

# DEVELOPMENT PLAN

## CENTER FOR ENERGY AND ENVIRONMENT RESEARCH



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

MAY 1985

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**DR. JUAN A. BONNET, JR.**  
**DIRECTOR**

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## TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
I. INTRODUCTION	1
II. BACKGROUND	3
A. GENERAL	3
B. LEGAL FRAMEWORK	5
C. BUDGET AND FUNDING	6
III. FUTURE PROGRAM DEVELOPMENT	8
A. PRIORITIES AND GOALS	8
1. Background	8
2. Goals	10
B. ENERGY SECTION	12
1. Projections for Changing Priorities	12
2. Needs	17
C. ENVIRONMENT SECTION	17
1. Projections for Changing Priorities	17
2. Needs	21
D. RESOURCES AT CEER	23
1. Mayaguez	24
2. Río Piedras	25
IV. SPECIAL CONSIDERATIONS CONCERNING THE ROLE OF CEER IN THE UPR SYSTEM	28
V. CONCLUSIONS AND RECOMMENDATIONS	31
APPENDIX A - APPLICATION OF CERTIFICATION 62 (1983-84) OF CHE TO THE CEER DEVELOPMENT PLAN	35

## EXECUTIVE SUMMARY

### Introduction

In accordance with the University Law of 1966, the Council on Higher Education (CHE) has directed the various units of the University of Puerto Rico (UPR) to formulate their plans for future development within the university system. This document delineates the development plan for the Center for Energy and Environment Research (CEER) within the framework of the UPR Master Plan that was approved by CHE in 1983. The development plan, using the CEER mission as its point of departure, provides for the allocation of available human, technical and financial resources needed to achieve its mission and sets programmatic goals and priorities on short, intermediate and long terms. It also considers the overall and general budgetary requirements and identifies major funding sources. Since UPR funding support and the potential for competitive fund raising is limited, the plan stresses a program of high quality research within the context of service to Puerto Rico for problem oriented energy and environment research and development activities and leadership for education and technology transfer in the Caribbean Basin.

CEER was established in 1976 as the successor to the Puerto Rico Nuclear Center, which had been established as a unit of UPR in 1957 under the Atoms for Peace Program. In its first seven years CEER has made significant advances in alternative energy research in biomass, solar energy, and ocean thermal energy conversion and in environmental areas such as terrestrial and marine ecosystems studies.

During the five year transition period from 1976 to 1981, the United States Department of Energy (DOE) provided CEER with approximately \$12



million in base and operational funding. Recognizing CEER as a unique research institution within the university system, UPR has provided base funding which has stabilized at \$1.2 million per year. The reduction of federal research funding and the stabilization of UPR funding has forced CEER to redefine its research priorities, to redouble its efforts to secure outside competitive funding, and to increase its productivity.

CEER holds a long term contract with DOE and has been recognized by the Council on Higher Education as a specialized research unit of the UPR. The Commonwealth of Puerto Rico has conferred official recognition on CEER by directing government agencies to use CEER's resources to the maximum to seek solutions to problems related to the development of alternative energy sources for the island.

The CEER Director appointed a three-member development plan committee which identified key needs and established guidelines for the formulation of the development plan. The committee recognized the need to provide for institutional stability and autonomy within the university system by increasing base funding in proportion to the annual increments in the UPR budget. If it is to remain a viable research unit, CEER must have a minimum annual budget of \$3.2 million in 1982 dollars.

Since 1981, CEER has worked to develop a mechanism for setting research priorities which takes into account the value of particular research programs to Puerto Rico and to other islands in the Caribbean, the value to the scientific community as a whole, and the potential resources that can be brought to bear on the research problem. CEER has updated its goals to reflect changed perceptions of research needs in energy and environment, the capabilities of the present staff, the availability of competitive and base funding, the recommendations of the CEER Senior Advisory Committee,

and the criteria for development plans for the institutional goals of the UPR. CEER's updated goals are as follows:

1. to become the focus for energy and environment research in Puerto Rico through high quality science and engineering programs.
2. to serve Puerto Rico through problem oriented research.
3. to establish a strong program of training and technology transfer within Puerto Rico and the Caribbean Basin.
4. To maintain an appropriate mix of institutional and competitive funding as a means of achieving operational stability.

### Programs

Concerning the projections and needs for the Energy Section, the plan proposes selective development in applied research, the creation of international assessment and training programs, the strengthening of ties between CEER and research units at the Mayaguez Campus, and increased cooperation with the Environment Section on those projects that require energy technology. One of the best ways to achieve stability would be to develop a long term training program fed by short term research projects that will add knowledge, material and equipment to the total program. The Energy Section will need a minimum of five scientists based at the Mayaguez site to maintain stability.

Concerning the projections and needs for the Environment Section, the plan states that programs are divided into three main groups. The first are studies of ecosystem structure and processes such as those being done at the Luquillo Experimental Forest. Future projects will include the baseline measurement of pollutant analogues transported from an undisturbed watershed, the recycling of nutrients through a tropical food web via consumption and decomposition, and baseline productivity in relation to

limiting factors in aquatic systems. The second area includes the ecological effects studies now in progress to understand the impacts of sediments and metals discharged from waste heat rejection systems upon representative marine organisms. Subprograms in water quality, waste disposal and management, and energy production and utilization are included within the area of ecological effects. The third area, resource management, encompasses subprograms relating to the prudent use of water and wildlife resources. Its goals are to quantify and characterize the ecological bases of resource problems on islands and to develop ecologically sound prescriptions for managing and restoring selected important environmental resources in Puerto Rico.

The plan assumes that the Environment Section will maintain control of the El Verde Field Station in the Luquillo Experimental Forest and will continue operations at the Wet Lab/Bioassay facilities in Mayaguez. Because of the complexity and multidimensional character of most environmental problems, a core staff of at least eight scientists is needed to provide diversity of expertise. Part-time specialists will also be employed from the appropriate departments of the Rio Piedras and Mayaguez Campuses. Various government agencies and industries have been identified as potential sources for competitive funding projects.

The CEER facilities have an acquisition value of approximately \$12 million and are located at sites in Rio Piedras, Mayaguez, Cornelia Hill on the coast south of Mayaguez, and at El Verde in the Luquillo Experimental Forest. The energy programs have operated from the Mayaguez facility because of its proximity to the UPR Engineering School and the plant facilities of the original Puerto Rico Nuclear Center. Several of the shops have been upgraded to meet the needs of the alternative energy programs

The Marine Ecology Division maintains a docking facility for research vessels and a flowing seawater bioassay laboratory at Cornelia Hill.

The Rio Piedras facility houses the office of the CEER Director, the Terrestrial Ecology Division, the Technology and Policy Assessment Program, the Microseismic Data Net, and the UPR Energy Conservation Program. The Terrestrial Ecology Division has been able to develop state-of-the-art laboratories for environmental chemistry, ecophysiology and microbiology with funds from DOE. The El Verde Field Station contains offices, living quarters, an herbarium, a micrometeorological station, and a sampling station for the National Atmospheric Deposition Program.

As a specialized unit dedicated exclusively to scientific research, CEER is uniquely qualified to help the UPR strengthen its research and graduate programs. In order for CEER to develop to its fullest potential, the Council on Higher Education and the presidency should give it special support in the areas of management, personnel, and budget. CEER should continue to enjoy administrative autonomy and flexibility so that it can compete successfully for external funding. Its personnel should be allowed to enter into long-range collaborative arrangements for teaching or research. Its budget should be increased proportionately to the UPR budget so that its capacity to compete for external funding will not be impaired.

#### Conclusions and Recommendations

Based on the conclusions reached by the development plan committee, the following recommendations should be implemented to insure CEER's continued service to Puerto Rico and the university.

1. As CEER's contractual ties with DOE are coming to an end, CEER should acquire a legislated legal status similar to that of other units of

the UPR system such as regional college campuses, university colleges and university campuses.

2. The university should increase its present annual commitment of institutional funding from \$1.2 million to \$1.6 million (1982 dollars) as per the minimum base budget projected in the Three Year Plan. The annual university allocation to CEER should increase at least proportionately to cost of living increases plus any across the board salary increments implemented in the UPR system.
3. A minimum staff of thirteen full-time equivalent scientist (Ph.D) positions is necessary to maintain the research and training functions of the Energy and Environment Sections. During periods of low external funding, the university should assume responsibility for maintaining this minimum staff size.
4. CEER should continue to maintain the administrative functions of accounting and purchasing independent from but integrated into the UPR system, as has been the practice since CEER began operations. This assures the dynamic administrative procedures necessary for an organization such as CEER which has research as its prime mission.
5. Vigorous efforts should be made to protect the integrity of the essential field research sites, i.e. the El Verde Field Station, the area of Joyuda Lagoon, and the north coast farm at Toa Baja.
6. CEER should maintain an appropriate mix of applied and basic research. A future focus for CEER programs will be on system models that integrate energy, environment, and economics.
7. CEER research programs should continue to involve, as much as possible, faculty and graduate students from the various campuses of the university system, thus enhancing the programs of both the university cam-

puses and CEER by using the resources of the university system more productively. Mechanisms should be instituted at the level of the Council on Higher Education to provide opportunities for CEER scientists to participate more fully in the academic pursuits of the university. Such mechanisms should set forth criteria for joint appointments, for sponsoring graduate students, and for cooperative research ventures between CEER scientific staff and members of academic departments throughout the university.

8. Because many of the problems and resources of Puerto Rico require trained people for their management, an interdisciplinary graduate curriculum composed of courses drawn from departments offering degrees in energy, environmental sciences, and engineering is urgently needed. CEER has the unique systems level experience in fields relevant to these areas. The precedent for this type of interdisciplinary curriculum was set by the formation of the Nuclear Science and Technology curriculum and MS degree program during the early years of the Puerto Rico Nuclear Center in cooperation with the Mayaguez campus. Because of the expertise of CEER scientific staff, CEER is ideally suited to participate in the formation of such a curriculum.

## I. INTRODUCTION

In November 1983 the Council on Higher Education (CHE) approved the Master Development Plan for the University of Puerto Rico (UPR) system mandated by the University Law of 1966. The plan set forth the general principles and guidelines for the formulation of development plans in the several units of the system.

The present document delineates the development plan for the Center for Energy and Environment Research (CEER) in the framework of the UPR master plan. The CEER plan provides for the allocation of available human, technical, and financial resources for the implementation of its mission and objectives and sets programmatic goals and priorities on short, intermediate and long terms. It also considers the overall and general budgetary requirements and the proportions thereof coming from major funding sources, i.e., UPR institutional funds, competitive grants from federal and Commonwealth agencies, and contracts with local agencies, private industry, and regional and international organizations.

As in previous development plans, the point of departure is the CEER mission, conceived in terms of CEER's role as a specialized research unit within the UPR system and geared to the needs of the broader Puerto Rican community and, to some extent, to the needs of neighboring countries in the Caribbean. In its revised version, the mission is stated as follows:

1. To serve as the focus for energy and environment research and development for Puerto Rico.
2. To develop alternative energy technologies that are economically competitive, socially useful, and environmentally acceptable.

3. To conduct tropical ecological research for the sound management of natural resources.
4. To serve as a focus for technology transfer and adaptation in energy and environmental matters for the Caribbean.

The accomplishment of this mission will depend on the availability of funds for the implementation of specific programs. From the outset, the major constraint is the continuing shortage of federal funds for energy-related research activities. Given the levels of UPR institutional funding for base operations and the potential for contractual fund raising, the strategy underlying this development plan concentrates on a program of service to Puerto Rico which CEER is uniquely suited to undertake. Emphasis is placed on problem-oriented energy and environmental research and development activities and on exerting leadership in technology transfer and adaptation for the Caribbean Basin.



## II. BACKGROUND

### A. GENERAL

CEER was established in 1976 as a successor to the Puerto Rico Nuclear Center (PRNC) founded in 1957 under the Atoms for Peace program and operated by the University of Puerto Rico under contract with the U.S. Atomic Energy Commission. In its 20 years of existence the PRNC attained an impressive record in research and training. Thousands of professionals and students from Puerto Rico and Latin America received specialized training in nuclear science and technology. Whereas the primary objective of PRNC was education and training, CEER's efforts are concentrated on research and development in alternative energy and environmental matters. In its first seven years CEER has made significant advances in various research areas, among them biomass, solar energy, and ocean thermal energy conversion (OTEC), and in terrestrial and marine ecosystems studies.

To assist the new research center through its transition period, the Energy Research and Development Administration and its successor, the Department of Energy (DOE), provided CEER with base and operational funding of approximately \$12 million during the five-year period from 1976 to 1981. Beginning in 1981, in response to its initial commitment and in recognition of CEER's role as a unique research institution within the UPR system, the university has been allocating institutional base funding every fiscal year. This allocation, however, has stabilized at \$1.2 million for FY 1983 and 1984, and it is expected to remain at that level for the next two fiscal years. This, combined with the increasing reductions in federal appropriations for energy R&D, has forced CEER to redefine its research priorities, to redouble its efforts to secure outside competitive funding, and to increase its productivity. This state of affairs underlies the present development plan in the short term.

In order to review the current Three-Year Plan (FY 1983-85), the CEER Director appointed a three-member development plan committee which identified the following needs:

1. The need for research, development, and training in three main areas: energy, environment, and technology and policy assessment.
2. The need for research aimed at the solution of practical problems affecting Puerto Rico and the Caribbean, including technology transfer and adaptation.
3. The need for institutional stability and autonomy within the UPR system.
4. The need to institutionalize innovation and diversity while preserving programmatic continuity and stability.
5. The need to preserve and enhance the unique opportunity in CEER for interdisciplinary problem solving.
6. The need to reexamine CEER's research priorities in the light of the present and foreseeable competitive funding situation.

Consideration of these needs led to the adoption of the following guidelines for the formulation of the CEER development plan:

1. Base funding will go to core program areas and staff.
2. Planning will be aimed at fostering institutional stability, productivity and program effectiveness.
3. Emphasis will be given to quality science and engineering relevant to the problems of Puerto Rico, the Caribbean, and other tropical areas.
4. Program organization will attempt to increase interdisciplinary interaction in problem solving.

5. Planning will incorporate assumptions of probable sources and levels of outside funding, recognizing that there is an optimal ratio of competitive to base funding.

## B. LEGAL FRAMEWORK

CEER has a continuing contractual relationship with DOE. The standing contract (DE-AC05-76OR01833) has been extended through September 1986. Although the contractual bond is tenuous, CEER is still subject to the federal regulations that apply to contract laboratories. Under the present arrangement, DOE remains responsible for the decontamination of the nuclear reactor in Mayaguez.

The relationship CEER has with the various units of the university system is broadly defined in Certification 149 approved by the Council on Higher Education on May 16, 1980. This certification recognizes CEER's unique status and role as a specialized research unit of the university. It also delineates the parameters and suggests mechanisms for CEER's collaboration in the research efforts of the various faculties, departments, and research units of the UPR. Finally, the certification provides for establishing links to other entities in Puerto Rico and abroad to undertake collaborative research projects.

Beyond the university setting, Law 128 of June 29, 1977 acknowledges CEER's mission in the field of energy research and development. Furthermore, the energy policy of Puerto Rico, as set forth in Administrative Bulletin No. 3645 issued by the Office of the Governor on July 2, 1979 states that the Commonwealth government will use CEER's scientific resources and capabilities to the maximum extent possible for problems related to development of alternative energy sources for Puerto Rico.

### C. BUDGET AND FUNDING

Table 1 shows the CEER budget by sources of funds over the past five years. The budget reflects the financial adjustments that CEER has undergone in the process of shifting from a DOE laboratory to a UPR facility.

As explained earlier, the termination of DOE institutional support and the restrictive fiscal policy that the U.S. government has followed in recent years account for the downward trend in total funding from 1981-82 to 1984-85. However, institutional support from UPR has increased gradually since 1980-81, and has leveled off at \$1.2 million from 1982-83 onward. DOE continues to provide financial assistance for research, mainly on the environment, and for nuclear decontamination. Another stabilizing factor has been the increasing effort made by CEER to secure competitive funds. Outstanding among these are the contracts obtained from the Puerto Rico Electric Power Authority (PREPA), the Puerto Rico Aqueduct and Sewer Authority (PRASA) and the Puerto Rico Office of Energy.

A minimum annual budget of \$3.2 million in 1982 dollars is needed to keep CEER as a viable research unit. Institutional funding should be increased annually at least in proportion to the annual increments in the UPR total budget.

TABLE 1  
 CEER TOTAL BUDGET BY SOURCE OF FUNDS  
 (THOUSANDS OF DOLLARS)

CATEGORY	80-81	81-82	82-83	83-84	84-85
DOE SUPPORT					
Institutional	850	0	27	102	120
Environmental Research	879	1116	315	250	300
Subtotal	1729	1116	342	352	420
UPR FUNDS					
Institutional	300	600	1200	1200	1200
Special Projects	69	35	272	169	217
Subtotal	369	635	1472	1369	1417
NUCLEAR DECONTAMINATION	230	127	111	110	110
SPONSORED RESEARCH (COMPETITIVE)					
a. Federal Sponsored					
DOE Hq. D.C.	744	752	376	345	193
DOE Laboratories	412	86	34	105	70
Other DOE Contractors	25	59	12	-	-
Other Federal	366	564	121	59	77
Subtotal Federal	1547	1461	543	509	340
b. Commonwealth Sponsored					
PREPA	816	0	81	109	330
PRASA	0	0	350	547	-
Other Commonwealth	65	75	167	260	400
Subtotal Commonwealth	881	75	598	916	730
c. Other Sponsored					
Caribbean Region	138	36	18	-	-
Private Industry	26	23	34	100	57
Private Non-Profit	16	21	7	-	-
SUBTOTAL OTHER	180	80	59	100	57
SUBTOTAL SPONSORED	2608	1616	1200	1525	1127
TOTAL BUDGET	4936	3494	3125	3356	3074

### III. FUTURE PROGRAM DEVELOPMENT

#### A. PRIORITIES AND GOALS

##### 1. Background

Establishing priorities for any research program is a process of matching the need for a given study with the resources available to conduct the study. When a particular study is both beneficial to society and attractive to funding sources, there is a high probability that the research will be performed. Because funding for basic research in Puerto Rico comes principally from federal sources, there is often a mismatch between the local need for a particular research program and its appeal to funding agencies. Islands often have unique research needs in the fields of environment and energy, but since island populations compose a small part of the constituency of federal agencies, their research needs are given low priority.

Occasionally, the converse situation develops. Funds may be readily available for research in areas of little interest to a research institution. If the institution conducts too many studies of this type, it may be distracted from its principal research goals. This danger is particularly acute when the organization has a low base funding or when the amount of competitive funds received fluctuates widely from year to year.

Because of its concern with these problems, CEER developed a mechanism for setting research priorities which take into account the value of particular research programs to Puerto Rico and, more generally, to other islands in the Caribbean, the value to the scientific community as a whole, and the potential resources that can be brought to bear on the research problem. In October 1981 the CEER Director appointed a five member committee made up of both staff and line managers to develop an organizational

plan for FY 1983-1985. A review and planning process was adopted to assign budgetary allocations for programs on the basis of their impact on the CEER mission. The steps in this process were:

1. to evaluate a list of possible CEER programs based on the suggestions of the staff and the committee;
2. to evaluate the proposed programs by using a Delphi technique employing as criteria: a) appropriateness and suitability for CEER in terms of capability and mission; b) opportunity to satisfy research and development needs in Puerto Rico; and c) prospects for funding from sources other than UPR;
3. to select a set of high priority programs from three basic areas: environment, energy, and technology and policy assessment;
4. to formulate of a zero-based budget for each of the main programs;
5. to reconcile the programs and budgets with the \$1.2 million budget allocation from UPR and outside funding expectations for FY 1983;
6. to project these programs and budgets against conditions expected for FY 1984 and 1985.

Following the completion of this review, CEER published a series of goals as a Three Year Plan (CEER-X-142). These goals were used in the preparation of the present document as the basis for the new set of institutional objectives. Modifications to the original goals were made through a staff review. These modifications were based on staff perceptions of research needs in energy and environment in both local and global contexts, the capabilities of the present CEER staff, the availability of base and competitive funding, the recommendations of the CEER Senior Advisory Com-

mittee and the criteria for development plans for the institutional units of the UPR.

2. Goals

The Committee also agreed that CEER must keep four goals in sight in order to continue as the leader in energy and environmental research in Puerto Rico and the Caribbean.

a. High Quality Science and Engineering

CEER can accomplish its mission of becoming the focus for energy and environment research for Puerto Rico only through high quality science and engineering. Quality can be measured by:

1. scientific publications in quality, peer-reviewed journals,
2. participation in international conferences and symposia,
3. the training of future scientists,
4. the development of commercially applicable products and processes.

b. Service to Puerto Rico

CEER will provide a program of service to Puerto Rico through problem-focused research in the areas of energy and environment. Given the limitations in outside funding, institutional funds will be provided to undertake research in selected priority areas independent of the availability of competitive funding. The extent of this funding will be based on the overall financial status of CEER. Priority areas will be based on CEER's ability to make substantial contributions to the island's well-being. These priority areas include:

Water Quality

Biomass

Waste Disposal and Management



Solar Thermal

Ecological Effects of Energy Production and Utilization

Resource Management

Technology and Policy Assessment

c. Training and Technology Transfer

CEER will endeavor to establish a strong program of training and technology transfer within Puerto Rico and the Caribbean Basin. This program is broadly defined to include:

1. Education and training of scientists, engineers, technicians and educators,
2. Adaptations of technologies developed in Puerto Rico and the U.S. to the needs of tropical island countries;
3. Assessments of the resources and needs of the region in energy and environment, and plans toward the sound management of these resources.

As a major aspect of this program, CEER will seek to enhance the existing graduate programs of the UPR by encouraging joint appointments, workshops, and research proposals with academic departments; encouraging CEER scientists to participate on graduate committees and to teach courses; developing adjunct staff relationships with UPR faculty; and promoting student and faculty research in areas consistent with the CEER mission through Oak Ridge Associated Universities fellowships and other sources of funding.

d. Operational Stability

The above three goals can only be attained through stable funding; a minimum of \$3.2 million in 1982 dollars is needed for this purpose. This must be attained through an appropriate mix of institutional and competitive funding.

## B. ENERGY SECTION

### 1. Projections for Changing Priorities

Historically, DOE sponsored energy programs at CEER have been most successful when the research has been site specific, not necessarily to Puerto Rico but at least to tropical locations. This statement applies more to technology or applied programs than to basic research.

Projections for general program areas may be divided into short term (1-3 years), medium term (4-6 years), and long term (7-10 years). Short term programs, in general, are usually for the development of a new idea or for a technology demonstration project. Medium term programs may include follow-on monitoring and performance evaluation of demonstration projects. Long term programs are those that include training that embody institutional links to UPR through the traditional academic programs, or that require data obtained over a long span. Solar and wind energy data modeling and the development of biomass agriculture are a few examples of long term programs.

Table 2 shows a matrix that places the long and short range programs in perspective, especially their needs and competitive funding possibilities. Four main programs are proposed: 1) applied research and development, 2) international programs, 3) institutional links to UPR, and 4) energy and environment sections links.

Under the applied research and development program, two technology programs have been included, biomass and solar thermal. CEER has been continually involved in these two areas of alternative energy research for over seven years and has developed expertise in phases such as energy cane and grass production, methane production, and shallow ponds. Wind and

TABLE 2  
ENERGY SECTION LONG RANGE PLAN

PROGRAMS	NEED			AVAILABILITY OF FUNDS		
	SHORT	MTD	LONG	SHORT	MTD	LONG
APPLIED RESEARCH & DEVELOPMENT						
BIOMASS						
ENERGY CANE & GRASS	HIGH	HIGH	HIGH	HIGH	MED	MED
METHANE PRODUCTION	MED	MED	HIGH	MED	MED	MED
SOLAR THERMAL	MED	MED	MED	LOW	LOW	LOW
SHALLOW PONDS	MED	MED	MED	LOW	LOW	LOW
WIND	LOW	LOW	MED	MED	MED	MED
PHOTOVOLTAIC						
INTERNATIONAL PROGRAMS						
TECHNOLOGY & POLICY ASSESSMENT						
NATIONAL ENERGY POLICY	HIGH	HIGH	MED	MED	MED	MED
CONSERVATION	HIGH	MED	LOW	MED	MED	LOW
TRAINING & TECHNOLOGY TRANSFER	HIGH	HIGH	HIGH	MED	MED	HIGH
(APPLIED R&D)						
INSTITUTIONAL LINKS TO UPB						
PHOTOCHEMICAL	MED	MED	MED	HIGH	HIGH	MED
ACADEMIC PROGRAMS	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
ENERGY & ENVIRONMENT SECTIONS LINKS						
NATIONAL ENERGY POLICY	MED	MED	MED	MED	MED	MED
TRAINING & TECHNOLOGY TRANSFER	HIGH	HIGH	HIGH	MED	MED	MED

photovoltaics have received less attention because of the lack of competitive funding.

In CEER's international program, Technology and Policy Assessment has been identified as a prime area of concentration. This includes National Energy Policy, Conservation, and Training and Technology Transfer. The training identified under this last area will involve some of the research and development done in the first major program, Applied Research and Development. Conservation of energy has been a regular program at CEER for several years, and CEER has coordinated the Energy Conservation Program of the entire UPR system. Institutional links between UPR and PRNC and currently between UPR and CEER have been primarily at the graduate level. This has been particularly true at the Mayaguez site where the nearness of the Mayaguez Campus has been an obvious advantage to attracting students and faculty to work in CEER facilities. PRNC had trained many graduate students at the MS level in nuclear engineering, and that component continued in the alternative energy programs of CEER. PRNC also had a strong program in nuclear chemistry. CEER has continued that component in the area of photoelectrochemistry by interacting with the UPR-Mayaguez Chemistry Department in the sharing of laboratory space and equipment and using both graduate and undergraduate students in research projects. This program is a good example of a basic research program that is now being sponsored by competitive federal funds, primarily because of its high quality scientific achievement.

Links between the Energy Section and the Environment Section should be easily established in CEER, given the present personnel and programs. This is not always so, however, because traditional funding sources tend to be either energy or environment oriented. CEER has recognized that some of

its technology programs have a strong environment impact associated with the particular energy technology. For several years OTEC research at CEER had both energy and environment components so that there was a fair amount of integration between the two programs. That integration, however, was carried out at the CEER level since funding for these programs came from different federal sources. CEER is in a unique position within the university system to be able to integrate the environmental component into the energy technology and this is important for the training aspect of the program.

The following is a general assessment of needs relative to Puerto Rico and the Caribbean and other tropical locations.

a. Solar Thermal

Solar ponds are most likely to be successful in tropical regions. CEER has developed shallow solar pond technology, and is currently monitoring systems installed in a private school and at the Mayaguez campus. This is an attractive technology because it is industrially oriented and should appeal to local industry, Fomento, and the Office of Energy.

b. Ocean Thermal Energy Conversion

This is attractive to countries located in the tropics such as those of the Caribbean and especially in those countries where there is an ocean depth of 1000 meters close to shore. Puerto Rico has an ideal site to meet this requirement. A basic OTEC program was carried out for over five years at CEER. The results of this work have been published and CEER is maintaining the capability to pursue further research in this area. This technology is also very good for areas that have a small installed power capacity such as many countries in the Caribbean.

c. Biomass

This technology uses tropical grasses such as "energy cane" and others that can be grown and harvested throughout the entire year. CEER maintained a federally funded project for the production of biomass and supported the project for over three years.

These programs all have related weaknesses. To function at a tolerant efficiency, OTEC requires oceans where the surface water is relatively warm during the entire year. Within United States jurisdiction only Puerto Rico and Hawaii meet this need. Similarly, tropical grasses can be grown throughout a twelve month season only at these two locations. Solar ponds are normally small power producers. In the Caribbean and in other island countries in the tropical zones, the majority of the installations are very small power plants in the range of kilowatts. Solar ponds may also be used for industrial process hot water, which is very useful to Puerto Rico and the other countries of the Caribbean which are trying to attract industry.

These are three broad program areas that could be considered for long range programs, including basic research, demonstration, continued monitoring and technology transfer to the Caribbean and other tropical Third World countries. This transferability appears to be one of the keys to attracting long range funding.

Based on the above scenario, one of the best ways to assure growing programs is to strengthen the area of training. This can be done at all levels--technician, professional continuing education, and academic advancement at the graduate level. Operating several levels of programs will cause an interweave of basic research through technology demonstration projects. In such a method of operation, stability will be enhanced with

the long term training program being fed by additional short term projects which will add knowledge, material and equipment to the training program.

## 2. Needs

The energy program will need about a decade to achieve full stability. First, the program needs a minimum scientific staff just to maintain stability. CEER's experience under decreasing federal funding indicates that there should be a minimum of five full-time equivalent scientist positions, the majority of which should hold the Ph.D. These positions should first be filled at one location, preferably Mayaguez since that has been the traditional site of energy activities. As the energy program grows, the Río Piedras site may increase its scientific staff. A financial requirement of \$100K per scientist to cover the complete program is a modest estimate considering that the work is mostly experimental and requires a higher dollar value than average to maintain the program. On the other hand, competitive research grants to the energy program should bring in higher dollar values per scientist than the average grant.

## C. ENVIRONMENT SECTION

### 1. Projections for Changing Priorities

Real solutions to environmental/ecological problems are rooted in an understanding of how ecosystems are organized and work. Most environmental questions are related to the movements of materials within and through systems or to the energy flows which maintain a particular structure in those systems. Information gathered from specific projects aimed at diagnosing and solving acute problems can be used to develop a general understanding of how systems work. A second approach emphasizes the study of whole ecosystems or ecosystem processes in their natural state without

reference to a particular problem but rather in the context of many possible environmental issues. Both approaches are embodied in the programs of the Environment Section.

The production and use of energy and material goods result in direct environmental disturbance and in the output of waste energy and substances which have the potential for indirectly altering the natural systems that support man. The three Environment Section programs focus on the relationship between anthropogenic outputs and the natural systems that receive them. Forming the background for an understanding of how natural processes may be disrupted is a set of studies of Ecosystem Structure and Processes. Projects relating to the resolution of acute problems of islands are pursued in the program areas of Ecological Effects and Resource Management. Results from each of these three programs bear on the overall goal of the Environment Section, which is to develop a general understanding of how biotic systems work.

a. Ecosystem Structure and Processes

These studies provide the backdrop for the evaluation of man's effect on the environment. Recent Environmental Section programs in this area include studies of the ocean environment near an OTEC operation, terrestrial and marine studies for the siting of a coal-fired power plant, and investigation of the cycling and transportation of carbon, sulfur, nitrogen, and phosphorus and the effects of energy development on these processes in tropical terrestrial ecosystems such as the Luquillo Rain Forest. The latter programs are the extension of twenty years of research activity at the El Verde Field Station and constitute one of the last remaining links between CEER and DOE.



Continuing studies of Ecosystem Structure and Process will include subprograms in terrestrial, marine, and aquatic site characterization. Future projects will include the baseline measurement of pollutant analogues transported from an undisturbed forested watershed, the recycling of nutrients through a tropical food web via consumption and decomposition, and baseline productivity in relation to limiting factors in aquatic systems.

b. Ecological Effects

Studies now in progress are aimed at understanding impacts of sediments and metals discharged from waste heat rejection systems upon representative marine organisms. Plans include measuring the ability of natural systems to process various wastes normally and without loss of integrity. The subprograms of Water Quality, Waste Disposal and Management, and Energy Production and Utilization are included within the area of Ecological Effects.

The Water Quality subprogram will identify and characterize the major water quality problems facing Puerto Rico and will assist island agencies in developing ecologically appropriate site specific water quality criteria. Examples of studies performed by the Environment Section in this subprogram include the diagnostic/restoration study of Lake La Plata, research on sublethal effects of heavy metals on the queen conch, *Strombus gigas*, and mixing-zone studies performed for PRASA.

The Waste Disposal subprogram will identify the major problems with waste or pollutants being released to the environment in Puerto Rico. The modes of transport and ecological effects of selected important wastes will be characterized. Methodologies appropriate for studying the fates and

effects of waste substances will be developed as background for managing wastes in Puerto Rico and other islands with similar problems.

In a third subprogram, environmental problems associated with energy production and utilization will be identified and quantified. Studies performed in this area include drift studies of the plume from the proposed OTEC plant and research on the environmental effects of the development of energy cane technology. Current projects in the area of Ecological Effects include a study of the ecotoxicological effects of the terrestrial disposal of wastes from the Barceloneta sewage treatment facility and a collaborative effort with the Environmental Quality Board and PRASA to develop research protocols for the evaluation of domestic and industrial waste disposal in coastal waters. Future projects may include the development of an oil spill trajectory model suitable for regions of Puerto Rico, the study of ecological transport of mining pollutants and marine organisms, and studies of nutrient leakage from cane producing fields.

c. Resources Management

This area encompasses subprograms relating to the prudent use of water and wildlife resources. The goals of the program are to quantify and characterize the ecological bases of resource problems on islands and to develop ecologically sound prescriptions for managing and restoring selected important environmental resources in Puerto Rico. Achievements in this area include a study of the feasibility of using water hyacinths as a biological filter in polluted waters and research on the distribution and conservation of the endangered Puerto Rican boa. Future projects include research on the critical life stages of the edible land crab and on the effect of introduced birds on crops such as rice.

Table 3 shows the best estimate of the necessity of research in these program areas to help resolve Puerto Rico's problems in the fields of environment in the short, intermediate, and long term, and provides estimates of the likelihood of obtaining outside funds for these program areas over the same time spans. The characterization of terrestrial and aquatic ecosystems represents a basic need which will continue for some time. The potential for funding is moderate during that period, except for the characterization of the rain forest where support from DOE is expected to continue, although perhaps at reduced levels. The need for research in the area of Ecological Effects is clearly indicated, but the possibility of funding is low at least in the short and mid-term. There will probably be an increase in the importance of research on waste disposal and the management of water resources over the next ten years, and outside funding will track the need for this research. Over the long term there will be an increased emphasis on the areas of environmental effects in the Environment Section with continued strong programs in Ecosystem Structure and Process.

## 2. Needs

Certain assumptions have been made about the continuity of competitive funding and resultant staff and facility requirements. One important assumption is that CEER will retain control of the operation of the El Verde Field Station in the Luquillo Rain Forest. DOE has projected \$200,000 per year for cycling and transport studies there and is presently negotiating to set up a long term legal status for the station within DOE. With this official DOE status comes the probable continuing commitment of General Plant Projects funds for major repair, maintenance, operations, and construction on the facility. The critical importance of this

TABLE 3  
ENVIRONMENT SECTION LONG RANGE PLAN

PROGRAMS	NEEDS			AVAILABILITY OF FUNDS		
	SHORT	MID	LONG	SHORT	MID	LONG
ECOLOGICAL EFFECTS						
WATER QUALITY	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM
WASTE DISPOSAL AND MANAGEMENT	MEDIUM	MEDIUM	HIGH	LOW	LOW	MEDIUM
ENERGY PRODUCTION AND UTILIZATION	LOW	LOW	LOW	LOW	LOW	LOW
ECOSYSTEM STRUCTURE AND PROCESS						
FOREST CHARACTERIZATION	HIGH	HIGH	HIGH	HIGH	HIGH	MEDIUM
FRESHWATER CHARACTERIZATION	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM
MARINE CHARACTERIZATION	HIGH	HIGH	HIGH	LOW	MEDIUM	MEDIUM
RESOURCE MANAGEMENT						
WILDLIFE	LOW	LOW	LOW	LOW	LOW	LOW
WATER	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH

facility for continued research in the rain forest is recognized by all parties and has been endorsed by the CEER Senior Advisory Committee. The projections assume the continued operation of the Wet Lab/Bioassay facilities and the sustained operation of chemical support groups in Río Piedras and Mayaguez.

Because of the complexity and multidimensional character of most serious environmental problems, a certain minimum diversity of expertise must be maintained within the staff. A core staff of scientists with broad backgrounds must be combined with a pool of specialists who will be employed on a part-time basis, preferably from various departments of the UPR. The core staff should be supported by institutional funds.

The current staff of eight Ph.D. scientists is the minimum needed to conduct the research programs described here. Any reduction would result in lower expectations in terms of research productivity and a narrowing of the research scope of the section. Since approximately half of the staff are supported by outside funds, maintenance of the current scientific staff requires about \$500,000 in competitive funds annually. PRASA, DOE, the Environmental Quality Board, the Agency for International Development, the National Science Foundation and various industries are the most likely sources of these competitive funds.

#### D. RESOURCES AT CEER

The CEER facilities have an acquisition value of approximately \$12 million and are located at four main sites: 1) Río Piedras, 2) Mayaguez, 3) Cornelia Hill, on the coast south of Mayaguez, and 4) El Verde, in the Luquillo Experimental Forest. A fifteen acre site in the north coast muni-

cipality of Toa Baja has been assigned to CEER by the UPR for the development of an experimental station.

1. Mayaguez

The CEER energy programs have been located at the Mayaguez facility rather than at the Río Piedras facility. This was logical since the PRNC research reactor had been placed in Mayaguez primarily because of the UPR engineering school. The major energy programs were operated from the Mayaguez site because they were highly experimental in nature. Accordingly the shops of the Mayaguez facility were upgraded to meet the needs of the alternative energy programs. Mayaguez presently has operating mechanical and glass blowing shops. There is also an electronic shop, but the equipment is outmoded.

The solar energy laboratory has basic measuring and testing equipment, most of which meets solar industry standards. The major equipment includes:

- Measurement station (Class A) for insolation measurements, global, total, and diffuse.
- Solar collector test stations for low, medium, and high temperature operating collectors.
- 100 ton operation solar assisted air conditioning system.
- Computer facilities for data logging and processing using both micro and mainframe computer systems.
- Operational shallow solar pond systems and monitoring instrumentation for solar water heating.

During the period of PRNC operations, the Mayaguez site had an excellent research program in nuclear chemistry. When CEER was formed, one of the chemistry laboratories was converted to a photoelectrochemistry laboratory. Research grant funding has provided for the acquisition of equipment

for high performance electronic absorption spectrophotometry, electroanalytical techniques, photochemical techniques in homogeneous solutions, and high performance liquid chromatography.

Cooperation with the Mayaguez campus has allowed for the use of undergraduate and graduate students. The purchase of new equipment and the proper staffing have made the Mayaguez facility an excellent research center in chemistry.

The Marine Ecology Division maintains a station on the coast at Punta Guanajibo, just a few miles from the main CEER facility. This station contains a flowing seawater bioassay laboratory with special equipment and facilities unique to Puerto Rico. In addition, there is a docking facility for research vessels. The largest of these is the R/V Sultana, a 42 foot diesel powered fiberglass vessel, fully equipped to perform bathymetric studies, benthic work, diver support and physical oceanography studies.

The Marine Ecology Division maintains water quality and biological and bacteriological laboratories at the Mayaguez facility.

The scientific staff of both the Energy Section and the Marine Ecology Division reside primarily at the Mayaguez site. In addition to the full time staff, some adjunct staff are drawn from various engineering and science departments of the Mayaguez Campus.

## 2. Río Piedras

CEER has 45,000 square feet of well-equipped laboratory and administrative space on one acre of land within the Río Piedras Medical Center. The Río Piedras facility houses the office of the CEER Director, the Terrestrial Ecology Division, Technology and Policy Assessment, the Microseismic Data Net, and the UPR Energy Conservation Program.

Terrestrial Ecology, one of the two divisions of the Environment Section, is housed in two facilities, one in Rio Piedras and the other at El Verde in the Luquillo Experimental Forest. The Rio Piedras facility houses offices and fully equipped laboratories, clerical facilities, a print shop, and a maintenance shop. The continuing association of the division with DOE has helped CEER to obtain \$180,000 to purchase capital equipment during FY 1983 and 1984. Because of these funds, Terrestrial Ecology has been able to develop state-of-the-art laboratories and purchase field equipment in the areas of environmental chemistry, ecophysiology, and microbiology.

The El Verde Field Station includes living quarters with fully equipped kitchens, two research buildings housing eleven offices and laboratories with gas, air, work benches and desks, a microcomputer, an herbarium, electrical and machine shops, and animal-holding facilities. The herbarium houses a reference collection which includes most animal and plant species representative of the Luquillo Experimental Forest. A micro-meteorological station and a sampling station for the National Atmospheric Deposition Program are part of the facility. Access to the rain forest canopy is made possible by an 80 foot walkway connecting two vertical towers.

Long-term study plots are located on land administered by the USDA Forest Service within a few minutes walk of the field station. A wealth of background information is available for the site, including a good understanding of the taxonomy of most plant and animal groups, 80 years of climatic observations, 30 years of data on forest growth and composition changes, complete vegetation, soils, and geologic maps, and 20 years of intense study of the forest around the field station.



The Microseismic Data Net program focuses on geophysical activities recorded by a microseismic network in Puerto Rico, with seismic activity measured by sensors scattered island-wide and transmitted by radiotelemetry to a central location in Cayey. Data is then processed at CEER in Río Piedras to determine magnitude and location of recorded events. Steps are being taken to incorporate the Virgin Islands' microseismic network within the Puerto Rico data net. Sites involved in this program are the thirteen field stations located at La Peregrina in Río Grande, Cerro Pandura in Patillas, Maguayo in Cabo Rojo, Mona Island, Cayey, Colonia Sabana in Bayamón, Lares, Desecheo Island, Peñuelas, Cerro de Punta in Villalba, Coamo and Morovis. One central data gathering and recording station is located at the U.S. Geological Observatory in Cayey, and one seismic data processing center at CEER in Río Piedras.

#### IV. SPECIAL CONSIDERATIONS CONCERNING THE ROLE OF CEER IN THE UNIVERSITY OF PUERTO RICO SYSTEM

The University of Puerto Rico has been traditionally a teaching institution. As a consequence, research and graduate studies are still largely undeveloped. In recent years, however, the Council on Higher Education has been concerned about the need to strengthen and expand both research and graduate programs. In 1984 the Council appointed a special committee to examine these two areas and make recommendations for their improvement. This is in harmony with the quest for excellence that the university is committed to pursue in the decade of the 80s and beyond.

As a specialized institutional unit dedicated exclusively to scientific research, CEER is uniquely qualified to contribute significantly to this quest for excellence. CEER is endowed with the basic human and technical resources and the research capabilities and expertise needed for the task. CEER has historically allocated funds specifically for the training and upgrading of scientific staff. This policy will continue. As previously indicated, CHE has formally recognized CEER's status and role within the university system. But in order to develop to its fullest potential, CEER needs a degree of institutional and budgetary stability with administrative flexibility that will permit it to function effectively as a viable entity.

There are certain special considerations that both the CHE and the Presidency must take into account to preserve and enhance CEER's position within the system. These considerations may be included under the three broad categories of management, personnel, and budgetary support.

In the area of institutional management, CEER has to continue enjoying sufficient administrative autonomy and flexibility to be able to compete successfully for external funding from various sources, especially through contracts with government agencies, either on its own or jointly with other public or private entities.

CEER has developed mechanisms to reward scientists of proven merit with promotions and raises according to criteria which emphasize scientific excellence. As part of this effort CEER has submitted a revised salary scale to bring scientists into parity with comparable academic staff of other units of UPR.

CEER's most valuable resource, its scientific staff, could be shared with the appropriate academic departments and research units to their mutual advantage. Built-in impediments at the departmental or faculty levels have often precluded the establishment of long-range collaborative arrangements for either teaching or research. Special provisions should be worked out at the level of the Presidency to facilitate mutually agreeable arrangements and interactions between CEER and other units.

Budgetary stability is a critical factor to insure institutional stability and development. The level of budgetary support extended by the UPR to CEER has remained static for the past three years. This means, in effect, a smaller budget from year to year since no allowance is made for cost of living increases and inflation. To avoid stagnation and foster normal incremental growth, some mechanism should be devised whereby CEER will receive annual budget increases commensurate with the annual increases of the UPR total budget. A sufficiency of institutional funding will improve CEER's capacity to compete for funding from the federal and Commonwealth governments and from private industry.

In addition to these considerations, there are external considerations in the public policy realm that have a bearing on CEER's mission and role. These involve relationships with local government agencies whose functions are germane to CEER's, such as the Puerto Rico Office of Energy and PREPA in the energy field and the Department of Natural Resources and the Environmental Quality Board in environmental programs. The policies and priorities of these agencies may influence CEER's research agenda and in turn be influenced by CEER's own research undertakings. Hence the importance of maintaining close working relationships and keeping abreast of these and other agencies' plans and projections.

The university authorities must keep these special considerations in mind so that CEER's status and role as an integral part of the UPR system be preserved while it is allowed to comply with federal norms and regulations applicable to federal contract laboratories.

## V. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions summarize the major points of this document:

1. The aim of this development plan is to provide for the allocation of available human, technical and financial resources for the implementation of the CEER mission in the short, intermediate, and long term.
2. The development plan considers CEER's continuing contractual relationship with DOE, its relationship with the other units of the university system as defined in CHE Certification No. 149 (1980), and its obligations to the Commonwealth as set forth in Law 128 of 1977 and Administrative Bulletin No. 3645 of July 2, 1979.
3. CEER can accomplish its mission of becoming the focus of energy and environment research for Puerto Rico only through the performance of high quality science and engineering.
4. A minimum annual budget of \$3.2 million in 1982 dollars is required to maintain CEER as a viable research unit. The difficulty of obtaining federal and private research funds and the impact of inflation have already brought CEER to the edge of this minimum budget.
5. Research priorities for CEER programs are based on the program's value to Puerto Rico, its value to the scientific community as a whole, and the available resources.
6. An annual review of research priorities is conducted by the CEER staff and the UPR President's Senior Advisory Committee, and modifications are made based on perceptions of research needs in energy and environment in both local and global contexts, the capabilities of CEER staff, and previous and current development plans.

7. Priority areas in which CEER can make substantial contributions to the quality of life in Puerto Rico include water quality, biomass, waste disposal and management, solar thermal energy, ecological effects of energy production and utilization, resource management, and technology and policy assessment.
8. As part of its program of training and technology transfer, CEER will seek to enhance the existing graduate programs of the university system by encouraging joint appointments, workshops, and research proposals, by participating on graduate committees, by teaching courses, by developing adjunct staff relationships with other UPR units, and by encouraging student and faculty research in areas consistent with the CEER mission through the Oak Ridge Associated Universities program and other sources of funding.
9. CEER continues to provide a regional center for training in technology serving the Caribbean Basin. This role should increase as funds for such activities become available. The eventual goal of the training program is to regain the level of activity that took place during the era of the Puerto Rico Nuclear Center.
10. During the last three fiscal years (1983-1985), CEER has been able to obtain at least \$1.50 in competitive grants for every \$1.00 in UPR institutional funds. This favorable matching fund ratio of 1.5 to 1 has been consistently maintained or exceeded by CEER for almost a decade, since its inception in 1976.

Based on the above conclusions, the following recommendations must be implemented to insure stability and growth:

1. As integration of CEER with UPR is now nearing completion, CEER should acquire a legislated legal status equal to that of other units

of the UPR system such as regional college campuses, university colleges and university campuses.

2. The university should increase its present commitment of institutional funding of \$1.2 million to \$1.6 million as per the minimum base budget (1982 dollars) projected in the Three Year Plan. The annual UPR allocation to CEER should increase at least proportionately to cost of living increases plus any across the board salary increments implemented in the system.
3. A minimum staff of thirteen full-time equivalent scientist (Ph.D.) positions is necessary to maintain the research and training functions of the Energy and Environment programs. During periods of low external funding, the UPR should assume responsibility for maintaining this minimum staff size.
4. CEER should continue to maintain the administrative functions of accounting and purchasing independent from, but integrated into the university system, as has been the practice since CEER began operations. This assures the dynamic administrative procedures necessary for an organization such as CEER, whose prime mission is the conduct of research.
5. Vigorous efforts should be made to protect the integrity of the essential field research sites, i.e., the El Verde Field Station, the area of Joyuda Lagoon, and the north coast farm at Toa Baja.
6. CEER should maintain an appropriate mix of applied and basic research and likewise, the systems approach to solving the energy and environment problems of Puerto Rico.
7. CEER research programs should continue to involve, as much as possible, faculty and graduate students from the various campuses of the univer-

sity, thus enhancing the programs of both the university campus and CEER by using the resources of the university more productively. Mechanisms should be instituted at the level of the Council on Higher Education to provide opportunities for CEER scientists to participate more fully in the academic pursuits of the university. Such mechanisms should set forth criteria for joint appointments, for sponsoring graduate students, and for cooperative research endeavors between CEER scientific staff and members of academic departments throughout the university.

8. Because the problems and resources of Puerto Rico require adequately trained people for their management, an interdisciplinary graduate curriculum composed of courses drawn from departments offering degrees in energy, environmental sciences, and engineering is urgently needed. CEER has the unique systems level experience in fields relevant to these areas. The precedent for this type of interdisciplinary curriculum was set by the formation of the Nuclear Science and Technology curriculum and MS degree program during the early years of the Puerto Rico Nuclear Center in cooperation with the Mayaguez campus. Because of the expertise of its scientific staff, CEER is ideally suited to participate in the formation of this curriculum.



APPENDIX A  
APPLICATION OF CHE CERTIFICATION NO. 62 (1983-84)  
TO THE CEER DEVELOPMENT PLAN

## APPENDIX A

### APPLICATION OF CERTIFICATION NO. 62 (1983-84) OF THE COUNCIL ON HIGHER EDUCATION TO THE CEER DEVELOPMENT PLAN

The CEER development plan committee carefully reviewed Certification Number 62 (1983-84) and addressed the points made therein when it prepared this document. The main problem that the committee faced is that, unlike the other entities in the UPR system, CEER is a research and not a teaching unit. CHE designed its guidelines primarily for the teaching units and certainly could not judge CEER objectively if the guidelines were applied too rigidly. A reading of the document will allow the reader to determine that it deals directly with the guidelines, as they apply to CEER.

This is especially true with the general objectives, which are dealt with throughout the document. The committee has reviewed the certification and picked out the objectives that apply to CEER and has gleaned the appropriate references from the CEER development plan to aid the readers in their evaluation of this planning document.

#### OBJECTIVES BY SPECIFIC DEVELOPMENT AREAS

##### 1. Academic Affairs

- To raise the level of excellence of CEER as a specialized research unit of the UPR System:  
Pages 3, 4, 10, 11; conclusion 3, page 31; recommendations 1,6 and 7.  
Pages 32 and 33.
- To promote and increase research oriented toward both the advancement of knowledge and the solution of Puerto Rico's problems:  
Pages 1, 2, 4, 5, 6, 9, 10, 11, 20; conclusions 3, 6, 7; recommendations 5 and 6.
- To institute measures to facilitate the recruitment, retention and promotion of the research staff:  
Pages 11, 17, 23, 29; conclusion 8; recommendations 3 and 7.

- To broaden and strengthen the participation of CEER at the various levels of the UPR System:  
Pages 5, 11, 14, 25, 28; conclusion 2; recommendations 1 and 4.
- To promote and make viable a plan for the academic and professional improvement of research staff and administrative personnel:  
Pages 11 and 28.
- To facilitate the hiring and retention of researchers of proven merit:  
Pages 17, 23 and 25.
- To revise and update research programs so that they respond to the institutional mission and Puerto Rico's needs:  
Pages 1, 2, 3, 4, 5, 8-12, 12-27; conclusions 1, 3, 5, 6 and 7; recommendations 6, 7 and 8.
- To improve criteria and requirements for the addition of new graduate and undergraduate programs:  
Recommendations 7 and 8.
- To make study programs more flexible through innovative options to better serve the needs of students:  
Recommendations 7 and 8.

## 2. Student Affairs

- To promote and facilitate the participation of graduate students in CEER's research and study programs:  
Pages 11, 14 and 25; conclusion 8; recommendations 7 and 8.

## 3. Administrative Affairs

- To establish flexible administrative procedures and speed up administrative actions to facilitate the accomplishment of the assigned mission:  
Recommendation 4.

## 4. Institutional Planning and Development

- To institutionalize a systematic planning process:  
Pages 4, 9 and 10; Tables 2 and 3; conclusion 6.
- To establish mechanisms for periodic programmatic review and evaluation:  
Pages 4, 5, 9 and 10; Tables 2 and 3; conclusion 6.

- To increase CEER's research resources through external funding:  
Pages 3, 4, 8, 10, 20, 30; Tables 2 and 3; conclusion 4; recommendation 6.
- To prepare a plan for the remodeling, expansion and maintenance of physical plant, laboratories and other research facilities:  
Recommendation 5.



