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DOE/SF/16306--28
DE91 005778

JAN 11 1991

COLORADO STATE UNIVERSITY PROGRAM FOR DEVELOPING, TESTING, EVALUATING AND OPTIMIZING SOLAR HEATING AND COOLING SYSTEMS

PROJECT STATUS REPORT FOR THE MONTHS OF NOVEMBER AND DECEMBER 1990

Prepared for the

U.S. Department of Energy
Conservation and Solar Applications
Under Grant DE-FG03-86-SF16306

Submitted by

Solar Energy Applications Laboratory
Colorado State University

January 7, 1991

MASTER

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January 7, 1991

Report No: SF-16306-28

Report Period: 1 November 1990 to 31 December 1990

PROJECT TITLE:

Developing, Testing, Evaluating and Optimizing Solar Heating and Cooling Systems

GRANT NUMBER: DE-FG03-86-SF16306

GRANTEE NAME: Solar Energy Applications Laboratory
Colorado State University
Fort Collins, Colorado 80523

GRANT PERIOD: 1 June 1986 to 30 November 1990
(Pre-award Costs authorized 1 December 1990 through 28 February, 1991)

GENERAL STATUS:

1. Project Objective:

The objective is to develop and test various integrated solar heating, cooling and domestic hot water systems, and to evaluate their performance.

2. Technical Approach:

Systems composed of new, as well as previously tested, components are carefully integrated so that effects of new components on system performance can be clearly delineated. The eight-month program for 1990 is separated into seven tasks. There are tasks for each of the three solar houses, a project to build and test several generic solar water heaters, a project that will evaluate advanced solar domestic hot water components and concepts and integrate them into solar domestic hot water systems, a management task, and a task funding travel to attend the "Field Monitoring for a Purpose" workshop which was held April 2-5, 1990, in Gothenburg, Sweden. The objectives and progress in each task are described in this report.

3. Project Tasks:

TASK 1a. SOLAR HEATING WITH ISOTHERMAL COLLECTOR OPERATION AND ADVANCED CONTROL STRATEGY

Status: The following specific tasks have been accomplished during the November-December, 1990 time period:

- Initial operation of isothermal collector control using the new Hewlett-Packard System 10 PC.
- Installation of siphon return pipe from collectors.

TASK 1b. SOLAR COOLING WITH SOLID DESICCANT

Status: Experimental work was not carried out on solar cooling during this period. Some consideration of the conditions for 1991 cooling tests and measurement improvements on air flow and dew point temperatures were addressed.

TASK 2. LIQUID DESICCANT COOLING SYSTEM DEVELOPMENT

Status: The graphs of condensation rate versus solution flow rate given in earlier reports have consistently shown a linear behavior with slope of 0.82, indicating that the liquid flow regime for mass transfer in the dehumidifier is turbulent. The plot of $1/(\text{condensation rate})$ versus $1/(\text{solution flow rate})^{0.82}$ is also a straight line with intercept 0.049. The small magnitude of the intercept suggests that the gas phase mass transfer resistance is negligible.

To calculate Sherwood number and Reynolds number it is essential to obtain the diffusivity of water in a LiBr solution and the equivalent diameter of the packing material. Experiments will be conducted to obtain the diffusivity data in the future. The equivalent diameter of a piece of the packing material will be determined by measuring its terminal velocity in a vertical cylinder filled with water.

TASK 3. SOLAR HOUSE III - DEVELOPMENT AND IMPROVEMENT OF SOLAR HEATING SYSTEMS EMPLOYING BOILING LIQUID COLLECTORS

Status: An analysis based on the second law of thermodynamics is progressing. Preliminary analysis suggests that it is possible to neglect the entropy produced by viscous dissipation relative to the entropy produced by heat transfer across a temperature difference. However, this assumption has been validated only for the condenser and is yet to be validated in general. Models for entropy generated in the conversion of solar radiation to thermal energy and for the entropy produced in the condenser have been developed, but suitable models for the entropy generated in the collector and by losses to the ambient are yet to be developed. The structure of an exergy cascade analysis has been developed and is to be coupled with the existing first law analysis to calculate entropy generated in the entire heat collection process.

TASK 4. GENERIC SOLAR DOMESTIC WATER HEATING SYSTEMS

Status: Analyses of the 16 experimental SRCC trials of the generic drain-back system were presented at the DOE Heating Program Review held at the Solar Energy Research Institute December 10-11, 1990. At that meeting, it was learned that the University of Wisconsin had corrected some mistakes in the TRNSYS runs for the drain-back system. As a result, it is necessary to re-do comparative analysis between experiment and simulation. This process has begun and the final report summarizing all test

data and the comparisons with TRNSYS simulation results will be resubmitted to DOE and SRCC by March 10, 1991.

Experimental evaluation of the anti-freeze system with two heat exchangers is in progress.

TASK 5. ADVANCED RESIDENTIAL SOLAR DOMESTIC HOT WATER (DHW)
SYSTEMS

Status: Project summaries and a detailed project work plan were submitted to the International Energy Agency Solar Heating and Cooling Program Task on Advanced Active Solar Energy Systems. This project is the United States DWH installation in this IEA task. The status and future plans for this project were presented at the DOE Heating Program Review in December. Preparations are currently being made to attend the IEA task meeting in January.

TASK 6. MANAGEMENT AND COORDINATION OF COLORADO STATE/DOE
PROGRAM

Status: Director Doug Hittle and SEAL researchers George Löf, Charles Smith, Jane Davidson and Bill Duff participated in the DOE heating review at the Solar Energy Research Institute on December 10 and 11. Doug Hittle, George Löf, Chuck Smith and Terry Lenz also participated in the DOE cooling review at SERI on December 11 and 12.

TASK 7. FIELD MONITORING WORKSHOP

Status: This task has been completed. Possibilities for further work as a result of the workshop are currently being pursued.

TASK 1A. SOLAR HEATING WITH ISOTHERMAL COLLECTOR OPERATION AND ADVANCED CONTROL STRATEGY

Research Team: Charles C. Smith, Task Leader
George Löf, Senior Advisor
Ihsan Abbud, Graduate Research Assistant

Objectives

The primary objective of the solar heating project in Colorado State University Solar House I during the past four years has been to increase operating efficiency of the system using the same solar hardware but with improved control strategy. A companion objective is to improve the comfort and air quality levels of the heated space. Also the project has succeeded in greatly reducing the parasitic electrical power requirements to operate the solar equipment.

During 1985-1988, a series of control system changes increased system efficiencies from 35.7 to 45.1 percent. This was realized at almost no added system cost. The 1989-90 project results are expected to show further improvement in efficiency and comfort.

The existing system operates with two solar energy storage tanks. A low temperature tank receives water flowing from the house heating load circuit and supplies water to the collector circuit. A high temperature tank receives the flow out of the collectors and supplies the heating load. A key element in the current system is a variable speed collector pump. This pump is controlled to maintain a nearly constant collector output temperature. Thus the hot storage tank is maintained at nearly constant temperature.

The principal objective of the 1990 solar heating development under Task 1a is control improvement, cost reduction, and size reduction of a low flow isothermal system.

Work Plan:

1. Investigate alternative low cost control methods and hardware for isothermal collector operation.
2. Design low cost, compact, highly stratified liquid storage.
3. Investigate load loop flow settings/control with respect to isothermal operation.
4. Select and prepare a plan to install new flat plate collectors in 1991.

Progress:

The following specific tasks have been accomplished during the November-December, 1990 time period:

- Initial operation of isothermal collector control using the new Hewlett-Packard System 10 PC.
- Installation of siphon return pipe from collectors.

Software development was completed in November to operate isothermal collector control from the new Hewlett-Packard computer system. The program was developed in the Lab Tech Notebook software package already installed by Hewlett-Packard on the new equipment.

The current setup employs eight hardware channels and 36 software channels. Software channels are menu setups which receive inputs, perform calculations, or send outputs. Fewer software channels can be used by running a background Quick Basic program (also provided on the system) for calculations.

Flow must be initiated in the collector based upon a tube wall temperature on the outlet header of the collector because initially there is no water in the drain-back collector circuit. Following a two-minute constant flow period (the approximate collector loop fill time), control is switched so the collector output water temperature is the input variable.

Figure 1 presents the results of the present control operation on day that was mostly clear. Control action consists of pump speed adjustment time periods proportional to the output temperature deviation from a set point. For example, an output temperature of two degrees above the set point would call for a signal to slowly increase the pump speed for five seconds. An output temperature of four degrees above the set point would call for a signal to increase the pump speed for ten seconds, etc.

It can be seen from Figure 1 that control of the output collector temperature is very good for a range of solar and ambient temperature conditions. At other conditions or under highly transient conditions, there is less satisfactory control. Continued development will include a look at integral and other control modes which offer the potential of improved control response.

The collector loop return pipe, from the collector outlet to the storage tank, was changed from one-inch to one-half-inch diameter. This was done to establish a siphon condition which lowers the pumping power and improves variable flow operation. The siphon condition results in a doubling of the flow rate at a given pump speed. Two solenoid valves are used to assure complete drainback of the collector loop when not in operation. Under warmer weather conditions it will be determined if these valves are necessary.

ISOTHERMAL TEST UNDER NEW (HP) COMPUTER CONTROL

December 3, 1990
(Output Temperature Setpoint- 60 Deg. C)

Figure 1.

TASK 1B. SOLAR COOLING WITH SOLID DESICCANT

Research Team: Charles C. Smith, Task Leader
George Löf, Senior Advisor
Ihsan Abbud, Graduate Research Assistant

Objectives

Desiccant cooling system research began with the ASK Energymaster unit in the summer of 1987. This first system employed a process known as the Pennington cycle. All of the conditioned air for cooling was taken from the outside. It was dried, cooled, and then rehumidified. This cycle exhibited the expected cooling capacity of the unit (3 tons); however the COP was only 1.0. Next, the SENC cycle was introduced which provides sensible cooling in the recirculated house air duct, and in principle will yield a higher COP. The COP did increase to approximately 1.5; however the capacity dropped substantially to the range of 1.0 to 1.5 tons.

The 1988 testing period was aimed primarily at increasing the capacity of the SENC cycle. The cooling tower was identified as improperly designed for the application. This unit provided too little residence time for the cooling water and wasted much of the drying effect provided by the ASK. The cooling tower was rebuilt with new packing, improved water distribution, and provisions for greater air and water flow adjustments. During the subsequent testing program it was found that the system capacity had not increased, so the duct cooling coil size was increased. Although these changes resulted in some modest improvement in the cooling capacity, the desired 3-ton target was not reached.

Testing of desiccant cooling was not conducted during the 1989-90 program, however important information was generated in an analysis based upon the testing in previous years. The ASK unit is oversized in comparison with the collector capacity and the cooling heat transfer capacity (the cooling tower-duct cooling coil combination). Since the company does not produce a smaller sized unit, it has been necessary to operate the existing unit at significantly reduced air flow. This degrades the overall performance.

The collector size has been increased from 12.5 to 20 square meters since last operating the SENC system in 1988. The cooling heat transfer capacity can be increased. This will allow for testing of a SENC cycle with better matched components.

The analysis also suggests that the SENS cycle (second stage cooling of the supply air out of the ASK unit using cooling tower discharge air - should be considered.

The primary objective of the 1990 solar desiccant cooling project is to determine the changes necessary to yield higher system performance; the goal is a cooling output approaching 3 tons and a COP of 1.5.

Work Plan:

1. The results of the 1988 tests will be analyzed in detail, and the significant findings will be reviewed with industry (ASK) engineers.
2. Based on analysis of the results and on information from industry specialists, design and specify changes in the system which will lead to increased capacity.
3. Short term testing of existing components will be carried out late in the 1990 cooling season.

Progress:

Experimental work was not carried out on solar cooling during this period. Some consideration of the conditions for 1991 cooling tests and measurement improvements on air flow and dew point temperatures were addressed.

TASK 2. LIQUID DESICCANT COOLING SYSTEM DEVELOPMENT

Research Team: Terry G. Lenz, Task Leader
Shailesh Potnis, Ph.D. Graduate Student

Objectives:

The following objectives have been met on this open-cycle liquid desiccant research:

1. Quantified the separate contributions of the spray sections and packed sections to overall mass transfer for both the regenerator and dehumidifier. This is the first time separate contributions to mass transfer for spray and packing have been determined for such composite spray/packed liquid desiccant contact units.
2. Determined that both the liquid and gas-side resistance to mass transfer are important in the regenerator.
3. Carried out a partial factorial statistical experimental study of the packed bed dehumidifier yielding the relative importance of key operating parameters on unit performance.
4. Completed converting piping, measuring, and pumping components to plastic construction. We now have a system in which nearly all components are constructed of low-cost plastic materials compatible with handling corrosive brines.

Although we have a good deal of operating experience with our open-cycle liquid desiccant dehumidification system, additional effort is needed to assemble and operate a complete, optimum system. Specific studies we feel are important toward achieving proper understanding for an optimally designed liquid desiccant cooling system are included in the Work Plan below.

Work Plan:

1. Assess the performance of alternate packing materials, such as Munters packing, in pursuit of improved mass transfer for both the regenerator and dehumidifier, at minimum pressure drop.
2. Add piping and instrumentation to permit long steady-state study for coupled regenerator-dehumidifier operation.
3. Discussions with Kathabar Company have indicated that the regenerator may perform better in a cocurrent rather than countercurrent mode for a hot-air energy source. No one has made such a comparison of these alternate operating modes, and our system should permit this study with minor modifications.

Progress:

The graphs of condensation rate versus solution flow rate given in earlier reports have consistently shown a linear behavior with slope of 0.82, indicating that the liquid flow regime for mass transfer in the dehumidifier is turbulent. The overall mass transfer coefficient and the individual phase mass transfer coefficients can be related by the equation,

$$\frac{1}{K_o} = \frac{1}{k_l} + \frac{1}{k_g} \quad (1)$$

where K_o = overall mass transfer coefficient
 k_l = liquid phase mass transfer coefficient
 k_g = gas phase mass transfer coefficient.

For the small change of concentration and temperature over the dehumidifier,

$$K_o \propto Sh \text{ and } Sh \propto \text{condensation rate} \quad (2)$$

$$k_l \propto Re^{0.82} \text{ and } Re \propto \text{solution flow rate} \quad (3)$$

Thus, a plot of $\frac{1}{(\text{condensation rate})}$ versus $\frac{1}{(\text{solution flow rate})^{0.82}}$

should be a straight line for a constant air flow rate. Figure 3 shows this graph with the intercept 0.049. The small magnitude of the intercept suggests that the gas phase mass transfer resistance is negligible.

To calculate Sherwood number and Reynolds number it is essential to obtain the diffusivity of water in a LiBr solution and the equivalent diameter of the packing material. Experiments will be conducted to obtain the diffusivity data in the future.

The equivalent diameter of a piece of the packing material will be determined by measuring its terminal velocity. The experiments will be conducted in a vertical cylinder filled with water. The diameter of the cylinder will be at least 20 times the particle diameter (= 1 inch) to avoid the wall effects. The terminal velocity can be obtained from the following equations:

$$C_D = 24 \times \frac{\mu}{D_e u_t \rho} \quad (4)$$

$$u_t = \sqrt{\frac{2g(\rho_p - \rho)m}{A_p \rho_p C_D \rho}} \quad (5)$$

where

C_D = drag coefficient

μ = viscosity of water

D_e = equivalent diameter

u_t = terminal velocity

ρ = density of water

ρ_p = density of the packing material

m = mass of the packing material

$$A_p = \pi D_e^2$$

Thus D_e can be obtained from equations 4 and 5.

The draft annual report for 1989-90 has also been completed during this period.

Figure 2

Figure 3

$$1/K_o = 1/k(l) + 1/k(g)$$

$$K(l) \longleftrightarrow u(l) \triangle 0.82$$

TASK 3. SOLAR HOUSE III - DEVELOPMENT AND IMPROVEMENT OF SOLAR HEATING SYSTEMS EMPLOYING BOILING LIQUID COLLECTORS

Research Team: Jane H. Davidson, Task Leader
Howard A. Walker, Graduate Research Assistant
Eugenia Vieira, Graduate Research Assistant

Objectives

Optimize the design and operation of boiling collector hot water/space heating systems to substantially increase system efficiency and reliability and eliminate reliance on environmentally unsafe refrigerants. Characterize the performance of flat-plate solar collectors during two-phase operation with R-123.

Work Plan

1. Build and instrument an optimized self-pumping system in Solar House III.
2. Initiate experimental study of the operation of the optimized system with alternative refrigerant R-123.
2. Assess the performance characteristics of two-phase collectors with R-123 using a separate test loop and analytical modeling.
3. Compare the self-pumping system to conventional domestic hot water systems on the basis of performance and economics.
4. Provide bimonthly progress reports. A final report will be submitted in March during the next grant period.

Progress:

An analysis based on the second law of thermodynamics is progressing. Preliminary analysis suggests that it is possible to neglect the entropy produced by viscous dissipation relative to the entropy produced by heat transfer across a temperature difference. However, this assumption has been validated only for the condenser and is yet to be validated in general. Models for entropy generated in the conversion of solar radiation to thermal energy and for the entropy produced in the condenser have been developed, but suitable models for the entropy generated in the collector and by losses to the ambient are yet to be developed. The structure of an exergy cascade analysis has been developed and is to be coupled with the existing first law analysis to calculate entropy generated in the entire heat collection process.

Construction of the experimental facility is ongoing. All components have been collected except for the finned tube for the in-tank heat exchanger, which has been ordered.

Further analysis with the Fort Collins yearly simulation is being conducted to provide a more detailed description of the behavior of the system under varying parameters. The results are to be presented in a forthcoming paper.

TASK 4. GENERIC SOLAR DOMESTIC WATER HEATING SYSTEMS

Research Team: William S. Duff, Task Leader
Jane Davidson, Task Leader
William Carlson, Graduate Research Assistant
Graduate Research Assistant

Objectives

1. Cooperatively establish a methodology by which manufacturers and installers of solar domestic hot water (SDHW) systems can obtain an SRCC rating, without retesting, when a component in the originally tested system is changed.
2. Provide detailed system and component data that will enable the research team at the University of Wisconsin to confidently apply numerical simulation models to various SDHW component assemblies.
3. Based on successful outcome of rating methodology for SDHW systems, develop rating methodology for rating generic solar space heating systems.

Work Plan

1. Complete the planned testing of the drain-back generic system. Testing of the recirculation and anti-freeze systems will be completed under a subsequent grant.
2. Provide data to the University of Wisconsin to assist in the development of numerical simulation models of the drain-back system. The numerical models will be used by University of Wisconsin to provide ratings for the DHW systems with fixed components and in fixed locations.
3. Provide an interim report to DOE which includes results and analysis of the drain-back system.

Progress:

Analyses of the 16 experimental SRCC trials of the generic drain-back system were presented at the DOE Heating Program Review held at the Solar Energy Research Institute December 10-11, 1990. At that meeting, it was learned that the University of Wisconsin had corrected some mistakes in the TRNSYS runs for the drain-back system. As a result, it is necessary to re-do comparative analysis between experiment and simulation. This process has begun and the final report summarizing all test data and the comparisons with TRNSYS simulation results will be resubmitted to DOE and SRCC by March 10, 1991.

Experimental evaluation of the anti-freeze system with two heat exchangers is in progress.

TASK 5. ADVANCED RESIDENTIAL SOLAR DOMESTIC HOT WATER (DHW) SYSTEMS

Research Team: William S. Duff, Task Leader
Jane Davidson, Associate Task Leader
Graduate Research Assistant

Objectives:

- 1) Compile and evaluate promising advanced solar domestic hot water components and concepts.
- 2) Integrate promising advanced components and concepts into conceptual solar domestic hot water systems.
- 3) Analyze the most promising systems in terms of thermal performance, cost effectiveness, and reliability.
- 4) Based on these analyses, design advanced solar domestic hot water system prototypes which can be manufactured commercially.
- 5) Analyze and experimentally evaluate these prototypes to establish their performance, cost, reliability, and maintainability advantages.
- 6) Set up a procedure whereby the United States solar industry will receive timely information regarding new solar domestic hot water components and concepts.

Work Plan:

- 1) Evaluate and select the most promising advanced solar domestic hot water components and concepts. Advanced components and concepts will be those developed by the investigators, contributed by United States industry, proposed in advanced systems research initiatives, and adapted from ideas of others in the United States, Europe, Japan, and elsewhere.
- 2) Perform preliminary analyses to determine the best ways to integrate the selected components and concepts into solar domestic hot water systems so as to best balance the goals of low initial cost, high performance, high reliability, low maintenance, and low operating cost.
- 3) Based on these analyses, design advanced solar domestic hot water systems that best meet the goals. The design process will also address component sizing, freeze protection, overheating prevention, material selection, good practice in overall system integration, and consumer acceptance.
- 4) Build and experimentally evaluate promising systems.
- 5) Using the generic DHW system project's data acquisition and automated testing hardware and software as the nucleus, establish a solar

domestic hot water system testing facility at the Solar Energy Applications Laboratory.

- 6) Establish a testing methodology of several weeks' duration which would provide estimates of seasonal performance that are within ± 1 percent of predictions from complete annual simulations.
- 7) Establish a procedure for timely dissemination to United States manufacturers of this information and other information on worldwide advances in solar domestic hot water systems, especially from Europe and Japan.
- 8) Participate as a United States installation in the International Energy Agency Solar Heating and Cooling Program's Task XIV -- Advanced Active Solar Energy Systems.

This project is a multi-year effort, with the selection, system design, and testing process being repeated several times and with parts of the process occurring in parallel. Conceptual evaluation, selection and design of advanced components, concepts, and systems will be performed in cooperation with SERI.

In this contract, only the organizational aspects of items 1, 2 and 3 and items 7 and 8 of the above project approach would be included. The remaining efforts would be included in subsequent contracts.

Progress:

This project was begun in the 1990 contract period at an initially low level of funding. It is DOE's expectation that funding will increase for the next Colorado State University contract beginning December 1, 1990. We are operating under pre-award funding for December, January, and February which is providing about one-third the professional staffing required as specified in the new contract proposal. It is expected that the new contract will be in place by the end of January. Consequently, effort has remained at a low level.

Project summaries and a detailed project work plan were submitted to the International Energy Agency Solar Heating and Cooling Program Task on Advanced Active Solar Energy Systems. This project is the United States DWH installation in this IEA task. The status and future plans for this project were presented at the DOE Heating Program Review in December. Preparations are currently being made to attend the IEA task meeting in January.

TASK 6. MANAGEMENT AND COORDINATION OF COLORADO STATE/DOE PROGRAM

Research Team:

Douglas C. Hittle, Director
George Löf, Senior Advisor
Janice Stapleman, Administrative Assistant

Objective

Coordinate SEAL-DOE task efforts, provide assistance to DOE, and attend programmatic meetings as requested by DOE.

Work Plan

1. Collaborate with leaders of the five technical tasks in coordination of SEAL program.
2. Organize team and sub-team planning sessions necessary for the conduct of the tasks.
3. Provide and manage necessary facilities and services to leaders and personnel involved in each task.
4. Provide timely bimonthly reports on all tasks as required by contract.
5. Maintain fiscal control of program.
6. Attend meetings and technical reporting sessions as requested by DOE.
7. Respond to DOE requests for information on solar equipment and its operation, for review of reports, and for panel and committee participation.
8. Provide technical consultation from director and senior advisor to task leaders and research personnel.
9. Participate in IEA Solar Heating Advisory Group Meeting in Stuttgart, Germany.

Progress:

Director Doug Hittle and SEAL researchers George Löf, Charles Smith, Jane Davidson and Bill Duff participated in the DOE heating review at the Solar Energy Research Institute on December 10 and 11. Doug Hittle, George Löf, Chuck Smith and Terry Lenz also participated in the DOE cooling review at SERI on December 11 and 12.

Negotiations continued on the renewal of the SEAL-DOE research grant which expired November 30. On November 19, a request for pre-award funding was sent to Bob Hassett at DOE-HQ and Mike Lopez at DOE-SAN. On December 3, the Office of Sponsored Programs at Colorado State received an advance agreement for pre-award costs from DOE for the SEAL program, but this contract contained several errors. An amended agreement for \$94,900 was received at Sponsored Programs on December 27 and has been signed and returned. On December 21, based on discussions at the heating and cooling

reviews, a revised, three-year pre-proposal was sent by FAX to Bob Hassett and John Ryan at DOE-HQ. (These negotiations and submissions were carried out at no cost to DOE and are mentioned here only as a record of current grant status.)

Coordination of research activities continued on the six research tasks under the DOE grant, accounts were maintained and updated, and progress reports were submitted as required.

TASK 7. FIELD MONITORING WORKSHOP

Research Team: Dr. William S. Duff

Objective and Work Plan:

Professor Duff was nominated by the International Energy Agency Solar Heating and Cooling Program and the United States Department of Energy to attend the "Field Monitoring for a Purpose" workshop which was held April 2-5, 1990, in Gothenburg, Sweden. The workshop was sponsored by three International Energy Agency organizations: (1) the Solar Heating and Cooling Program, (2) the Program for Energy Conservation in Buildings, and (3) the Center for the Analysis and Dissemination of Demonstrated Energy Technologies. A paper was to be presented in the workshop.

Progress:

This task has been completed. Possibilities for further work as a result of the workshop are currently being pursued.

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