

CEER-S-111

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PUERTO RICO STATE SOLAR

PORT PROJECT

Final Report

FY 1981

Submitted to:

SOUTHERN SOLAR ENERGY CENTER

under

Contract No.

SSEC-1200-C-230-0016

October 1, 1982

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?CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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Prepared by: approved by:

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?William Ocasio

Salvador Lugo i

State Solar Convact rojo? Steeute

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Director

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Introduction

1.0 Agency Response

2.0 Impacts and Accomplishnente

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?Te State Solar Support Program sponsored by the Southern Solar Energy

Conter (S8EC), w

established in July 1979 to faciivate the regional and institutional coordination fundamental to the effective promotion and rapid commercialization of colar technologies. Its established goals have been

te augment the capacity of state agencies in renewable resource activities

and to provide state assi

nce to SSEC in pursuit of ts mission.

?To respond to these goals, CHER has utilized the SSC in support of

the solar commercialization components of its Energy Assessment and Analysis

and Community Awareness efforts. Through these, the Puerto Rico State Solar

Support Project has provided staff support to CEER planning and programming

efforts in each one of our divisions that are involved with solar and

renewable energy technologies

The Center for Energy and Environment Research (CEER) began its par-

ticipation in the Puerto Rico Solar Support Program in July 1979. It was

continued during FY 1980 and FY 1981. William Casio has served as Project

Director and State Solar Contact until February 1981, when Salvador Lugo

was named State Solar Contact, with Mr. Casio remaining as Project Director.

Able secretarial support has been provided by Sylvia Medina and Blanca

Maldonado.

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1.0 AGENCY FEsPoNsE

1.1 Goals,

Starting in 1957 as @ nuclear science oriented research and training institution the Center evolved into a highly diversified research and development organization working in the areas of energy and environment. This transition was made possible by an agreement between the university of Puerto Rico and the U. S. Department of Energy in 1976,

Ever since, CEER has actively sought and developed projects aimed at tapping the inexhaustible resources of sun, wind, and sea while also exploring the potentials inherent in recycling conversion or elimination of the waste products and pollutants of modern society. More specific goals of the Institution are:

111.2, To provide the focal point for energy research in Puerto Rico, to help the island achieve energy independence while contributing to DOE's effort to enable the entire nation to achieve the

same goal. In this sense CER is a microcosm that can easily be amplified to other areas.

To help Puerto Rico develop the scientific, engineering and

other

needed personnel needed for the future in energy, and
in related environmental areas.

1.1.4 To continue research and training programs in environmental

sciences and technologies

1.1.5 To serve as a center for international cooperation in the energy

and environmental fields, particularly for scientists, and technicians from tropical and subtropical areas in the Caribbean,

Latin America and the sun belt of the U. S. mainland

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It should be stressed that the nature of these goals are @

reflection of the surrounding environment and the perceived local needs. For instance, agriculture has been declining rapidly in Puerto Rico and it could use some profitable crops -Like energy cane, The emerging poultry industry, may have a problem of disposal of wastes. The same problem is faced by the dairy industry. Hence these animal wastes could be tapped for energy production, while at the same time solving the environmental problem.

20 more general terms, climate has influenced our work. Close

Proximity to cool ocean water helped bring about experience!

OME. The prevailing winds are an asset for passive

cooling. And

there is plenty of sun to be tapped. ?Thus, it is against this

background that we have pursued our more specific objectives,

Objectives

Bionase

?This division aims to develop an optimum strain of energy cane

which will serve the dual function of supplying Puerto Rico's need for fermentable solids and a waste product that can be burned to Produce steam and electricity.

Considerable success has already been achieved in the creation of new, highly efficient crop management techniques. The field of biomass candidates for energy had been narrowed to the most promising short, intermediate and long rotation varieties to include trees

and water hyacinths. Wood terrestrial species

are being evaluated

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8 sources of boiler fuel, cellulosic feedstocks and base stocks for methyl alcohol production.

Feasibility studies are underway to determine the shape and operation of the bioconversion facility ~one that would produce high= test molasses and electricity.

Bioconversion

Two primary aspects of this program include studies of terrestrial and marine energy farms; anaerobic digestion systems for production of methane; ethanol from agricultural wastes; utilization of animal feedlot wastes and solid waste landfill for energy recovery.

Energy recovery.

Energy is

Expected that through our bioconversion program, we will

be able to:

- * produce, use, and demonstrate the technical and economic feasibility of fermentative biogas production,

- * to instrument and monitor existing or newly constructed

biogas production facilities

+ to develop alternate uses for anaerobically fermented waste residue and effluent,

* to work with local industry to help reduce environmental pollution and petroleum derived energy dependence,

* to optimize and demonstrate hydrogen production by bio-photolysis,

* to act as a central technology data source for tropical

biogas production information and expertise.

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Ocean thermal energy Conversion

As a potential source for commercial supplies of electrical

energy, Ocean Thermal Energy Conversion (OTEC) offers a viable

answer as one of the most economical sources of energy yet con-

ceived. The fuel for generating electricity is free and limitless

which will quickly recover the rather formidable initial equipment

conte.

CHER has already made significant progr

in overcoming the

major obstacles to the development of an OTEC pilot plant. CEER's ocean platform has run longer, continuously, than any other data gathering station.

What makes CEER's explorations in OTEC unique is the fact that.

the work is being performed at what may be the best site in the

United States for a pilot plant. Off Punta Tuna, 2000 foot a

water is found within two miles of Puerto Rico's coast and close to an electrical grid that could utilize an abundant amount of ocean energy.

solar

The principal objective of the Solar Division ?s to harno

solar energy for application in industrial and agricultural situations. Puerto Rico is an excellent laboratory because of its location in a tropical zone.

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1.3 GEER Response to ssp

To enable the Center to respond to the State Solar Support Project, a new program was created with enough breadth to encompass ongoing solar activities as well as new areas of broad economic analysis and community awareness. Thus Energy Assessment and Analysis and Community Awareness (EXACA) came into being with Mr. William Casio, a Ph. D. Candidate from MIT, as Project Director. His training in economics and in energy matters was crucial in getting this effort going. This program has been recently renamed Analysis and Applications. Energy Conservation and Technology Transfer Activities are also included.

as th

areas developed, Mr. Salvador Lugo was brought in.

His experience in economics and energy planning helped carry out our responsibilities.

During this year part of Mr. Ccasio's time has been devoted

to Institutional Planning and Development**.

These activities indirectly support all the solar and

renewable energy programs at CEER.

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2.0. INPACTS AND ACCOMPLISHMENTS

2.1 Identifiable advances

AS was mentioned before, one direct result of the state

Solar Support Project was the creation of the Energy Analysis

fund Applications Program with a strong emphasis on a development approach. That is, to utilize existing funding to obtain further

Financial as

instance for undertakings that would strengthen the Programs capabilities to deal with renewable energy resources.

Along th

Lines, funding was obtained from DOE for a study on the impact of the increase in electricity prices upon low income families in Puerto Rico. It is our hypothesis that this upward move in electricity rates will greatly increase the need to turn to renewable onergy resources.

?The Community Awacene!

Area started growing when funding was obtained from the National Science Foundation to study the

possibility of energy self-sufficiency for Culebra, an island municipality off the East Coast of Puerto Rico. The objective of the project is to explore the possibility of reducing Culebra's dependence on imported energy. To this end, a series of workshops were started to explain to the public the options available to them in terms of renewable energy technologies. Four out of six workshops were held with an estimated attendance of 95 persons. The subject of discussion in each occasion was:

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energy production technologies, wind energy, biomass and bioconversion, solar and conservation. Expansion of the Energy Analysis area continued when we obtained financial assistance from the Association of Caribbean Universities!

and Research institutes (UNICA) and from Bexon Corporation

to hold four seminars (Barbados, San Juan, Jamaica, and Venezuela) on engineering aspects of renewable energy technologies.

Other accomplishments of the Energy Analysis are

wore as follows:

ce. Ocasio, as a member of the Technical Committee of UPADI (Pan American Union of Engineering Associations) has contributed in the organization of this event which will take place in 1982.

Messrs. #. Coasio and J. A. Honnet, Jr. wrote a paper for the International Engineering Week held in Mexico in 1980, on the energy situation in Puerto Rico.

The paper will soon be published by the Puerto Rican Academy of Arts and sciences.

As a sequel to conversations held with Argonne Laboratories, we were visited by them for possible participation of the Energy Analysis Group in the data base development phase of an energy plan for

Puerto Rico and the Virgin Islands.

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Mr. Ocasio participated in a symposium on biomass for agriculture in Puerto Rico. The activity was sponsored by the University of Puerto Rico.

Both Mr. Lugo and My. Ceasto contributed to the text and graphic illustration of the Annual Report, particularly, in regard to solar energy

Mr. Ocazio contributed to a substantial amount of the time to institutional planning.

We coordinated with SS8C an effort to get local architectural firms interested in passive cooling.

Very good information was obtained from SSEC on the subject and we passed it on to the architectural firms. We requested and obtained from SSEC information on industrial process heat and other renewable energy resources. We also obtained a slide show and accompanying text on the same subject. On our part, we responded to several requests for information from SSBC.

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Advances in other areas of CEER were as follows

MAJOR BIOMASS PROTECTS:

Sugarcane and Tropical Grasses: A study of three sugarcane varieties revealed the following trends: (a) there are increased yields with a delay in harvest frequency of from 2 to 12 months (b) narrow row spacing is ineffective: (c) napier grass is superior to sugarcane when harvested at less than 6-month intervals;

and (a) there is greater bulk in first ratoon-yields over plant-crop yields.

Horyesting: Tests have been conducted on high density cane with several types of harvesting equipment. Best results, with commercial promise, were obtained with the Klaas sholecane harvester, a modified Kaas harvester, a V-cutter with subsequent loader and a V-cutter with continuous loader.

Moody Species: *Bucalyptus robusta* has clearly emerged as the leading candidate in terms of survival and yield,

MAJOR BIOCONVERSION PROJECTS

Energetic Pig Farm: A CEER monitoring program was authorized by a farmer who had constructed three anaerobic digestors with

sloping bas

a5 part of a project to become energy self-suffi-

cient. Data were gathered on waste treatment and energy produc-

tion.

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1 Methane: One of several biogas projects undertaken

recently was @ food waste experiment using leftovers from the U.S. Army mess hall at Fort Buchanan in San Juan with productive results.

Gas and Fertilizer from Rum Waste: The objective of this research was to convert rum waste into a valuable energy and fertilizer resource by utilizing tubular Fermentors, Biogas produced in the process can be used to fire boilers and produce steam that will drive turbines. The fuel is renewable and abundantly available.

NAZOR OTEC Program:

Biofouling Tests: In Situ biofouling of simulated OTEC heat exchanger tubes at an OTEC site, Biofouling and heat transfer as a function of cleaning frequency and season of the year were determined between January 1980 and March 1981. During this period of time both 5052 aluminum and grade 2 titanium tubes were Corrosion Analysis: Corrosion analysis of zinc diffusion

coated extruded 3004 aluminum OTEC heat exch!

unger elements is,

currently being determined.

Surfactant Test: Open cycle OTEC surfactant studies have

been concluded.

Drogue Study: An extensive drogue study has been conducted

to determine the flow direction and velocity from an OTEC plant

if it were to be sited at Punta Tuna.

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Cable Fouts

The OTEC Division also conducted a study

funded by the Simplex Mine and Cable Company to determine the

biofouling of eight different proposed OTEC power cables

MAJOR SOLAR PRogEcTS;

Solar Data - Measurements and Modelling: The Division operates five solar data measuring stations throughout Puerto Rico. A computer program has been developed for a mathematical model of this data in a format amenable for utilization of scientists and engineers for basic research use and design information.

Solar Collector and System Test Facilities: solar testing

loops have been designed and constructed for low temperature

(less than 100°C) collectors, either liquid or air and medium-high temperature (200°C) Liquid collectors. ALL test loops are designed per American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standards,

Collector Development: Solar collectors have been developed for use in tropical climate conditions from low temperature (less than 100°C) to medium-high temperature (300°C) for utilization in

industrial heat processes.

Solar Air Conditioning: An experiment facility for testing

Drying of humid air has been developed utilizing silica gel and solar energy as the source of regeneration energy. Various sys

tem configurations have been investigated.

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Demonstration Projects: The Solar Division has participated

in a number of demonstrations

a) photovoltaics ~ thermal system for utilization in hospitals - Phase 1

b) Solar industrial process heat system for a food industry- Phase 1

c) Development and testing on site a medium temperature concentrator for steam production at a pharmaceutical

plant in Puerto Rico.

search

Solar Fond: the Division is currently involved in a re

?and development program in solar pond application for industrial

Technology Transfer ~ Panamé.

Participation in an energy assessment master plant for Panans.

current activity also includes

Another advance worth mentioning is the strengthening of the Divi-

sion with the appointment of Dr. George Pytlineki as its Director.

Accomplishment outside CEER includes the followings

Act 11 was enacted by the Puerto Rican Legislature to amend

the income tax to define solar equipment as any equipment that will

convert solar energy into direct or indirect usable energy, and

apply deductions for solar water heaters to all solar equipment.

Other action to promote solar was the approval by the Office of

Energy of a solar code aimed at guaranteeing efficiency and engineer-

ing adequacy of solar equipment.

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One last advance in solar was the completion of the award

winning design of a passive cooling structure to house the Center.

Mr. Pedro Muiz, was the architect in charge and the award was

given by the American Association of Collegiate Schools of Archi-

tecture.

In terms of solar education, tools developed by CEER were

Published, in collaboration with the Mayaguez Campus of the Uni-
versity of Puerto Rico, a 75-page handbook in Spanish describing

the principles and the basics of solar hot water heaters construc-

tion. Another publication was the Proceeding of the Symposiua on

Buels and Feedstocks from tropical Biomss, held in san Suan,

Puerto Rico on Noverber 24 and 25, 1980.

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3.0 EVALUATION

There is no doubt that CEER's area of public awareness

(Culebra Project) that began with the advent of the SSS will have

fan ongoing impact for years to cone. The experiance received on

information dissemination and interaction with the community is

jet that will help CEER in the promotion of renewable energy

resources with different citizens groups. Another ongoing impact,

although it affocts solar somewhat indirectly, is the study of the

impact of increased electricity rates on low income families.

?There is no doubt in our minds that the results of the study will emphasize the need to develop solar.

?The Assessment Area has also helped provide technical information from SSBC and indirect support to the other divisions. Ongoing work in these areas are as follows:

In the biomass area, a consortium has

been formed to develop

the technology that would go into a biomass conversion and power facility. Design studies are currently underway.

With respect to biogas, a research project has been established to design, construct, and demonstrate an energy-integrated pullet and layer farm incorporating energy and nutrient recovery.

"The use of other renewable energy technologies, such as solar and wind conversion have also been incorporated into the project.

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the primary objectives is to produce sufficient energy internally to operate @ farm and minimize dependence on costly, non-renewable energy resources.

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C infrastructure continues to be improved. The major facility of the Division is the research vessel platform which consists of a modified 115 foot long army LCU. The vessel platform has been extensively refurbished so as to enable it to remain moored at an open ocean site for at least one year at a time and perform OTEC bio-fouling and corrosion studies. In addition to a wet laboratory for Biological studies and a facility for acquiring and analyzing heat transfer data, the vessel also has been refurbished so that extensive Physical, chemical, and biological oceanographic studies can be performed.

In the Solar Division, work is in process for the construction and monitoring of a solar system for the production of industrial process heat for the food industry. There are also residential and industrial Photovoltaic demonstration projects; and solar pond development. In the international area there are alternative energy assessments and

training programs for several countries.

We have been describing the advances made at CEER in regard to

Research and applications of renewable energy resources. in Puerto

Rico continue:

to depend on petroleum for 98% of its energy needs.

Moreover, the cost of electricity to the consumer is sharply up.

As an alternative to oil, coal was thought of, but discarded.

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?The only attempt that seems to have had some small results

to ameliorate the problem is the use of solar hot water heaters

and conservation. But the bulk of the problems still remains.

?Thus we must rely on solar to continue to probe for alternatives, capitalizing on local conditions. For instance, utilizing existing agricultural facilities and infrastructure for growing and processing tropical biomass. If energy cane is grown, it would also benefit the rum industry. The local poultry and cattle industry could use chicken and cattle wastes to generate some biogas and at the same time solve an environmental problem,

?And in this fashion we keep trying to find solutions to the problem. It will soon be twenty five years since we became involved with energy. As the problems and perceived solutions have evolved, our Institution has shifted its emphasis adjusting our laboratory policy accordingly. With the effective help received from the Southern Solar Energy Center, we have been able to expand our effort in new areas. Additional scientific information has been

made available that

added impetus to our efforts:

our search for solutions have been attuned to local conditions:

any of which may not be found elsewhere in the mainland. ?These
unique conditions may at some future time be required for any
particular energy effort. And in this respect, we remain in a

position to share our experiences with others.

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