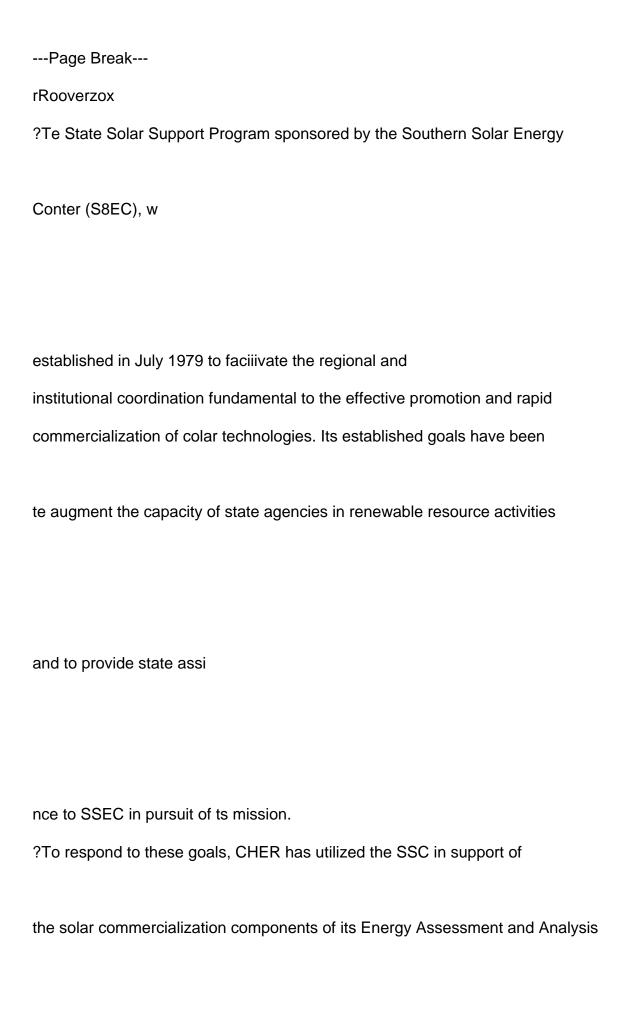
PUERTO RICO STATE SOLAR
PORT PROJECT
Final Report
FY 1981
Submitted to:
SOUTHERN SOLAR ENERGY CENTER
under
Contract No.
SSEC-1200-C-230-0016
October 1, 1982
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?CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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Prepared by: approved by:
Lhe Org
?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
3.0 Evaluation



?and Community Awareness efforts. Through these, the Puerto Rico State Solar
Support Project has provided staff susport to CEER planning and programning
efforts in each one of our divisions chat are involved with solar and
renewable energy technologies
?The Center for Bnorgy and Environment Research (CEER) began its par-
?pation in the Puerto Rico Solar Support Program in July 1979, Tt was
continued during FY 1990 and FY 1961, Willian casio has served as Project
Director and State Solar Contact until February 1961, when Salvador Lugo
was named State Solar Contact, with Mr. Oeasio remaining as Project Director.
Able secretarial cupport has been provided by Sylvia Medina and Blanca
Maldonado.

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1.0 AGENCY FESPONSE

1.1 Goats,

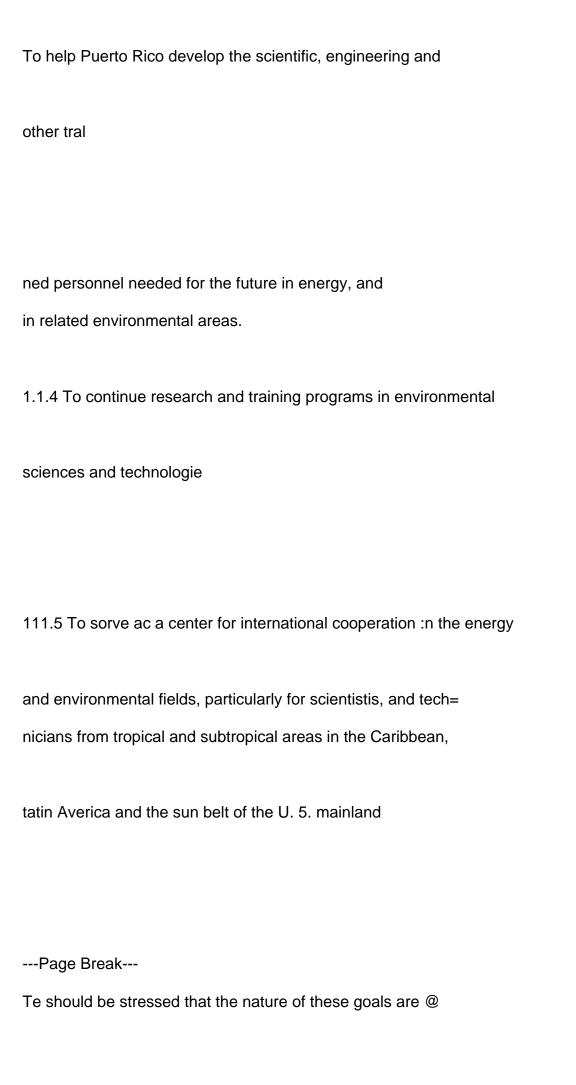
Starting in 1957 as @ nuclear science oriented research and train ing institution the Center envolved into a highly diversified research and evelopment organization working in the areas of energy and environment. This transition was nade possible by an agreenent between the

university of Puerto Rico and the U.S. Department of Energy in 1976,

Bver since, CEER has actively sought and developed projects aired fat tapping the inexhaustible resources of sun, wind, and sea vhile also exploring the potentials inherent in recyeling 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 enersy research in Puerto Rico,te help the island achieve energy independence while contribut~?ing to DOE's effort to cnable the entire nation to achieve the

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



reflection of the surrounding environment and the perceived local needs. For instance, agriculture has been declining rapidly in Fuerte Rico and it could use sone profitable crops -Like energy cane, The energing poultry industry, may have a problem of dis posal of wastes. The sane problem is faced by the dairy industry. Hence these animal wastes could be tapped for energy production, while at the sane tine solving che environmental problem.

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

Proximity to cool ocean water helped bring about experine!

OME. The prevailing winds are an asset for pai

sive cooling. And

there is plenty of sun to be tapped. ?Thus, it is against this background that we have pursued our nore specific objectives, Objectives

Bionase

?This division aims to develop an optimum strain of enersy 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 tachniques. ?the field of biomass candidates for energy had been narrowed to the most promis~ing short, intermediate and tong rotation varieties to include trees

and water hyacinths. Wood terrestrial speci

are being evaluated

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a8 sources of boiler fuel, cellulosic feedstocks and base stocks for methyl alcohol production.

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

Bioconvereion

Que primary appeats of this program include studies of torres	
?wo primary aspects of this program include studies of terres~	
trial and marine energy farms; anaerobic digestion systems for pro~	
@uction of methane; ethanol from agricultural wastes; utilization	
of animal feedlot wastes and solid waste landfill for e!	
gy recovery.	
te is	
oped that through our bioconversion program, ve will	
be able to:	
* produce, use, and demonstrate the technical and economic	
·	
feasibility of fermentative biogas production,	
* to dnstrusent and sonitor existing or newly constructed	
biogas produetion faci litss	

- + to develop alternate uses for anaerobically fermented waste residue and effluent,
- * to work with local industry to help reduce environmental pollution and petroleun 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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Qcean thermal mergy 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 ie freo and Linitiess

cwhich 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 coart and close
to an electrical grid that could utilize an abundant amount of
ocean enersy.
solar
The principal objective of the Solar Division ?s to harno

solar energy for application in industrial and agricultural situa~ tions. 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 cormunity avareness. Thus Energy Assesoment and Analy-?sis and Community Awarcness (EXACA) came into being with Mr, William casio, a Ph. D. Candidate from MIT, ax Project Director. His training in economics and in energy matters was crucial in getting ?this effort going. ?This program has been recently renaned Analysis ?and Applications. Energy Conservation and Technology Transfer Activities are also included.

as th

areas developed, Mr. Salvador Lugo was brought in.
Mis experience in economics and energy planning helped carry out
our responsibilities.
Daring this year part of Mr. Ccasio's tine has been devoted
to Institutional Planning and Development**.
?Theso activities indixectly support all the solar and
renewable energy programs at CEER.
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2.0. INPACTS AND AccoMPLStBLENDS
2.1 Identifiable advances
AS was mentioned before, one diect rosult of the state
Solar Support Project was the creation of the Energy Analysis

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

Financial as

istance 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
vas obtained from the National Science Foundation to study the

possibility of energy self-sufficiency for Culebra, an island municipality off the East Coast of Pusrte Rico. the objective of the project is to explore the possibility of reducing Gulebra's dependence on inported energy. To this end, a series Of workshops were started to explain to the public the options available to then in tems of renewable energy technologies. Pour out of six workshops were held with an estimated attendance

of 95 persons. The subject of aigcuseion 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 Universitic!

land Rosearch 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 ares

wore as follows:

ce. Ocasio, ag a nenber of the Technical Commit

tee of UPADI (Pan Averican Union of Engineering

Associations) has contributed in the organization

of this event which witl take place in 1982.

Messrs. #. Coasio and J. A. Honnet, Je. 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.

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

Puerto Rico and the Viegin Islands.

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Me. Ocasio participated in a symposium on bionass for agriculture in Puerto Rico. The activity was eponsored by the University of Puerto Rico.

Both Mr. Lugo and My. Ceasto contributed to the text and

graphic itlustration of the Annual Report, particularly,

in regard to solar enersy

?Mr. Ocazio contributed to a substantial anount of

hie tino to institutional planaing.

?Wo coordinated with SS8C an effort to got local

architectural firms interested in passive cooling.

Vory good information was obtained from SSEC on

the subject and we passed it on to the architectural

firms, Me requested and obtained from SSEC inforna-

tion on industrial process heat and other renewable

energy resources. We also obtained a slide show

land accompanying text on the sane subject. On our

part, wo responded to several requests for information

from SSBC.

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Aavances in other areas of CEER vere 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 dolay in harvest frequency of from 2 to 12 months

(®) narrow row spacing is ineffective: (c) napier grass is supe~

lor to sugarcane when harvested at less than G-nonth intervals;

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

crop yields.

Horyesting: Tests have been conducted on hish density cane

with several types of harvesting equipment. Best results, with

commercial promise, were obtained with @ Klaas sholecane harvest

er, a modifica Kaas harvester, a V-cutter with subsequent loader

and a V-outter with continuous loader.

Moody Species: Bucalyptus robusta has clearly emerged az

the leading candidate in torn: of survival and yield,

MAJOR BIOCONVERSION PHOJBCTS Bnergetic 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 becone energy self-suttichent. Data were gathered on waste treatment and energy produc~ thon.

1 Methane: One of several biogas projects undertaken

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Mess

recently was @ food waste experinent using leftovers from the U.S.

Army mess hall at Fort Buchanan in San Juan with productive results.

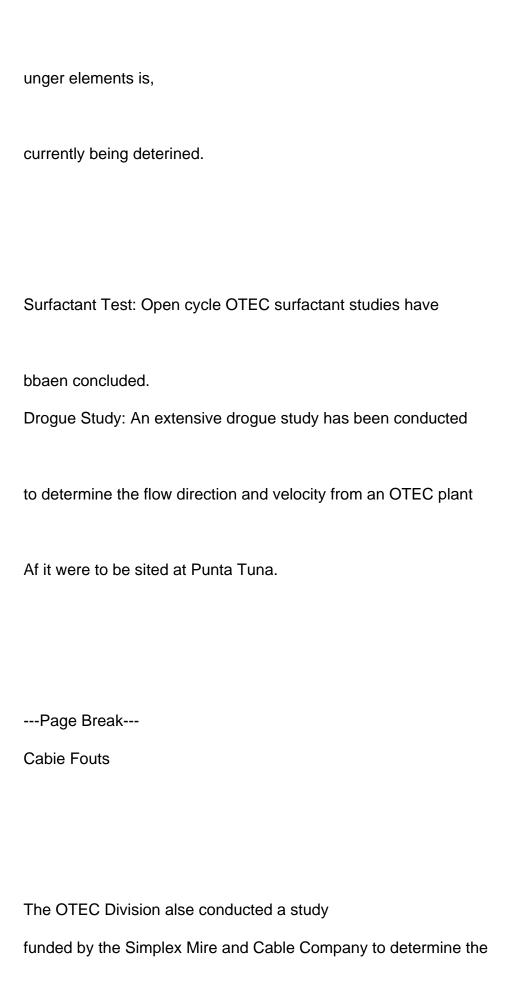
Gas_and Fertilizer from Rum Waste: The objective of this re~?search was to convert rum waste into a valuable energy and fertil-Aner resource by utilising tubular Fermentors, Biogas produced in the process can be used to fire boilers and produce steam that will drive turbines. Te ?Fuel? te renewable and abundantly

available.

NAZOR o7EC pRagBcTS:

Biofouling Testa: In Situ biofouling of simulated OTEC heat exchanger tubes at an OTEC site, Siofouling and heat transfer as fa function of cleaning frequency and season of the year were determined between January 1980 and March 1981. Daring this peri-(od of time both 5052 aluninum and grade 2 titanium tubes vere Corrosion Analysis: Corrosion analysis of zinc diffusion

coated extruded 3004 aluninus OTBC heat exc!



biofouling of eight different proposed OTEC power cables

MAJOR SOLAR PROGECTS;

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

Solar Collector and System Test Facilities: solar testing

oops have been designed and constructed for low temperature

(ess than 100°C) collectors, either liquid or air and medium-high temperature (200°C) Liquid collectors. ALL test loops are designed per Anerican Society of Heating, Refrigerating and Air Condition ing Engineors (ASHRAE) standards,

Collector Developsent: Solar collectors have been developed for use in tropical climate conditions from low temperature (less than 100°C) to mediumnigh cemperature (300°C) for utilization in

industrial heat processes.

Solar Air Conditioning: An experiment facility for testing

Grying of huni 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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Bb

Demonstration Projects: ?the Solar Division has participated

in a munber of denonstrations

a) photovoltaics ~ thermal aysten for utilization in hospi-

tats - Phase 1

b) Solar industrial process hoat system for a food industry-

Phase 1

©) Development and testing on site a nediuetesverature concentrator for stean 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 ite Director.
Accomplishmentzouteide CEER includes the followings Act 11 was cnacted by the Puerto Rican Legislature to amend

the incom: tax to define solar equipment as any equipment that iil

convert solar energy into direct or indirect usable energy, and

apply deductions for solar water heaters to all solar equipment.

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

nergy of @ solar code aimed at quaranteeing efficiency and engineer

ing adequacy of solar equipnent.

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one last advance in sclar was the completion of the avard winning design of a passive cooling structure to house the Center.

Mr. Pedro Muiz, was the architect in charger and the award was given by the American Association of Collegiate Schools of Archi~eecture.

In tems of coler educations] tools developed by CEER we

Published, in collaboration with the Mayaguez Caspus of the University 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 winds 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 aivisions. Ongoing work in these areas are as follows:

In the biomass area, a consortium hi

been formed to developed

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

With respect to biogas, a resoarch project has been esta~ blished to design, construct, and demonstrate an energy-integrated pullet and layer farm incorporacing energy and nutrient recovery.

"The use of other renevable energy technologies, such av solar and

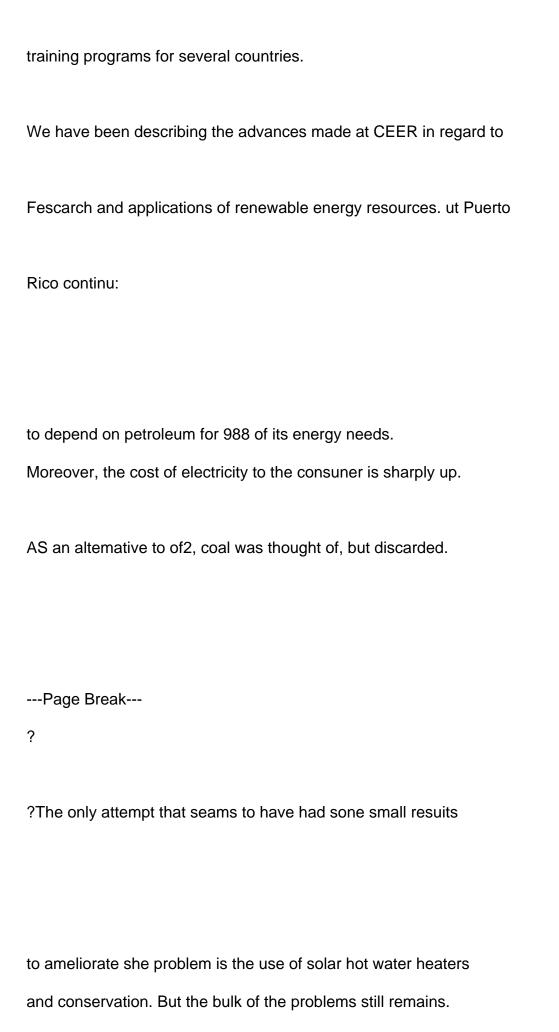
wind conversion have also been incorporated into the project.

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

om

C infrastyucture continues to be Amproved. ?The major facility of the Division is the research vessel platform which consists of a Rodified 115 foot long army LCU. The vessel platform has been exten sively refurbished so as to enable it to remain moored at an open fecean site for at least one year at a tine and perform OTEC biofouling and corrosion studies. In addition to a wet laboratory for Biological studies and a facility for acquiring and analyzing heat fransfor data, the vessel also has been refurbished so that extensive Physical, chemical, and biologicl oceanographic studies can be per formed.

In the Solar Division, work isin process for the construction and monitoring of a solar system for the production of industrial process hheat for the food industry. There are also residential and industria: Photovoltaic demonstration projects; and solar pond develorment. to the international area there are alternative energy assessments and



?Thus we mast rely on solar to continue to probe for alternatives, capitalizing on local conditions. Por instance, utilizing existing agricultural facilities and infrastructure for growing and proces= ?sing 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 sone biogas and at the same tine solve an environmental prodlen,

?And in this fashion ve keop trying to find solutions to the problen. Tt will soon be twenty five years since we becane involved with energy. As the problens and perceived solutions have envolved, our Institution has shifted it onphasie 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

sade available that

added impetus to our efforts:

our search for solutions have been attuned to local condition:

any of which may not be found elsewhere in the mainland. ?These unique conditions may at sone future tine 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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