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PROJECT STATUS REPORT
ON
FIELD RESEARCH TASKS AND TECHNICAL SERVICES
Period March 1, 1983 through May 31, 1983

ENERGY SYSTEMS GROUP
ESG, INC.
ATLANTA, GEORGIA

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CHICAGO OPERATIONS OFFICE
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MASTER

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ABSTRACT

This status report covers progress by ESG, Inc. under Contract DE-AC02-82CH10122 during the period March 1, 1983 through May 31, 1983. The work is divided into two areas as follows:

1. Field Measurement, Analyses, and Reporting Related to Building Energy Systems and Biomass Projects.

The key effort is on the Class B performance monitoring program, including a limited amount of special data evaluation and analysis. Other work relates to design tools, passive selection criteria, hot water performance documentation, and other renewable systems.

2. Technical Services in Support of Appropriate Technology Program.

A total of 84 project files have been reviewed and summarized, telephone contacts and selected site visits are being made on a small number of active projects, and technical information dissemination tasks are underway. A summary paper on project activities was prepared and approved for publication.

1.0 INTRODUCTION

This status report covers work being undertaken on certain tasks which were initiated at the Southern Solar Energy Center, and also includes technical services in support of the Appropriate Technology Small Grants Program at the DOE Chicago Operations Office. The effort is under contract DE-AC02-82CH10122 and covers the reporting period from March 1, 1983 through June 30, 1983.

In general, sound progress continues to be made. As noted in the following section, DOE has agreed in principal to the continuation of the Class B sites through the summer period. This agreement has provided new direction to that part of the program.

It should be noted that the format of this status report follows the format of the contract work statement. Also, Appendix A provides a cumulative listing of reports or other publications issued during this and the previous reporting period.

2.0 TASK STATUS

A. FIELD ACTIVITIES IN BUILDING ENERGY SYSTEMS AND BIOMASS.

1. Residential Building Energy Systems

The work being conducted under this task was initiated by SSEC and is being completed in order to make critical data available to industry and the research community. This task includes work in the refinement of design methods for accommodating cooling loads; analysis of data on passive residences and related support of the passive monitoring program; an investigation of integrated PV-thermal storage concepts; and work on improved passive system selection criteria. A summary of activities during the reporting period follows.

Design Tool Development - In the last quarterly report, ESG noted the results of their reexamination of their earlier work on cooling load impacts of passive solar heating systems, specifically mass walls. In brief, it was reported that comparisons with numeric solutions of the governing equation indicated significant error potential in the earlier approach. However, this observation was countered by some preliminary results which indicated that a correction factor could be generated which would bring the agreement to within + 5% of the exact solution for 27 years of TMY data. Since continuation of this work would entail efforts deemed outside the original intent of this task, ESG has not proceeded with this activity. ESG feels that this problem (over heating of passive systems in the summer) is a critical one in all southern locations. There is no accepted way of treating the analysis accurately in the design phase. ESG is prepared to propose the effort required to develop an accurate and useable design tool and strongly recommends that DOE consider such an objective in their R&D planning efforts.

The SLR-Plus Version 1.0 User's Manual was submitted to DOE during the previous reporting period. The related Reference Manual received little effort during this period due to the pressure of other activities--but will receive its final review and submission to DOE. Copies of the reports were sent to LBL (Ron Kammerud) for comment.

Performance Monitoring - The principal effort expended during this reporting period was on support of the Class B passive solar monitoring program. Figure 1 extends the graphic description of the program activities for the present reporting period.

ESG and DOE are presently discussing the options for extending at least some of the current sites through the summer season. In anticipation of coming to a satisfactory agreement, ESG has extended all homeowner agreements through September 30. Also, all sites have had the summer algorithms installed in their PDLs and all sites are operational at the present time.

The significant activities and accomplishments are the following:

- o All the sites except SA and SB were visited during May. The following list summarizes the status of each site:
 - Site A System operating fine. Have only received data to end of 4/83.
 - Site B System operating fine. Homeowner on vacation. System down one week.
 - Site F System working fine.
 - Site G System working fine.
 - Site J Replaced PDL. System working fine.
 - Site K System working fine.
 - Site L System working fine.
 - Site N Electrical storm took out sensor terminal at end of 4/83. System repaired and working fine.

The attached figure (Figure 2) provides an overview of the one time measurements and standard ASHRAE calculations. The vertical axis locates the value of the total heat loss coefficient as measured by the one time test. For the three sites where it was possible to measure the effective crack area with the blower door test, a "measured" infiltration loss could be subtracted from the total coefficient to arrive at a "measured" UA value. As can be seen on the figure for sites K, L, and N the comparison of UA values so derived with ASRHAE procedure estimates compares within 15%.

For the remaining houses the story is quite different. The blower door was unable to pressurize these much larger homes. Thus we can only compare the measured total load coefficient with the calculated UA. As the figure clearly shows for sites B, J, and A the measured total loss coefficient indicates a UA value of 1/2 the calculated values even if there were no infiltration losses during the coheating test. Since there are many factors which can affect either the values measured in the

CLASS B STATUS

SITE	J/82	A/82	S/82	O/82	N/82	D/82	J/83	F/83	M/83	A/83	M/83	J/83
A												
B												
F												
G												
J												
K												
L												
N												

- V Anemometer Instl.
- INIT2 Software
- Software Updates
- Coheating Tests
- ⊕ Blower Door
- ₁ Bag #1
- ₂ Bag #2
- Summer '83 Software

FIGURE 1 - UPDATE STATUS CHART

FIGURE 2 - COMPARISON OF MEASURED AND CALCULATED
TOTAL HEAT LOSS AND UA VALUES

coheating test or the calculation of the UA values it is not yet possible to say what these large differences means. That they exist at even this somewhat preliminary level has however significant implications in the interpretation of the passive performance of the buildings. It is in recognition of this fact that ESG has been looking at the test results themselves, using regression techniques, to determine if the data sets are reliable. One result of these efforts is described below and in Appendix A.

In this period work continued on testing the data for consistency. With the aid of Mr. Swisher of SERI, ESG was able to read the hourly data for one site, SN, into its computer. Preliminary multivariate regressions with this data have shown that the night time hourly data can be used to derive a house loss coefficient which compares with the one time test value. If other tests duplicate this result, it may be possible to eliminate the one time coheating test as part of the Class B procedure--see Appendix for a description of the results.

Toward the end of this period Mr. Swisher read the hourly data for two more houses onto the 9-track tape format and ESG is proceeding to perform regressions on this data to make the comparisons with the one time measurements.

Work continued and is essentially completed on preparation of the updated winter site handbook which will include complete descriptions of all sites in their current year test configuration. This book will be delivered to SERI in June.

Passive Solar Selection Criteria - This document--described briefly in last quarter's report has received very little attention during this period due to the pressures of Class B and other related programs. ESG management is presently reexamining the status of this document and will prepare a program plan which will maximize the benefits and minimize the costs to DOE. As noted in the last quarter write-up, the material exists in three separate reports--the critical issue is how much integration is necessary to provide a document of immediate use to the building industry.

2. Domestic Solar Hot Water Performance Monitoring

This tasks continues the work begun by SSEC in the Domestic Solar Hot Water Program. The work in this quarter has been devoted to continuing the data gathering process through the end of March 1983. The data have been entered into the ESG analysis program and the performance reports have been prepared for sending to the participants. The outline of the final performance analysis report has also been prepared and about fifty percent of the data for that report has been developed.

During this period ESG submitted a proposal to DOE to prepare a summary review of all the available large scale solar domestic hot water field test data--principally the data reported in the July 1982 conference and the ESG data. The proposal was given to SERI who asked that it be modified to include a task which would analyze the ESG data on the

reliability and maintainability of the system under test. ESG has done this and is currently delaying the shutdown of the field test program so that a final set of data inputs having particular reference to this new task can be obtained from the test population. The change was negotiated at a meeting in January at a time when the effort fit well within the intended shutdown sequence of the test program. The continued delay in getting the contract processed is causing some extra costs and some hazard that the test participants will not be as cooperative as they have been to date.

3. Industrial/Commercial Renewable Energy Systems

Under this task ESG will complete assessment of existing simulation models and their applicability to light commercial buildings. In addition, a design guide for commercial applications requiring moderate-temperature hot water systems will be developed based on earlier work at SSEC.

Thermal Mass Analysis - No work was expended on this task this quarter. The analytical work has been completed. It was decided to reevaluate the scope of this task in light of the requirements of the Class B program. A reevaluation and assessment will be made to define the form and content of the final report.

Design Guide - "A Guide for Commercial Water Heating Applications" will present technical guidance on reducing water heating costs for small to medium commercial operations. The "Guide" contains an assessment of three options: conservation measures; waste heat recovery; and solar energy systems. Emphasis is placed on solar energy systems including sizing, economics, installation, and performance monitoring. The material is directed toward the commercial owner or user and does not require familiarity with design of equipment. Two appendices are provided which outline solar components and systems and a solar installation checklist. The Guide has been reviewed by several industry specialists. As a result of these reviews and ESG review, extensive revisions have been made this quarter. The present plan is to complete the report in the coming quarter.

4. Industry Reviews and Technology Transfer

There have been no substantial efforts under this task during this quarter.

5. Biomass Field Projects

This task relates to technical activities originally conducted by SSEC in support of certain DOE biomass field projects. One of these projects was concerned with an ethanol plant at Agri-Fuels, Inc. in Tupelo, Mississippi. Another effort is related to a wood gasification system which was originally intended for use by the utility at Starke, Florida.

Due to personnel utilization on other programs, no activity was conducted on these programs in this quarter. Therefore their status remains as reported in the previous quarterly report.

B. TECHNICAL SERVICES RELATED TO THE APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM

This effort relates to supporting the conduct of the Midwest Appropriate Technology Small Grants Program as administered by the DOE Chicago Operations Office. This involves three tasks: (I) Management Analysis and Technical Evaluation of Completed Projects; (II) Monitoring and Technical Assistance for ongoing Projects; and (III) Technical Information Dissemination. An overview of project efforts follow:

Under Task I, all 84 of the completed project files received by ESG have been evaluated and summarized. A draft of the Management Analysis has been prepared and delivered to the DOE Program Manager, along with draft copies of all of the Project Summaries and Assessment Memorandums. Pending DOE approval of these documents, Task I is 100% complete.

Under Task II, telephone contact was initiated with grantees identified for monitoring in order to assess their progress and schedule site visits where appropriate. Two site visits were conducted during the reporting period; one in conjunction with DOE/Chicago and Washington Program Managers.

As a result of the site visits conducted, one grantee was found to be progressing while the other is encountering difficulty. DOE/Chicago was notified of the problem immediately. Neither grantee was in need of technical assistance from ESG.

Task II, the dissemination of information on Task I projects selected as having "significant technical value and promise for commercialization," is progressing. The progress achieved under Task I directly advances the status of this task, particularly the completion of the Project Summaries. In addition, a paper for the American Solar Energy Society's Annual Meeting and Technologies Conference was prepared and approved for publication by DOE. A poster session display was created for the presentation to take place June 1st and 3rd.

APPENDIX A
LISTING OF DOCUMENTS

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- Jones, William M., and Jacobs, Ronald A., Analysis of Field Test Data From Domestic Solar Water Heaters in the Southern United States - Period Through May 1982. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Lau, Andrew S., Hill, John M. and Ball, David E., Analysis of Selected Photovoltaic Systems and Storage Options for Residential Applications in Hot Humid Climates. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Final Report on SSEC Programs Conducted with State Agencies. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Summary of SSEC Technical Information Activities. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Project Status Report on Field Research Tasks and Technical Services - Period from June 1 through August 31, 1982. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Proceedings of Solar Hot Water Field Test Technical Review Meeting. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Hill, John M., SLR-Plus Version 1.0 Users Manual. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Project Status Report on Field Research Tasks and Technical Services - Period from September 1-November 30, 1982. Atlanta: Energy Systems Group, ESG, Inc. (1982).
- Analysis of Field Test Data from Domestic Solar Water Heaters in the Southern United States - Period through September 1982. Atlanta: Energy Systems Group, ESG, Inc. (1983).
- Project Status Report on Field Research Tasks and Technical Services - Period from December 1, 1982 through February 28, 1983. Atlanta: Energy Systems Group, ESG, Inc. (1983).
- Project Status Report on Field Research Tasks and Technical Services - Period from March 1, 1983 through May 31, 1983. Atlanta: Energy Systems Group, ESG, Inc. (1983).

APPENDIX B
ONE TIME LOSS COEFFICIENT

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ONE TIME LOSS COEFFICIENT

Initial comparisons of the measured thermal loss coefficient on a number of Class B sites with steady state UA values calculated using standard (ASHRAE) procedures indicated that the measured values were significantly lower than the calculated values. Although resulting analyses has narrowed the discrepancy between measured and calculated values for some sites, regression techniques were applied to data taken at one of the sites in hopes of determining the difference between measured and calculated values and selecting one of the two values as the Class B one time heat loss coefficient of greatest confidence. Site SN data was used in this preliminary study. This site has a relatively complete data set over two heating seasons (1981-82 and 1982-83), wind speed data for the 1982-83 heating season, and does not have a complex solar system or floor plan. Hourly data for this site obtained from SERI was transferred to the ESG in-house computer for analysis.

The method used to examine the data is to regress the heating load against environmental parameters. In particular, coefficients of the equation,

$$AUX = a_0 + a_1(X_1) + a_2(X_2) + \dots + a_n(X_n),$$

where AUX is the auxillary heating used, X_1 , X_2 , ..., X_n are the environmental parameters (solar radiation, wind speed, inside - outside temperature difference, etc.), and a_0 , a_1 , ..., a_n are the regression coefficients, are compared to physical parameters of the house. One expects that if the independent variable (one of the X 's) is the difference between the inside and outside temperature, then the corresponding regression coefficient would relate to the heat loss coefficient of the house. This regression analysis is applied to both hourly and daily average Class B data. The results shown here are from results obtained from looking at daily data. Hourly data provides similar results but contains additional information which clouds the desired relationships.

Initial analyses use daily total radiation on a vertical surface, daily average delta temperature (inside minus outside), and daily change in the house temperature as independent variable. These independent variables are regressed against the auxillary heating energy for monthly, seasonal, and multi-seasonal data groups. The analysis is repeated for the 1982-83 heating season data with an infiltration parameter included as an independent variable. This is not possible for 1981-82 data since wind speed data was not taken until the fall of 1982. The infiltration parameter used is based on the Sherman and Grimsrud model used in the Class B data reduction software. This variable is defined as:

$$X_i = \text{Delta Temp} [\text{Sqrt}(\text{WS} + 322.0(\text{Delta Temp}))],$$

where X_i is the infiltration parameter, Delta Temp is the daily average temperature difference between the inside and outside in degrees Farenheit, and WS is the square of the wind speed in miles per hour. Finally, the data

base is screened to include only data taken from midnight to 8 AM each day. For this data base, only delta temperature and infiltration are used as independent variables. It is worth noting that runs made using night time data which include solar radiation as an independent variable indicate that the heating load during this time period is independent of the previous day's sunshine (ie, solar radiation is a statistically insignificant independent variable in the correlation). Sample results from these runs are given in Table 1.

The values of the regressed delta temperature coefficient given in Table 1 all imply that the measured loss coefficient of 232 Btu/F-hr is more likely to overstate rather than understate the heat loss from the house. The coefficients found using night time heating requirements from the 1982-83 data give a heat loss coefficient within 2% of the co-heated value (when the coefficient based on delta temperature is adjusted for infiltration using blower door results and measured wind conditions). The measured loss coefficient is generally within one standard deviation of the regressed delta temperature coefficient obtained from monthly data groups.

Results using full 24 hour average data indicate a lower temperature dependency than either the measured value or coefficients obtained using only night time data. It is easy to suppose that lower temperature value of this coefficient results from using daily average daily temperature difference that includes overheating due to solar and internal gains. Using solar radiation as an independent variable results in higher temperature dependent coefficients while including windspeed reduces the coefficient. Unfortunately regression analysis only relates one variable to another and cannot totally separate solar and internal gains and temperature dependent infiltration from a conduction loss coefficient.

As a summary, preliminary regression analysis indicates that the measured loss coefficient from Class B site SN corresponds closely to values determined from two seasons of heating data. In fact, the Class B data can be used in lieu of co-heating results for this one site with no appreciable loss of accuracy.

DATA PERIOD	REGRESSED LOSS ¹ COEFFICIENT	INDEPENDENT ² VARIABLES	# OF DATA POINTS	R ² VALUE	T-TEST ³ OF LOSS COEFFICIENT
FULL 24 HOUR DATA					
Nov81-Mar82	200	Vert Rad., Delta Temp DT/Dtau	89	.783	16.4
Nov82-Mar83	207	Vert Rad., Delta Temp DT/Dtau	93	.845	20.4
Nov82-Mar83	193	Vert Rad., Delta Temp DT/Dtau, Infil.	93	.883	21.1
NIGHT TIME DATA ⁴					
Jan82	250	Delta Temp	17	.642	5.2
Feb82	183	Delta Temp	26	.481	4.7
Mar82	219	Delta Temp	30	.645	7.1
Dec82	213	Delta Temp	28	.729	8.4
Feb83	277	Delta Temp	27	.685	7.4
Mar83	212	Delta Temp	27	.532	5.3
Nov81-Mar82	209	Delta Temp	92	.604	11.7
Nov82-Mar83	242	Delta Temp	99	.720	15.8
Nov81-Mar83	227	Delta Temp	191	.667	19.4
Dec82	247	Delta Temp, Infil.	28	.755	7.7
Feb83	292	Delta Temp, Infil.	27	.820	10.0
Mar83	226	Delta Temp, Infil.	27	.749	7.5
Nov82-Dec83	228	Delta Temp, Infil.	100	.793	16.8

Notes:

¹Regressed Loss Coefficient in Btu/hr-°F²Independent VariablesVert Rad. is Vertical Solar Radiation on south surface (Btu/ft²-day)

Delta Temp is Inside Dry Bulb-Outside Dry Bulb (°F)

DT/Dtau is daily change in Inside Dry Bulb (°F/day)

Infil. is the Sherman-Grimsrud infiltration parameter

³T-Test is the ratio of the loss coefficient to the standard deviation of the loss coefficient⁴Data sets with less than 15 points not reported

TABLE 1. REGRESSED LOSS COEFFICIENTS