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SOLAR TECHNOLOGY DIVISION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

UNIVERSITY OF PUERTO RICO

marcH 1979

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SOLAR THERMAL SYSTEM TEST FACILITY

FOR LOW AND MEDIUM TEMPERATURE RANGE

ProposaL To THE DEPARTMENT oF ENERGY'S

NorTHEAST REGIONAL APPROPRIATE TECHNOLOGY PROGRAM

SOLAR TECHNOLOGY DIVISION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

UNIVERSITY OF PUERTO RICO

march 1979

ENDORSEMENTS:

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DR. UGYR ORTABASI, HEAD, St \R TECHNOLOGY DIV, ?DATE

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Solar Division, CEER

SOLAR THERMAL SYSTEM TEST FACILITY

FOR LOW AND MEDIUM TEMPERATURE RANGE

Prepared by:

Project Site:

Telephone:

Total Funding

Requested:

Solar Technology Division

Center for Energy and Environnent Research

College Station

Mayaguez, Puerto Rico 00708

Center for Energy and Environment Research

Carretera 108, Km. 1.3

80. Miradero

Mayaguez, Puerto Rico

809-832-1414

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This project is a development project in the area of solar process steam and solar hot water.

The Center for Energy and Environment Research is a part of the University of Puerto Rico, a public institution of higher

learning.

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Solar Division, CEER

1, PROJECT OVERVIEW

AS part of its research and development program in medium temperature solar thermal energy systems, the Solar Division of the Center for Energy and Environment Research of the University of Puerto Rico (CEER), proposes to build a test facility for such systems. The main objective of this project is to achieve the capability of doing detailed and precise measurements of the efficiency of solar thermal systems in a tropical environment
This unique test facility in the Caribbean will offer the opportunity

to study low to medium temperature (140°F-550°F) solar collector systems under operating conditions. The funding requested for this project will be utilized to install, test and operate the thermal loop designed previously at CER.

The proposed test facility has been designed after studying the experience of other researchers with similar facilities in the United States. Many of the problems encountered by them have been eliminated in our design.

Fuel costs for the production of hot water and low pressure, medium temperature (350°F) steam for domestic and commercial use in Puerto Rico cen be conservatively estimated at $150 M per year. The Solar Division of CEER 1s engaged in an active research Program to develop cost effective systems which can fill this energy need with a renewable, local, non-polluting resource.

An experimental test facility is indispensable for the evaluation of prototype systems and for the eventual development of systems which are best suited to the climatic conditions Prevalent in Puerto Rico.

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11, BENEFITS FROM THE PROJECT

The Center for Energy and Environment Research of the University of Puerto Rico was established on July 1, 1976, under an agreement between the President of the University and the U.S. Energy Research and Development Administration, now a part of the U.S. Department of Energy. CEER has as its main goals: (1) to help Puerto Rico achieve energy independence by serving as the Island's focal point for energy research;

{2) to help Puerto Rico develop scientific, engineering and other trained personnel in the energy and environmental fields. The Solar Technology Division of CEER is engaged in an active, on going research program which includes, among others, measurement of solar insolation, computer simulation of thermal systems, and design and development of concentrating collectors.

At this point in the program, a strong need is felt for an experimental test facility which will provide detailed, precise data on the performance of solar thermal systems in a tropical environment. This data is indispensable for the continuation of the research program in thernal systems.

The Solar Technology Division of CEER has iden ied

thermal systems (in particular hot water and medium temperature

steam systems) as one of its focal areas of research. The

main reason for this decision is the potential for a substantial

?impact on fuel use within a relatively short development period.

In Puerto Rico, fuel costs for such systems amount to at least

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$150 M per year (18% of all fuel use). The technological

feasibility of using solar systems for these applications has

already been well established. The main challenge lies in

developing efficient, low cost systens,

Besides providing basic efficiency data, the test facility

Will be used to test system materials and reliability. It will

also provide long-term performance data which is a very important

consideration in system appraisal.

Another benefit from this project will be the educational

Opportunities it will provide to students at the U.P.R.'s School of Engineering. In the last two years 10 undergraduate Students have worked or done projects in the Solar Division.

The plans are to use students to help in the testing of solar collectors and systems. This represents for them an invaluable, hands-on experience in solar. For Puerto Rico it represents a growing number of professionals trained in the solar field.

In sunmary, this project deals with a renewable, locally-available, non-polluting resource, solar energy. The application involved represents a substantial percentage of the total energy needs of Puerto Rico and has a large potential impact on both the domestic and commercial markets. The proposed test facility will be an indispensable part of the research program of the Solar Division of CEER and will allow it to continue to meet its commitment as a research and educational institstion

working on behalf of the Commonwealth of Puerto Rico.

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III, TECHNICAL DESCRIPTION OF PROJECT

The proposed solar collector test facility can be used for collectors having an aperture area of up to 5 m2 (54 ft2) at temperatures between ambient and 288°C (550°F). It will be 4 low pressure closed loop system using a liquid phase heat transfer fluid. The system will have a pumping station; heaterss flow, pressure, temperature, insolation, wind speed and direction monitors: coolers filter; tenperature controls: expansion tank and associated piping system. AT] data will be monitored and written on paper by means of a data logger.

The test station will be built on top of the machine shop at CEER's Mayaguez site, The monitoring station will be in a Foom at the machine shop directly under the loop where the test station will be constructed.

The testing loop configuration is shown in Figures 1 and 2

A. Instrunentation

1, Solar radiation measurements will be made by a Dyranometer and a pyrheliometer.

2. Temperature measurements will be made by platinum resistance thermometers (RTD) and J type iron-constantan thermocouples (TC).

3. Liquid flow rate measurements will be done by two

different types of Flowmeters and will be checked

against each other. A turbine type and a strain

gage type flowmeter will be used.

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Solar Division, CEER

?4. The pressure measurements will be made by bonded

strain gage transducers.

5. The wind velocity and direction measurement will be made by electro-mechanical anenometers.

6. All data will be monitored by @ data logger which is built around a microprocessor and printed on papertape. Individual monitoring equipment will also be used for flow, pressure and wind measurements.

Apparatus

The main function of the collector test loop is to feed the solar collectors under test with constant flow rate, constant temperature fluid. For a complete efficiency test, this loop supplies an input temperature between ambient and 298°C with a wide variety of flow rates from 0.025 to 2.5 liters per minute per square meter of collector.

The system will utilize Dowtherm A as a heat transfer fluid which is a composition of 73.5% dipheny!

oxide, 26.5% biphenyl.

To avoid oxidation of Dowtherm A at elevated temperatures, the system will be kept under nitrogen gas blanket at 50 psi.

A 50 micron size wire mesh strainer filter will be put in the system to ensure contamination free liquid

and elongate punp life. Two pressure gauges will serve

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for the filter cleanliness indication

The pumps. will circulate the liquid in the system and through collectors. They will be selected as stainless steel gear pumps with high temperature packings.

Four 500 watt,on-line heaters will be used to heat ?the liquid to desired temperatures. Due to thermal shocking limitations, they are specially selected as low watt density (20W/in2) firerod immersible heaters. The heating elements will be controlled by a solid state digital proportional controller in order to keep the inlet temperature to the collector within a very narrow deviation range.

The two flowrate measuring devices will be on the final line to the solar collector and a temperature measuring RTD will be supplied at this point in order to make necessary corrections due to physical property changes of the fluid with temperature.

To supply flexibility to the system, the connections to collectors will be made by teflon lined, stainless steel, braided hoses. Inlet and outlet temperatures and pressure measurements across the collector will be done as close as possible to the collector. Two platinum RTD's and two pressure transducers will be located

at inlet and outlet of the collector.

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To simulate @ load, a 2.5 KW heat rejection capacity, air-cooled, fluid cooler will be used. The amount of temperature drop, i.e. heat removal, will be controlled by @ proportional temperature controller where the final eTement will be a three way valve.

To stabilize the flow rate and to prevent oscillations, a 40 liter hold tank will be used.

The expansion tank will serve as a main ventilation point for the system. It will be sized such that it is one-quarter full at ambient temperature and three-quarters full at 260°C.

Loading of the system will be accomplished from the storage tank by @ small load tank where this tank also acts as» catchpot for the system

Valves, check valves, and pressure relief valves Wil] be all selected for high tenperature usage and located as shown in Fig, 1. All relief valve exits will be collected at a common pipe to avoid spilling of fluid

to the working area which can be hazardous to workers.

Controls

The level control of the expansion tank will

serve as a level gauge and a low Tevel alarm switch. Any

leakage from the system can be detected by this control.

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A low level alarm will automatically turn off the pumps

and electric heaters and an audio alarm system is triggered.

A pressure alarm switch which will detect a

loss of flow will be put after the pumps. This condition

will turn on the spare pump and turn off the main pump

The first proportional temperature will control

the heaters as mentioned in the previous section. Two

thermocouples located at the exit of the heaters will be

used as high alarms to avoid boiling of the heat transfer

fluid. In such a case, power to the heaters will be shut orf.

Another high temperature alarm will become effective

if the collector outlet fluid temperature exceeds the

preset limits. This alarm will result in an audio alarm

which necessitates shading of the collector.

A proportional temperature controller will)

control the temperature of the fluid which goes to the

hold tank. The amount of cooling is adjusted by the

three way valve which diverts the fluid proportionally

to cooler and by pass

D. Data Collection

Monitor Lab. Model 9300 Data Logger will be

used to monitor and record system outputs.

This data logger has the capabilities of scaling,

averaging, converting TC and RTD outputs to °C or °F,

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alarming, scanning etc, With its 60 channels it can handle all the data to be recorded or monitored.

AN] instrumentation will fullfil the requirements of ASHRAE STANDARDS No. 93-77, No. 41.8-78, No. 41.1-74.

Future Plans

The proposed system will constitute an unique oppor-

tunity to test and evaluate low to medium temperature

solar collector systems in Puerto Rico and the Caribbean. Although the system is suitable to test solar water

heaters, its main purpose is to evaluate solar process

heat collectors. As a part of its program, the Solar

Division is now developing a series of prototypes suitable

for operation in the tropical environment. The photograph

fon the next page shows one of the prototypes recently developed by CEER. Plans call for testing of other collectors

developed in the U.S.R. and elsewhere. Comparative testing

of these collectors will supply the data to determine the

most cost effective type that can be applied to Puerto Rico's

needs.

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IV, QUALIFICATIONS OF KEY PERSONNEL

. A. Dr. Angel Mario Lopez Berrios, Project Manager

Dr. Lépez has a 8.5. degree in Physics from the

University of Puerto Rico end an M.S. and Ph.D. in Physics from the University of Massachusetts. His doctoral thesis was in experimental particle physics. He-has been working in the solar energy field for the last two years and was appointed as a Scientist at CEER in September, 1978.

B. Mr. Levent Ozakgay, Graduate Student

Nr. Ozakgay obtained a 8.5. in Chemical Engineering from the Middle fast Technical University in Ankara, Turkey. We has been working in the Solar Eneray Division of the.Wineral Research and Exploration Institute of Turkey for the last 3 1/2 years. uring 1977, Mr. Ozakgay worked with the Solar Energy Group at Argonne National Laboratory, Chicago, [11inois on

: an United Nations Fellowship.

. C. Or. Ugur Ortabasi, Consultant

Dr. Ortabagi did undergraduate and graduate studies

in Physics at the Universities of Gottingen and

Hamburg, Germany. He received his Ph.0. from the

University of Florida in the area of Nuclear Physics.

His work in the solar field dates to 1973 when he

became Senior Physicist at Corning Glass Morks and

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served as Technical Leader of the Solar Energy Prosran
there. His work has included the theory, design and
experimental testing of evacuated collectors and he is
recognized internationally as an expert in this field.
Presently, he is a Senior Visiting Research Scientist
and Head of the Solar Technology Division at CER.

Dr Kenneth G. Soderstrom, Consultant

Or. Soderstrom received BSME, MSE and Ph.D. degrees from the University of Florida. He has been a menber of the Mechanical Engineering Faculty of the University of Puerto Rico since 1961. During the last five years, Or, Soderstrom has been engaged in research in the measurement of solar insolation, in the computer simulation of solar thermal systems and in the testing of solar collectors. He has also served as a consultant to government and private industries in energy related problens. Presently, he is Associate Director of CEER's Mayaguez site and has an appointment as Senior Scientist and Project Director in Solar Technology.

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V. SCHEDULE

Nonths after adjudication date

activity ji] 2}3f4]s]e6l7{a]o] io] a | i

Order Materials

Receive Materials

Construction

Testing Te

Report

S = Starting date of activity

E « Ending date of activity

* = Continuation of activity

- = 15 days noncritical path

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Solar Division, CEER

BUDGET

. Total Funding Requested $41868.00

1, Salaries & wages firs/week Total weeks $/hr, ?Total.

Dr. A. Lépez = Project Manager 8 4a $11.00 $ 4226.00

L. Ozakgay - Grad, Student 35 48 3.93 6600.00

Technician 20 2 5.20 2496.00

Dr. U. Ortabagi, - Consultant 1 48 22.00 1056.00

Dr. K. Soderstrom - Consultant 1 48 22.00 1056.00

$15432.00

2. Marginal Benefits 908.41

3. Equipment 4217.00

Materials

5. Rent

6. Supplies

7. Trips

8. Subcontractors

9. Other direct costs ($00 hours of shop charges at $12/hr.) 4800.00

. Total direct costs 63313.41

| 10, Indirect costs 5463.59

Total cost of project 6877.00

, CEER/UPR Contribution to the project 26889.00

Funding requested from DOE 441888.00

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Solar Division, CEER

MARGINAL BENEFITS

(Budget Item # 2)

Benefit Amount

Social Security (FICA) $411.93

Retirement 295.68

Workmen's Compensation 100.80

Medical Insurance 96.00

Total $904.41

Note: These were calculated following the usual CEER formulas.

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