aerobic petroleum degradation and various media containing peptone or thioglycolate are in use for the anaerobic, H_2S producing biodegradation. The use of a 350-525°C high sulfur aromatics fraction (Morichal crude oil) and a

correspondingly low sulfur-high paraffinic substrate (Amna Amal crude) as well as benzothiophene permits the comparative assessment of the isolated microorganisms. The biodegradations are monitored by three different parameters: The actual disappearance of the substrate from bacterial cultures, by increase in the oxygen uptake by the bacteria in presence of the compounds and by comparisons of the chromatographic analysis of the bacterial culture.

From that perspective, we will study the extend and full effects of bacteria in a petroleum reservoir. Our intentions is to establish the basic criteria for evaluation of amenability of oil formations to bacteria treatment. It is known that water-flooded oil reservoirs of high porosity and permeability hold the most promise for positive results, for bacteria can effectively penetrate such deposits, and carry out their reactions in situ. In addition, aerobic microorganisms can grow in the earth, at the expense of petroleum, down to depths of 7-9000 feet. We propose to study the controlling factors in such biodegradations.

Principal Objectives of this Project:

i. Optimize the growth conditions of the organisms that utilize or grow in presence of petrosulfur compounds or components separated from high sulfur containing crude oil fractions.

ii. Provide an assessment of aerobic-anaerobic dual systems involved in the degradation of synthetic mixtures of organo-sulfur compounds, high sulfur crude oils or refinery wastewaters.

iii. Develop detailed mechanisms for joint efforts with the Venezuelan Government.

iv. Field tests on the in situ biodegradation of heavy crudes utilizing selected microorganisms.

v. Establish the practicality of the microbial oil stimulation method in marginal wells and/or wells producing very heavy crudes and selected from Venezuelan fields.

Rationale for selected Approach

From previous knowledge, several points should be taken into account:

a. Laboratory and simulated field studies demonstrate that hydrocarbonoclastic bacteria ability to degrade hydrocarbons is related to the degree of hydrocarbon pollution of the isolation site. Evidence indicates that isolates from the polluted sites effects greater degradation and that oil degradation is enhanced especially in the presence of sufficient nitrogen and phosphorus.

b. A single microorganisms will not possess the enzymatic capacity to metabolize all of the many compounds present in crude oil.

c. Compared to the saturate fraction, the aromatic fraction is less easily biodegraded, susceptibility decreasing as the number of aromatic or alicyclic rings in the molecule increases with sulfur-containing aromatics roughly twice as recalcitrant as their non-sulfur analogues.

d. The presence at C. E. E. R. of several bacterial isolates obtained from oil contaminated environments from Puerto Rico and from different areas of Venezuela's Orinoco Petroleum Belt and lake Guanoco.

e. These organisms are able to grow and/or degrade benzothiophene and crude petroleum fractions.

f. anaerobic bacteria which produces H_2S from organic sulfur compounds, as well as from crude oil, residue oil, and asphaltenes have been obtained from oil wells or bottoms of crude oil reservoirs and refinery water treatment sediments.

Specific aims

Since the basic analytical methodology have been developed and a selection of hydrocarbon degrading organisms is available it is proposed to:

a. Isolate and characterize quantitatively the petroleum degrading capacities of the more capable aerobic and anaerobic microorganisms.

b. Study compositional changes originated by the anaerobic digestion of heavy petroleum fractions and model sulfur compounds before and after aerobic digestion and viceversa.

c. Study appropriate methods for injection and recovery of cultures and microbe product mix respectively.

d. Stablish an inventory of failure -causing problems and trouble shooting measures.

e. Monitoring and control measures needed to ensure the maintenance of the desired microbial activities.

f. Test the biodegradation products for mutagenicity and teratogenicity.

Unusual Features

a. The presence of at least 15 bacterial isolates obtained from heavily polluted sites and capable of growing in presence and degrading different fractions of crude oil.

b. The convenience of having access to basic information regarding the Venezuelan Orinoco Petroleum Belt and Lake Guanoco high sulfur extra heavy oil reservoirs.

c. The long standing personal relationship existing between the key energy officials of the Republic of Venezuela and our research group which permits us to collect onsite Venezuelan soil microorganisms adapted to heavy oil environments and to initiate badly needed research on production and environmental aspects of heavy crudes under the sponsorship of the Federal Department of Energy. This fact opens an excellent opportunity for more ambitious cooperative agreements in areas of mutual interest involving the United States, Puerto Rico, and the principal South American oil producer (i.e., microbial processes useful in enhanced oil recovery).

d. This project represents the first and only project ever conducted in Puerto Rico involving research on the production and environmental aspects of high sulfur heavy oils and petroleum composition and is a basic undertaking from which local scientists could start contributing to our fossil energy problems particularly if commercial crude oil deposits are found on the North Coast of Puerto Rico.

Benefits of Proposed Work

It is known that crude oil and petroleum products discharged at the water surface are rapidly modified under the effect of physico-chemical and biological transformations, themselves closely dependent on

ecological factors. Advancing on that experience, this research in progress will help:

a. Understand the microbial degradation of heavy crudes and/or heavy oil fractions when discharged into the environment; particularly the anaerobic degradation of hydrocarbons, something of great significance to understand the formation and alteration of fossil organic materials.

b. Increase knowledge as to how specific heavy oils might behave subsequent to a spill, before the spill takes place in order to anticipate the consequences.

c. Understand the behaviour of the aromatic sulfur heterocompounds in petroleum, substrate hard to biodegrade, when exposed to microorganisms adapted to grow in the presence of high sulfur heavy crudes, and/or model petrosulfur compounds.

d. Improve our knowledge on the treatment and disposal of effluents and industrial wastes.

e. Improve our knowledge in microbiological processes useful in enhanced oil recovery.

f. Evaluate the relative toxicity of biodegradation products from heavy oil fractions of low and high sulfur content and explore health and safety considerations asociated with the handling of large amounts of cultures under field conditions.

Project B: Comparative Toxicities of Petroleum Water Soluble Fractions and Biodegradation Products on Tropical Marine Organisms

This project will provide results on a two year laboratory study of the effects of petroleum fractions on selected tropical marine organisms. The fractions of interest will also be subjected to the action of petroleum degrading microorganisms isolated by culturing in aromatic substrates. The study will be conducted by a multidisciplinary team of researchers from the Center for Energy and Environment Research in San Juan, Puerto Rico. Since increasing awareness is present about the need for information on the effects of crude oil on tropical marine organisms and particularly the effects a release of crude oil will have on commercially important species of marine organisms, we have decided to employ well characterized fractions of crude oil, to chemically analyze the water soluble fractions (WSF), to conduct comparative studies on the sensitivity of different life stages of tropical marine species exposed to different WSF, to expose the test fractions of crude oil to the action of petroleum degrading microorganisms and compare the relative toxicities of the resulting WSF, to conduct histopathological observations, and to determine the rate and degree of uptake and depuration of hydrocarbons by selected species of organisms when they are exposed to sub-lethal concentrations of the water-soluble fractions of Venezuelan and Libian high boiling distillates.

Most previous bioassay studies on the effect of oil on organisms are of limited value because "the concentrations of oil that the test species

were actually exposed to in these studies are almost completely unrelated to the amount of oil used to prepare the test solutions" (Rice et al 1977). Therefore, well defined water-soluble fractions will be used during exposure. Fractions will be characterized by modern analytical techniques, and obtained from high sulfur-aromatic content and high paraffinic-low sulfur content crude oils of significant commercial value. Due consideration to mixing energy, mixing duration, viscosity of the test fractions, pH, salinity and temperature will be taken. In addition, since microbial organisms and evaporation seems to be by far the main cause of the decline in oil concentrations with time in bioassays, we will study the biodegration of selected oil fractions and employ a high boiling petroleum distillate from which selected fractions will be studied. After biodegradation of the fractions of interest the resulting water soluble compounds will be tested for its toxicity on marine organisms. This will help determine the contribution of biodegradation to the toxic effects on marine organisms of selected oil fractions; of particular interest when primary substances of low solubility such as polynuclear aromatics are used as the test fractions. Biodegradation studies on test fractions will help establish if the same relative toxicities apply when the primary test substances are subjected to biodegradation conditions. We feel this is important since in the past the presence and toxicity of polar hydrocarbon derivatives or polar oxidation products of oil hydrocarbons have generally been ignored. The use of more effective analytical techniques will help us unravel the difficult problem of identification and quantitation of the water-soluble test fractions and the rate and degree of uptake and depuration of hydrocarbons by tropical marine organisms.

Objectives of this Project

a. Principal Objectives

1. To compare the sensitivity of different life stages of tropical marine species exposed to various well defined fractions extracted from a high boiling point cut (350-525°C) of two crude oils utilizing both static and flow through techniques.
2. To determine the relative importance of individual fractions of saturates, mono-aromatics, di-aromatics, acid, basic, nitrogen and sulfure concentrates in regard to the acute toxicity of the test organisms under various conditions of temperature and organic substrate concentrations.
3. To conduct detailed chemical characterizations of the test solutions at various times during the experiments and to test for longer periods of time a few selected species, so that the relationships between oil concentrations that are toxic for short and long exposures can be determined.
4. To expose selected crude oil fractions to petroleum degrading microorganisms in order to study the relative toxicities of their water phase soluble products.
5. To conduct histopathological observations and to determine the rate and degree of uptake and depuration of hydrocarbons by species of marine organisms when they are exposed to sub-lethal concentrations of the water-soluble fractions of Venezuelan and Libian high boiling distillates.

b. Subordinate objective

To compare the results obtained in this study with those reported for the temperature zone. Care must be taken since there will be differences in test oils, temperature, salinity and test procedures.

Results and/or Benefits Expected

a. Heavy and light crude oils like the ones to be used here are defined in Puerto Rico and the effects of oil spills on certain tropical marine organisms may be predicted. This will improve our understanding of hydrocarbon uptake and depuration by marine organisms.

b. The relative importance of the major components present in two petroleum distillates boiling between 350-525°C will be noted. Chemical studies on the principal constituents in the water soluble fractions will be conducted and differences between the various petroleum oils such as how oil concentrations change with time recognized. As a result, information on the families of compounds that occur in the test mixed substrates and suspected of having deleterious properties will be gathered.

C. Toxic effects of biodegradation products will be assessed using well defined substrates, single or mixed cultures of microorganisms, and test marine specimens.

d. Better understanding of the role of microorganisms in removing oils from the marine environment.

Project C: Freshwater Indicator Organisms of a Tropical Refinery Effluent Pathway

It is a well known phenomenon that water quality influences the composition of aquatic organisms in both species diversity and abundance. For

example, man's activities, which introduce excess nutrients along with other pollutants, into lakes, streams, rivers and estuaries are causing significant changes in aquatic environments. Excess nutrients greatly accelerate the process of eutrophication and putrescible organic matter such as domestic sewage also reduces dissolved oxygen concentration and number of species while a few species become exceedingly abundant. On the other hand, when other contaminants containing toxic substances are introduced into a river with inadequate dilution, most life is eliminated.

Environmental effects of oil pollution and bioassays on the toxicity of oil and its components have been limited mainly to the Temperate Zone, whereas in the tropics where environmental conditions are quite different, practically no published work is available. It is proposed that a series of tropical oil pollution environmental studies be considered. The first and most obvious study is to characterize organisms which are tolerant to continuous exposure of oil and an ideal location is the Caribbean Gulf Refining Corporation (Bayamón) and its surrounding environment. Subsequent detailed studies should include hydrocarbon concentrations accumulated in organisms, bottom sediments and water, bioassays and mutagenesis.

In 1955, the Esso Refining Company (Bayamón) was established and was later acquired by the Caribbean Gulf Refining Corporation in 1962. From 1962 to 1977, Ecuadorian crude oil was commonly processed and during the past two years, a mixture of Santa Rosa condensate and Leona crude oil from Venezuela is being refined. At present, about half of a million gallons of wastewater per day are discharged into a freshwater stream, namely, Las Lajas Creek. This creek unites with the Malaria Control Canal (Las Cucharillas Canal) before discharging into San Juan Bay and covers a total distance of 4 river km.

Personal observations and those by residents living along the Malaria Control Canal have noted that surface water oil films in the canal are common. It should also be noted that apparently there is no other industrial discharge in the effluent pathway of Gulf Refining Corporation and some of the results of the proposed study will be compared with those of a previous ecological survey.

Objectives of this Project:

a. To determine the levels of hydrocarbons in the tropical freshwater effluent pathway of a petroleum oil refinery that would be tolerated by certain organisms so as to help set permissible level guidelines. Special emphasis will be placed on the concentrations of total saturates, polars, and aromatics on bottom sediments and water samples and tolerant organisms associated with these components of the oil refinery effluent.

b. To identify organisms which may be used as indicator of oil pollution.

c. To biomonitor sensitive species observed at control stations in the freshwater stream exposed to the oil refinery effluent.

Results and/or Benefits Expected

Implications of the proposed research to oil pollution originating from petroleum producing or refining operations, environmental impacts associated with coal consuming power plants, and the chemical characterization of botton sediments in heavily polluted water bodies are significant and profitable knowledge should be gained from this experience.

Project D: Biological Degradation of Sulfur Construction Materials and the Effect of Microbial Inhibitors

THIOBACILLUS THIOXIDANS, a bacterium implicated in the degradation of concrete will be added to sulfur concrete bars, sulfur-based composite coatings for concrete protection, and to a Calgary "Pronk" sulfur asphalt. Samples to be used in the work will be supplied by local and foreign private firms. The test bars will be immersed in a sulfur free synthetic salts medium at 28°C. Changes in the pH of the media, in bacterial cells numbers, and in the flexural strength of the test bars will be determined. Also, we will study the presence of any surface etching in the test specimens. Commercial biocides will be selected and incorporated in the sulfur composites and its inhibition properties studied as well as any leaching of the bactericide into the media. Leaching effects of the inhibitor in the sulfur concrete, for example, will be considered as a function of the type of composite formulation. Finally, an Ames' Mutagenicity Test of the biocides of interes will be made

to assess any potential environmental effect associated with the biocides in sulfur composites.

The composites of interest are new technology materials of potential impact in energy conservation, present unique advantages for the protection of masonry, concrete, and other surfaces exposes to the corroding effect of sea water, for lining water impoundment ponds, etc. Sulfur coatings and concretes show great resistance to acids and salts having other physical and structural properties of great potential as a material for special applications in regard to the OTEC project.

Objectives of this Project:

a. Principal Objectives:

1. To delineate the extend of sulfur composites biodegradation under laboratory controlled conditions and under tropical field conditions in the presence of sulfur-oxidizing bacteria and/or anaerobic and reducing bacteria.
2. To establish the populations of sulfur degrading microorganisms, pH and sulfate levels in the media at different periods during the experiments and to help define what significance this may have on the performance of the composites in their intended end uses.
3. To explore the effect of several commercial bactericides to protect the sulfur composites from biodegradation, and to see if they leach-out of the composite or affect the structural strength of the test material.
4. To test any effective microbial inhibitors to be used in this study for mutagenicity.

b. Subordinate Objective

To generate badly needed information on the short and long term exposure to microbial organisms of selected sulfur composites of commercial importance. These materials already have attractive potential insulating and/or constructional applications by utilizing the low thermal conductivity of sulfur and/or the ability of sulfur to act as a bonding cement. The importance to energy conservation and to the recycling of a valuable element in growing over supply as a result of the increasing consumption of high sulfur natural gas and petroleum is obvious.

Project E: The Characterization of Airbone Particulates and their Toxic Properties in Selected industrial Environments

Selected hydrocarbons, and other air contaminants in particulate matter in a heavily industrialized site in tropical Puerto Rico will be isolated, identified, and characterized by various chromatographic and spectrometric means. Initially efforts will be dedicated to explore the peculiar toxicological potential of the emissions producted in the South Coast petroleum-petrochemical complex followed by similar studies in the Cataño industrial park. Base line studies associated with recently proposed coal operated power-plant will be pursued as a result of the initial work. Special effort will be dedicated to establish the size distribution of airbone particulates and to identify the nitron and sulfur containing plycyclic aromatic heterocompounds, volatile hydrocarbons and potentially toxic trace elements. Aassociated mutagenic and teratogenic effects of selected fractions will be studied in an effort to define some toxic properties of help in predicting potential hazards concerning human health. Knowledge of computer simulation

and modelling, composition and size distribution of particule material, chemical transformation of pollutants and its associated toxicological effects will support biomedical studies in Puerto Rico dealing with a very wide spectrum of personal discomfort and illness.

Objectives of this project

a. Principal Objectives

1. Initiate a systematic effort to characterize potentially toxic trace elements and organic constituents (especially sulfur and nitrogen derivatives) downwind and upwind the neighborhood of a petroleum-petrochemical complex.

2. Correlate the principal families of compounds (group-type analysis) detected with their possible mutagenic and teratogenic effects. Extracts from particulate matter of various sizes will be obtained and evaluated for biological activity.

3. Improve our knowledge of sources of toxic substances by studying airborne particulate composition with an orientation to establish (a) if the particulate matter in the south coast industrial complex is responsible for impacting the atmosphere from neighboring cities downwind from the complex and (b) if the particulates bearing these contaminants are small enough to be deposited efficiently in human lungs.

b. Subordinate Objectives

1. Employ air pollution computer simulation methods to correlate the chemical nature of the contaminants which the prevailing meterology of the region.

2. Conduct research in areas remote from immediate sources of pollution to provide background values in areas directly unaffected by point source emissions.

3. Train research scientists and students in environmental health research by developing an interdisciplinary research program to increase our knowledge of toxic substances in the environment.

Results and/or Benefits Expected:

This project attempts to:

a. Improve our knowledge of the chemical composition of the volatile hydrocarbons and the acidic, basic, neutral, and polar fractions isolated from airborne particulates in the neighborhood of a petroleum-petrochemical environment. This is necessary to obtain a better understanding of the potential health hazards associated with the transportand penetration of particulates into the respiratory system from petroleum or coal consuming operations.

b. Measure both the size distributions and chemical composition of particles in ambient air, in order to understand the sources, and the behaviour of airborne particulates in the atmosphere. Observations on size distributions of trace elements and/or key organics in particulates, if sufficiently distinctive, could be used as a means of source identification if data on size distributions of particles from specific types of sources were available.

c. Correlate toxic properties such as mutagenic and teratogenic effects with the chemical composition of selected test fractions.

The proposed research will be of significance also to:

a. Cancer epidemiology studies underway in Puerto Rico as well as field, clinical, toxicological or laboratory investigations to be undertaken as a result of this effort.

b. Help initiate work toward establishing a damage function for the Guayanilla-Peñuelas area. This will serve to stimulate Puerto Rico researchers in planning studies oriented to characterize the nature and magnitude of the population at risk affected by given levels of pollutants.

c. Strengthen the infrastructure for complex compositional studies related to the atmospheric emissions arising from coal or coal-oil slurries combustion power plants. These fossil fuels are alternatives presently under the active consideration of our government energy policy makers. Studies on the nature of air emssions will affect decisions regarding control techniques or after combustion.

d. Provide public officials with an effective data base for efficiently allocating limited resources among the many conflicting demands for pollution control and other aspects of social welfare.

e. Act as a vehicle for the training of environmental health scientists and for continuing mission oriented research in Puerto Rico.

Rationale for Selected Approach

TABLE IV-1

FOSSIL FUELS RESEARCH

Budget ($ thousands)

Project	82	83	84	85	86	Total
A	382	382	600	600	500	2,464
B	167	146	146		-	459
C	80	80	-	-	-	160
D	115	115	-	-	-	230
E	380	326	326	326	326	1,684
Totals	1,124	1,049	1,072	962	826	4,997

TABLE IV-2

FOSSIL FUELS RESEARCH PERSONNEL DISTRIBUTION (MAN YEARS)

	82	83	84	85	86
Project A					
Scientific Staff	3.75	3.75	6.00	6.0	6.0
Tech. Staff	4.00	4.00	6.00	6.0	6.0
Adm. Staf	1	1	1	1	0
Project B					
Scientific Staff	1.75	1.75	1.75	-	-
Tech. Staff	3.5	3.5	3.5	-	-
Adm. Staff	.5	.5	.5	-	-
Project C					
Scientific Staff	1.25	1.25	-	-	-
Tech. Staff	1.00	1.00	-	-	-
Adm. Staff	.50	.50	-	-	-
Project D					
Scientific Staff	1.5	1.5	-	-	-
Tech. Staff	1.0	1.0	-	-	-
Adm. Staff	.25	.25	-	-	-
Project E					
Scientific Staff	3.5	3.5	3.5	3.5	3.5
Tech. Staff	5.5	5.5	5.5	5.5	5.5
Adm. Staff	1.0	1.25	1.25	1.25	1.25
TOTALS					
Scientific Staff	11.75	11.75	11.25	9.5	9.5
Tech. Staff	15	15	15	11.5	11.5
Adm. Staff	3.25	3.50	2.75	2.25	2.25

TABLE IV-3

FOSSIL FUELS RESEARCH
($ thousands)

	82	83	84	85	86	
Project A						
Basic Research	342	342	120	120	-	
Development	40	40	480	480	-	
Demonstration	-	-	-	-	500	
Education & Training	-	-	-	-	-	
Project B						
Basic Research	167	146	146	-	-	
Development	-	-	-	-	-	
Demonstration	-	-	-	-	-	
Education & Training	-	-	-	-	-	
Project C						
Basic Research	80	80	-	-	-	
Development	-	-	-	-	-	
Demonstration	-	-	-	-	-	
Education & Training	-	-	-	-	-	
Project D						
Basic Research	65	40	-	-	-	
Development	50	75	-	-	-	
Demonstration	-	-	-	-	-	
Education & Training	-	-	-	-	-	
Project E						
Basic Research	340	286	286	286	286	
Development	-	-	-	-	-	
Demonstration	-	-	-	-	-	
Training & Education	40	40	40	40	40	
TOTALS						
Basic Research	994	894	266	406	-	2560
Demonstration	90	115	766	480	286	1737
Demonstration	-	-	-	-	500	500
Training & Education	40	40	40	40	40	200
TOTALS	1124	1049	1072	926	826	4997

TABLE IV-4

FOSSIL FUELS RESEARCH

Program Budget Distribution Classified
($ Thousands)

	82	83	84	85	86	
Project A						
Personnel	220	220	332	332	332	
Equipment & Materials	112	60	60	60	20	
Services	50	102	208	208	148	
Project B						
Personnel	131	131	131	-	-	
Equipment & Materials	16	5	5	-	-	
Services	20	10	10	-	-	
Project C						
Personnel	70	70	-	-	-	
Equipment & Materials	5	5	-	-	-	
Services	5	5	-	-	-	
Project D						
Personnel	75	75	-	-	-	
Equipment & Materials	30	30	-	-	-	
Services	10	10	-	-	-	
Project E						
Personnel	230	236	236	236	236	
Equipment & Materials	100	40	40	40	40	
Services	50	50	50	50	50	
TOTALS						
Personnel	726	732	699	568	568	3293
Equipment & Materials	263	140	105	100	60	668
Services	135	177	268	258	198	1036
TOTALS	1124	1049	1072	926	826	4997

SOLAR ENERGY PROGRAM

V. SOLAR ENERGY PROGRAM

Introduction

The goal of the solar energy program of CEER/UPR is to help develop at the earliest feasible time commercially, attractive and environmentally acceptable applications of solar energy. The high insolation rates in Puerto Rico is an important factor which could lead toward the demonstration of economic competetiveness by DOE sooner then in any other U.S. areas. Average daily total insolation recently measured at Ponce, Puerto Rico at 18° latitude indicates a value of approximately 1950 BTU per sq.ft. per day on a horizontal surface.

Solar radiation is readily converted into thermal energy, electricity and clean fuels through conversion processes and systems that are accepted as technically feasible. The important next phase is to design and prove practical, reliable, economical systems.

The high levels of solar energy over Puerto Rico make it possible to consider systems that provide thermal and/or electrical energy at the point of use. At the same time there are two disadvantages of solar energy that pose challenges to development of economical solar energy systems and to innovators in research and technology. First, sunlight provides a relatively small energy flux density compared to that obtained in power systems using fossil or nuclear fuels; that is, its natural intensity is relatively low presenting a technological challenge to achieve

economical conversion to useful forms of energy. In addition, direct application forms of solar energy are intermittent and variable due to daily, seasonal, and environmental effect. The direct energy conversion systems must be designed either to utilize the energy when it is available, or in conjunction with storage and with back up systems using other fuel sources.

Solar programs supported by CEER/UPR include systematic solar data acquisition throughout Puerto Rico, solar cooling of buildings in tropical regions, generation of electricity from photovoltaic conversion of sunlight, industrial solar process heat and solar materials research. A summary of ongoing solar energy areas and involved organizations are shown in Table V-A.

During the five year program emphasis will be continued and expanded to involve private industry and enterprise in all phases of the solar energy research, development and demonstration program in order to accelerate the transition of solar technology to the commercial sector.

As a result of research and development projects underway and planned it is anticipated that by 1985 solar energy systems like solar hot water heating, solar cooling and agricultural applications will start to have their commercial impact at competitive prices for selected applications. Some technologies like solar photovoltaic and thermal power generation can be ready for large scale utilization by the late 1980's.

The major problem in each technology area is to develop systems that are economically acceptable to the public and

TABLE V-A

SUMMARY OF SOLAR ENERGY PROGRAM AREAS - INVOLVED ORGANIZATIONS

SOLAR ENERGY PROGRAM AREAS / INVOLED ORGANIZATION	CEER (RIO PIEDRAS)	CEER (MAYAGUEZ)	UPR (RIO PIEDRAS) (MAYAGUEZ)	CATHOLIC UNIVERSITY (PONCE)	U.S. DEPARTMENT OF ENERGY	PR OFFICE OF ENERGY	PR PRIVATE SECTOR	U.S. LABS AND UNIVERSITIES	OTHER PR GOVERNMENT AGENCIES
DIRECT AND DIFFUSE INSOLATION AND SOLAR RESEARCH PROJECT	X		X	X			X		
SOLAR SERVICE HOT WATER	X	X			X				
SOLAR COOLING	X	X							
INDUSTRIAL AND AGRICULTURAL PROCESS HEAT	X		X		X	X	X	X	X
PHOTOVOLTAICS	X				X	X			
SOLAR MATERIALS	X		X						
SOLAR TECHNOLOGY ASSESMENT	X								
INTERNATIONAL PROGRAMS ON SOLAR TECHNOLOGY TRANSFER	X							X	

commercial sectors. This requires innovative engineering as well as new and improved approaches to solar energy collection, energy storage, transport and conversion; new system approaches; and, perhaps most importantly, investigation of new and cheaper materials to improve system performance, reliability and economic attractiveness.

CEER will also help to solve important problems dealing with environmental, social, legal, regulatory and economic factors associated with widespread utilization of solar energy systems.

PROGRAMS

A. Solar Data Network for Puerto Rico

In order to properly design solar energy utilization systems, long term trends in availability of solar energy in diffuse and direct form should be known. The strong variations in the micro-climate distributions in Puerto Rico requires establishment of a number stations to obtain accurate data for the specific site of use.

This program plan has as its major goal the development of a continuing network throughout Puerto Rico, for the collection of total and diffuse solar radiation data. Through this network, accurate, consistent and orderly data will be gathered and analyzed and tabulated. Four monthly insolation data reports for each site containing relevant parameters will be published periodically for effective dissemination of information.

According to the pattern of the microclimate distribution and anticipated potential for solar activity, following solar data

stations will be established and operated at least one full year or more: 1) Río Piedras, 2) Mayaguez, 3) Ponce*

B. Service Hot Water

The objectives of this program is to assist the customer and the small but viable Puerto Rican solar water heater industry by testing commercially available hot water systems of different price categories under tropical conditions to provide them with characteristic data. The emphasis wil be on determining the long term climate/performance requirements, methods of integration with existing hot water systems, characteristics of existing use patterns and cost performance characteristics of the tested system. The results will be summarized in a simple handbook for dissemination of information.

C. Industrial and Agricultural Process Heat

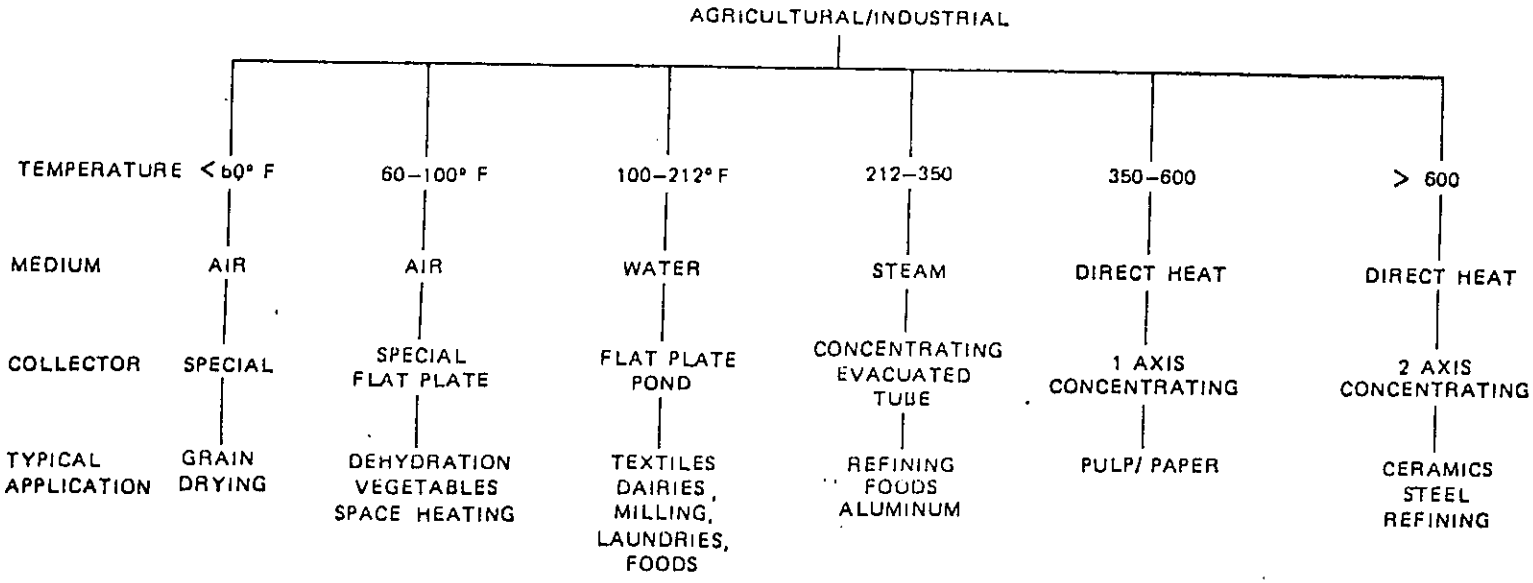
The objectives of this program include design development, test in and help in demonstrating solar process heat application systems.

In the states industry accounts for about 40% of the energy consumed. If non-substitutable electricity use and feed stocks are substracted, the fraction is about 30%. Recent data indicates that the same percent ratio's are also valid for Puerto Rico. Because of this large size this demand is a very attractive target for solar energy use.

The highest use potential for solar heat are those industrial processes that require hot water and low-temperature ($< 350°F$) steam.

*Stations already operating

Figure VI


AGRICULTURAL/INDUSTRIAL
TEMPERATURE
< 60° F
60–100° F
100–212° F
212–350
350–600
> 600
MEDIUM
AIR
AIR
WATER
STEAM
DIRECT HEAT
DIRECT HEAT
COLLECTOR
SPECIAL
SPECIAL FLAT PLATE
FLAT PLATE POND
CONCENTRATING EVACUATED TUBE
1 AXIS CONCENTRATING
2 AXIS CONCENTRATING
TYPICAL APPLICATION
GRAIN DRYING
DEHYDRATION VEGETABLES SPACE HEATING
TEXTILES DAIRIES, MILLING, LAUNDRIES, FOODS
REFINING FOODS ALUMINUM
PULP/ PAPER
CERAMICS STEEL REFINING

These uses represent about one-third of the energy required by industry.

The use of solar energy to provide industrial heat is in the demonstration stage. The hardware necessary for these solar uses is mostly available and the remaining constraint to its wide-spread use is economical because of the high cost of the solar collectors. CEER program recognizes this and has focused its efforts accordingly.

In the industrial sector, most current demonstrations focus on providing hot water. The hardware for these uses is essentially the same flat plate collectors as are used for domestic water heating. However, the production of industrial steam is less advanced because the required collectors are somewhat less developed. For these high temperatures evacuated and/or concentrating collectors are required.

The major R and D efforts in CEER program is the development and testing of a high efficiency, low cost concentrator resistant to tropical island conditions. The program also emphasizes participation in ongoing demonstration projects according to DOE's National Program Plan for Research and Development in Solar Industrial Heat.

This program also contemplates extension of industrial process heat program to include agricultural and biomass applications as well as to include other important temperature ranges as shown in Figure V-1.

D. Solar Space Cooling

The objectives of CEER's cooling program is to conduct research and development designed to assist in creating a viable solar

industry for Puerto Rico. The specific objective of the directed R and D is to provide the emerging solar industrial base the materials, components and information needed for cost effective cooling systems in the tropics.

DOE's R and D program on cooling has been very extensive and is built upon the development of specific approaches, called paths. Following paths have been identified for solar cooling:

PATHS TO SOLAR COOLING

ENERGY SOURCE/ SINK	ENERGY COLLECTION/ REJECTION	ENERGY CONDITIONING	APPLICATION
1. sun	Liquid-Heating collector	Desiccant Chiller	Space Cooling
2. sun	Air-Heating collector	Desiccant Chiller	Space Cooling
3. sun	Advanced Non-Concentrating Collectors	Absorption or Rankine cycle chiller	Space Cooling
4. sun	Concentrating Non-Tracking Collectors	Absorption or Rankine cycle chiller	Space Cooling
5. sun	Concentrating Tracking collectors	Absorption or Rankine cycle chiller	Space Cooling
6. environment	Night Effect Cooling	----------	Space Cooling
7. environment	Evaporative Cooling	----------	Space Cooling

Special conditions in a tropical/subtropical region as they exist in Puerto Rico, require a cooling system where most of the energy is used to remove the humidity from the ambient air. R and D at the CEER is concentrated on the development of a system very close to the one

described in path 2, (i.e., a combination of a highly advanced evacuated air collector in conjunction with a solid/water desiccant chiller. The tasks involve the testing and analysis of the air collector, as well as the development of the technology for its fabrication. The interfacing of the collector with the desiccant system and the overall design is a major part of the program.

E. Photovoltaics

The overall objectives of the Photovoltaic Conversion program is to help to develop economically viable photovoltaic electric power systems (PEPS) suitable for a variety of terrestrial applications and capable of providing a significant amount of Puerto Rico's requirements by the year 2000.

To accomplish the same objectives for U.S.A., the Department of Energy has set up goals involving following sub-programs:

1. Develop practical low cost solar photovoltaic arrays
2. Perform detailed PEPS analysis, cost and integration evaluations necesàrry to characterize subsystems and components in these power generating systems.
3. Develop low cost, energy efficient processes required to fabricate photovoltaic array
4. Develop technolgical and research base for further improvement in photovoltaic material, device and system capabilities.
5. Perform carefully planned experiments and demonstrations with flat and focusing photovoltaic systems.

In accordance with DOE's program goals CEER will concentrate on the following sub-programs:

1. Conduct advanced photovoltaic materials and solar cell research.

2. Perform conceptual design studies of photovoltaic systems for an on site residence, central power station and intermediate power station.

3. Perform assessment studies on cell manufacturing technology in Puerto Rico.

4. Market analysis assessments for photovoltaic application systems in Puerto Rico.

5. Participate in competitive DOE programs for systems demonstration projects,

F. Solar Thermal Power Generation

The conversion of solar energy into electricity is a problem with a variety of possible solutions. One method is solar thermal conversion. The conversion method utilizes various types of solar collectors to generate steam which drives a turbine and generator to produce electricity. Only the solar heating of the boiler distinguishes this cycle from that of a coal or gas fired plant. This use of existing power-technology is a major reason that solar thermal power systems are being studied for future commercial applications.

Two major types of solar collecting systems are being developed for solar thermal power systems:

a) Central Receiver (Power Tower)

b) Distributed Collector Systems

Central Receiver systems consist of a large tower surrounded by a field of tracking mirrors which concentrate the sun's rays onto a boiler located in the top of the tower. Distributed collector systems consist of a thermally coupled field of smaller mirrored

concentrators that focus the light onto a focally positioned receiver. The thermal energy in form of steam is then fed into central power generating equipment. Possible collector types are parabolic troughs (line focus) or parabolic disches (point focus). For high temperatures to be maintained at the receiver, these systems must track the sun across the sky by moving either the concentrating mirror or the receiver.

The planned goals of the Solar Thermal Programs at the CEER are:

1) Help to provide a full technology base for the production of thermal-electric power conversion in the late 1980's to meet the utility requirements for load-following or intermediate load electric power generating systems.

2) Help to provide a full technology base for total energy systems for urban complexes, rural communities and industrial parks.

To achieve the goals of the Solar Thermal subprogram area the following objectives have been established:

1) Design, fabrication and testing of prototype components and subsystems that are critical to the success of the distributed collector system concept.

2) Evaluation of total energy system applications for urban and rural communities and industrial parks.

3) Investigation of critical interface problems and issues associated with the implementation of solar thermal electric systems and total energy systems.

4) Research and development of materials, components, subsystems and concepts.

5) Continued cost benefit studies to identify cost and performance criteria for components, subsystems and systems.

TABLE V- 1

SOLAR PROGRAM OVERALL BUDGET DISTRIBUTION

(Thous. of Dollars)

	FY-82	FY-83	FY-84	FY-85	FY-86	Totals
A. Solar Data Network for Puerto Rico	16.5	18.2	20.0	22.0	10.0	
B. Service Hot Water	11.0	12.1	-	-	-	
C. Industrial and Agricultural Process Heat	200	250	300	350	350	
D. Solar Space Cooling	75	100	150	200	250	
E. Photovoltaics	400	440	540	660	750	
F. Solar Thermal Power Generation	75	100	125	150	200	
G. High Temperature Solar Technologies	50	75	100	125	150	
Totals	827.5	995.3	1,235	1,507	1,710	

TABLE V- 2

SOLAR PROGRAM PERSONNEL DISTRIBUTION

(Man Years)

	FY-82	FY-83	FY-84	FY-85	FY-86
A. Solar Data Network for Puerto Rico					
Scientific Staff	.14	.15	.17	.18	.08
Technical Staff	.27	.30	.33	.36	.17
Administrative Staff	.09	.10	.11	.12	.06
B. Service Hot Water					
Scientific Staff	0.09	.10	-	-	-
Technical Staff	.18	.20	-	-	-
Administrative Staff	.06	.07	-	-	-
C. Industrial and Agicultural Process Heat					
Scientific Staff	1.67	2.08	2.5	2.94	2.94
Technical Staff	3.33	4.16	5.0	5.88	5.88
Administrative Staff	1.11	1.39	1.67	1.96	1.96
D. Solar Space Cooling					
Scientific Staff	.63	.83	1.25	1.67	2.08
Technical Staff	1.26	1.66	2.50	3.33	4.16

	FY-82	FY-83	FY-84	FY-85	FY-86
E. Photovoltaics					
Scientific Staff	3.33	3.57	4.55	5.56	6.25
Technical Staff	6.66	7.14	9.10	11.11	12.50
Administrative Staff	2.22	2.38	3.03	3.7	4.17
F. Solar Thermal Power Generation					
Scientific Staff	.63	.83	1.04	1.25	1.67
Technical Staff	1.26	1.66	2.08	2.50	3.33
Administrative Staff	.42	.55	.69	.83	1.11
G. High Temperature Solar Technologies					
Scientific Staff	.42	.63	.83	1.04	1.67
Technical Staff	.84	1.26	1.66	2.08	3.33
Administrative Staff	.28	.42	.55	.69	1.11
Totals					
Scientific Staff	6.91	8.19	10.34	12.64	14.69
Technical Staff	13.80	16.38	20.67	25.26	29.37
Administrative Staff	4.60	5.46	6.88	8.41	9.80
All Staff	25.31	30.03	37.89	46.31	53.86

TABLE V - 3

SOLAR PROGRAM BUDGET DISTRIBUTION

Type of Research

(Thous. of Dollars)

	FY-82	FY-83	FY-84	FY-85	FY-86
A. Solar Data Network for Puerto Rico					
Basic Research	16.5	18.2	20.0	22.0	10.0
Development	-	-	-	-	-
Demonstration	-	-	-	-	-
Education & Training	-	-	-	-	-
B. Service Hot Water					
Basic Research	-	-	-	-	-
Development	11.0	12.1	-	-	-
Demonstration	-	-	-	-	-
Education & Training	-	-	-	-	-
C. Industrial and Agricultural Process Heat					
Basic Research	20.0	25.0	30.0	35.0	35.0
Development	80.0	125.0	170.0	215.0	215.0
Demonstration	100.0	100.0	100.0	100.0	100.0

	FY-82	FY-83	FY-84	FY-85	FY-86
D. Solar Space Cooling					
Basic Research	50	75	100	25	25
Development	25	25	50	25	25
Demonstration	-	-	-	150	200
Education & Training	-	-	-	-	-
E. Photovoltaics					
Basic Research	300	340	400	460	200
Development	100	100	140	200	100
Demonstration	-	-	-	-	450
Education & Training	-	-	-	-	-
F. Solar Thermal Power Generation					
Basic Research	40	50	50	50	-
Development	35	50	75	100	200
Demonstration	-	-	-	-	-
G. High Temperature Solar Technologies					
Basic Research	50	50	60	75	25
Development	-	25	40	50	125
Demonstration	-	-	-	-	-
Education & Training	-	-	-	-	-
Totals					
Basic Research	476.5	558.2	660	667	295
Development	216.0	337.1	475	590	665

	FY-82	FY-83	FY-84	FY-85	FY-86
Demonstration	135.0	100.0	100	250	750
Education & Training	-	-	-	-	-
Totals	827.5	995.3	1235	1507	1710

TABLE V - 4

SOLAR PROGRAM BUDGET DISTRIBUTION CLASSIFIED

(Thous. of Dollars)

	FY-82	FY-83	FY-84	FY-85	FY-86
A. Solar Data Network for Puerto Rico					
Personnel	12.38	13.65	15.0	16.5	7.5
Equipment & Materials	3.30	3.64	4.0	4.4	2.0
Services	.83	.91	1.0	1.10	.5
B. Service Hot Water					
Personnel	8.25	9.08	-	-	-
Equipment & Materials	2.20	2.42	-	-	-
Services	.55	.61	-	-	-
C. Industrial and Agricultural Process Heat					
Personnel	150	187.5	225	262.5	262.5
Equipment & Materials	40	50.0	60	70	70
Services	10	12.50	15	17.5	17.5
D. Solar Space Cooling					
Personnel	56.25	75.0	112.5	150	50
Equipment & Materials	15	20.0	30	40	50
Services	3.75	5.0	7.5	10	12.5

	FY-82	FY-83	FY-84	FY-85	FY-86
E. Photovoltaics					
Personnel	300	330	405	495	562.5
Equipment & Materials	80	88	108	132	150
Services	20	22	27	33	37.5
F. Solar Thermal Power Generation					
Personnel	56.25	75	93.75	112.5	150
Equipment & Materials	15.0	20.0	25.0	30.0	40
Services	3.75	5.0	6.25	7.5	10
G. High Temperature Solar Technologies					
Personnel	37.50	56.25	75	93.75	30
Equipment & Materials	10	15	20	25	30
Services	2.5	3.75	5.0	6.25	7.5
Totals					
Personnel	620.63	746.48	926.25	1130.25	1282.5
Equipment & Materials	165.50	199.06	247	301.4	342
Services	41.38	49.77	61.75	75.35	85.5
Totals	827.5	995.3	1235	1507	1710

ECOLOGY PROGRAMS

VI - ECOLOGY PROGRAMS

A. Ecosystem Structure and Process Studies

Any energy development can be expected to have effects upon ecosystems. Prediction of the quality direction and magnitude of these effects depends upon understanding of the normal composition and functioning of the systems upon which they impinge. The objective of CEER studies of tropical ecosystems is to develop such understanding. A number of separately funded projects contribute to this general goal. A large fraction of the ecological studies for the Ocean Thermal Energy Conversion (OTEC) Program is of this nature but has been singled out for special treatment because of its linkage to a specific developing technology. Studies for industrial siting (as in the case of power plants) are included here as are the more basic background studies of cycling and transport in the rainforest. Plans by the local electric utility to build a coal plant, oil and mining exploration for copper and nickel has been factored in. Also included are the Long Term Ecological Research studies being developed for possible NSF funding in collaboration with the U.S. Forest Service Institute of Tropical Forestry. The National Environmental Research Park will provide the organization for much of the above mentioned terrestrial ecological work. These are expected to continue a series of basic ecological research studies on individual species by individual investigators. These are also included for accounting purposes here.

Obviously, this program of studies overlaps with the more specifically directed "Ecological Effects Studies". Information generated in such program will be utilized by the others.

Ecosystem Structure and Process Studies

Projects

OTEC (Program Funding included under OTEC Program)

National Environmental Research Park

Cycling and Transport in Tropical Forests

Long Term Geological Monitoring

Industrial Siting

Miscellaneous Basic Ecological Studies

B. Cycling and Transport Studies in Tropical Ecosystems

The objective of these studies is to understand the processes of cycling and transport of materials in tropical terrestrial ecosystems in order to be able to predict the effects of energy development upon these basic processes.

RESOURCES MANAGEMENT STUDIES

Included in this category are studies aimed at the reclamation and management of fresh water, soil, biological and industrial wastes and wildlife especially where man's activities impact upon these. Present programs include bioreclamation of water and wastewater, magnetic separation, factors influencing land crab survival and sewage composting. Future programs are anticipated in land disposal of wastes, mariculture and aquaculture.

C. Ecological Effects Studies

This program emphasized experimental or correlational studies explicitly directed toward the investigation of specific perturbing factors and in that sense more applied. It is clear that the "Ecosystem Structure and Process" studies will contribute to a background for effects studies and that the study of specific perturbations will reveal important features of structure and process simultaneously. In this category of research will fall the following sorts of projects.

- The measurement of assimilative capacity
- The aspects of intensive biomass culture on ecosystems
- Oil spill recovery studies as in Bahía Sucia (or possible oil drills in northerm P.R. seas).
- Guayanilla Bay Hermal, mercury and hydrocarbon effects studies

TABLE VI-1

$K ECOLOGY PROJECTIONS

A. Ecosystem Structure and Process Study

Project	FY Budget $K 82	83	84	85	86
National Environmental Research Park	100	200	200	200	200
Cycling and Transport in Forests	300	300	300	300	300
Long Term Ecological Monitoring	200	200	200	200	200
Industrial Siting	600	175	300	500	600
Miscellaneous Basic Studies	200	200	200	200	200
TOTALS	1400	1075	1200	1400	1500

B. Resource Management Studies

Project					
Bioreclamation of Water	150	200	200	200	200
Physical/Chemical Water Treatment	100	50	-	-	-
Water Use and Reuse Studies	150	200	200	200	200
Waste Disposal Research	300	250	100	100	100
Aquaculture and Mariculture	150	200	200	200	200
TOTALS	850	900	700	700	700

C. Ecological Effects Studies

Project					
Energy Pollutants - Marine	400	250	200	200	200
Biomass Culture Effects	150	150	50	-	-
Energy Pollutants - Terrestrial	50	100	150	200	250
TOTALS	600	500	400	400	450
GRAND TOTALS (Ecology excluding OTEC)	2850	2475	2300	2500	2650

TABLE VI-2

PERSONNEL MAN YEARS - ECOLOGY

	82	83	84	85	86
A. Ecosystem Structure and Process Studies					
Scientific Staff	14	10	12	14	15
Technical Staff	14	10	12	14	15
Administrative Staff	4	4	4	4	4
B. Resource Management Studies					
Scientific Staff	10	10	9	9	9
Technical Staff	10	10	9	9	9
Administrative Staff	3.5	3.5	3.5	3.5	3.5
C. Ecological Effects Studies					
Scientific Staff	8	7	5	5	6
Technical Staff	8	7	5	5	6
Administrative Staff	1.5	1.5	1.5	1.5	1.5
Totals					
Scientific Staff	32	27	26	28	30
Technical Staff	32	27	26	28	30
Administrative Staff	9	9	9	9	9
Total Staff	73	63	61	65	69

TABLE VI-3

RESEARCH TYPE ECOLOGY PROGRAMS

Kind of Research	FY 82	83	84	85	$K 86
A. Ecosystem Structure and Process Studies					
Basic	308	236	264	308	330
Development	1036	796	888	1036	1110
Demostration	-	-	-	-	-
Education & Training	5	43	48	56	60
B. Resource Management Studies					
Basic	85	90	70	70	70
Development	366	387	301	301	301
Demostration	340	360	280	280	280
Education & Training	60	63	49	49	49
C. Ecological Effects Studies					
Basic	90	75	60	60	68
Development	360	300	240	240	270
Demonstration	150	125	100	100	112
Education & Training	0	0	0	0	0
Totals					
Basic	482	401	394	438	468
Development	1762	1483	1429	1577	1681
Demonstration	490	485	380	380	392
Education & Training	116	106	97	105	109
	2850	2475	2300	2500	2650

TABLE VI-4

ECOLOGY PROGRAM BUDGET DISTRIBUTION - CLASSIFIED (DISTRIBUTED AS 65% PERSONNEL, 25% EQUIPMENT AND MATERIALS & 10% SERVICES)

All Studies A, B, and C (excluding OTEC) ($K)

	Year					
	82	83	84	85	86	Totals
Personnel	1852.5	1608.75	1495	1625	1722.5	7653.75
Equipment & Materials	712.5	618.75	575	625	662.5	2943.75
Services	285	247.50	230	250	265.0	1205.50
TOTALS	2850	2475	2300	2500	2650	

ENVIRONMENTAL HEALTH

VII. Environmental Health and Impact Studies

Introduction

The major environmental health problems in the past for Puerto Rico were Malaria and Bilharzia, the parasitic diseases spread by vectors. Construction of hydroelectric and irrigation systems in the south coast during the 1920's touched off a bilharzia epidemic that was only recently brought under control. Malaria was eradicated in the late 1940's. The Environmental Health Division has studied biological and environmental methods for control of bilharzia related to hydroelectric reservoirs in Puerto Rico and the Dominican Republic. Evaluation of the infection rate by means of the skin test (indirect method, 1974) was performed in a representative sample of fifth grade classrooms throughout the island to corroborate the decrease in transmission of this disease as compared with equivalent surveys performed in 1963, and 1968.

Since 1978 the Division has been analyzing respiratory disease mortality to determine geographical distribution, by means of crude attack rates, and age-adjusted attack rates and investigating the reliability of the mortality data by examining the hospital records of

the deceased by means of a representative sample of the 1976 deaths in Puerto Rico. Twenty-eight years of respiratory cancer data is being analyzed to determine the trends of this disease in the island. Correlation of these data with known air pollution sources will be performed to develop more detailed studies in such areas.

The future work of this division will be directed towards the following Projects:

A. Mortality and Morbidity Respiratory Studies

Prospective studies of mortality and morbidity in areas with relatively high incidence and prevalence of respiratory diseases mortality which is associated with energy producing pollution sources: Cataño, Yabucoa, and Guayanillas areas.

B. Mortality Studies (Water Quality related)

Prospective studies of mortality on Cardiovascular, Gastro-intestinal and Renal diseases and its relation with water sources, geographical distribution, prevalence, incidence and the correlation of such factors to perform specific studies of mortality and morbidity in areas which demonstrate positive correlations and trends. Also establish bio-monitoring with Marisa cornuarietis in the water bodies to determine contaminants present if this method is feasible.

C. Disease Morbidity Monitoring Related to Alternative Energy Sources-CEER personnel

Develop disease (morbidity) monitoring of the CEER personnel that will be working with new sources of Energy for Puerto Rico (Solar Energy, OTEC, Biomass and others). This will be an area that will grow along with CEER's total growth in time. We will perform surveillance and special studies of outbreaks as they occur. Later, if justified, more detailed monitoring will be performed, to determine cause and effect, develop preventive measures for such disorders. Establish the type of health criteria to be used in determining the capabilities of an individual to be hired to perform a task within a given project according to the risks to which he will be exposed and the periodical determinations to be made once he is hired to monitor disorder development.

D. Schstosomiasis Studies

Develop schistosomiasis projects with the Dominican Republic Institutions in research and control of this disease in their country. The areas to be considered will be training, surveillance, evaluation, biological control and environmental modifications. In Puerto Rico Irrigation Canal studies and Marisa infectivity with S. mansoni. Rice fields transmission project with

Caribbean countries.

E. Environmental & Occupational Morbidity - Energy Production Related with Industry

Develop retrospective and prospective studies with energy producing institutions within the island to determine high risk environmental and occupational morbidity and recommend solution to such problems. The five proposed areas of research are to be undertaken by the Division of Environmental Health and Impact on its own but there are several other areas which could be developed in cooperation with Fossil Fuels and Terrestrial Ecology.

TABLE VII -1

ENVIRONMENTAL HEALTH
(Total Budget-in thousands)

	82	83	84	85	86
Project A	250	265	305	345	385
Project B	160	145	175	210	245
Project C	20	35	100	110	120
Project D	50	50	50	40	30
Project E	120	110	130	145	160
TOTALS	600	605	760	850	940

TABLE VII-2

ENVIRONMENTAL HEALTH
PERSONNEL DISTRIBUTION

Project A - Mortality and Morbidity Respiratory Studies

	82	83	84	85	86
Scientific Staff	1	1	1	1	1
Technical Staff	1.5	1.5	1.5	1.5	1.5
Administrative Staff	2	2	2	2	2

Project B - Mortality Studies (Water Quality related)

	82	83	84	85	86
Scientific Staff	1	1	1	1	1
Technical Staff	1.5	1.5	1.5	1.5	1.5
Administrative Staff	2	2	2	2	2

Project C - Disease Morbidity Monitoring related to Alternative Energy Sources - CEER Personnel

	82	83	84	85	86
Scientific Staff	.1	.1	.5	.5	.5
Technical Staff	.25	1	2.5	2.5	2.5
Administrative Staff	1.25	1.5	2	2	2.0

Project D - Schstosomiasis Studies

	82	83	84	85	86
Scientific Staff	1	1	1	1	1
Technical Staff	.5	.5	.5	.5	.5
Administrative Staff	.25	.25	.25	.25	.25

Totals

	82	83	84	85	86
Scientific Staff	3.10	3.10	3.50	3.50	3.50
Technical Staff	4.25	5.00	6.50	6.50	6.50
Administrative Staff	7.50	7.75	8.25	8.25	8.25
All Staff	14.85	15.85	18.25	18.25	18.25

TABLE VII-3

ENVIRONMENTAL HEALTH BUDGET DISTRIBUTION BY TYPE OF RESEARCH

	All Projects ($K)					
	82	83	84	85	86	Total
Basic Research	600	605	760	850	940	3755
Development	-	-	-	-	-	-
Demonstration	-	-	-	-	-	-
Education & Training	-	-	-	-	-	-

TABLE VII-4

ENVIRONMENTAL HEALTH BUDGET DISTRIBUTION BY CLASSIFICATION
($K)

All Projects
(Distribution made 60% personnel, 25% equipment & materials, & 15% services)

	82	83	84	85	86	Totals
Personnel	360	363	456	510	564	2253
Equipment & Mat.	150	151.25	190	212.5	235	938.75
Services	90	90.75	114	127.5	141	563.25
TOTALS	600	605	760	850.0	940	3755

MATERIAL DEVELOPMENT

VIII - MATERIALS DEVELOPMENT

The most pressing problems in the development of energy conversion, transmission and storage technologies are material problems. The involvement of the technical and scientific disciplines of solid state physics and physical chemistry in the development of materials for energy conversion, storage and transmission is of paramount importance. A CEER research program on materials problems, at a low level of funding, has been under development during the last three years. Included within this program were the following research projects: a) Photo Induced Electron Transfer State: A possible source of hydrogen, b) Study of the optical and aging characteristics of various selective surfaces, c) Study of surface of electrodes used in fuel cells and d) Energy conversion making use of thermal differentials by means of ferroelectric materials.

The above indicated efforts, at a low level of funding, has been a basic type of research and has established a base for continuance of this program. CEER feels that basic type of research on materials problems should continue at UPR/CEER but that main efforts should be readdressed to research appropriate to the local conditions and the tropical areas of the Caribbean and certain similar weather regions in South USA mainland.

The main efforts of the present proposed materials program will be focused, therefore, on the following projects:

A. Data Center

The main objective of this program will be the collection

of data on various types of materials. This Data Center will be used as the base for the development of other CEER/UPR and other government and private sectors programs in the Caribbean and Latin America. Some materials of interest to be considered are metals, plastics and ceramics. Data of interest includes thermal conductivity, electrical and ionic conductivity, pyroelectric and piezoelectric coefficients, mechanical properties of bulk materials, corrosion properties, mass transport (diffusion), energy levels and spectra. Table VIII-A "Materials Problems Related to Energy Conversion" illustrates the general scope for addressing this material data bank information center.

B. Material Degradation

This program will consider studies related to corrosion, mechanical and chemical degradation in the tropics of the most pertinent materials listed in Table VIII-A.

This program will also characterize or determine changes in radiation/reflection spectra of pertinent solar materials under tropical conditions.

An argon 7 watt laser in the blue and green spectra and a Raman grating spectrometer available at CEER from UPR/Mayaguez campus together with available expertise in the field already existing at Mayaguez will provide the analytical tools and "base" for the development of this part of the program. An U.V. source will be added into the program.

TABLE VIII-A

MATERIALS PROBLEMS RELATED TO ENERGY CONVERSION

Energy System	MATERIAL CLASS						
	Metals	Polymers	Inorganics & Ceramics	Thin Films	Liquids	Gases	Glasses
OTEC	1,4,8	4,1,3b	4,8,3b		9,5	5	
Solar Thermal	1,7,5	3a,8		3a,5	9,5		3a
Solar Electric	7,8,5				5		
Photovoltaic	1,3a		1,3a	8,3a,8,1			
Biomass	4,7						
Fossil	7,5,8				5		
Batteries and sensible Heat storage	1,2,8		5,6,2,8		6,2,5		
Nuclear	3,7,8	3a,c	3a,c		5,9		
Conservate							

Legend

(1) Electronic Conductivity
(2) Fonic Conductivity
(3) Radiation interactions
  (a) Electromagnetic
  (b) Accoustic
  (c) Particles
(4) Mechanical Properties
(5) Chemical Thermodynamic and Thermal Transport Properties
(6) Diffusion and Mass Transport.
(7) Corrosion (subdivision of 2)
(8) General Materials degradation will become radation or mechanical or chemical problems under more intensive investigation
(9) Surface Properties

C. Time Resolved Studies

Attempts are being made by CEER to obtain funds for research on synchorotion sources for diffraction and scattering studies in ferroelectric and other materials to characterize crystal structures. CEER personnel has many years of experience in neutron diffraction and scattering experimental studies with the decomissioned Triga research reactor.

This program proposes studies on time resolved structures of ferroelectric materials sith syncrotion sources.

D. Electrode Surfaces Studies

This program includes the development of scattering studies of electrode surface by EXAFS. A carbon electrode will be coated with a fraction of a monomolecular layer of suitable electrode material and the surrounding liquid of the electrode atoms examined by EXAFS. This will characterize or determine the radial distribution.

E. Electrochemical Cell Development

Electrochemical cells have two interesting large scale applications. The first is load leveling. The second, an electric car power source would put the transportation system on the utility grid. As long as oil is used for most generation, this seems pointless unless residual fuels become very much more plentiful than gasoline.

The field of solid state electrodes and solid electrolytes would, however, make excellent use of our backlog of

crystallographic knowledge skill and information and of much of the x-ray and electrical equipment that we have available.

One idea that comes to mind is the use of solid hydrates having high proton mobility (e.g. copper formate Cu $4H_2O$) as electrolytes together with a rare earth nickel hydride anode.

This program contemplates the possibilities of developing an electrochemical cell based on the indicated principles.

F. Plastic Materials Applications

Heat exchanger cleaning problems in OTEC systems represent an important consideration in total efficiency and power output of the plant. While it may not be true that ultrasonic will either enhance heat exchange much or reduce microfouling it has been shown to eliminate macrofouling. Thus it could replace Cl_2 which is environmentally unacceptable as a biogrowth inhibition in heat exchangers. PVDF can be manufactured as a rather inexpensive plastic film with piezoelectric properties that permit it to be used as an ultrasonic transducer. It may also be of use in water pipe screens and filters.

It is evident that of all the materials that were examined during the recent activity in one dimensional conductors, doped polyacetylene is perhaps most interesting. It is essentially a doped plastic with conductivity from insulator up to about 2000 mhl cm^{-1}. This is 2 orders of magnitude down from copper, but could be of interest for special application where metals are not wanted. It is also in the semi conductor range and

should be looked at for photovoltaic properties. Such polymers would conduct without the necessity of insulation i.e. they are 1 dimensional. A program to investigate the above possibilities of PVDF materials is proposed.

G. Solar Collector Surfactant Cleaning

Knowledge gained on surface and surfactant chemistry spreading, and contact angle phenomena could perhaps be used to examine possible methods of cleaning solar collectors without scrubbing. A knowledge of major airborne particulates would be necessary.

This program proposes to assess the potentiality of this new cleaning method.

H. Hydrogen Production via Solar Energy

Hydrogen represents probably the best form of storing solar energy. CEER will continue efforts initiated in Hydrogen production by use of solar energy. Research subjects such as Photo Induced Electron Transfer States, photocatalytic cycles, or photoelectrocatalysis using pervoskite photoelectrodes or thermochemical cycles will be examined for the most appropriate research development in the tropics.

TABLE VIII-1

MATERIAL PROGRAM OVERALL BUDGET DISTRIBUTION
(Thousands of Dollars)

Program Titles	82	83	84	85	86
A. Data Center	50	30	10	10	10
B. Materials Degradation	50	80	150	150	150
C. Time Resolved Studies	40	35	60	70	80
D. Electrode Surfaces	60	80	100	100	100
E. Electrochemical Cell Development	-	50	70	100	100
F. Plastic Material Applications	-	50	75	100	100
G. Solar Collectors-Surfactant Cleaning	-	30	40	50	50
H. Hydrogen Production via Solar Energy	50	100	150	200	200
TOTALS	250	455	655	780	790

TABLE VIII-2

MATERIAL PROGRAM PERSONNEL DISTRIBUTION
(Man-Years)

	Program Titles	82	83	84	85	86
A.	Data Center					
	Scientific Staff	.6	.2	.1	.1	.1
	Technical Staff	.6	.5	.1	.1	.1
	Administrative Staff	.6	.5	.1	.1	.1
B.	Materials Degradation					
	Scientific Staff	.5	.7	1.5	1.7	1.7
	Technical Staff	.7	.7	1.0	1.5	1.5
	Administrative Staff	.3	.3	.5	.8	.8
C.	Time Resolved Studies					
	Scientific Staff	.7	.5	1.0	1.1	1.2
	Technical Staff	.2	.2	.5	.5	.5
	Administrative Staff	.1	.1	.1	.2	.2
D.	Electrode Surfaces					
	Scientific Staff	.6	1.0	1.5	1.5	1.5
	Technical Staff	.6	.7	.8	.8	.8
	Administrative Staff	.2	.2	.2	.2	.2
E.	Electrochemical cell Development					
	Scientific Staff	-	.4	.8	1.2	1.2
	Technical Staff	-	.8	.8	1.4	1.4
	Administrative Staff	-	.4	.5	.5	.5
F.	Plastic Material Applications					
	Scientific Staff	-	.6	.9	.9	.9
	Technical Staff	-	.5	.8	.8	.8
	Administrative Staff	-	.3	.3	.3	.3
G.	Solar Collector - Surfactant Cleaning					
	Scientific Staff	-	.4	.4	.7	.7
	Technical Staff	-	.2	.2	.5	.5
	Administrative	-	.1	.1	.1	.1

TABLE VIII-2 (Continuation)

H. Hydrogen Production via Solar Energy					
Scientific Staff	.2	.6	1.5	1.8	1.8
Technical Staff	.5	.8	1.0	1.6	1.6
Administrative Staff	.2	.3	.3	.5	.5
TOTALS PERSONNEL, MATERIAL PROGRAM					
Scientific Staff	2.6	4.1	7.3	8.6	8.9
Technical Staff	2.6	4.4	5.2	7.2	7.2
Administrative Staff	1.4	2.2	2.1	2.7	2.7
TOTAL	6.6	10.7	14.6	18.5	18.8

TABLE VIII-3

MATERIAL PROGRAM BUDGET DISTRIBUTION
TYPE OF RESEARCH
(Thousand of Dollars)

Program Titles	82	83	84	85	86
A. Data Center					
Development	50	30	10	10	10
B. Materials Degradation					
Development	50	80	150	150	150
C. Time Resolved Studies					
Basic Research	40	35	60	70	80
D. Electrode Surfaces					
Basic Research	60	80	100	100	100
E. Electrochemical Cell Development		50	70	100	100
F. Plastic Material Application					
Development	-	50	75	100	100
G. Solar Collector-Surfactant Cleaning					
Development	-	30	40	50	50
H. Hydrogen Production via Solar Energy					
Basic Research	50	100	150	200	200
TOTALS ALL PROJECTS ($ Thousands)					
Basic Research	150	215	310	370	380
Development	100	240	345	410	410
Demonstration	0	0	0	0	0
Education & Training	0	0	0	0	0
TOTALS	250	455	655	780	790

TABLE VIII-4

MATERIALS PROGRAM BUDGET DISTRIBUTION
CLASSIFIED (Thousand of Dollars)

Program Titles	82	83	84	85	86
A. Data Center					
Personnel	45	25	7	7	7
Equipment & Mats.	-	-	-	-	-
Services	5	5	3	3	3
B. Material Degradation					
Personnel	35	45	80	100	100
Equipment & Mats.	10	30	55	35	35
Services	5	5	15	15	15
C. Time Resolved Studies					
Personnel	30	25	45	50	55
Equipment & Mats.	5	5	10	10	10
Services	5	5	5	10	75
D. Electrodes Surfaces					
Personnel	35	50	70	70	70
Equipment & Mats.	20	20	15	15	15
Services	5	10	15	15	15
E. Electrochemical Cell Development					
Personnel	0	35	50	75	75
Equipment & Mats.	0	10	15	15	15
Services	0	5	5	10	10
F. Plastic Material Application					
Personnel	-	35	50	50	50
Equipment & Mats.	-	10	15	10	10
Services	-	0	5	5	5
G. Solar Collectors- Surfactant Cleaning					
Personnel	-	20	20	35	35
Equipment & Mats.	-	10	15	10	10
Services	-	0	5	5	5

TABLE VIII-4 (Cont.)

	82	83	84	85	86	
H. Hydrogen Production via Solar Energy						
Personnel	20	40	75	100	100	
Equipment & Mats.	20	40	50	50	50	
Services	10	20	25	50	50	
TOTALS All Material Programs						Totals
Personnel	165	275	397	487	492	1816
Equipment & Mats.	55	125	180	175	175	710
Services	30	55	78	118	123	404
TOTAL	250	455	655	780	790	2930

INTEGRATED TECH. ASSESSMENT

IX. Integrated Assessment Technology Program

The technology developed for the energy alternatives of (a) Solar Hot Water Systems, (b) wind driven electrical generators and pumps and, (c) photovoltaic arrays arrangements need to be placed as soon as practicable at the disposal of local manufacturing groups, salesmen and users in order to use effectively the R&D accomplished at the laboratory.

We propose to develop programs in each of the above three mentioned alternatives and with emphasis in the order given to integrate technological know-how to the local community. For the integrated assessment of large energy power systems using such alternatives as Biomass, OTEC, and central photovoltaics power plants, CEER proposes to continue economic evaluations of such alternatives on a periodic basis with computer developed programs to adequately program the needs of R&D funds for the development of such alternatives in the P.R. scenario. This requires coordination or integration with all government concerned agencies. The following programs and budget estimate are proposed:

A. Solar Hot Water Systems Program

Offer all hot water system manufacturers through an appropriate P.R. Government Agency such as Departamento de Asuntos del Consumidor (DACO), general

technical services and independent assurances:

1. economic analysis of calculated savings are correct

2. system capacity design is correct for expected loading

3. manufacturer equipment meets required tests successfully and is of proper quality

4. publish for the benefit of manufacturers any late developments which might improve the economics of his operation and promote technical conferences

5. publish for the benefit of users general literature about solar water heating systems and do-it yourself pamphlet.

B. Wind Driven Turbines Program

Under this program CEER will establish a small community involved demonstration program of a wind driven electrical generator 1-5Kw and wind driven irrigation pump tests. Data will be generated for local manufacturers and entrepeneurs for commercialization. Users manuals will be prepared and also a do-it yourself pamphlet. Wind data will be developed for the whole island such that expected power output and energy could be determined from turbine characteristics. A mechanic will be available for direct help to users.

C. Photovoltaics Community Program

Under this program CEER will establish a small demonstration community involved program for photovoltaics

installations for communication applications and other small users.

Direct technical help and advice will be provided to manufacturers and users. Descriptive literature will be presented. This program will not become effective until 1985.

TABLE IX-1

INTEGRATED ASSESMENT TECHNOLOGY PROGRAM BUDGET ($ Thousands

	82	83	84	85	86	Total
A. Solar Hot Water System	50	55	60	65	70	300
B. Wind Driven Turbines	75	80	85	90	95	425
C. Photovoltaics Community	-	-	-	50	60	110
D. Energy Analysis	30	35	40	50	60	215
TOTALS	155	170	185	255	285	1050

TABLE IX-2

INTEGRATED ASSESSMENT TECHNOLOGY PROGRAM
PERSONNEL DISTRIBUTION

	82	83	84	85	86
Project A - Solar Hot Water Systems					
Scientific Staff	-	-	-	-	-
Technical Staff	1	1	1	1.3	1.3
Administrative Staff	.6	1	1	1.0	1.0
Project B - Wind Driven Turbines					
Scientific Staff	-	-	-	-	-
Technical Staff	2	2	2	2.4	2.4
Administrative Staff	.8	1	1	1	1.0
Project C - Photovoltaics Community					
Scientific Staff	-	-	-	-	-
Technical Staff	-	-	-	1	1
Administrative Staff	-	-	-	1	1
Project D - Energy Analysis					
Scientific Staff	.5	.6	.8	.9	1.0
Technical Staff	-	-	-	-	-
Administrative Staff	.5	.5	.5	.5	1.0
TOTALS All Projects					
Scientific Staff	.5	.6	.8	.9	1.0
Technical Staff	3	3.0	3.0	4.7	4.7
Administrative Staff	1.9	2.5	2.5	3.5	4.0

TABLE IX-3

INTEGRATED ASSESMENT TECHNOLOGY PROGRAM BUDGET
TYPE OF RESEARCH

	82	83	84	85	86	Totals
A. Solar Hot Water System						
Basic Research	-	-	-	-	-	
Development						
Demonstration						
Education & Training	50	55	60	65	70	
B. Wind Driven Turbines						
Basic Research						
Development						
Demonstration						
Education & Training	75	80	85	90	95	
C. Photovoltaics Community						
Basic Research						
Development						
Demonstration						
Education & Training				50	60	
D. Energy Analysis						
Basic Research						
Development	30	35	40	50	60	
Demonstration						
Education & Training						
TOTALS						
Basic Research						
Development	30	35	40	50	60	215
Demonstration						
Education & Training	125	135	145	205	225	835

TABLE IX-4

INTEGRATED ASSESMENT TECHNOLOGY PROGRAM BUDGET
CLASSIFIED

	82	83	84	85	86	Total
A. Solar Hot Water System						
Personnel	30	35	35	40	40	180
Equipment & Mats.	20	20	20	20	20	100
Services	-	-	5	5	10	20
B. Wind Driven Turbines						
Personnel	50	50	55	60	60	275
Equipment & Mats.	25	25	25	25	30	130
Services	-	5	5	5	5	20
C. Photovoltaics-Community						
Personnel	-	-	-	30	35	65
Equipment & Mats.	-	-	-	20	25	45
Services	-	-	-	-	-	-
D. Energy Analysis						
Personnel	25	30	35	40	50	180
Equipment & Mats.	5	5	5	5	5	25
Services	-	-	-	5	5	10
TOTALS						
Personnel	105	115	125	170	185	700
Equipment & Mats.	50	50	50	70	80	300
Services	-	5	10	15	20	50
	155	170	185	255	285	1050

NUCLEAR PROGRAM

X. NUCLEAR PROGRAM

A. Nuclear Fusion Program

Nuclear fusion promises to be the ultimate and optimum solution of the energy problem for humanity. The first nuclear fusion reactors will use tritium fuel. Approximately 85% of the energy in this type of reaction is liberated in the form of 14MEV neutrons. Any machine designed to harness the energy produced by this type of reaction must convert the 14MEV neutronic energy into a manageable form.

> The most commonly considered concept to harness the 14MEV neutron energy in fusion reactors is by permitting the energy to be deposited in a lithium blanket designed to breed the required tritium 107 and the heat generated in the blanket is remcved by conventional heat exchanger technology to operate a rankine cycle. This approach does not lend itself to the generation of out reactor fuels.

Hydrogen production from water decomposition with 14MEV neutrons is of particular interest in the harnessing of this fusion energy for the generation of out reactors fuels. CEER has at its facilities in Mayaguez a 150KEV proton accelerator and facility which produces 14MEV neutrons in a target reaction which could be effectively used for this purpose.

> Existing experimental data on the conversion efficiencies of radiolytic water decomposition indicate values of 10%. Some experimental data indicate higher efficiencies (30 to 40%), but these results are not fully understood and the researchers have

not been able to duplicate experimental results such as the CIRENE reactor experiments. More important, however, there is no data using 14MEV neutrons as a source. It is estimated that 30-40% conversion efficencies in radiolytic decomposition of water with 14MEV neutrons can result in acceptable hydrogen/electricity production scenarios.

CEER proposal of February 1977 entitled "Feasibility Design Study Project for a 100KWE Level Pilot Plant Fueled by Hydrogen Produced by Direct Solar Heat" contains a detailed discussion of the most promising thermochemical cycles to that date. The use of 14MEV neutrons in a thermochemical step can result in eliminating incovenient high temperature steps of a particular switable thermochemical cycle.

CEER has been in contact with KMS Fusion of Ann Arbor, Michigan in an effort to establish such a program. KMS Fusion is willing to develop a joint effort with CEER in this area. In addition, CEER personnel will maintain itself abreast of the new developments in Fusion Technology by attending seminars, symposia, reading the literature and holding occasional local lectures.

B. Nuclear Fission Program

In the field of nuclear fission CEER proposes to monitor and transfer technological information from the national laboratories to interested CEER/UPR, P. R. industry and Latin American countries interested personnel. Distinguished investigators and professors will be invited from time to time to present findings and developments to CEER

personnel. CEER personnel will attend national meetings, conferences, symposia, etc.

Tables XI-1 through XI-4 illustrate the funding and effort scheduled.

TABLE X-1

NUCLEAR PROGRAM
BUDGET (In Thousands $)

	82	83	84	85	86	Total
A. Nuclear Fusion Program	60	75	75	100	100	410
B. Nuclear Fission Program	5	5	5	5	5	25
TOTAL	65	80	80	105	105	135

TABLE X-2

NUCLEAR PROGRAM
BUDGET - PROGRAM PERSONNEL DISTRIBUTION

	82	83	84	85	86
Nuclear Program					
Scientific Staff	1	1	1	1.25	1.25
Technical Staff	.5	.5	.5	.1	.1
Administrative Staff	.1	.1	.1	.5	.5

TABLE X-3

NUCLEAR PROGRAM
TYPE OF RESEARCH

	82	83	84	85	86	Total
Nuclear Program						
Basic Research	60	75	75	100	100	410
Development						
Demonstration						
Education & Training	5	5	5	5	5	75

TABLE X-4

NUCLEAR PROGRAM

	82	83	84	85	86	Total
Personnel	45	45	45	70	70	275
Equipment & Materials	20	35	30	30	30	145
Services	-	-	5	5	5	15
TOTALS	65	80	80	105	105	435

TRANSPORTATION AND CONSERVATION

XI TRANSPORTATION AND CONSERVATION

CEER has an ongoing program on the important transportation and conservation area. Approximately 25% of all energy consumption in Puerto Rico is accounted for by the Transportation Sector. Over 17 millions barrels of distillates will be consumed in Puerto Rico during 1979 by nearly one million vehicles.

CEER ongoing programs in this area are classified under two main topics:

- Hybrid Vehicle Test and Demonstration Program, and
- Socio-Economic and Decision Policy Studies.

CEER has been in contact with JPL and the University of Florida in the program development for the Hybrid Vehicle Test and Demonstration Program. A Hybrid Vehicle has already being purchased by CEER for this program.

In the area of Socio-Economic and Decision Policy Studies CEER has already published studies on:

- San Juan Transit: Outline of a Policy Analysis for Decision Making (October 1977).
- Energy Conservation in Transportation in P. R: A Policy Study (September 1978).
- Policy R&D: Outline of a methodology with reference to decision making in the fields of energy, transportation and environment (September 1979).

Description of the above two main topics on transportation follows.

Hybrid Vehicle Development, Test and Demonstration Program

It is believed that due to the unique driving conditions in Puerto Rico (80% of all driving is done in the urban areas) considerable energy savings can be accomplished by utilizing transportation modes matched to a particular driving cycle. One of this modes is the hybrid vehicle. This vehicle utilizes an electric motor in its propulsion train with a modest bank of batteries as a power source. A gasoline or diesel driven electric generator is used to recharge the batteries while the vehicle is in motion, while driving at slow speeds in urban traffic or while stopped awaiting a traffic light change. When properly matched (electric motor-gas driven generator) the hybrid vehicle's range is essentially dictated by the capacity of the internal combustion engine fuel tank.

The CEER's Hybrid Vehicle Development, Test and Demonstration Program seeks to demonstrate the technical feasibility, and greater fuel economy of this mode of transportation. It also seeks to create public awareness and acceptance of the hybrid vehicle in Puerto Rico as a viable transportation alternative through information dissemination and vehicle demonstrations.

To accomplish these goals the Hybrid Vehicle Development Test and Demonstrations Program proposes the following projects:

A. Development of a Driving Cycle for Urban P. R.

B. Hybrid Vehicle Power Train Optimization

C. Hybrid Vehicle Demonstration

D. Motor-Generator Engine Development for Hybrid Vehicle Applications

Project A seeks to characterize the unique driving conditions in Puerto Rico. Due to the fact that 80% of all personal driving in the island is performed in the urban areas substantial fuel economies can be achieved by utilizing electric propulsion where motor efficiency is essentially independent of speed and load. In order to make valid testing and comparisons a driving cycle characteristic of the urban driving conditions in Puerto Rico must be developed and confirmed.

Project B is expected to optime the hybrid vehicle power train. The interrelationships between speed, range, vehicle and battery pack weight, electric motor horsepower and generator set capacity as applied to a particular driving cycle have a marked impact on the energy consumption. This subprogram seeks to model the system and to test one or more actual power train arrangements.

Project C will be directed towards the demonstration of the feasibility of utilizing hybrid vehicles in fleet operation. The program will be tailored to a particular driving application stressing fuel economy, personnel training, public awareness and overall vehicle evaluation.

A fleet of at least ten vehicles is to be purchased and operated by the University of Puerto Rico, Mayaguez Campus Buildings and Grounds Department. Funds from DOE and the P. R. Energy Office are expected to be obtained.

Project D is directed towards the development of motor generators specifically applied to hybrid vehicle use. Such parameters as type of generator winding, motor controls and weight will be optimized, build and tested.

fuel-efficient mix of transportation/mobility modes:

(i) More sensible uses of private automobiles (total mileage; increased occupancy)

(ii) Bus-and-publico system (integrated)

(iii) Realistic rail concepts for San Juan and the Island

(iv) Mobility alternative to Private Vehicle Transportation System PUTS)

- bycycles
- walking
- (Synthesis and development of existing plans)

(v) Water-based transportation

(vi) Incentives/disincentives, positive restraints on PVTS (see C. and D. below)

3. Non-construction methods of improving TSM.
4. Management/information system.
5. Socio-environmental aspects of TSM; e.g. traffic flow/density studies related to institutional location, operations, work hours, residences of employees--as input into the development of short-term, quick-fix measures, as well as of longer-term planning.
6. Analysis and anticipation of new parameters (technology, fuels, supply, cost, etc.).

C. Transportation Economics

1. Analysis of the extent to which PVTS is publicly subsidized (fuel cost, parking, highway use, violations, low inspection/ maintenance standards with resulting accident cost and air quality impact, use of general funds for highway maintenance, etc. -- see "Energy Conservation in Transportation..., pages 56-60, for a more detailed inventory of apparent categories of subsidies).
2. Analysis of the real C/B of public transportation vs. non-subsidized PVTS.
3. The elasticity of demand for private transportation in function of the Puerto Rican socioeconomic structure.
4. The resulting policy directives.

D. Transportation Policy R&D

1. Feasibility of active restraints on PVTS through
   (i) controlled availability of fuel
   (ii) cost (removal of subsidies)
   (iii) Physical restraints (access, parking, etc.)
   (iv) taxing and other disincentives
   (v) regulatory and enforcement
2. Analysis of the elements and causes of the previous failures to adopt and implement a rapid transit in San Juan ("Metro") and on the Island ("Tusca").

3. Elaborate for concrete application the concept of transportation as function of human and environmental resources and opportunities vs. the limited technoeconomic conception and planning. (This "ecomanagement" concept of transportation was outlined in "San Juan Transit..."). Develop this study so it would also contribute to national EDP in transportation.
4. Improvement of the degree of certainty in transportation decision making through better methodology, system analysis and synthesis, increased quantification of the socio-environmental data, and other techniques or policy R&D.
5. Progressive improvement through concrete applications of technology and environmental impact assessment in transportation, also with the aim of contributing to EDP on the national level.

E. Institutional and Legal Elements

1. Foster through specific programs and proposals the integration of transportation research and operations in Puerto Rico: CEER, RUM Transportation Institute, TOP, CSP, Office of Energy, Planning Board, Ports Authority, etc.
2. Have input in
   (i) Revision of the P. R. Traffic Code
   (ii) Reorganization of the Executive Branch, so as to foster TSC and TSM policies. (E.G., the Traffic Code is energy "blind"; the present organization of the government promotes fragmentation in policy development and

implementation).

3. Provide policy and drafting support in the development and revision of laws and regulations pertaining to:
   (i) licensing
   (ii) enforcement
   (iii) tax structure and other incentives/disincentives favoring TEC and TSM.
4. Monitor reaction of agencies to CEER studies and provide active support enhancing favorable measures and actions.

F. Education

1. Publication and dissemination of CEER studies:
   (i) Puerto Rican government
   (ii) National circulation where indicated
   (iii) Adaptation and translation into Spanish (where necessary) of research results judged potentially useful in the context of Latin American transportation/energy problems.
2. Development of more effective techniques and programs aimed at TEC, based on public opinion and related studies.
3. Sectoral contribution to CEER public information and awareness programs.

TABLE XI-1a

TRANSPORTATION AND CONSERVATION - HYBRID VEHICLE

Overall Budget Distribution
(Thousands of Dollars)

Hybrid Vehicle	81	82	83	84	85	86
A. Driving Cycle	147.5					
B. Power Train Optimization	152.5	202.5				
C. Hybrid Demonstration		272.5	202.5	202.5	202.05	
D. M-G Dev. for Hybrid Vehicle				242.5	167.5	167.5
TOTALS	300	475	202.5	445	370	167.5

TABLE XI-2a

PROGRAM PERSONNEL DISTRIBUTION HYBRID VEHICLE
(Man-Years)

	81	82	83	84	85	86
Program Titles						
A. Driving Cycle						
Scientific Staff	2					
Tech. Staff	2					
Admin. Staff	1					
B. Power Train Optimization						
Scientific Staff	2	3				
Tech. Staff	1	2				
Admn. Staff		1				
C Hybrid Vehicle Demonstration						
Scientific Staff		2	2	2	2	
Tech. Staff		4	4	4	4	
Admin. Staff		1	1	1	1	
D. M-G Dev. for Hybrid Vehicle						
Scientific Staff				3	2	2
Tech. Staff				2	2	2
Admin. Staff				1	1	1
Total						
Scientific Staff	4	5	2	2	5	2
Technical Staff	3	6	4	4	6	2
Administrative Staff	1	2	1	1	1	1
TOTALS	8	13	7	7	13	5

TABLE XI-3a

PROGRAM BUDGET DISTRIBUTION - HYBRID VEHICLE
TYPE OF RESEARCH (Thousands of $)

	81	82	83	84	85	86
Program Titles						
A. Driving Cycle						
Development	147.5					
B. Power Train Optimization						
Development	152.5	202.5				
C. Hybrid Vehicle Demonstration						
Demonstration		272.5	202.5	202.5	202.5	
D. M-G Development for Hybrid Vehicle						
Development	———	———	———	242.5	167.5	167.5
TOTALS	300	475	202.5	445	370	167.5

TABLE XI-4a

PROGRAM BUDGET DISTRIBUTION - HYBRID VEHICLE

Program Titles	81	82	83	84	85	86
A. Driving Cycle						
Personnel	122.5					
Equipment & Materials	20					
Services	5					
B. Power Train Optm.						
Personnel	87.5	157.5				
Equipment & Materials	60	40				
Services	5	5				
C. Hybrid Vehicle Demons.						
Personnel		157.5	157.5	157.5	157.5	
Equipment & Materials		110	40	40	40	
Services		5	5	5	5	
D. M-G Development for Hybrid Vehicle						
Personnel				157.5	122.5	122.5
Equipment & Materials				80	40	40
Services				5	5	5
All Programs						
Personnel	210	315	157.5	315	280	122.5
Equipment & Materials	80	150	40	120	80	40
Services	10	10	5	10	10	5
TOTALS	300	475	202.5	445	370	167.5

Table XI -1b

POLICY STUDIES BUDGET (Thousands of $)

Policy Studies	82	83	84	85	86
A. Scenarios Up date	15	15	50	20	60
B. Transportation System Management	45	45	45	60	65
C. Transportation Economics	20	25	10	15	20
D. Trasnportation Policty R & D	37	42	45	50	55
E. Institutional and Legal	18	21	20	30	30
F. Education	15	17	18	25	30
Totals	150	165	188	200	220

TABLE XI-2b

PROGRAM PERSONNEL DISTRIBUTION - TRANSPORTATION POLICY STUDIES
(Man-Years)

	82	83	84	85	86
Scientific Staff					
A. Scenarios	.6	.6	.8	.7	.6
B. TSM	.9	.9	.9	1.0	1.1
C. Energy/Economics	.4	.4	.3	.3	.3
D. Policy	.8	.8	.7	.7	.7
E. Legal/Institutional	.3	.3	.3	.3	.3
Total Sc (A-E)	3	3	3.1	3	3
Pers. Tech. (A-E)	.5	.5	1.0	1.0	2.0
Pers. Adm. (A-E)	.75	.75	.75	.75	.75
F. Educational					
Sc	-	-	-	-	-
Tech	.5	.5	1.0	1.0	1.0
Adm	.25	.25	.25	.25	.25
All Programs (A-E)					
Sc	3	3	3	3	3
Tech	1	1	2	2	3
Adm	1	1	1	1	1
All	5	5	6	6	7

TABLE XI-3b

BUDGET DISTRIBUTION — POLICY STUDIES

(Thousands of $)

	ALL PROGRAMS (A-F)				
	82	82	84	85	86
Basic Research					
Development	135	148	170	175	190
Demonstration	-	-	-	-	-
Education and Training	15	17	18	25	30

TABLE XI-4b
BUDGET DISTRIBUTION - TRANSPORTATION POLICY STUDIES
(Thousands of $)

	82	83	84	85	86
All Policy Studies (A-F)					
Pesonnel	130	140	155	161	175
Equipment/Materials	1	2	3	4	5
Services	19	23	30	35	40
	150	165	188	200	220

PUBLIC AWARENESS

XII THE PUBLIC AWARENESS PROGRAM

Puerto Rico is a self contained community with energy problems which stem from a worldwide scenario superimposed by unique societal and geopolitical circumstances.

Much of the Department of Energy efforts addressed to improve public awareness in the energy plight are not, in general, effective in Puerto Rico, the Caribbean and other South American countries. Programs effective to a local community such as Puerto Rico should consider the following set of unique conditions:

- The most effective means of promotion and communication among people is through the Spanish language.
- Daily experience is geared to a tropical climate, with hardly any seasonal change. All references to winter rigor preparation and awareness are totally meaningless.
- Government and public services are all centralized. Health, education, justice, public order, and utilities, all of these are regulated by the state government. Puerto Rico for all purposes, could be viewed as a big county with little, if any municipal government independence. Puerto Rico is densely populated - as dense as if all the population of the world were living in the U. S.
- Puerto Rico has a very dense automobile population, about five times as dense as the U. S. That is comparable to a billion cars in continental U. S. A.

- Puerto Rico is little known by the majority of the American people. Even at the cultural level represented by the project evaluators, unexpected and serious gaps of information become evident from their comments with disastrous effect for the fairness of the competition.
- Puerto Rico has a total lack of geological energy resources. P. R. institutions buy energy at the price imposed by OPEC. Further large increases on oil prices could paralize P. R. economy and make Puerto Rico largely dependent on energy sources from the U. S., posting an additional burden to an already taxed energy situation. Public awareness of this fragil scenario is imperative among both local and continental citizenry.

There is, therefore, a strong rational to include a Public Awareness Program as an institutional component in a proposed Five Year Plan.

CEER's Public Awareness Program is subdivided into four areas: Educational Program, Source Information Program, Active Information Program, Community Participation Program.

A. Educational Program

The main goal of this Program is to develop a state of awareness, interest, and enthusiasm among primary, secondary and community college teachers for the energy predicament both global and national

and its effect and implication to the peculiar situation of Puerto Rico. It is expected that the awareness stirred by this program be translated into positive and meaningful educational achievements which the program in turn will support and promote.

A list of activities, by no means inclusive, is the following:

- Visits, informal talks and demonstrations to teachers by scientists, educators, and administrators.
- Chautauqua type sessions with teachers where educators, scientists, engineers, technicians and other specialists present different aspects of the energy situation.
- Actual visit to the classroom by educators for teaching demonstrations, field trips, experiments, etc.
- Limited student and teacher research participation in collaboration with CEER staff and/or professors from sponsoring universities. Although these studies may range from simple short range projects to more complex involvements they must seek solutions to clearly identified problems of local importance.
- Production and/or adaptation of curricular materials and/or methodologies directed to enhance the student and community awareness to the energy plight. CEER will sponsor this activity as single teachers projects but preferably as a collaborative effort among teachers, researchers, and other educational specialists.
- Organization and/or support of teachers and students summer workshops.

A. Educational Program Budget

Activity	FY-82	FY-83	FY-84	FY-85	FY-86
Visits, chautauqua, teaching	$12,000	$13,000	$14,000	$15,000	$16,000
Research participation, teachers	12,000	13,000	14,000	15,000	16,000
Research participation, students	5,000	5,000	6,000	6,000	7,000
Curricular projects	10,000	11,000	12,000	13,000	14,000
Teacher's workshops	10,000	11,000	12,000	13,000	14,000
TOTALS	$49,000	$53,000	$58,000	$62,000	$67,000

B. Source Information Program

This Program intends to perform as a clearing house for the flow of information to the public and among organizations dealing with energy related projects. The following activities are relevant to this program:

- Store energy related information particularly that relevant to Puerto Rico and other Caribbean areas.
- Prepare a data bank files for computerized retrieval of the important features of the stored information. Make accessible these files to both local and national users.
- Establish an information retrieval center connected to the main national systems.
- Provide the necessary information when requested by private individuals and institutions.
- Sponsor the formation of Teacher's Centers throughout the Island where information, advise and instructional material could be provided to the teacher.

B. Source Information Program Budget

Activity	FY-82	FY-83	FY-84	FY-85	FY-86
Data acquisition	$20,000	$12,000	$13,000	$14,000	$15,000
File preparation and update	50,000	12,000	13,000	14,000	15,000
Information Center hardware and maintenance	300,000	10,000	10,000	11,000	11,000
Information Center software and maintenance	100,000	10,000	10,000	11,000	11,000
Service	18,000	19,000	20,000	21,000	22,000
Teachers Centers (1/2 support) Four Centers	12,000	26,000	42,000	60,000	64,000
TOTALS	$500,000	$89,000	$108,000	$131,000	$138,000

C. Active Information Program

This Program is the CEER's arm for disseminating information to the general public. It responds to the needs of springing public awareness on energy related topics and events. Again, emphasis will be placed on information relevant to Puerto Rico and the Caribbean area.

Some of the activities for this information center are the following:

- Production of regular short (4 page) and non technical publication (probably monthly, possibly, twice a month). This will be distributed to all schools, churches, government offices and to all who request receiving it. It should include one or more non technical articles analyzing the current news on energy and the national and local societal impact. Translation with adaptation of suitable articles published elsewhere could also be included, as well as a summary of important events and news.
- Sponsor public lectures, colloquia and seminars.
- Prepare and show in public theaters, schools, universities films on CEER's activities.
- Prepare and distribute posters, shirts, captions, bumper stickers, etc., with energy messages in Spanish and with local flavor. Adapt, translate and distribute public information material prepared by DOE.

- With the cooperation of the government TV and radio stations prepare spots, documentals, regular news programs and children programs on energy.
- Prepare public exhibitions, mobile exhibitions and demonstrations.
- Organize periodically open houses in CEER facilities to make the public conscious of the island's energy problem and to promote the appreciation of the research and development programs necessary to cope with it.

C. Active Information Program Budget

Activity	FY-82	FY-33	FY-84	FY-85	FY-86
Regular publication (10 issues a year)	$50,000	$52,000	$54,000	$56,000	$60,000
Public lectures	2,000	2,000	3,000	3,000	3,000
Posters, etc.	5,000	5,000	6,000	6,000	7,000
Translations, adaptation, disemination	5,000	5,000	6,000	6,000	7,000
Films (one a year)	4,000	4,000	5,000	5,000	5,000
TV + radio spots	4,000	4,000	4,000	5,000	5,000
Stationary & Mobile exhibitions	25,000	8,000	9,000	10,000	12,000
Open houses	2,000	2,000	3,000	3,000	3,000
Totals	$97,000	$82,000	$90,000	$94,000	$102,000

D. Community Participation Programs

In addition to arousing public interest and understanding to the energy plight, CEER should spur citizen participation through community action and by sponsoring community initiated proposals.

These are some of the activities that CEER could develop under this Program:

- Contact civic, professional and youth organizations as well as private groups to promote community action. Offer help in such endeavor. Suggest formations of stirring committees where CEER personnel could be used as resources.
- Assist civic, professional and youth organizations as well as private groups in the preparation of proposals to CEER and/or government agencies. Offer advise in carrying out activities supported by grants and awards.
- Encourage the formation of energy clubs; sponsor debates on energy issues.
- Promote citizen's participation, as full as possible, in assisting CEER's research projects as well as those conducted in other institutions. Deputize young and adult groups to participate as full as possible in selecting phases of CEER's Public Awareness Program.
- Organize and sponsor regional and islandwide meetings of representatives from civic, professional and youth organizations as well as from other interested groups to report on current community participation projects and plan future actions and collaborations.

D. Community Participation Program Budget

Activity	FY-82	FY-83	FY-84	FY-85	FY-86
Promotion of community action	$5,000	$5,000	$6,000	$6,000	$7,000
Community assistance	10,000	10,000	11,000	11,000	12,000
Meetings	6,000	6,000	7,000	7,000	8,000
TOTALS	$21,000	$21,000	$24,000	$24,000	$27,000

TABLE XII-1

PUBLIC AWARENESS PROGRAM
(Thousands $)
Total Budget

Program	FY-82	FY-83	FY-84	FY-85	FY-86	Total
A. Education	$49,	$53,	$58,	$62,	$67,	289
B. Source Information	500,	89,	108,	131,	138,	966
C. Active Information	97,	82,	90,	94,	102,	465
D. Community Participation	21,	21,	24,	24,	27,	117
TOTAL	$667,	$245,	$280,	$311,	$334,	1,837,

TABLE XII-2

PUBLIC AWARENESS PROGRAM
BUDGET PERSONNEL DISTRIBUTION
ALL PROGRAMS

	82	83	84	85	86
Scientific Staff	1	1	1	1	1
Technical Staff	4	4	4	4	4
Administrative Staff	3	3	3	3	3

TABLE XII-3

PUBLIC AWARENESS PROGRAM
BUDGET TYPE OF RESEARCH (Thousands)

	82	83	84	85	86	Total
Basic Research	-	-	-	-	-	
Development	-	-	-	-	-	
Demonstration	-	-	-	-	-	
Education & Training	667	245	280	311	334	1,837

TABLE XII-4

PUBLIC AWARENESS PROGRAM
BUDGET DISTRIBUTION-CLASSIFIED (thousands $)

	82	83	84	85	86	Total
Personnel	150	150	160	160	170	790
Equipment & Mats.	47	35	40	40	50	212
Services	470	60	80	111	114	835
	667	245	280	311	334	1837

INTERNATIONAL PROGRAMS

XIII. INTERNATIONAL PROGRAMS

One of CEER's principal objectives is to serve as a center for international cooperation in the energy and environmental fields, particularly for scientists and technicians from tropical and sub-tropical areas, especially in the Caribbean and Latin America. In the past, efforts in this area have been extensive but ad hoc; there is at present no distinct international division or program. In the further definitions of its international goals, CEER proposes to concentrate its efforts on becoming a lead institution in U. S. efforts to transfer new energy technologies to the Caribbean community.

The islands and nations of the Caribbean community, defined as all the West Indies, Central America, and the countries on the Caribbean coast of South America, share with United States and Puerto Rico the need of achieving greater energy independence. The great majority of the individual countries, with the exception of Venezuela, and Trinidad and Tobago, are heavily or exclusively dependent on imported petroleum for their energy needs. To continue their process of economic growth and development and to lessen their balance of payment problems, greater energy independence becomes imperative. Alternative energy technologies, appropriate to the physical, cultural and economic condition of each individual country, have a great potential to help meet this goal.

The natural energy resource base of the Caribbean is most advantageous for the adoption and commercialization of renewable energy technologies throughout the region. These resources include high levels of solar radiation, excellent biomass growth rates, trade wind, geothermal formations, ocean currents and thermal gradients. These resources and their associated energy technologies have in many instances the capability of becoming cost competitive in the Caribbean sooner than in the U. S. due to their greater availability and the comparatively higher cost in most of the region of presently available alternatives.

Most individual countries in the Caribbean have a limited capacity to develop these technologies. The U. S. government and DOE has an important role to play in the region through a coordinated energy technology transfer program designed to assist in the assessment of energy needs, in the development and adaptation of technologies appropriate for individual countries, in the training and education of the requisite scientific and technical manpower and in providing technical assistance in the final adoption and implementation of the new energy technologies. A regionally-based institution is needed to serve as a focal point in these efforts and CEER is the logical choice to become such an institution. The technologies involved include not only the solar and renewable energy technologies previously mentioned but technologies such as enhancement oil recovery of heavy Venezuelan crude.

The rationale for converting CEER into a lead institution and focal point for U. S. efforts for the transfer of energy technologies in the Caribbean is as follows:

1) CEER's past and present international cooperative efforts serve as groundwork on which to build a visible and efficient institutional mechanism for energy technology transfer. These efforts include international conferences, country energy assessments and technical cooperation in research and development activities. These will be described below in greater detail. A network of scientific and in some cases political contacts have resulted from these efforts.

2. CEER's predecessor, the Puerto Rico Nuclear Center, served as a nuclear energy technology transfer and education and training center for scientists and technicians throughout Latin America. This heritage can be put to use in analoguous activities of technology transfer for renewable energy technologies by CEER.

3. CEER's divisional programs in the areas of Solar, OTEC, biomass, bioconversion, fossil fuels and ecology provide the scientific and technical expertise required to support a program of transfer of non-conventional energy technologies. Since the technologies need in many instances to be adapted to the particular circumstances of the countries involved, further developmental efforts are required. A technology transfer program for energy must therefore be coupled with established supportive research and development efforts to be successful. CEER's past achievements and future plans, as described elsewhere in this document, provide such support.

4. CEER already enjoys a unique position and reputation as a center for research and development of non-conventional energy technologies in the Caribbean. This position has been recognized in reports by Donovan, Hamester, and Rattien and by the U. S. Agency for Internatonal Development in recommending the extensive involvement and participation by CEER in national and international programs for energy technology transfer in the Caribbean.

5. CEER's staff possesses the bilingual capabilities and cultural ties needed to interact with scientists, officials, and technicians of the Caribbean community. While there is a diverse cultural background in the Caribbean, particularly in the West Indies, the Spanish language and heritage predominates. Puerto Rico stands in an unique position in this respect with its bilingualism, its cultural and language ties to the hispanic community and its economic and political ties to the United States.

6. CEER, by its location in Puerto Rico, and its ecological and environmental research capabilities, can play an important role in the environmental assessment of new energy technologies for the Caribbean. Puerto Rico's tropical environment shares similar physical and climatological traits with much of the Caribbean community.

As previously mentioned, CEER's past and present international cooperative efforts will serve as a basis for an expanded role as an energy technology transfer center for the Caribbean. These efforts

have been as follows: CEER sponsored the First Caribbean Conference on Energy for Development, held in April 1978, in San Juan, Puerto Rico. Representatives from twenty six countries or territories and seven international organizations attended. CEER was co-sponsor of a technical Congress for the Investigation and Conservation of Energy . Resources held in San Juan, November 1979. Participants from nine countries attended. CEER has also participated in two Caribbean conferences in Barbados, in a meeting on Caribbean Energy Accounting Systems in San Juan, and in the Final Report Conference on Preliminary Energy Sector Assessments of Jamaica.

CEER is presently involved in two country energy assessment projects in Panama and in Ecuador. CEER in cooperation with the Institute of Energy Conversion of the University of Delaware and with the University of Pennsylvania is in the final stages of a proposal for "Assistance in Developing a Master Plan for Utilizing Renewable Energy Resources of the Republic of Panama" submitted to IRHE, the Water Resources and Electrification Institute of the Republic of Panama. A joint CEER/SERI Project of assisting Ecuador's National Energy Institute in its development of an energy balance sheet has been proposed as a preliminary part of an Alternative Sources of Energy Project.

CEER has been involved in technical cooperation efforts with the Ministry of Energy and Mines of Venezuela. The Ministry has provided services to CEER's Fossil Fuels Program in its research efforts

in the Orinoco Valley. A cooperative program, funded in part by the Venezuelan Government, has been agreed in principle between the Energy Section of the Ministry of Energy and Mines and CEER. The first phase will give emphasis to energy assessment and developmental efforts in two areas: energy conservation and bio-conversion. The second phase will include extensive applied research and development efforts in oil-well enhancement technologies for heavy Venezuelan crude. This may subsequently include education and training activities.

CEER will present a proposal to DOE to develop a program plan for new energy technology transfer efforts by CEER in the Caribbean region. This study will result in a plan which will present recommendations on the scope and extent of technology transfer activities by CEER, on its organizational structure and integration with CEER's divisional programs, on opportunities for cooperation with national and international agencies for energy assessment and technology transfer efforts and with budgetary and manpower requirements for such programs.

Since the study has yet to be undertaken, it is premature to present budgetary or manpower requirements for CEER's International Programs. Nevertheless, a brief summary of the scope of the effort will be undertaken. These are subject to revision. The intent is to convert CEER into a lead Center for U. S. technology transfer efforts for solar and renewable energy in the Caribbean community.

Based on CEER's capabilities, the scope of these efforts may be extended in special cases as in the energy assessment studies for Ecuador and in the fossil fuels enhancement oil recovery activities for heavy Venezuelan crude. Two levels of activities are envisioned. The first being on an ongoing nature and at the regional level and the second being in-depth energy assessment efforts for particular countries. The areas of work at both levels may include energy assessments, research, development and demonstration activities, education and training and commercialization efforts. In particular this involves:

- studies of energy demand and resource base assessments;
- technical and economic feasibility studies of renewable energy technologies;
- research and development activities aimed at appropriate technologies;
- prototype demonstration and testing;
- institutional and industrial liaison activities;
- studies of financial and social incentives and barriers to commercialization;
- information dissemination activities for scientists, industry and consumers;
- and education and training activities aimed at training and technical manpower.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

April 11, 1976

ACTION MEMORANDUM 6108

TO: Administrator

FROM: Assistant Administrator for Field Operations

SUBJECT: REQUEST FOR APPROVAL OF A CHANGE IN THE ARRANGEMENT WITH THE UNIVERSITY OF PUERTO RICO (UPR) FOR MANAGEMENT OF THE PUERTO RICO NUCLEAR CENTER (PRNC)

ISSUE

To determine the programmatic and institutional future of the Puerto Rico Nuclear Center facilities and recommend, if necessary, changes to assure that the PRNC's future management and operation are consistent with ERDA's programmatic requirements.

METHOD

An ERDA Task Force was appointed by the AFO at the request of the AAA and AES to address the issue. A counterpart Puerto Rican Task Force was appointed by the President, UPR, to complement the ERDA Task Force effort (Enclosure 1).

BACKGROUND

Funding

The PRNC was established in 1958, under the Atoms-for-Peace program, to train Latin American students in nuclear medicine and technology. Due to funding restraints, the training and education program has diminished over the years. The annual training budget ($1.2 million in FY 76) has been used principally for basic operating support of the Center. AAA funding of this activity is expected to decrease to reflect the decreasing nuclear training needs at PRNC. However, PRNC's research role has grown, mainly with funds from AES ($1.062 million in FY 76) and sound expertise has been developed in terrestrial ecology, tropical marine biology and tropical human ecology. AES support for the marine biology, terrestrial ecology and human ecology programs is expected to continue and may increase slightly to pick up overhead costs previously carried in other programs. Research in nuclear medicine and agriculture is not a high

priority ERDA program and direct support for such research is not provided in FY 76. (Additional narrative background material is contained in Enclosure 2. Additional funding information is contained in Enclosure 3.)

FACILITIES

ERDA facilities associated with the PRNC had an acquisition value of about $9.0M. They are located at four sites on the island.

Rio Piedras Site

In the San Juan area are well-equipped medically-oriented facilities located adjacent to the UPR Medical School. These facilities include a biomedical building, animal quarters and a maintenance shop. These cost about $3.0M.

Mayaguez Site

The principal nuclear facilities of the Center are located on 20 acres of property adjacent to the UPR campus in the city of Mayaguez. These facilities include a research reactor (TRIGA); nuclear laboratories and hot cells; and several adjacent structures housing offices, nuclear engineering facilities, maintenance shops, and a greenhouse. Cost of these facilities was about $4.6M.

Cornelia Hill Site

Also located near the city of Mayaguez are the Cornelia Hill facilities which house the marine biology program. These are relatively new and well-equipped environmental analysis laboratories located on the ocean adjacent to the pier for the PRNC Research Vessel PALUMBO. Cost of facilities at Cornelia Hill was about $860K.

Luquillo National Forest Site

In the Luquillo Rain Forest is a data acquisition laboratory costing $120K.

(Additional facilities information is contained in Enclosure 4.)

RECENT EVENTS

A new contract with the University was authorized by the Administrator in June 1975 extending through 1981*. Since then, the following significant events have occurred: ERDA has proposed a reduction in funding for FY 77; a decision was made to transfer the TRIGA reactor to ID; a

* Contract AT(40-1)-1853 administered by ORO.

new Director, Dr. Ismael Almodovar, has assumed forceful and responsive leadership and initiated substantial cost reduction actions totaling $700K to be realized in FY 77; the University has proposed that the PRNC become the core of a new Energy and Environment Center (Enclosure 6), which would serve both ERDA and address the unique problems of the Commonwealth.

OPTIONS FOR CHANGE

After reviewing a broad range of options the following three options for accomplishing this change were explored in depth:

1. Continue the PRNC GOCO Arrangement with the UPR – making certain management and funding modifications.
2. Develop a mixed ERDA GOCO and Non-GOCO Arrangement with the UPR.
3. Discontinue the ERDA GOCO operations, transferring facilities to the UPR, or others, or close them if appropriate, and executing ERDA programs under other contractual bases.

Additional summary prepared ERDA background material on these options, including pros and cons, is contained in Enclosure 5. Additional detailed PRNC prepared background materials are contained in Enclosure 6.

RECOMMENDED OPTION

A transition from Option 1 (current status) to Option 3 over a three to five year period was determined by the joint Task Force to be the management arrangement in the best interests of the U.S. Government and the University of Puerto Rico for the following reasons: (1) it will permit ERDA to continue its high priority program work; (2) low priority ERDA programs can be phased out; (3) it will provide for the most economical use of Government funds; and (4) this arrangement will promote UPR institutional development consistent with both Commonwealth and U.S. needs.

This management change has the following features: (1) ownership of most of the facilities/equipment would be transferred to the UPR over a three-year period (FY 77-79); (2) certain facilities of no value to either party would be closed or transferred to other government agencies as soon as possible; (3) ERDA priority research and training programs would continue through appropriate contractual arrangement; (4) ERDA would provide institutional and developmental funding support for a five-year period (FY 78-82) to provide the University an opportunity to both use the newly acquired ERDA facilities for other energy technology areas (conservation, solar, ocean thermal energy conversion, and materials research and development), and to develop professional capability in

these new program areas; and (5) educational and training funding will be adjusted during the next three years (FY 77-79) to reflect the actual training requirements of ERDA at the UPR.

ERDA transfer of properties to the UPR and commitment of developmental funds provide a unique opportunity for the UPR to acquire excellent facilities and diversify its research and developmental base to take advantage of Puerto Rico's unique geographic features and to solve Commonwealth problems. This course is considered by the Joint Task Force to be a reasonable one to chart for a minority institution that is striving to increase its professional status and competitiveness in academe, as well as to serve both the U.S. Government and the Commonwealth of Puerto Rico.

This recommended option has been arrived at by a Joint ERDA/PR Task Force through a deliberative process which included examination of historical data, on-site examination of the facilities, and a thorough analysis of the three reasonable options. Puerto Rico interest groups, including the PRNC, the Commonwealth and the University, have participated extensively in the entire process and endorse the recommendation. The President, UPR, can be expected to endorse this recommendation.

RECOMMENDATION

The Task Force recommends the Administrator approve a three to five year transition from Option 1 to Option 3.

Approve: Robert C. Seamans, Jr.

Disapprove: _____

Date: April 13, 1976

NEXT STEPS

1. The AFO will advise the Manager, ORO, and the President, UPR, of the Administrator's decision.

2. The AFO will direct the Manager, ORO, to execute a contractual agreement with UPR to effect the transition. (Administrative guidance for this step is contained in Enclosure 8.)

3. The AFO will direct the Director, HQS OPA, to prepare a public announcement and arrange for a joint UPR and ERDA facilities transfer ceremony.

4. The AFO will direct the Director, HQS OCA, to notify the Puerto Rico Resident Commissioner of the Administrator's decision.

5. The AAA will direct the Manager, ORO, to initiate a study to determine the amount and cost of radioactive clean-up required at the Mayaguez site and funding options for the work.

6. The AFO and AAA jointly will work out the details of introducing development and institutional funding categories into the FY 78 budget and reducing the education and training base funding. Joint Task Force proposed transition funding levels FY 77-82 are shown in Enclosure 7. (See Red Tab)

7. The AAA in cooperation with AIA will explore the potential of its Puerto Rico Energy Environmental Center as a focal point for Latin American training.

Concurrences

AES, BER, Liverman	Date 4/11/76	Concur Liverman Nonconcur	Tab _____
AAA, Romatowski	Date 3/29/76	Concur [signature] Nonconcur	Tab _____
GC, Johnson	Date _____	Concur See Tab A Nonconcur	Tab _____
AIA, Sievering	Date 4/9/76	Concur [signature] Nonconcur	Tab _____
OCR, Cantus	Date 4/9/76	Concur [signature] Nonconcur	Tab _____
ISL, Smith	Date 4/12/76	Concur F. Smith Nonconcur	Tab _____
OC, Greer	Date 4-5-76	Concur MC Greer Nonconcur	Tab _____
OEO, Bowden	Date _____	Concur See Tab B Nonconcur	Tab _____
OPA, King	Date _____	Concur See Tab C Nonconcur	Tab _____

University of Puerto Rico
G. P. O. Box 4984—C
San Juan, Puerto Rico 00936

e of the President

April 9, 1976

Dr. Vitalij Garber
Energy Research and Development Administration
20 Massachusetts Avenue NW
Washington, D.C. 20545

Dear Dr. Garber:

I take pleasure in writing to you to endorse the plan for the UPR/PRNC Energy and Environmental Research Center prepared by our joint task forces during the meetings at ERDA headquarters March 24-26. The time frame proposed in the action memorandum should be feasible for us, so I do hope that Dr. Seamans will find the memorandum acceptable.

I wish to express special appreciation to the members of the ERDA Task Force for responding so constructively to the letter that I sent with Dr. Almodóvar emphasizing our obligations as a minority institution and our present tight budgetary situation.

My deep thanks go to all the members of our respective task forces for their hard work and splendid cooperation. I have high hopes for the success of our common endeavors.

Cordially,

Arturo Morales Carrión
President

MAY 5 1976

V-37088

ERDA TASK FORCE

Vitalij Garber (Chairman)
Technical Director
Office of the Assistant
Administrator for Field Operations

Russell Ritchie (Alternate Chairman)
Special Assistant to the Assistant
Administrator for Administration

John Whitnah
Office of the Assistant Administrator
for Environment and Safety

Jeff Swinebroad
Deputy Associate Director for
Research and Development
Division of Biomedical and
Environmental Research

James Kellett, Jr./Harold H. Young
Division of University and
Manpower Development/AAA

Joseph A. Lenhard, Director
Research and Technical Support Division
Oak Ridge Operations Office

Gail Bradshaw
Chief, Conservation, Environment and
Safety, News Branch
Office of Public Affairs

PRNC TASK FORCE

Ismael Almodovar (Chairman)
Acting Director
Puerto Rico Nuclear Center

Flavio Acarón, Dean
School of Engineering
Mayagues Campus

Manuel Gómez, Dean
College of Natural Sciences
Rio Piedras Campus

Juan J. Rigau, Director
Office of Petroleum Fuels Affairs
Office of the Governor
Commonwealth of Puerto Rico

Conrado F. Asenjo
Associate Dean
School of Medicine

Paul Harrison (Liaison)
Special Assistant to
UPR President

Luis E. Boothby
General Administrative Officer
Puerto Rico Nuclear Center

MANAGEMENT-FINANCE SUB-COMMITTEE

Petra L. de Toro
Acting Director
Office of Personnel
UPR Central Administration

Irma Vázquez, Director
Budget Division
UPR Central Administration

Andrés Medina-Peña
Acting Director
Finance Division
UPR Central Administration

BACKGROUND INFORMATION

Under its present form of government, Puerto Rico is a Commonwealth, electing its own chief executive and legislature, levying its own income, excise and other taxes, and sharing with the United States citizenship, defense, free trade and currency. A strong minority of the electorate favors becoming a State of the Union, while a much smaller but highly vocal minority favors complete and separate independence. The present Governor, Rafael Hernandez-Colon, is a strong advocate of Commonwealth with maximum autonomy consistent with continued common citizenship, defense, commerce and currency.

Puerto Rico has a land area of 3400 square miles, about three times the size of Rhode Island, but with 3.1 million people it has about three times Rhode Island's population, and it is totally dependent on imported petroleum. The rising costs of oil and the recent economic problem in the United States have combined to reduce the Commonwealth's real income and to drive the unemployment rate to over twenty percent, leaving many with college educations out of work.

The University of Puerto Rico

Education is of high priority in the Commonwealth. About 27 percent of the budget goes directly to support education. Another 4-6 percent provides indirect support. With a population of just over three million, and a per capita income lower than any mainland state, Puerto Rico has more than 100,000 students enrolled in its private and public colleges and universities. The UPR, one of the largest universities in the Western Hemisphere, has 52,000 students, mostly Puerto Rican. More than 20,000 of them receive some direct financial aid. The University is a source of pride and a center for development in the Commonwealth.

UPR is a land grant institution. Its funds come from tuition, relatively low by comparison ($80 per semester) to the mainland, and from legislative allocations. UPR gets a flat nine percent of the Commonwealth's income as basic funding, with special allotments added. In recent years, with the economic downturn, Commonwealth real income has declined and the University's budgetary base has been squeezed.

The University is guided by a Council on Higher Education which is appointed by the Governor and which, in turn, appoints the UPR President. The current President is Arturo Morales-Carrion. All significant appointments of chancellors, deans of faculties, and the Director of PRNC - must be approved by the Council. In recent years, there has been a frequent turnover in many of the major positions at UPR. There is a conscious effort to appoint qualified Puerto Ricans to major posts.

The University participates in a number of U.S. educational grants and research programs. Under a new policy, each contract, grant, or proposal for a grant or contract, must be in harmony with Council policy and be approved by the President of the University. Similarly, ERDA's arrangements with the University for the management of PRNC, must have the approval of the President and the Council of Higher Education.

Office of Petroleum Fuels Affairs

The office was created by the Legislature of the Commonwealth of Puerto Rico in July, 1973 to formulate a dynamic energy policy for the Commonwealth based upon empirical information which has been well quantified and qualified for analytical purposes. Among the fundamental objectives are the following: (i) To assure the availability of required energy supplies from secured sources; (ii) To obtain for our society the lowest possible cost for energy; minimizing the impact of energy costs on economic welfare and progress; (iii) To minimize the unfavorable effects which are induced by marketing problems and international energy policies; (iv) To establish a well correlated relationship between environmental matters, generation and utilization of energy; (v) To minimize inequities which may arise as a consequence of economic or regional factors in terms of costs and availability of energy sources; (vi) To promote efficiency and optimum use of energy in all energy operations and uses; (vii) To carry on scientific research in reference to alternate energy sources, orienting such efforts for the achievement of a regional energy sufficiency.

The Division of Scientific and Technological Reseach is an energy research and service unit which is an integral part of the Office of Petroleum Fuels Affairs.

The principal fields of interest include petroleum refining, energy utilization, fuel combustion, chemical composition, mathemetical modelling of atomspheric pollutants, and sulfur chemistry. The Office develops its applied reseach and service programs in a combined effort, when necessary, with industry, government and university scientific and technical personnel.

PROGRAM COST SUMMARY
PUERTO RICO NUCLEAR CENTER
FY 1958 – FY 1976

Fiscal Year	Training & Education Program	Physical Research	BER Programmatic Research	Other Programmatic Research	Latin American Exhibit	Work for Others: Federal Agencies	Work for Others: PRWRA & Misc.	Total Program Costs
1958	$ 119,000	$	$	$	$	$	$	$ 119,100
1959	376,700							376,700
1960	450,300							450,300
1961	750,509							750,509
1962	1,210,646		58,324					1,268,970
1963	1,181,042	38,845	217,847					1,437,734
1964	1,105,997	146,662	524,998					1,777,657
1965	1,121,262	170,317	620,738		33,727			1,946,014
1966	1,100,058	212,984	660,049	17,711[b]	54,023	3,365		2,048,190
1967	1,126,764	252,002	557,006	41,996[b]	56,101	0		2,033,869
1968	1,225,215	272,346	549,198	34,509[b]	58,349	11,390		2,161,007
1969	1,277,309	270,381	597,466	12,245[b]	45,702	24,438		2,227,541
1970	1,342,719	274,028	671,394		33,013	12,895		2,334,049
1971	1,440,302[a]	195,001	671,003	42,000[c]	2.3	5,000	156,620	2,509,926
1972	1,301,535	92,808	673,110	52,000[c]	2.1	73,712	315,467	2,508,632
1973	1,284,988	33,764	899,633	52,000[c]	2.3	0	762,833	3,033,218
1974	1,200,582	35,057	761,438	10,000[c]	1.996	0	1,390,569	3,397,646
1975	1,232,070	34,999	975,001		2.24	51,560	1,468,995	3,762,625
1976*	1,230,000		1,062,000		2.3	220,000	174,000	2,686,000

[a] Includes $164,600 for new reactor fuel and $1,275,702 for Training and Education activities.
[b] AEC Isotopes Development Program – Irradiation of Tropical Foods
[c] AEC-RRD contribution to support of PRWRA Power Reactor Studies.
* Estimate

6 yrs and 2.21

LAND AND BUILDINGS

March 1, 1976

I. Land

20 acres, Mayagüez, Federal Agricultural Experiment Station
20 acres, Mayagüez, Cornelia Hill
1 acre, Rio Piedras, Puerto Rico Medical Center
200 acres, Luquillo National Forest, Use Permit from the U.S. Forestry Service

Total 241 acres

II. Buildings

A- Mayagüez, Federal Agricultural Experiment Station

Building	Laboratory Space (sq.ft.)	Administrative Space (sq.ft.)	Other (sq.ft.)
1. Main	30,000	10,000	
2. Shop		1,000	5,000
3. Administration		5,800	
4. Nuclear Engineering	720	885	
5. Agricultural Shed	1,848		
6. Greenhouse	1,872		
7. Marine Biology Lab.	1,300		
8. Annex	2,400		
9. Neutron Generator	2,500		
10. Helium Liquefier	600		
B- Rio Piedras, Puerto Rico Medical Center			
1. Bio-Medical	30,000	10,000	
2. Animal Shop	3,000		2,500
C- Cornelia Hill, Mayagüez			
1. Laboratory	2,500	1,000	
2. Aquarium	1,920		
D- El Verde, Luquillo National Forest			
1. Laboratory	5,000		
Totals	83,660	28,685	7,500

Grand Total: 15 Buildings-119,845 square feet

III. New Construction

A- El Verde			
1. Data Acquisition Lab.	1,184		168
B- Cornelia Hill			
1. Laboratory	1,884	600	575
Totals	3,068	600	743

Grand Total: 2 Buildings-4,411 square feet

FACILITY INVESTMENT
PUERTO RICO NUCLEAR CENTER
FY 1958 thru FY 1975

FUNDING

Facility	Initial Occupancy	Cost
Mayagüez Site		
Nuclear Center Laboratory and Reactor	Sep. 1960	$2,960,811
Center Modifications and Minor Additions	--	785,907
Conversion of PRNC Reactor	Apr. 1972[a]	355,000
Nuclear Engineering and Training Reactor Annex	Jun. 1961	116,305
Marine Biology Laboratory	Jun. 1966	36,619
Administration Building	Jan. 1967	95,668
Shop Building and Additions	Mar. 1967	141,538
Agricultural Biosciences Laboratory and Additions	May 1968	95,568
Shielded Facility for Neutron Generator	Sep. 1971	49,295
Total Investment Mayagüez		$4,636,711
Río Piedras Site		
Biomedical Building	Feb. 1961	$ 589,278
Biomedical Building Addition	Sep. 1970	1,398,683
Radiotherapy Linear Accelerator	Aug. 1973	360,470
Modifications and Minor Additions	--	212,665
Animal Quarters and Virus Laboratory	Aug. 1965	203,224
Animal Experimental Facilities	Mar. 1975[a]	132,000
Maintenance Shop Facility	Sep. 1974	98,934
Total Investment-Río Piedras		$2,995,254
Cornelia Hill Site		
Marine Biology Lab. and Site Acquisition	Aug. 1966	$ 130,000
Modifications and Additions	--	280,974
Aquarium Laboratory	--[a]	101,200
Waterfront Facilities for Research Vessel	Jan. 1974	355,363
Total Investment-Cornelia Hill		$ 867,537
Luquillo National Forest Site		
Data Acquisition Laboratory	--[a]	$ 123,510
Total Investment - PRNC		$8,623,012

[a]Construction not Complete .

A Detailed ERDA Analysis of Three Principal Options

Option 1 - Continue PRNC GOCO Arrangement with the University of Puerto Rico - Make Certain Management and Funding Modifications

Maintain the current PRNC GOCO status but substantially improve it as follows:

1. Centralize the two PRNC administrative units (Mayaguez and Rio Piedras) into one, at Rio Piedras, to facilitate financial savings.

2. Eliminate programs that are of low priority for ERDA's purposes and which neither UPR nor others wish to support.

3. Seek support from other Federal agencies or other sources for any current PRNC programs that are of value to Puerto Rico and/or the United States, but are of low ERDA priority.

4. Phase out Base Program funding by reducing the education and training budget to the level that ERDA deems essential for these purposes and concurrently seek supplemental support from UPR, NSF, HEW, the Commonwealth of Puerto Rico, or other agencies as appropriate.

5. Strengthen existing valuable research programs and initiate new programs in ERDA high priority energy development areas through the introduction of developmental and institutional funding. The major program emphases would include five principal areas, the first two of which are ongoing, and the latter three of which will require devlopmental attention.

1. Environmental sciences.
2. Human ecology (biomedical).
3. Conservation.
4. Solar scientific and engineering research and development including OTEC.
5. Materials research and development.

Option 1 - Pros and Cons

Pros:

1. GOCO operation provides a very capable management organization and associated administrative and maintenance operations which can execute high technology R&D programs in a more effective and timely manner than would normally be available in the UPR complex.

2. GOCO operation provides a clearer focal point for the UPR Energy Center and a more obvious ERDA presence in Puerto Rico than would otherwise be possible.

3. GOCO operation provides a vehicle for putting other Federal agency work into PRNC under interagency agreement.

4. GOCO operation permits use of GSA supply contracts, FTS communication, and motor pool services.

Cons:

1. The GOCO operation requires its own separate administrative network within UPR which, while more efficient, is more expensive than if the central UPR administration handled the business activities.

2. The GOCO method of operation requires UPR compliance with a host of Federal requirements and procedures which necessitates a large PRNC administrative and overhead staff (As well as considerable ORO Contract Administration effort.)

3. The GOCO operation reduces UPR flexibility for use of PRNC facilities. It eliminates UPR ability to compete for commercial work to be partly or wholly performed in PRNC facilities and, under current restrictions, prevents UPR from responding to ERDA RFP's in new program areas of interest to UPR for performance in ERDA facilities.

4. The GOCO operation requires indefinite ERDA funding support for facilities and administrative support staff, irrespective of the quality of the program or relevance to developing ERDA priorities.

5. The GOCO operation historically has evoked clear separation between PRNC and the remainder of UPR and, while expected to improve, still will inhibit truly cooperative programs.

Further detailed supporting analysis of this option is contained in Appendix 10.

Option 2 - Develop a Mixed GOCO and Non-GOCO Arrangement with the UPR

Those current PRNC facilities which predominately house BER programs and are of high ERDA priority would be retained as Federal property. Those facilities of PRNC which appear closely integrated with and important to UPR programs would be programmatically transferred to the UPR and would be fiscally supported by those programs (ERDA program and institutional, UPR, or other) which utilize the facilities. The facilities which would be retained under Federal ownership would be:

1. Cornelia Hill
2. Rain Forest Facilities
3. Human Ecology Building at Rio Piedras

The facilities which would become a part of the UPR or otherwise disposed of by ERDA would be:

1. The Mayaguez Facilities
2. The Cornelia Hill Dock
3. The Main Building at Rio Piedras

Option 2 - Pros and Cons

Pros:

1. Retains maximum management and organizational strength for execution of life science and environmental programs at PRNC which are currently of highest program priority to ERDA.

2. Maintains clear and viable ERDA presence in Puerto Rico as a GOCO "Environmental Center".

3. Provides some facilities and equipment to UPR as a base for broadened energy center programs relevant to ERDA and the Commonwealth of Puerto Rico.

4. Provides UPR with flexibility to compete for some outside work and ERDA RFP's in those facilities transferred to the University.

Cons:

1. Will continue to require maintenance of a costly GOCO type administrative network within UPR the burden of which will borne solely by the last supporting ERDA program division (BER).

2. Separates ERDA energy development from the environmental work at UPR, and probably will create a less than desirable degree of interaction.

3. Prevents UPR from competing for other than ERDA environmental areas for execution in the facilities maintained as GOCO.

4. Requires indefinite ERDA funding support for the administrative staff and the facilities retained as GOCO, irrespective of the quality of the program or relevance to developing ERDA priorities.

Further detailed supporting analysis of this option is contained in Appendix 11.

Option 3 - Discontinue GOCO Operations and Transfering Facilities to the UPR, or other, or close them if appropriate, executing ERDA's programs with UPR on other contractual basis.

Under this option, ERDA would programmatically transfer PRNC facilities to UPR, phase out the GOCO method of operation at UPR, encourage development of a viable "Energy and Environmental Center" at the University through institutional support, and would execute priority ERDA programs through this UPR center on other contractual basis.

All PRNC facilities except the Rain Forest Station would be offered to UPR to form a base for their "Energy and Environmental Center". The Rain Forest facilities would be retained as Federal property but would be made available to UPR under a use permit. Any PRNC facilities determined not to be of interest to UPR would be disposed of by ERDA in accordance with Federal property procedures.

Under this option, ERDA and UPR would enter into a Agreement and Commitment of Mutual Benefit. The Commitment would:

1. Assure that high priority ERDA programs will continue to receive priority UPR facilities and personnel attention.

2. Support a five year programmatic development effort by providing ERDA developmental and institutional support to the Center to stimulate development of new areas of technical excellence and interdisciplinary support.

Option 3 - Pros and Cons

Pros:

1. The need for a separate, duplicate, and complex PRNC administrative and maintenance network to comply with GOCO contractual requirements is eliminated.

2. The artificial and undesirable separation of PRNC and UPR programs would be eliminated, promoting more cooperative endeavors, and enhancing both programs.

3. UPR would have full flexibility to execute programs of interest to the Commonwealth in current PRNC facilities, to compete for private or other Federal agency contracts or RFP's for execution in those facilities, and to compete for ERDA RFP's in new areas of energy interest to UPR.

4. ERDA support to UPR would gradually shift to funding of only technically competitive programs and the need for ERDA support of facilities, irrespective of their relevance to developing ERDA programmatic priorities, would be eliminated.

Cons:

1. With loss of GOCO administrative and maintenance network, it may take UPR a few years to develop similar capability to execute priority ERDA programs in a highly effective manner.

2. ERDA presence in Puerto Rico will be less obvious.

3. Other Federal agency work in the energy center will have to be undertaken through contract with UPR rather than interagency agreement with ERDA.

ENCLOSURE 7

PROPOSED TRANSITION FUNDING LEVEL [6/]
UNIVERSITY OF PUERTO RICO
ENERGY AND ENVIRONMENTAL CENTER

Funding Source	FY 1976	FY 1977	FY 1978	FY 1979	FY 1980[1/]	FY 1981	FY 1982	Finish Transition FY 1983
Base[2/]	$1,230	$ 775	$ 500	$ 250	$ 0	$ 0	$ 0	$ 0
Training[2/]	0	100	150	200	250	250	250	250
Development[2/]	0	50	250	600	650	500	200	0
BER	1,082	845	900	950	950	1,000	1,000	1,000
Institutional*	0	100	300	300	300	300	300	300 [7/]
ERDA Current Programs[3/]	$2,280	$1,870	$2,100	$2,300	$2,150	$2,050	$1,750	$1,550
New ERDA Programs[4/]	0	0	100	150	250	400	500	600
TOTAL ERDA	2,292	1,870	2,200	2,400	2,400	2,450	2,250	2,150
UPR Medical	0	135	270	425	475	450	450	450
UPR Energy[5/]	0	100	100	200	225	250	300	300
CENTER TOTAL	$2,292	$2,105	$2,570	$3,025	$3,100	$3,150	$3,000	$2,900

1/ Facilities should all be fully transferred to UPR during FY 1980.
2/ These three items total the current base budget commitment.
3/ This "ERDA Current Program" line represents the ERDA "promise" to UPR.
4/ This line is not an ERDA guarantee but an estimate of what UPR may be successful in competing for.
5/ This is UPR contribution to Center activity which may be partly comprised of Work-for-Others.
6/ This level is based on FY 77 dollars.
7/ Amount to be determined based on program and ERDA needs.

* Exploratory Research and Program Coordination Funds

SUGGESTED ADMINISTRATIVE APPROACH TO ORO FOR TRANSFER OF FACILITIES TO THE UPR

1. ORO is to be directed to execute an agreement or contract modification with UPR to proceed with programmatic transfer of appropriate ERDA facilities to UPR and orderly closeout of GOCO operation. The agreement should include a timetable for completion of the implementation elements and clear indication of ERDA plans for long-term funding support by funding category. Included in the agreement shall be a provision to change the PRNC name to Puerto Rico Energy and Environmental Center.

2. The actual programmatic transfer of facilities will be a phased process taking about three years for full implementation and transfer. However, upon execution of the above agreement, ERDA can begin handling UPR-PRNC as a non-GOCO facility for purposes of permitting non-ERDA work in PRNC facilities; UPR will have flexibility to compete for RFP's in the private or Federal sector; and UPR will be eligible to receive ERDA "institutional" support.

3. The administrative and fiscal steps of closing out the GOCO operation and transferring the facilities are to be handled by ORO. While the administrative procedures associated with the transition can be accomplished in one year, the "technical" problems of radioactively contaiminated facilities and the need for UPR to obtain NRC licenses for possession and operation of the PRNC facilities, will extend the transition period to an estimated three years.

4. Rain Forest facilities are made available to ERDA under a use permit from the U.S. Forest Service and will not be transferred to UPR. However, the use permit will be transferred to UPR.

5. Cornelia Hill facilities contain no radioactive contamination, therefore, they can be removed from the GOCO method of operation and placed on other funding arrangements during FY 77 or FY 78.

6. The Rio Piedras facilities (all or part) can be programmatically transferred to UPR in about 18 months. The final transfer will be contingent upon UPR extending its NRC licence for possession and operation of the radiological facilities at Rio Piedras.

7. The Mayaguez facilities require radioactive cleanup prior to transfer and obtaining of NRC licenses for source materials, byproduct materials, and the training reactor (L-77). For planning purposes, it is assumed this can be accomplished in three years. The steps, from the radiological standpoint, are:

   a. Have PRNC-UPR undertake a decontamination study in FY 77. Factor in radioactivity levels which would be acceptable to UPR, the Commonwealth, the ERDA and the NRC.

b. Have UPR engage in early discussions with NRC regarding requirements for source, byproduct, and training reactor licenses (for the L-77). This should be associated with the above study.

c. Have UPR proceed with necessary steps towards licensing with NRC.

8. The Research Vessel PALUMBO is to be transferred to a stateside organization having programmatic need for such a vessel.

9. The AFO will oversee the ORO implementation of this new management arrangement.

CEER INSTITUTIONAL AND DEVELOPMENTAL PROGRAMS: FY '77 THROUGH FY '79

Proj. No.	Project Title	Class.	Location	Proj. Leader	Funding FY 77	FY 78	FY 79
04	Ethanol & Ethanol Evaluation as a Motor Fuel	Transp.	UPR-AES	Dr. H. Batiz	---	---	$ 11,040(I)
07	A Study of the Nutritional Qualities of Various Cellulolytic Microorganisms	Biomass	Cath.Univ.	Dr. L.A. Roig	---	---	13,800(I)
10	Preliminary Bio-Assay Studies of Commercial Fish, Shellfish and Other Organisms	Environ.	CEER	Dr. W. Jobin	---	---	22,425(I)
14	Photo-Induced Electron Transfer States	Other	UPR-RP	Dr. M. Gómez	$ 14,418(D)	---	---
15	Developmental	Dev. Accnt.	CEER	Dr. J.A. Bonnet	14,305	$ 63,652	78,006
18	Water Hyacinth for the Clarification of Waste-waters	Biocconv.	CEER	Dr. R. Clements Mr. J. Villamil	---	---	26,795(I)
19	Study of the Weather-ability and Wear of Solar Applications Materials	Solar	CEER	Dr. U. Ortabasi Dr. C. Cordero	---	---	9,775(I)
20	Economic and Technical Feasibility Study of a Bagasse Energy Pilot Plant	Biomass	Guaynabo, P. R.	Dr. L. Smith	---	---	5,750(D)

APPENDIX B

TABLE 3- Continued

Proj. No.	Project Title	Class.	Location	Proj. Leader	Funding FY 77	FY 78	FY 79
29	Heat Transfer Study as a Function of Biofouling (OTEC)	OTEC	CEER	Dr. D.S. Sasscer	$ 81,729	---	$ 89,999(I)
35	Magnetic Separation	Environ.	CEER	Dr. U. Ortabasi	---	---	45,210(I)
36	OTEC Foam System	OTEC	CEER	Dr. M.I. Kay	---	$ 7,351(D)	---
37	OTEC Impact in P.R.	OTEC	CEER	Dr. D.S. Sasscer	---	10,528(I)	---
40	Recovery and Solubilization of Petroleum Derivatives by Micelle Forming Surfactants	Petrol.	Cath. Univ.	Dr. G. Infante	6,932(D)	6,583(I)	16,100(I)
41	Studies of the Surface of Electrodes	Other	UPR-RP	Dr. Blum & Dr. Vassos	12,099(I)	---	---
43	Assessment of the Potential of Energy Cogeneration on the P.R. Energy System	Conserv.	Santurce, P.R.	Mr. M. Robinson	---	---	28,750(I)
45	Marine Biomass	Biomass	CEER	Dr. E. Werner	---	24,472(I)	---
47	Institutional	Inst. Accnt.	CEER	Dr. J.A. Bonnet	32,591(I)	26,052(I)	26,450(I)
48	Expansion of the Saccharum	Biomass	UPR-AES	Dr. A. Alexander	12,329(I)	---	---
48A	Venezuelan Heavy Crude Oils	Petrol.	CEER	Dr. J. Rigau	---	12,113(I)	9,200(I)

TABLE 3- Continued

Proj. No.	Project Title	Class.	Location	Proj. Leader	Funding FY 77	FY 78	FY 79
50	Energy Study	Other	CEER	Dr. M. Iriarte	---	---	$ 17,250(I)
51	Methane Production	Bioconv.	CEER	Dr. E. Werner	---	---	23,000(D)
54	Study of the Optical and Aging Charact. of Various Selective Surfaces	Solar	UPR-RP	Dr. S.V. Weisz	$ 20,116(I)	---	33,005
54A	Social Aspects Espíritu Santo Basine	Environ.	CEER	Mr. P. Soto	---	$ 11,954(I)	---
55	Measurement of the Solar Insol. in P.R.	Solar	UPR-RP	Dr. Vassos	7,295(I)	---	---
55A	Model of the Aquatic Ecology of Joyuda	Environ.	CEER	Dr. J. González	---	---	11,500(D)
57	Direct & Diffuse Insolation; & Solar Research Project	Solar	CEER UPR-MAZ	Dr. K. Soderstrom	18,451(I)	49,354(I)	22,540(D)
58	Environmental Research on Bioluminiscence	Environ.	UPR-Cayey	Prof. M. Trujillo	---	---	3,105(I)
59	Energy Conserv. in Transportation	Transp.	UPR-RP	Dr. J. Mayda	9,150(I)	5,600(I)	---
59A	Conversion of Tropical Biomass to Liquid & Gaseous Fuels by Short-Residence Pyrolisis	Biomass	CEER UPR-MAZ	Dr. R. Cabán	---	---	58,345(I)

TABLE 3 - Continued

Proj. No.	Project Title	Class.	Location	Proj. Leader	Funding FY 77	Funding FY 78	Funding FY 79
61	Solar Technology	Solar	CEER	Dr. U. Ortabasi	---	$ 80,417(I)	$ 69,460(D)
62	Energetic Pig Farm	Bioconv.	CEER	Dr. E. Werner	---	---	23,000(I)
63	Culebra Workshop	Other	Wash. Univ.	Dr.J.P.R. Falconer	$ 2,240(D)	---	---
65	Thermal Conv. of Solar Energy	Solar	UPR-RP	Dr. S.V. Weisz	---	28,126(D)	---
66.	Energy Conserv. in the Res. Sector by Shading & Insul. of a Typical P.R. House	Conserv.	UPR-MAZ	Dr. H. Plaza	---	51.992(D)	10,345(D)
67	Studies on the Surfaces of Electrodes Used in Fuel Cells	Other	UPR-RP	Dr. Blum & Dr. Vassos	---	27,983(I)	29,900(I)
69	Resources MGN+/Espíritu Santo Basine	Environ.	UPR-RP	Dr. López Pumarejo	---	9,751(I)	---
69A	Ocean Wave Generation	Other	Mass.	Alden Lab.	---	---	4,600(I)
72	Solar Air Conditioning Machine	Solar	CEER UPR-MAZ	Dr. F. Pla	---	19,889(I)	23,000(D)
74	Thermal Energy Storage	Solar	CEER UPR-MAZ	Dr. R. Singh	---	17,322(I)	---
74A	Expansion of the Saccharum Genetic Base	Biomass	UPR-AES	Dr. A. Alexander	---	---	12,650(D)

TABLE 3- Continued

Proj. No.	Project Title	Class.	Location	Proj. Leader	Funding FY 77	Funding FY 78	Funding FY 79
75	Ferroelectric Converters	Other	CEER	Dr. M. Kay	---	$ 16,217(I)	---
78	Energy Policy Study	Other	P.R. Energy Office	Mr. F. Castellón	---	22,400(I)	---

COMPETITIVE AWARDS

CA-16 Electric System Planning	PRWRA
CA-17 Energy Conservation	PR Energy Office
CA-18 Spectrographic Studies of Solar Energy Conversion Processes in Tropical Grasses	
CA-19 Summer Course on Energy (A. Cobas)	DOE (Conservation & Env.)
CA-20 Environmental and Ecological Studies off the South Coast of St. Croiz	College of V. I.
CA-21 Policy R & D - Outline of a Methodology with Reference to decision making the field of energy, transportation & Env.	Howard Bayne Foundation
CA-22 Replanting and Maintenance of Mangroves	PRWRA
CA-23 Summer Science Student Program (Site 1 and Site 2)	DOE-Dept. of Labor
CA-24 PRASA (trailer)	Puerto Rico Sewer Authority
CA-25 SSEC Contact	SSC
CA-26 Process Steam Generations	Roche
CA-27 Production of a Usable Energy Sourcey by Anaerobic Digestion	DOE & PREO
CA-28 Trials of HGMF on waste streams under study by SKF Lab.	SKF Company
CA-29 To characterize a conceptual design of a biological/ chemical system for the treatment of our waste water effluent	SKF Company
CA-30 General Energy Conservation Plan	funded by President's Office
CA-31 Par Pond Summary Report for Savannah River Lab. (under purchased order with SRS)	SRL

COMPETITIVE AWARDS

CA-1 ✓	Sugarcane and other Tropical Grasses as Potential Renewable Energy Sources	DOE through UPR -
CA-2	Effects of Rum Slops	U.S. Environmental Prot. Agency
CA-3	"EL FARO" Environmental Park	P.R. Conservation Trust
CA-4 ✓	OTEC-Biofouling Corrosion and Materials Study and Punta Tuna, Puerto Rico	DOE through Argonne
CA-5 ✓	OTEC Measurements of Oceanographic Environmental Parameters Relatable to OTEC installation at Punta Tuna	DOE through Berkley
CA-6 ✓	OTEC Parameter Spatial Variability Relatable to an OTEC installation at Punta Vaca, Vieques	PRWRA
CA-7 ✓	Otec Integration Issue	Consultores Técnicos Asociados
CA-8 ✓	Seawater surfactant systems and variability relationship to foam OTEC systems	ORNL
CA-9	Concentrating Photovoltaics for the tropics	DOE through Albuquerque
CA-10	Process steam generation by non-imaging solar concentration	Bacardí Corporation
CA-11	Ecological Survey of Hydroelectric Power	Dominican Republic Electric Co.
CA-12	Cancer Grant	American College of Radiology
CA-13	Field determination of limiting velocities for control of Biomphalaria glabrata in Irrigation Canals - GUAJATACA CANAL SYSTEM	World Health Organization
CA-14	Assessing the environmental impact of hydro-electric power generation at the Patillas reservoir	Energy Research & Application, Inc.
CA-15	TransmissionLine Study	PRWRA