SOLAR HEATING AND COOLING
TECHNICAL DATA AND SYSTEMS ANALYSIS

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Johnson Environmental and Energy Center

The University Of Alabama In Huntsville

PROGRESS REPORT

MAY 1977

SOLAR HEATING AND COOLING
TECHNICAL DATA AND SYSTEMS ANALYSIS

PROGRESS REPORT

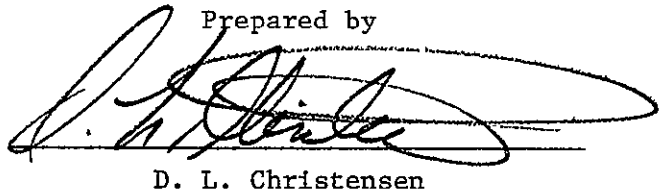
CONTRACT NAS8-31293

Submitted to

National Aeronautics & Space Administration
Marshall Space Flight Center, Alabama

(For the Period of Performance through April 30, 1977)

Prepared by



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ABSTRACT

The research activities described herein were accomplished by The University of Alabama in Huntsville (UAH) under Contract NAS8-31293 for the Marshall Space Flight Center (MSFC), National Space and Aeronautics Administration (NASA).

This summary of research activities covers an overall period of performance from October 1974 to April 30, 1977, for a total contractual amount of $393,545. It is supported by previous progress reports prepared by the UAH and delivered to MSFC and provides emphasis on contract activities since June 1976.

ACKNOWLEDGEMENTS

This report has been prepared by a solar energy research team of the Johnson Environmental and Energy Center (JEEC) at The University of Alabama in Huntsville. David L. Christensen, Research Associate, is the Principal Investigator of NASA Contract NAS8-31293, which funded the research described in this report. Other major contributors to the project and this report are:

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The University of Alabama in Huntsville gratefully acknowledges the direction, support, and cooperation of the NASA-MSFC Solar Heating and Cooling Task Team and other MSFC personnel who provided technical assistance. In particular, thanks must go to Mr. John Price, MSFC Contractor Representative and Manager of the Solar Heating and Cooling Task Team, and to Task CORs, Messrs. O. L. Smith, John Pavlick, Andrew G. Kromis, Robert Middleton, Mike Myers, and Hoyt Weathers for their support.

The research team also wishes to acknowledge the assistance and valuable contributions made by numerous other individuals of The University of Alabama in Huntsville and the NASA-MSFC, and to express thanks for the cooperation of various government agencies, industries, universities, technical societies, and other professional organizations. A special thanks is due the representatives of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. and the AIA Research Corporation for their thorough and timely performance of assigned subcontract tasks.

The support of the design and engineering team for the solar heating module development by Messrs. Otto Nussbaum, Arthur Gallagher, Thomas Spencer, L. Whinnery, Chuck Koptis, Don Bowden and their respective organizations and the cooperation of the Alabama Space and Rocket Center in the installation phase of the program are also greatly appreciated.

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I. INTRODUCTION AND BACKGROUND

The Johnson Environmental and Energy Center (JEEC) at The University of Alabama in Huntsville (UAH) has supported the NASA Marshall Space Flight Center (MSFC) in research activities for solar energy heating and cooling systems development since October 1974 under Contract NAS8-31293.

This research effort is directly related to implementing the National Solar Heating and Cooling Demonstration Act which is under the direction of the United States Energy Research and Development Administration (ERDA). Since its beginning in October of 1974, the contract, "Solar Heating and Cooling Technical Data and Systems Analysis", has developed into an extensive research and supporting activity. Basic UAH efforts in the national data survey and acquisition program for systems analysis have concentrated on the areas of economics, heating and cooling systems, architectural design, materials characteristics, climatic conditions, educational information packages, and evaluation of solar energy systems and components. The collection and processing of the data has been required to develop the computerized data base needed for the systems analysis support of the MSFC systems development role in the national solar energy demonstration program.

The MSFC data base has an extensive capability to be expanded to include data for any type of energy consideration and is intended to permit rapid retrieval of varied types of data in formats accessible by remote terminals through interactive operations. The comprehensive data base incorporates an abundance of statistical data on such diverse items as weather trends, population, equipment cost and performance data, facility description parameters, operational data from national solar heating and cooling demonstration sites, utility rates, construction and urbanization trends, and price indices.

Since its inception in October of 1974, the contract has gone through 14 separate amendments for a total value of $393,545. Four basic tasks were specified for performance by the UAH solar energy task team in the original contract:

1. Utilizing the data bank and in-depth knowledge gained in previous solar heating and cooling activities, accomplish professional research and supporting activities to develop and/or evaluate solar heating and cooling technical data.

2. Using the capabilities of the UAH/Solar and Wind Energy Programs, provide inputs into the MSFC program and project planning documents in selected areas of technical expertise. Accomplish and document systems analysis activities in support of above, as required.

3. Provide technical liaison and interface with organizations involved in solar heating and cooling, as required, and provide appropriate data to the COR.

4. Document overall technical data and provide trade/evaluation reports of technical data packages as required.

During the period of January 1, 1975 through February 28, 1975, the UAH continued work under Contract NAS8-31293 without a change in the original cost. This extension was designated Amendment 2, and was primarily to complete certain tasks then underway. Amendment 3 added another task to the initial statement of work. This task was to provide in-depth analysis and support in the areas of solar energy systems, collection and storage systems, energy transport concepts and data development.

The contract was extended through 30 April 1975 at an additional cost of $3000 with Amendment 4. This effort included specialized seminar and consulting services and activities. The UAH coordinated a series of meetings in Huntsville with national solar energy experts during the period from March 31 through April 4, 1975. In May of 1975, a new amendment (Amendment 5) was added at a contract value of $31,000. This task called for the UAH to gather significant data on climatic conditions, architectural designs and techniques, topographical information on selected construction sites, thermal properties of construction materials, heating and cooling systems costs, and economic data from nationwide locations.

This data was formatted for inclusion into the existing MSFC data bank designated as MIRADS which is the acronym for "Marshall Information Retrieval and Display Systems". Amendments 6, 7 and 8 were extensions and administrative adjustments that continued the effort through 31 December of 1975.

January 1976 brought an additional expansion to the scope of the contract. Another $22,692 was added to the existing national survey effort, which was designated Task I - Data Collection. Task II - Project Analysis and Evaluation, was added with a funding of $22,500. There were five original subtasks for Task II: Subtask 1 was to develop a slide package on overall energy conditions; Subtask 2 to catalog and file all available and meaningful slides on solar energy according to subject matter; Subtask 3 to develop slide-supported speech modules on the MSFC solar energy effort; Subtask 4, to survey and make recommendations for effective use of the MSFC Solar Energy Control Room; and Subtask 5, to establish and make recommendations for an MSFC Solar Energy Information Room.

In March of 1976, work was authorized to develop small, portable solar energy water heaters for demonstration purposes. Three models were eventually delivered. The third prototype model weighed a total of 8½ pounds including water, with outside case dimensions of 18" x 5" x 12". A wafer-thin collector of only 38 square inches by 3/32 thick was used with a 32-ounce water tank. A tank temperature of 180°F was achievable by the demonstration unit after one hour running time.

Tasks III and IV were added to the contract by Amendment 10 in June of 1976, with $8000 to Task III and $12,000 to Task IV. An additional $11,254 was awarded to Task I to continue the data collecting and processing efforts. Task III required the UAH to develop a Solar Radiation Instrument Catalog, and Task IV called for information on, and data from, Solar Radiation Monitoring Sites not archived by the National Weather Service, and to coordinate a plan with MSFC, ERDA, and NOAA to evaluate and use the data.

Amendment 11 increased the value of the contract by $56,000 in August of 1976. This extension continued the work under Tasks I and II and added Task V, Commercial Demonstration Design Review Support. Under this task, the UAH was required to coordinate the subcontract activities of ASHRAE in support of the MSFC commercial demonstration program management activities. The first award for this effort was $21,660.

After two administrative adjustments to the contract, Amendments 12 and 13, Tasks III and IV were completed 31 December 1976, and the two required solar radiation data catalogs were delivered to MSFC. Amendment 14 became effective on 1 January 1977, and is the amendment under which the current contractual agreement exists. This amendment continued the efforts of Tasks I, II and IV, and established Task VI, Solar Heating Module Development. The monetary breakdown for Amendment 14 is Task I - $78,981, Task II - $30,463, Task V - $51, 657, and Task VI - $20,000 to give a sum total for Amendment 11 of $181,101.

Table I and Figure I together summarize the amendment and contract extension activity of the NAS8-31293 contract. Figure 2 shows the Key Activities and Milestones accomplished during the contract period, October 1974 - May 1977. Figure 3 outlines the organizational structure of the contract.

Table I

Amendment and Funding Summary for NAS8-31293

	TASK	PROJECT	FUNDING	DURATION
Original Contract	NAS8-31293	Systems Analysis Sup.	$5,998	10/74 - 12/74
Amendment 2	"	"	n.c.e.*	1/75 - 2/75
Amendment 3	"	"	n.c.e.	2/75 - 4/75
Amendment 4	"	"	$3,000	3/75 - 4/75
Amendment 5	"TASK I"	Data Collection	$31,000	5/75 - 7/75
Amendment 6	"	"	n.c.e.	7/75 - 8/75
Amendment 7	"	"	$40,000	8/75 - 12/75
Amendment 8	"	"	Admin. Chg.	
Amendment 9	TASK I	Data Collection	$22,692	1/76 - 5/76
	TASK II	Project Anal. & Eval.	$22,500	1/76 - 5/76
Amendment 10	TASK I	Data Collection	$11,254	5/76 - 6/76
	TASK II	Project Anal. & Eval.	n.c.e.	5/76 - 6/76
	TASK III	Solar Rad. Instr. Ctlg.	$8,000	5/76 - 7/76
	TASK IV	Solar Rad. Monitor. Sites	$12,000	5/76 - 9/76
Amendment 11	TASK I	Data Base Development**	$23,802	7/76 - 10/76
	TASK II	Project Anal. & Eval.	$10,538	7/76 - 10/76
	TASK V	Commercial Design Review	$21,660	7/76 - 10/76
Amendment 12	TASK III	Solar Rad. Instr. Ctlg.	n.c.e.	8/76 - 12/76
Amendment 13	TASK I	Data Base Development	n.c.e.	10/76 - 12/76
	TASK II	Visual Aids Support**	n.c.e.	10/76 - 12/76
	TASK V	Commercial Design Review	n.c.e.	10/76 - 12/76
Amendment 14	TASK I	Data Base Development	$78,981	1/77 - 10/77
	TASK II	Visual Aids Support	$30,463	1/77 - 10/77
	TASK V	Commercial Design Review	$51,657	1/77 - 4/77
	TASK VI	Solar Heating Mod. Dev.	$20,000	1/77 - 3/77
Amendment 15	TASK VI	Solar Heating Mod. Dev.	n.c.e.	3/77 - 6/77
			$393,545	

* n.c.e. = No cost extension
** Note change in Title/Emphasis

FIGURE 1

ACCUMULATIVE COST SUMMARY FOR NAS8-31293

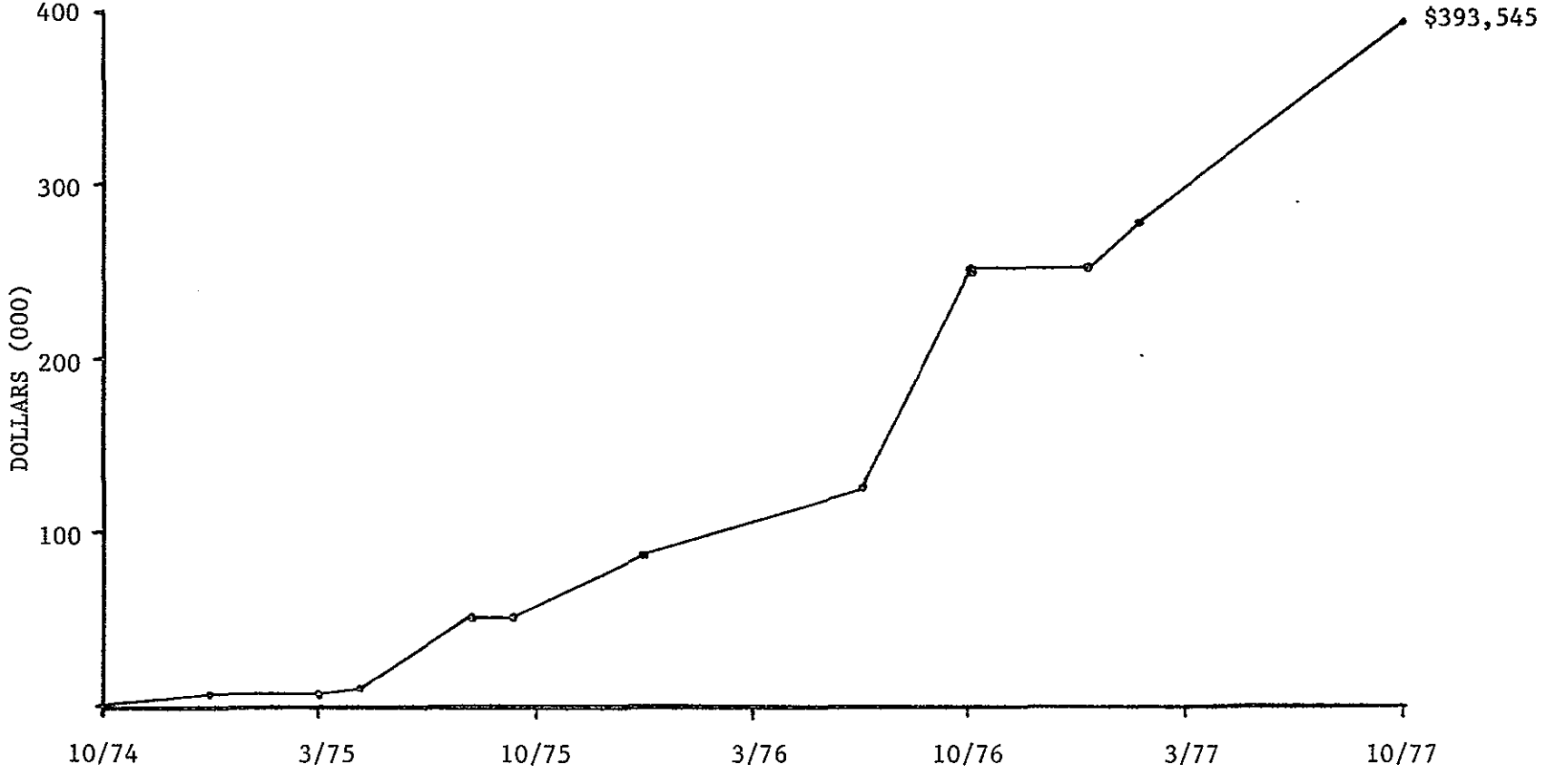


FIGURE 2

KEY ACTIVITIES AND MILESTONES FOR NAS8-31293

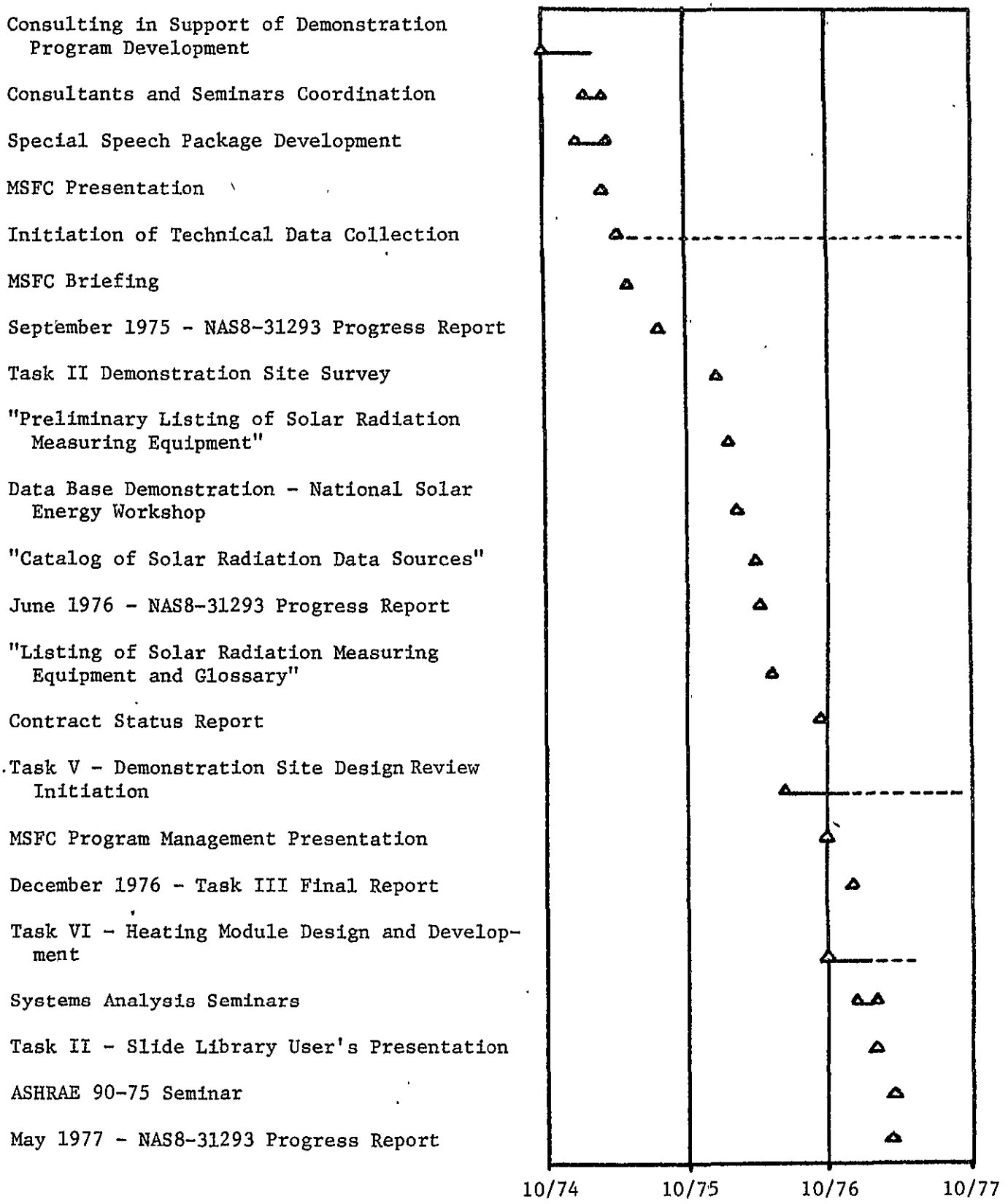
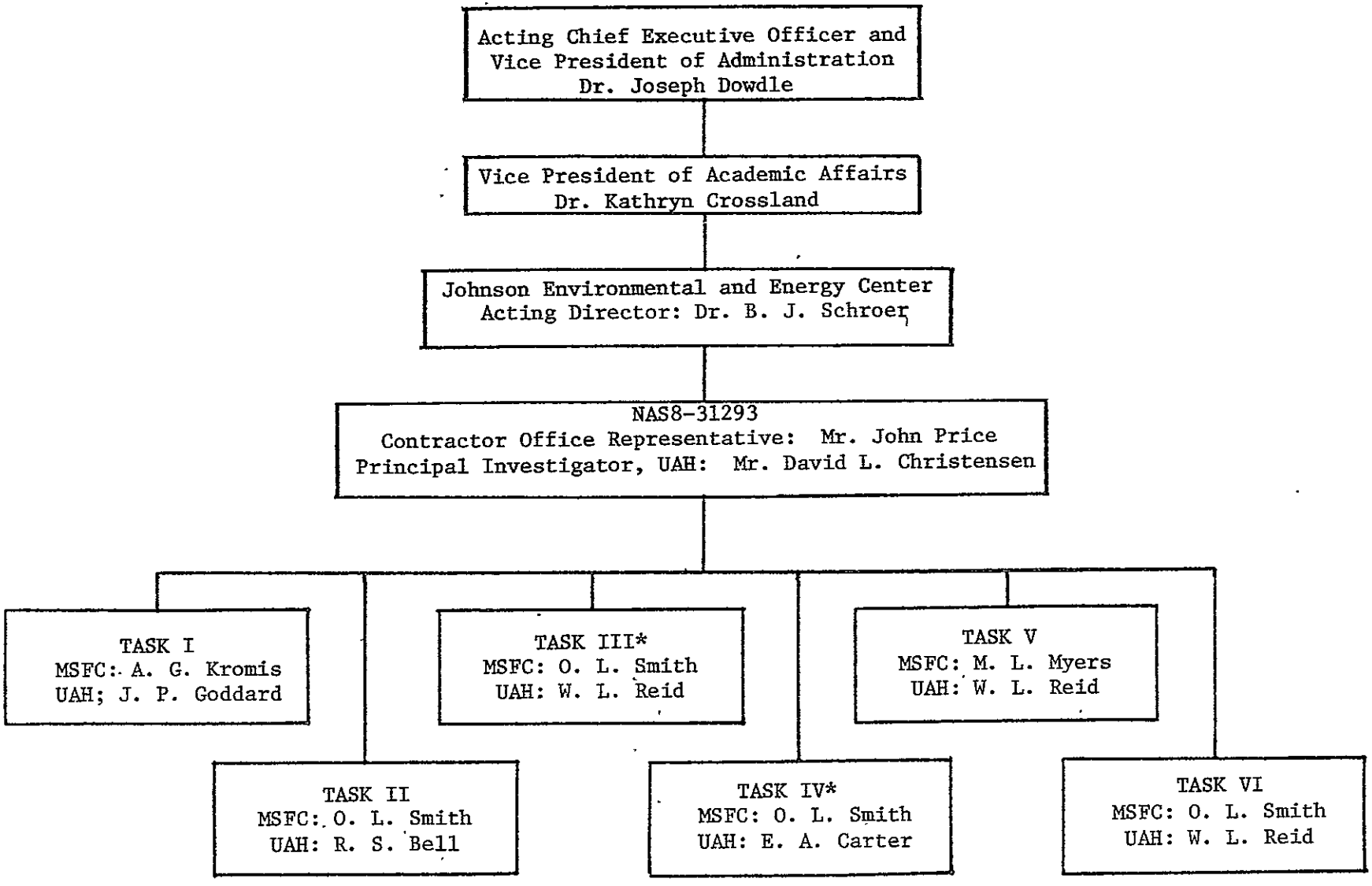


FIGURE 3

UAH ORGANIZATIONAL CHART - NAS8-31293



* - Denotes Task Completed: Task III - 12/76; Task IV - 9/76

B L A N K

II. CURRENT CONTRACT ACTIVITIES

A. TASK I - DATA COLLECTION

Data describing climatic conditions, architectural details of homes, office buildings and manufacturing buildings, heating and cooling systems and components including cost and performance parameters, and energy availability and related costs are required for conducting systems analyses of solar heating and cooling applications. These types of data are needed as primary input parameters for computer programs which allow analyses of application and site requirements, performance criteria, research and development needs, and economic comparisons related to solar heating and cooling systems in order to determine their market impact.

The following work statements, covering a period of performance from January 1, 1976 through December 31, 1976, were added to NASA Contract NAS8-31293 by amendments and this work is now being performed by The University of Alabama in Huntsville.

1. Continue to research the solar energy systems simulation models available; consider the parameters the models require not already being gathered, for further investigation and possible collection and entry into the Data Base.

2. Continue the gathering of solar radiation and surface weather data from the National Weather Service (NWS); continue the effort of collecting climatological data and maintain the MSFC/UAH awareness and participation in climatological data gathering projects for use in solar energy utilization analyses; provide updates, as they become available, to the initial list of solar radiation data sources.

3. Continue to seek authoritative and centralized sources of representative building associations who can provide blueprints and catalogs; maintain the search, collection and sorting of useful books, documents, publications, etc. necessary to the task (i.e. listing recognized associations involved with building materials); continue to evaluate and provide new source documents containing the physical properties and costs of materials.

4. Continue the compilation of source lists of government documents available throughout the various government depository systems to be utilized within the program; continue the efforts being provided to maintain the bibliography card file for the Statistical Abstract source material; continue to update and complete, as necessary, the computerized data format sheets and submit them to the MSFC Technical Monitor.

5. Continue to search for additional information involving the characteristics and performance of heating and cooling equipment; maintain continuous updates to the source lists of heating and cooling manufacturers. Utilize the results of the ERDA Program Opportunity Announcements and other data to develop a cataloging of standardized descriptions on solar systems and components; continue the collection and cataloging of available data through the use of the ARI Index of Manufacturers.

Detailed data formats required for entry into the computer have been developed through the combined efforts of MSFC and UAH personnel and are being used to insure flexibility and effectiveness in the final analyses. Each of the task areas (climate, equipment, architecture, economics) are discussed in detail in the following sections of this report and activities to date are included. All responsible task team members have been completing these format sheets with as much data as is available within the designated data categories.

Other Activities

Efforts are being made to provide additional pictorial and graphic data to enhance the visual output capability of the computerized Data Base. Pictorial materials being developed under related tasks in this contract may possibly be utilized.

Regular weekday meetings have been held between MSFC and UAH and a Weekly Progress Report is prepared and presented by the UAH Task Team Leader in accordance with contractual requirements. Copies of these detailed activites are available upon request and this material has been incorporated into the Summary Progress Reports (see Reference Section). Also, other meetings and contacts have been held on an almost daily basis between UAH, the MSFC contractor, and Computer Sciences Corporation (CSC). Other discussions and interface meetings have been held with representatives from MSFC, HUD, IBM, etc.

Presentations concerning the UAH program status and activities have been given by UAH personnel at both MSFC and at ERDA Headquarters in Washington, D. C.

Figure 4 outlines the data flow in the Solar Heating and Cooling Demonstration Program and shows the role that the MSFC Data Base plays. The Data Base not only handles national survey information, such as climatological data, energy costs, and equipment performance and costs, for use in design and cost optimization, support demonstration site selection and proposal evaluation, but is also designed to handle the "feed-back" instrumented data from the established sites. In this way, the success of site selections in previous phases and the overall program status can both be seen. Thus, determination of new sites for both climatological data collection and demonstration purposes can be greatly aided by the use of the Data Base. This capability can be used by ERDA, HUD, DOD, NBS, NASA and any others with remote terminals capable of using the Data Base.

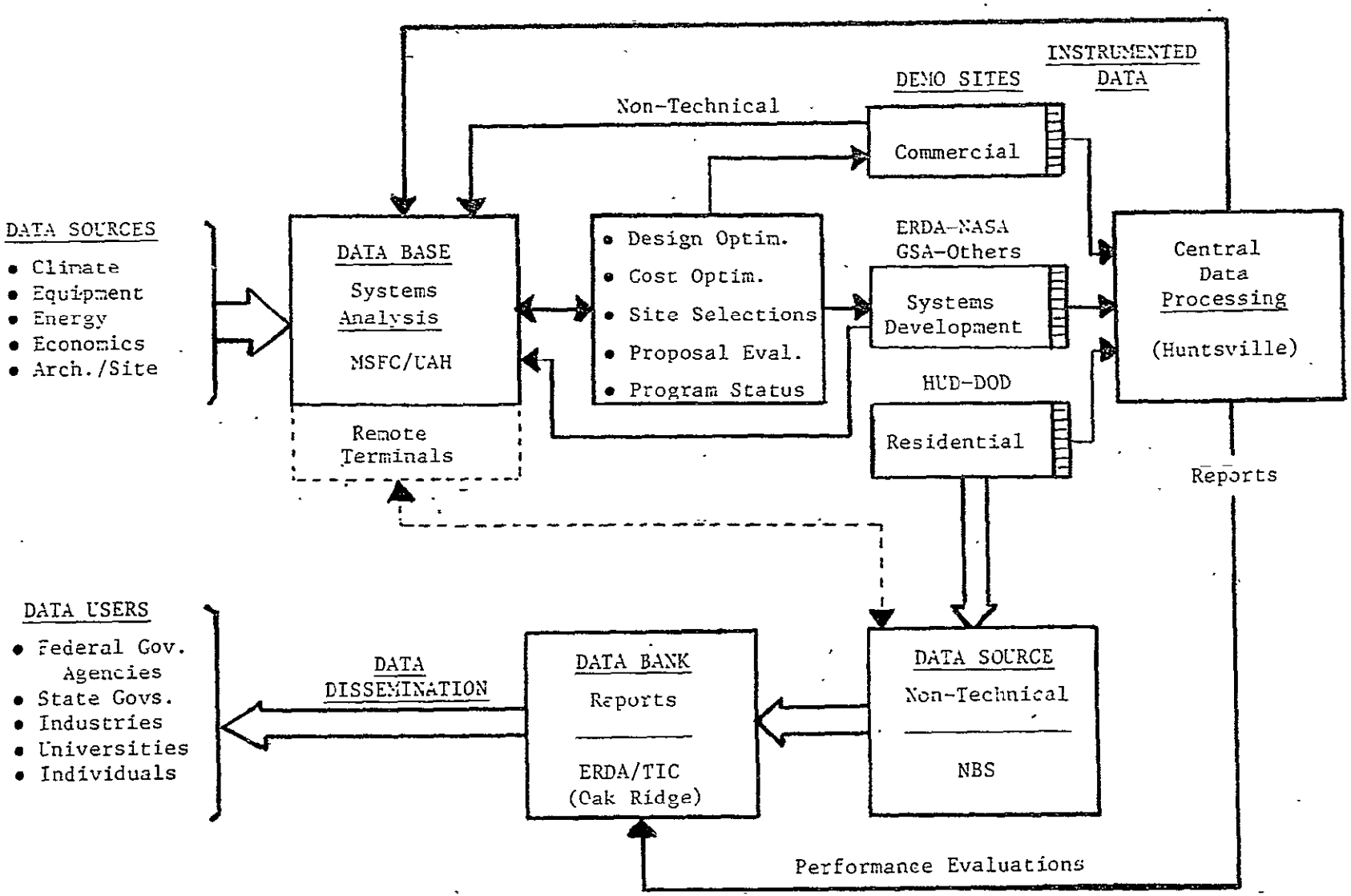
Task I Expenditures

Contract funding for Task I covering the period of performance 1 May 1975 through 31 December amounted to $128,744; funding through October 1977 amounts to $207,725.

FIGURE 4

DATA FLOW

SOLAR HEATING & COOLING DEMONSTRATION PROGRAM



SOLAR ENERGY SYSTEMS SIMULATIONS MODELS - SUB-TASK I

SUB-TASK OBJECTIVES

To survey the current listing of simulation models related to solar energy systems analysis in order to analyze their methods and effectiveness and to record the parameters needed by the models.

APPROACH

Mail out questionnaires to the known organizations that have produced such simulation models. Analyze the responses and examine the possibilities of collecting data on parameters needed for all models if this is not already carried out by the task team.

ACTIVITIES AND PROGRESS

Responses to the questionnaires have been received in varying detail for fourteen of those surveyed. Table II summarizes in matrix form the capabilities of those computer simulation models surveyed. Attachment A presents more detailed abstracts and contact names and addresses for the simulation programs researched by this sub-task team.

F-CHART, a system simulation program developed by Drs. Duffie and Beckman at the University of Wisconsin, was ordered for evaluation and delivered to Mr. Dick Stonemetz at the System Analysis Division of MSFC in March of 1977.

TABLE II

SOLAR ENERGY COMPUTER SIMULATION MODELS

Program Name	Program Language	Source	System Mod.	System Generic	Load Calc.	Tech. Perf. of Solar Component	Econ. Eval.	Sys. Perf.	Cost
TRNSYS	FORTRAN	U. of Wisc.	X		X	X		X	$200
F-CHART	FORTRAN	U. of Wisc.		X	X	X	X	X	$100
SOLRI	FORTRAN	A. D. Little		X		X		X	$1000
MINISHAC	APL	IBM/Huntsville		X			X	X	
CERES	APL	IBM/Huntsville					X		
CAP	APL	IBM/Huntsville					X		
LOCKHEED	FORTRAN	LOCKHEED/ Huntsville		X				X	Government Development
SHACSAC-1	FORTRAN	Charles Stark Draper Lab, Inc.		X	X	X	X	X	
SIMSHAC	FORTRAN	Colorado St. University	X		X	X		X	
SOLSYS	FORTRAN	Sandia Lab NM	X		X	X		X	Government Development
SUN	FORTRAN	Berkeley Solar Group CA		X	X	X		X	
SOLAR-LASL	HYBRID/ FORTRAN	Los Alamos SCI Lab		X	X	X		X	Government Development
SOL COST	FORTRAN	IBS - Washington	X		X	X	X	X	$70/Serv.

CLIMATIC DATA - SUB-TASK 2

SUB-TASK OBJECTIVES

To collect atmospheric, solar radiation and environmental data and to organize it for use in simulations and evaluations of solar energy in various forms.

APPROACH

Review available sources and determine the availability and present format of atmospheric observations data. Determine specific locations and regions of primary interest and establish priorities.

ACTIVITIES AND PROGRESS

Resulting from a survey to locate new sources of solar radiation and hourly surface data, the "Initial Report on the Availability of Solar Radiation Data" document describes the need for solar radiation data having stricter controls on maintenance of equipment and recording procedures. As it takes several years before the new data reaches sufficient quantity to apply to solar energy projects, it is desirable to locate these alternate sources of solar radiation data as soon as possible.

The preliminary report was prepared with the cooperation of the National Weather Service and other organizations and provides locations which have recorded and collected solar radiation data applicable to current and planned solar energy projects. An address list of organizations who participated in this survey was included in the June 1976 Progress Report.

The following electronic tape data were acquired by UAH during the report period:

1. Five reels of daily solar radiation data; this completes the entire availability of solar radiation data collected for the periods under analysis.

2. Three reels of surface data and seven reels of solar radiation data.

3. Sixty-four reels of hourly surface data encompassing 27 different weather stations.

As a further aid to support the MSFC climatological studies, the JEEC collected various sets of documents from the National Climatic Center (NCC) at Asheville, North Carolina, including:

1. "Monthly Norms of Temperature, Precipitation, and Heating and Cooling Degree Days 1941-70".

2. "Monthly Averages of Temperature and Precipitation for State Climatic Divisions 1941-70".

The climatological normals and averages presented in these documents are based on records for the 30-year period 1941-71, inclusive. Data are assembled by individual states.

A further set of tapes has been ordered from the NCC which will replace those already in the data base and will bring the information up to date. The data will be arranged in the SOLMET format developed by NOAA thereby adding solar radiation monitoring parameters to the customary meteorological inputs.

Other contractual activities, now being performed by the UAH-JEEC solar energy research team, directly support the collection and evaluation of solar radiation data.

These activities under funding from the ERDA Division of Solar Energy include the publication of an updated "Catalog of Solar Radiation Measuring Equipment" which provides a reference source for detailed technical, operational and cost data to aid in the selection and evaluation of solar radiation instrumentation. Likewise, a methodology for digitizing, recording, and preparing "raw" solar radiation data for use in computerized applications is being developed which will permit the reclaiming of information which might not otherwise be used.

A "Solar Radiation Network Design Handbook" is also being developed for publication to provide guidelines for the establishment of new monitoring stations. This and the other related Center activities in solar radiation research are being used to expand and improve the quality of the Data Base, particularly in the essential area of climatic data.

ARCHITECTURAL DATA - SUB-TASK 3

SUB-TASK OBJECTIVES

Acquire architectural data sufficient to describe typical buildings, including residential, commercial, public and manufacturing facilities.

APPROACH

Since completion of the formats for describing architectural data for any building, research efforts have concentrated on locating suppliers of residential and commercial blueprints, such as known architects affiliated with the AIA and motel/hotel corporations willing to loan blueprints, for analysis of their adaptability to solar heating and cooling systems. This effort has expanded into contacting professional associations and such agencies as HUD to acquire various data on minimum housing standards and standardized building cost data (i.e., labor rates, materials cost, etc.).

ACTIVITIES AND PROGRESS

A supplier of blueprints for "standard" home construction has been utilized to assist in the home construction analyses. This firm has, as one of its functions, the capability of providing blueprints of typical homes that could be considered compatible for conversion to a solar heating and cooling system. Twelve different home designs have been acquired from the Homes for Living Corporation of New York, N. Y. These plans were useful except for the lack of schematics depicting the duct work for the heating and cooling system. Through the assistance of the ASHRAE Manual J document for heating and cooling load calculations (also entered as a unit in the Data Base) it is possible to include appropriate HVAC systems for the various home plans. Its utilization allows a workable heating and cooling layout system for each of the 12 blueprints.

To assist the activity of identifying various standard construction costs and related construction parameters, the aid of the Robert Snow Means Construction Company, which annually publishes Construction Cost Data, was acquired.

The Department of Housing and Urban Development (HUD) provided several volumes of data related to minimum standards for the construction industry. The specific volumes being utilized are: HUD - Minimum Property Standards, (1973 editions), for care-type housing, and one-family and two-family dwellings. HUD is presently in the process of developing minimum standards that would be applicable to the utilization of solar heating and cooling systems for specific structures.

To assist in the problem of collecting specific construction data representative of a Standard Metropolitan Statistical Area (SMSA), formal communications were established with key city personnel for each SMSA,

such as the City Building Permit Officer. These sources, along with the various professional and trade associations have proven very instrumental in the collection of the various site construction and other related architectural information.

In addition to the various home site blueprints, the UAH has been successful in soliciting commercial blueprints of motel construction from Holiday Inns of America and from Days Inns Incorporated. Analysis of these blueprints should aid in determining the feasibility of applying solar energy heating and cooling systems to structures of this type. As they have become available, the materials have been submitted to various technical groups at MSFC.

This sub-task team has also collected blueprints from several multi-family residences along with the relevant utilities consumption and cost figures for natural gas and electricity. These data have been given to the System Analysis Support Division at the MSFC to help develop the High Speed Performance Solar Heating and Cooling (HISPER) Program. The comparison of predicted and actual performance will greatly expedite this development.

Particular attention is being given to energy conservation considerations to reduce the heating and cooling loads and hot water thermal losses of buildings. The UAH team has worked closely with the technical community to keep abreast of new developments in energy conservation design and installation methods and has provided seminar services in support of this effort.

Early in May 1977, a seminar is scheduled to be held concerning the ASHRAE Standard 90-75 "Energy Conservation in New Building Design". Much interest has been shown in this document by MSFC personnel. The Birmingham Chapter of ASHRAE will be represented by William Martin and Charles McDowell. It may be that a similar seminar will be conducted upon publication of ASHRAE Standard 100-77 to be published in 1977 and which covers energy conservation practices in retrofitting existing structures for reduced energy consumption.

THERMAL LOADS DATA - SUB-TASK 4

SUB-TASK OBJECTIVES

Collect the thermal properties of various categories of materials to allow thermal analyses of residential or commercial buildings and associated equipment.

ACTIVITIES AND PROGRESS

Various references on building materials have been collected. However, due to the variation of sources, no single reference has all the information necessary to meet data entry requirements. Only small portions of the required data may be found in each reference, and most of the existing physical property data are given in a range of values since the intended use of the various materials is quite diversified.

The ASHRAE "Manual J, Heating and Cooling Loads Calculation Handbook" has been entered into the Data Base. Selected data from Building Construction Cost Data ; a publication of Robert Snow Means Construction, is now ready to be entered pending its copyright clearance. This is being negotiated by the NASA Legal Office.

HEATING AND COOLING EQUIPMENT AND MANUFACTURERS SURVEY - SUB-TASK 5

SUB-TASK OBJECTIVES

Continue the acquisition of data on conventional and solar heating and cooling systems, subsystems, and components sufficient for performance evaluation, and the updating and maintenance of a listing of the related manufacturers.

APPROACH

Survey manufacturer's literature and handbooks, ASHRAE data books, manufacturer computer programs, and governmental and industrial studies and surveys for pertinent data. Develop composite listing of sources and contacts for gathering additional data.

ACTIVITIES AND PROGRESS

Conventional Equipment

The Air Conditioning and Refrigeration Institute (ARI) Index to Manufacturers, a representation of sixty-one firms supplying HVAC equipment on the U. S. market, is presently being utilized in the research efforts.

All of the firms in the report were contacted by telephone or by formal letter requesting specific data on product line and related prices. In addition, the Thomas Register and the 1975 Plant Engineering Directory and Specifications Catalog have been utilized to obtain data on additional manufacturers which market HVAC equipment.

Contacts have been made with the U. S. Department of Commerce in Washington, D. C. as well as affiliated offices in Birmingham, Alabama, resulting in the receipt of the 1973 and 1974 statistical reports on sales of Air Conditioning and Refrigeration Equipment and warm air furnaces. This data was useful in determining priorities of work based on the significance of equipment sales.

Solar Equipment

The equipment research team has assembled data sources for solar collector manufacturers and suppliers of components (coatings, plating, paint, glaze absorbers, storage, etc.). This list is being continuously refined and purged of errors and duplications and is included in this report as Attachment B. This list gives additional information concerning manufacturers of solar energy collectors that have been gathered and organized during the contract period. The files now contain some 200 manufacturers of solar collectors. Technical data on about two-thirds of these are available. The flow of data has been on a constant basis, and as it becomes available, it is incorporated into the files.

CONCLUSION

As new information is received on conventional and solar heating and cooling manufacturers and their products, it is processed and entered into the Data Base.

Efforts have been made to establish a more reliable standard for solar collector performance based on data points which state efficiency according to the standards established by the National Bureau of Standards (NBS). The Data Base is now using a standard format developed to present the solar collector performance data graphically for entry into a supplementary graphics file. These graphs are designed to allow direct comparison between collectors' performance under various conditions.

Product information related to solar heating and cooling systems, sub-systems, and components has been inventoried, cataloged, and delivered to the MSFC Technical Monitor. Systems installations from throughout the United States have been identified to date, ranging from residential to heavy commercial and process applications. Many of these are privately-funded programs but in some cases may provide data of interest to the National Demonstration Program (such as site solar radiation) and for entry into the Data Base. The Design Applications File has been developed to handle this information (see Subtask 9).

A major effort was completed to purge and re-enter all known vendors involved with the manufacture or study of solar and conventional heating and cooling equipment, including a total update of the manufacturers' survey. The task team has also purged the Standard Change Integration Tracking (SCIT) listings (used by the Solar Heating and Cooling Team of NASA-MSFC) and incorporated only pertinent manufacturers into the Manufacturers' Survey. This documentation effort is representative of all available vendors involved with the research, development, manufacturing, and sales aspects of conventional as well as solar heating and cooling equipment; it is continuously updated as new products and vendors are researched.

New efforts are now being implemented to review and assess technical reports and progress reports which reflect research, development and operational activities involving solar energy systems and subsystems. Many firms are now involved in the National Solar Heating and Cooling of Buildings Demonstration Program and also in the non-federal funded category of private program development. These reports will be reviewed and abstracted and pertinent data will be included in periodic reports and summaries.

ECONOMIC DATA - SUB-TASK 6

SUB-TASK OBJECTIVES

Define economic parameters and acquire data for specific geographic areas that will allow analysis of economic influences on building costs, equipment costs, amortization, labor rates, home and equipment maintenance, materials costs and availability, and energy rates and availability.

APPROACH

Investigate and acquire new sources and data to be utilized in the overall project.

ACTIVITIES AND PROGRESS

Most of the activity within the Economics section has been devoted to completing the large number of format sheets developed for related subjects, such as economics, fuel rates, construction costs, etc. The activities and progress achieved under Economics have been divided into the following activities: economics as related to the statistical abstracts; energy; REmote CONsole (RECON); insurance data; library research; and bibliography control.

Economics

Over 11,000 format sheets based on the Statistical Abstract of the United States have been completed and delivered to the Technical Monitor for entry. Topics covered by and entered from the Statistical Abstract for 1950, 1955, 1960-76 data years are listed below:

1. Population
2. Vital Statistics
3. Education
4. Geography and Environment
5. Finances and Employment
6. Labor Force, Employment and Earnings
7. Income, Expenditures and Wealth
8. Prices
9. Transportation and Agriculture
10. Mining and Mineral Products
11. Distribution and Services
12. Energy
13. Construction and Housing

Energy

Format sheets for recording data related to energy have been provided in support of the data-gathering activity.

Rate schedules for residential, commercial and industrial electric service for communities with more than 2,500 population are received from the Federal Power Commission (FPC). The National Electric Rate Books are published monthly and cover all fifty states. Listed are all the counties and SMSA's served by the utility companies, summer and winter rates according to service type and other service and cost related data.

The FPC provides further assistance through their publication, FPC News Release Bulletins. They provide fuel cost and quality data in such areas as: coal purchases and deliveries at steam-electric plants; fuel oil and gas purchases and deliveries for steam electric plants and for combustion turbine and internal combustion units.

A third FPC release entitled Typical Electric Bills has been entered into the Data Base. This publication lists electric bills for selected amounts of electricity at residential, commercial and industrial rates in all communities with more than 2,500 population throughout the U. S. A similar publication from the National Association of Regulatory Utility Commissioners (NARUC) is being compiled by NARUC at present; when it is published, it may be handled in like manner as the typical electric bills. The American Gas Association (AGA) rate service publications do provide gas rate data by state and by community served. The information incorporates service and cost related data for residential, commercial, industrial and institutional customers. This very detailed data is being entered to the same format as the electric rates.

Finances and Employment

Federal Reserve Bank releases and State Employment Statistics (both issued monthly) provide diverse information on income, employment and banking finance in both actual numbers and in index (base year - 1967) form.

REmote CONsole (RECON) Data Search

As an aid in the search for data related to the various disciplines necessary for overall project analyses, various UAH team members have been trained to use the MSFC RECON data search system. This system provides a means to search for data under various topics (i.e., construction, population, demography, economic development, etc.).

If a topic search results in a favorable response, the particular document listings of interest are then requested form the NASA and associated data banks. Once UAH is in receipt of the listing, the abstracts are reviewed in greater depth to determine if any part of the subject matter should be pursued further. The following list represents various topics that have been investigated by the UAH task team for submittal to MSFC and, as such, have been requested from the data bank for further analysis:

1. Architecture
2. Buildings
3. Ceilings
4. Comprehensive Strength
5. Materials Conductivity

6. Construction Materials
7. Elastic Properties
8. Materials Flexibility
9. Floors
10. Inflatable Structures
11. Roofs
12. Shelters
13. Solar Furnaces
14. Walls

These fourteen different topical bibliographies were reviewed and summaries of the relevant references were proposed by the economics task team. Typical references include the following:

1. The Utilization of Solar Energy to Help Meet our Nation's Energy Needs
2. Proceedings of the Solar Heating and Cooling for Building Workshop
3. Consumption of Energy in New York State 1972 (with estimates for 1973)
4. Domestic Solar Energy Systems for Delaware
5. Systems Analyses of Solar Energy Programs. Appendix: Research Tasks
6. Energy Conservation Handbook for Light Industries and Commercial Buildings
7. Fuel Energy and the Steel Industry, A Bibliography
8. Energy and Economic Analyses of Total Energy Systems for Residential and Commercial Buildings - Utilizing Waste Heat Recovery Techniques
9. Current Energy Shortages Oversight Series (The Major Oil Companies) Part 2
10. Current Energy Shortages Oversight Series (The Major Oil Companies) Part 4
11. Current Energy Shortages Oversight Series (The Major Oil Companies) Part 3
12. Available Energy Conversion and Utilization in the U. S. ASME Paper
13. Future U. S. Demand Patterns and the Use of Hydrogen
14. The National Coal Conversion Act and The National Crude Oil Refinery Development Act
15. Sizing of Solar Energy Storage Systems Using Local Weather Records
16. Optimization Study of Solar Absorption Air Conditioning Systems Semiannual Progress Report
17. Solar Heating and Cooling of Buildings, Phase 0. Feasibility and Planning Study
18. Solar Heating and Cooling of Buildings, Phase 0, Feasibility and Planning Study, Final Report, Vol. III, Book 1, Appendix A, Task 1, Development of Requirements, Appendix B. Task 2, Systems Definition
19. Total Energy Supply and Demand, Vol. I, Ch 6--Natural Gas, Economic Analyses
20. Energy Use in the Commercial and Industrial Sectors of the U. S. Economy, 1963
21. Study of Industrial Uses of Energy Relative to Environmental Effects
22. Industrial Energy Study of the Hydraulic Cement Industry. Final Report

23. Data Base for the Industrial Energy Study of the Industrial Chemicals Group. Final Report
24. Fuel and Energy Consumption in the Coal Industries. Final Report
25. The Economic Impact of Environmental Programs. Summary Report, Nov.-Dec. 1974
26. Energy Consumption, The Chemical Industry. Final Report, Aug. 1974-Mar. 1975

Many other topics were also reviewed and many were found to be irrelevant.

Insurance

The Insurance Services Organization in New York City has sent the UAH task team their Homeowners and Businessowners Handbooks for all the states. These Handbooks cover all basic, broad, and comprehensive policy rates for the nation in great detail and are being held in hard copy pending contact with the MSFC Systems Analysis Division; it is hoped that they will help to select the specific insurance data to be entered for needed economic analyses.

Library Research

The Economics Section has put a great deal of effort into establishing a good working relationship with the various libraries in the area in order to assist in the data collection effort.

The UAH Library has been very helpful within its limits and has made available over 500 government documents. The Alabama A&M Library also permitted the use of 32 documents. Inter-library loans have been arranged with both the Auburn University and the University of Alabama (Tuscaloosa) Libraries for documents that UAH, A&M, and the Redstone Scientific Information Center (RSIC) were unable to provide. The task team prepared a listing of documents requested by the NASA technical monitor: this listing, which represents all government documents selected from the 1976 Monthly Catalogs, indicates the comprehensive nature of the Data Base (See Progress Report, June 1976, Appendix D).

Working Bibliography

The Economics Section maintains an up-to-date card catalog on all sources of data used throughout this project by all team members. The subject headings used for maintaining documentation control are listed below:

Accounting	Housing
Architectural	Insurance
Catalog	Materials
Concrete	Measurement
Construction	Metals
Economics	Metric System
Electricity	Solar Energy
Energy	Statistics
Energy Growth	Wind
Gas	

USER'S GUIDE BROCHURE - SUB-TASK 7

SUB-TASK OBJECTIVES

Prepare for publication a brochure-style document for broad dissemination to all potential users of the Data Base. The brochure would complement the Technical User's Guide to the MIRADS, but in addition, would explain the rationale and potential uses of the files' contents.

APPROACH

Design layout following general format of the User's Guide; provide text, diagrams and other illustrative material for publication.

ACTIVITIES AND PROGRESS

The User's Guide has been updated with regrouping and restructuring of several of the files as well as the addition of others (See Sub-Task 9). The publication of the User's Guide Brochure will follow the republishing of the User's Guide itself by two weeks. The Preliminary Draft of the User's Guide Brochure is attached as Attachment C. Presented below is the contents listing for the User's Guide Brochure:

1) Primary Solar Data File
2) Design Applications File
3) Automated Monthly Reports File
4) Climatic Atlas*
5) Weather Information File
6) Utility Rates File
7) Fuel Cost and Quality
8) Utility Operating Statistics
9) Typical Electric Bills
10) Architectural Graphics*
11) Loads Calculations File
12) Manufacturers' File
13) Equipment File
14) Heating Products
15) Cooling Products
16) Economics File
17) Income, Employment and Finances File
18) Housing Starts File
19) Residential Alternatives & Reparis
20) HUD Statistics
21) SMSA Maps*
22) Geographic Area Maps*

*Denotes graphic file

SYSTEMS ANALYSIS SEMINARS - SUB-TASK 8

SUB-TASK OBJECTIVES

Bring together solar energy and systems analysis consultants with MSFC personnel for a series of seminars in the history and state-of-the-art of any and all aspects of solar energy utilization.

APPROACH

Invite consultants of known expertise in particular areas of solar energy systems analysis to the MSFC for a series of one-day seminars. The "proceedings" should be reproduced for dissemination to a greater number of people than would be able to attend the seminar itself.

ACTIVITIES AND PROGRESS

On February 9 and 10, 1977, Drs. Löf and Beckman, Mr. Dick Stonemetz from the MSFC System Analysis Division, Mr. David L. Christensen, Principal Investigator, UAH, and Mr. John Irby from IBM/Huntsville spoke to a grouping of 34 people from various offices at the MSFC, UAH and IBM. Dr. George Löf, a pioneer in contemporary solar energy utilization, and of air systems in particular, addressed the advantages and disadvantages of air systems. Dr. William Beckman from the University of Wisconsin spoke on the TRNSYS and F-CHART programs developed by his laboratory for the simulation of systems by computer modeling for both performance and cost analyses. Mr. Dick Stonemetz introduced the HISPER program that the MSFC has been developing and Mr. John Irby spoke of IBM's MINISHAC and other systems analysis programs used by his organization. Mr. Christensen acted as moderator and emphasized the need for more effective interaction with all potential users of the Data Base.

On March 11, 1977, Professor John Yellott from Arizona State University and a contemporary of Dr. Löf, addressed the same group on the varied but interrelated topics of solar radiation monitoring and instrumentation; architectural designs; passive systems; and active systems. In this way, Dr. Yellott provided a comprehensive overview of the history and the state-of-the-art of solar energy utilization.

A report is being prepared from transcripts of the presentation. The visual aids and slides used in the presentations will be integrated into the transcribed text. Dr. Yellott's presentation will be transcribed directly to provide an overview. Dr. Löf and the other specialist participants will have their presentations summarized with the reproduction of their visual aids.

PRIMARY DATA AND DESIGN APPLICATIONS FILES - SUB-TASK 9

SUB-TASK OBJECTIVES

Respond to the demands by several system simulation programs for localities' "averaged" climatological data; add to this the energy costs for electricity, gas, coal and fuel oil to common pricing parameters; and add the capability to see what other designers have built in the locale of interest in response to the same climatological and economic factors.

APPROACH

Design a concise format to use both English and metric units for climatological and utility rate data for all communities for which sufficiently detailed information is available - this is to be the Primary Data File. The complementary Design Applications File will provide design, performance and costs information on all federal, state and private solar energy projects.

ACTIVITIES AND PROGRESS

Both the Primary Data File and the Design Applications File have been formatted and programmed. They have been sent for review to many of the potential users so that the design may be tailored to their specific needs. To this end, both English and metric units are printed out saving units-conversion time for the user.

The UAH has collected an abundance of projects data for the Design Applications File, which is being entered at present. The Primary Data File sources are the NOAA network and other weather stations, and the utility companies which serve the relevant communities. The types of data included in the Primary Data File and Design Applications File are listed below. See Attachment C for a more extensive description of the files.

Primary Data File

Data is entered as the monthly average data in both English and Metric Units, where applicable.

Location
Latitude, Longitude, Elevation
Heating and Cooling Degree Days
Dry Bulb Temperature
Dew Point Temperature
Relative Humidity
Cloud Cover Masking Factor
Percent Possible Sunshine
Ground Water Temperature
Average Wind Velocity
Average Wind Direction
Average Daily Solar Irradiation
Utility Rates - Electricity, Natural Gas, Coal and Oil for both Residential and Commercial Rates expressed in both $/mil. Btu or /mil. kJ

The Design Applications File contains the following project-related information:

Project Title, Location, Latitude, Longitude and Elevation
Owner, Architect, Solar System Designer, Key Contact
Type of Solar Service, Application and Initial Operation Date
Building Design Loads, Thermal Loads of Heating, Costing and Hot Water
Solar Energy Subsystems: type, manufacturer, cost, size/capacity
- collector
- storage
- heat exchanger
- controls
- auxiliary heating unit
- air conditioning unit
- heat pump

System Performance
- Solar Fraction of Heating, Cooling, and Hot Water Load
- ECCS Conversion Efficiency
- System Performance Factor

System Cost
- Total System Cost
- Cost Break-even points @ current fuel costs
  @ 10% increase/yr in fuel costs
  @ 20% increase/yr in fuel costs

B. TASK II - PROJECT ANALYSIS AND EVALUATION

A prime responsibility of the Marshall Space Flight Center in its role in solar heating and cooling systems development is to make the public aware of program activities and the advantages and limitations of solar energy systems. Under Task II of Contract NAS8-31293, the UAH has been involved in the development of educational demonstration units, information packages, data collection and dissemination methods, slide packages, and speech modules on all phases of solar energy and its applications, but with emphasis on the solar heating and cooling of buildings.

A comprehensive research, acquisition and screening activity of available materials was performed as an early effort to prepare effective communication materials. Another early program effort related to the support of program management activities involved UAH representatives and Tom Spencer of Spencer Graphic who conducted a survey of the MSFC Solar Energy Control Room to improve its functional and operational performance. A report covering the findings of that survey and certain recommendations was prepared and delivered to the MSFC (See Attachment D). Also at that time, certain projects for the Control Room were discussed; these included designing a logo for the MSFC Solar Energy Task Team, and a display model for the two glass enclosed cases located in the Control Room. The logo for the Task Team was designed and is used on selected slides.

Task II Expenditures

Contract funding for Task II covering the period of performance 1 January 1976 through 31 December 1976 amounted to $33,038. Total funding projected through October 1977 is $63,501.

MAINTAIN SOLAR ENERGY SLIDE CATALOG - SUB-TASK 1

SUB-TASK OBJECTIVES

The purpose of this sub-task is to make a comprehensive library of quality slides on solar energy activities available to MSFC personnel to support technical presentations whenever needed.

APPROACH

Slides are sought from all viable sources including industry, universities, private projects, other research centers, and from MSFC activities. The slides are screened for applicability and validity of information.

ACTIVITIES AND PROGRESS

During the six-month period from June 1976 through 31 December 1976, six sets of slides covering many phases of solar energy were delivered to MSFC. It was determined that a better system control and a more comprehensive subject-related filing system was needed.

As a result, a new numbering system based on 10 broad subject categories has been developed and all slides in the file renumbered to reflect this new filing system. New slides from numerous sources have been added to the collection and a complete catalog of matching photographs has been assembled. As a result, the entire package with control procedures has been delivered to MSFC. The new cataloging system and a User's Manual are included in this report as Attachment E. These materials were presented at a seminar held by the UAH task team for MSFC on April 15, 1977. Listed below are the 10 basic categories of the Slide Catalog Reference File:

SE-1	History
SE-2	Available Systems (Heating & Cooling)
SE-3	Available Sub-Systems
SE-4	Solar Energy Research & Development Projects (& Testing)
SE-5	New Concepts
SE-6	Program Information
SE-7	Energy Data
SE-8	Environment & Climate
SE-9	Solar Sites & Applications (by States)
SE-10	Foreign

In addition, a brief paragraph explaining each slide is being prepared and incorporated into the catalog and tailored packages are being developed and documented on various subjects and directed toward various audiences. Copies of each package showing its subject, suggested uses and audience type, and slide numbers will be maintained in the MSFC Solar Energy Information Room.

MAINTAIN AND DEVELOP PORTABLE SOLAR HOT WATER DEMONSTRATION - SUB-TASK 2

SUB-TASK OBJECTIVES

Under this sub-task, the UAH was required to develop a lightweight, portable, self-contained and functional unit to demonstrate clearly the principles of heating water by solar energy.

APPROACH

The project was accomplished with the assistance of a UAH consultant with engineering prototype development experience and with a good working knowledge of the basics of solar energy and close cooperation with local suppliers.

ACTIVITIES AND PROGRESS

The general specifications for the demonstration unit stated that it would heat one quart of water to approximately 140°F and would be lightweight. The first prototype met these requirements although it was large by portability standards. Its dimensions were 24" x 14" x 8½"; it weighed 18 pounds when water was in place.

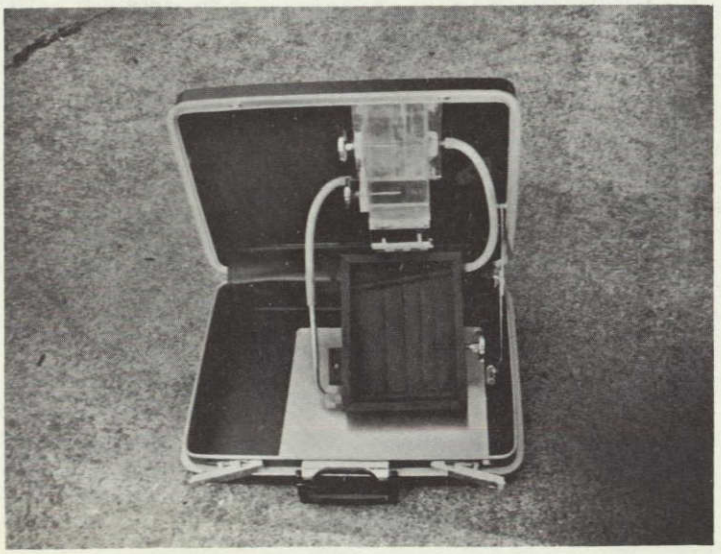
The second prototype used an improved water tank and collection system which brought the overall dimensions down to more desirable limits. However, the weight of the case increased the weight (wet) to 22 pounds. With the improved collector and thermo-syphon system, a water tank temperature after one hour's exposure of 250°F using the enclosed heat lamp, or 160°F in the sun, could be reached.

The third prototype provided all requirements with ease, having a total weight of 8½ pounds with water and dimensions of 18" x 12" x 5". A wafer-thin collector of 38 square inches was used with the 32-ounce water tank. Flow could be restricted with a sensor so that any excessive temperature rise of the water could be checked. A maximum teperature of 180°F in one hour's running time was established. The unit is self-contained, including the heat source for demonstration purposes indoors.

Investigations are continuing on further improvements to the efficiency of the unit, and cost investigations are being conducted for producing the demonstration packages on a limited basis. The usefulness of the demonstration units developed so far will also be determined, as well as any need for additional units which will be designed and developed according to MSFC guidance. The following page shows photographs of the demonstration model in its final form.

Demonstration unit rigged for indoor use

Unit set up for <u>true</u> solar energy collection demonstration



"Sun's eye view"

32

SOLAR ENERGY INFORMATION ROOM - SUB-TASK 3

SUB-TASK OBJECTIVES

The MSFC Solar Energy Information Room was originally conceived as a central holding area for all solar energy information. The room would be a showplace for visiting dignitaries and tours. Lack of space has prevented its being used in this fashion, but the Program Management Control Room continues to provide a part of this function.

ACTIVITIES AND PROGRESS

The Solar Energy Information Room now contains the Solar Energy Slide File and related catalogs. The slides are kept in specially-designed 2 x 2 slide cabinets; inventory control is maintained by a UAH representative. Also located in the room are slide-viewing equipment for rapid organization of slide packages and work tables for convenience of MSFC personnel. Viewgraph-size copies of these visual materials will be maintained and available at the Solar Energy Information Room. There is a great deal of written material on solar energy equipment and research that is continuously being sent out in response to public requests. This material is being filed by subject matter in the same manner as the slide system.

UPDATE TOTAL ENERGY SLIDE PACKAGE - SUB-TASK 4

SUB-TASK OBJECTIVES

This task requires UAH to gather visual material on all facets of the energy situation throughout the United States and the world. These slides are valuable tools for MSFC presentations which describe the potential advantages of solar energy utilization to help reduce our dependence on fossil fuels.

APPROACH

Energy information was gathered from recognized expert sources and converted into slide form. Slides from private industry and other non-proven sources were validated with Federal government energy agencies before including them in the package.

ACTIVITIES AND PROGRESS

A complete update and more comprehensive Energy Slide Package was developed and delivered to MSFC as a part of the slide file maintained in Sub-Task 1. Category SE-7 (Energy Data) in the Slide Catalog Reference File deals with this subject. New and more current energy information and predictions from the Statistical Abstract, the Energy Research and Development Administration, and other reliable information sources were included. The slide package with its "Story Board" has been delivered to MSFC (See Attachment F). Its maintenance and updating is a constant endeavor for the UAH.

C. TASK III - LITERATURE SURVEY OF TYPES AND PERFORMANCE OF SOLAR RADIATION MEASURING EQUIPMENT

This task was added to the contract in June of 1976 with a six-month period of performance. Basically, it was divided into three sub-tasks: firstly, to add to the existing list of equipment any known additional solar radiation measuring equipment; secondly, to expand that list to include sensor type and description, manufacturer specifications, cost and requirements; the third sub-task was to use published literature to the maximum extent to develop a method for ranking the equipment as to performance and cost.

PURPOSE

The field of solar energy is experiencing a sudden and accelerated growth period. There are numerous industries, research centers and private individuals engaged in development activities. Many new measuring devices are being developed and need to be brought to the notice of all those concerned.

APPROACH

A comprehensive list of equipment manufacturers was developed and a questionnaire sent to each one. The purpose of the questionnaire was not only to acquire information on new equipment that the particular manufacturer might have, but also to identify any other manufacturers.

ACTIVITIES AND PROGRESS

A Preliminary Listing of Solar Radiation Measuring Equipment was prepared and distributed to participants at the ERDA National Solar Energy Workshop held in Huntsville in May 1976 and coordinated by the UAH. As a result of that action and the questionnaire sent to manufacturers, further equipment was identified and a format was developed to provide a standard description of each model. The final report, "Listing of Solar Radiation Measuring Equipment and Glossary", was prepared and published by the UAH and delivered to MSFC. Thirty-eight manufacturers or distributors were identified and their products listed and compared for use, availability, cost, accuracy, reliability and other pertinent factors. The period of performance for Task III ended on December 31, 1976.

CONTRACT EXPENDITURES

The funding for Task III during the period June 1976 through 31 December 1976 was $8,000.

BLANK

D. TASK IV - CATALOG OF SOLAR RADIATION DATA SOURCES

Task IV was added to the basic contract in June of 1976 for a period of performance of six months. The need for this task was established when the government agencies involved with solar energy R&D recognized that there were numerous individuals and organizations gathering solar radiation data that were not being archived by the National Weather Service (NWS).

APPROACH

In Task I of the MSFC Contract NAS8-31293 which is gathering data to be used for solar energy system analysis, National Weather Service solar irradiation has been acquired for inclusion in the MSFC Data Base. Because of the admitted questionable quality of the available NWS data, an in-house project was initiated concurrently by the UAH to locate other potentially useful irradiation data. Task IV expanded that search and provided funding for the preparation of a catalog containing the results.

ACTIVITIES AND PROGRESS

A preliminary listing of the locations already identified was prepared and distributed to interested parties for their additions and comments. This list was compared to a revised list from the NWS and a meeting was held with UAH, MSFC, ERDA, and NOAA representatives to evaluate the resulting data. Besides the 150 solar radiation stations archived by the NWS, 166 additional stations were identified through this project. (See Attachment G). A final report entitled,"Solar Radiation Observation Stations with Complete Listing of Data Archived by the National Climatic Center, Asheville, N. C. and Initial Listing of Data Not Currently Archived", was prepared, published by the UAH, and submitted to MSFC in November 1976. The period of performance for Task IV ended December 31, 1976.

CONTRACT EXPENDITURES

Funding for Task IV for the period June 1976 through December 31, 1976, was $12,000.

B L A N K

E. TASK V - COMMERCIAL DEMONSTRATIONS DESIGN REVIEW

This task was added to the contract in June of 1976. It is basically a coordination of the efforts of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE) and the AIA Research Corporation in making technical evaluations of and offering advice to the 32 non-residential demonstration sites under MSFC management.

PURPOSE

The purposes of the task are: first, to help assure the successful operation of the solar heating and cooling systems; second, to obtain maximum usage of the data collected by dissemination to the public; and third, to assure an optimum cost-effectiveness of the demonstration projects.

APPROACH

A group of qualified designers and installers of HVAC systems was selected to support the design review needs of the commercial demonstration program. Each visit to a selected site results in a short summary report on the experts' recommendations for design improvements. A comprehensive questionnaire was also developed and submitted to all site contractors to help the government program managers to assess problem areas and improve later project cycles.

ACTIVITIES AND PROGRESS

As of March 31, 1977, ASHRAE and AIA Research representatives had participated in design and cost evaluations of 14 demonstration sites. Reports had been submitted to MSFC on the results of 13 of these visits

Following is a list of the sites where design reviews have been held:

Irvine Elementary School, Irvine, California
Tempe Union High School, Tempe, Arizona
Kansas City Fire Station No. 46, Kansas City, Missouri
RKL, Inc., Moorestown, New Jersey
Hogates Restaurant, Washington, D. C.
El Camino Real Elementary School, Irvine, California
Trinity University, San Antonio, Texas
Olympic Engineering, Richland, Washington
Mt. Rushmore Park National Park, Rapids City, South Dakota
Corona Del Sol High School, Tempe, Arizona
Alabama Power Company, Montevallo, Alabama
Frenchmans Reef Hotel, St. Thomas, Virgin Islands
Reedy Creek Utilities Division, Disney World, Buena Vista, Florida

The UAH will continue to work closely with MSFC, ASHRAE, and AIA Research, Inc. to identify, evaluate and minimize problems in design, applications, and costs in the Systems Development and Commercial Demonstration Programs.

Task V Expenditures

Contract funding for the period of performance July 1, 1976 through April 1977 amounted to $73,317. A further effort to be funded through April 1978 for $80,000 is under negotiation.

B L A N K

F. TASK VI - SOLAR ENERGY HEATING MODULE DEVELOPMENT

Task VI was initiated January 1, 1977. It required the UAH to furnish management, research, design, engineering and implementation expertise to build and install a solar space heating module at a local commercial site. The Alabama Space and Rocket Center, one of the nation's largest tourist attractions and a state designated energy information center, was selected for the site. The value of this project is multiplied when consideration is given to the impact that such exposure to solar energy and its capabilities will have on visitors from all over the nation.

The heating system structure is modular in design and accommodates all components and subsystems. Extensive insulation minimizes heat losses in the structure, the storage, and the fluid handling subsystems. The design also allows easy installation and removal of all major subsystems, such as collectors, the storage tank, and the air handler and duct assembly. The structure itself can be used for numerous applications, including use as a storage facility, workshop, utility shed, etc. In the demonstration, it is being used for space heating of the "Lunar Odyssey" space ride which simulates a trip to the moon (See Figure 5) and provides hot water for general use at the Center.

The UAH project team for this task designed the heating module to accommodate a liquid solar collector and storage system although air collectors and storage could also be incorporated into the basic design for other applications. Some 500 gallons of hot water storage will provide a year around source of wash water for tour busses and mobile exhibit vans stationed at the Alabama Space & Rocket Center, in addition to meeting the primary space heating requirements.

The solar collector array of 240 square feet now uses five of the Ying Manufacturing Corporation solar collectors which were furnished by the Marshall Space Flight Center as subsystems from the inventory of solar collectors now being used in the systems development program. All other components, materials and subsystems were acquired by the UAH Task Team and installation and checkout was accomplished as a joint effort by the UAH team, local contractors, and personnel of the Alabama Space and Rocket Center.

The unit is designed to demonstrate the functions and capabilities of the various subsystems, including the solar collectors, manifolds, pumps, controls, storage, heat transfer fluids and heat exchangers through the use of color coding and descriptive layouts of the various system elements.

A complete set of engineering drawings have been prepared which can be provided along with descriptive brochures, performance data, and various application layouts for do-it-yourself projects by individuals or for production of standard modules by utility shed manufacturers, mobile and manufactured home industries, solar collector companies and other organizations.

The following illustrations show the current installation details of the module and other possible applications now under consideration.

Task VI Expenditures

Contract funding for Task VI for the period of performance 1 January 1977 to 30 June 1977 will amount to $20,000.

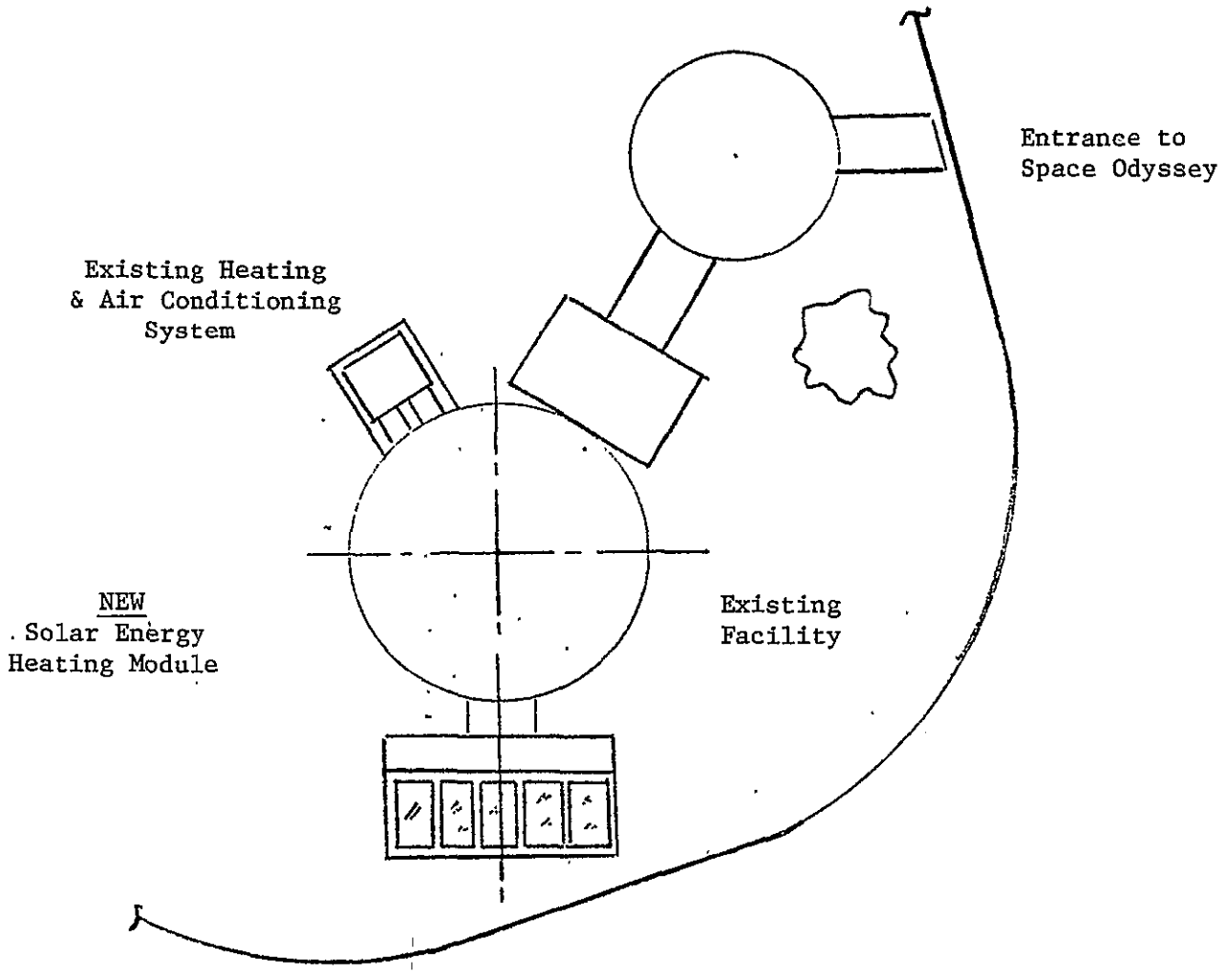
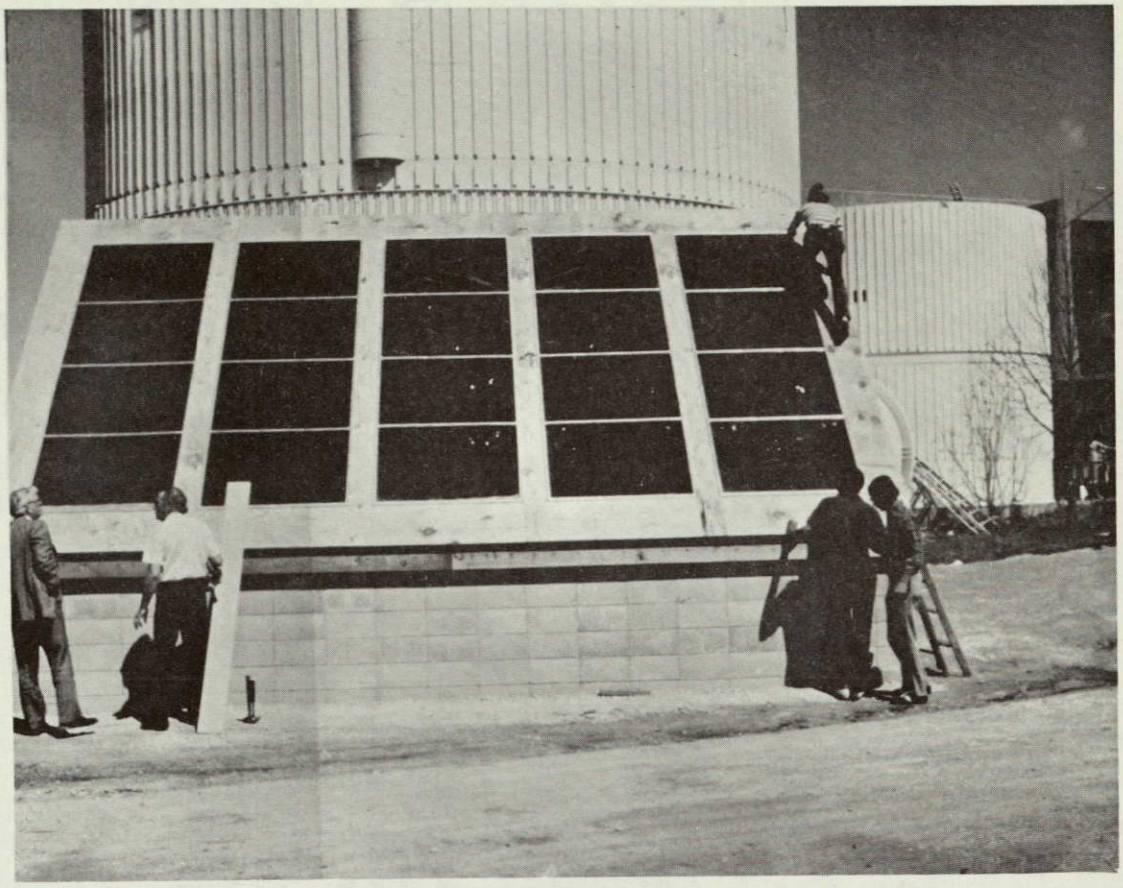
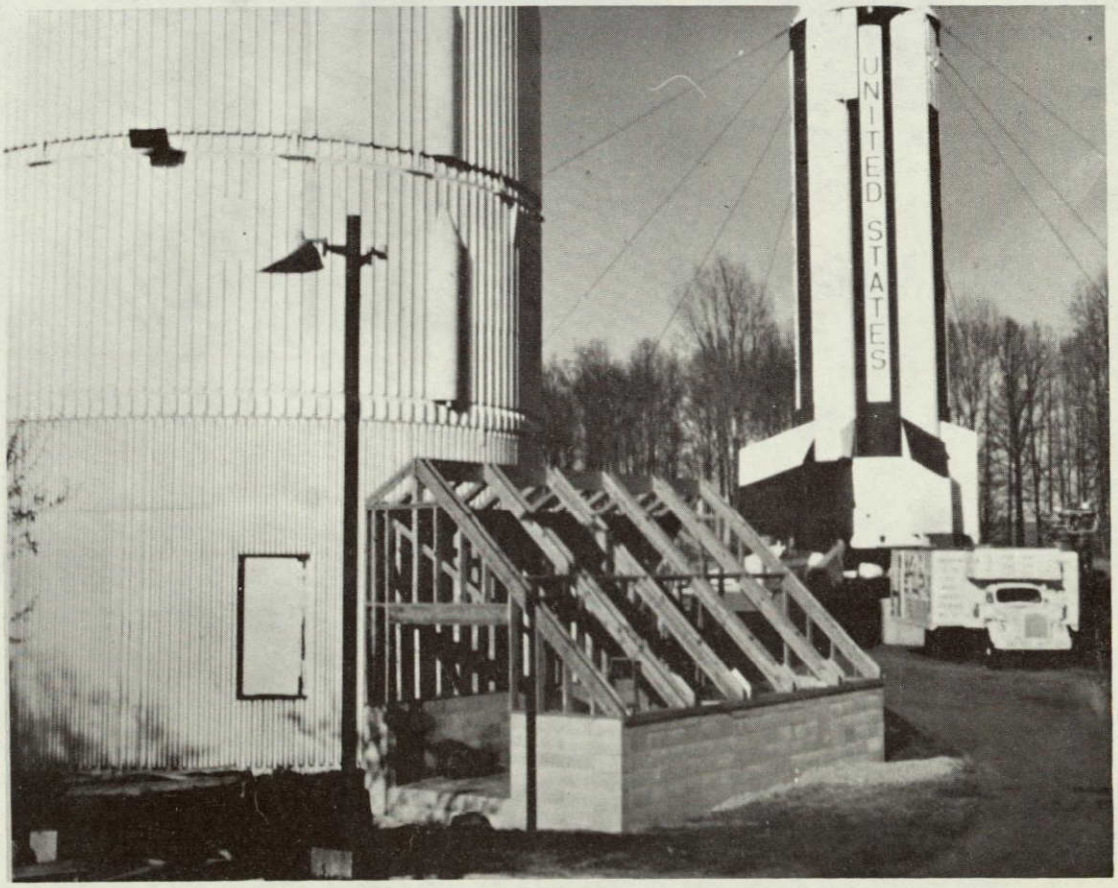


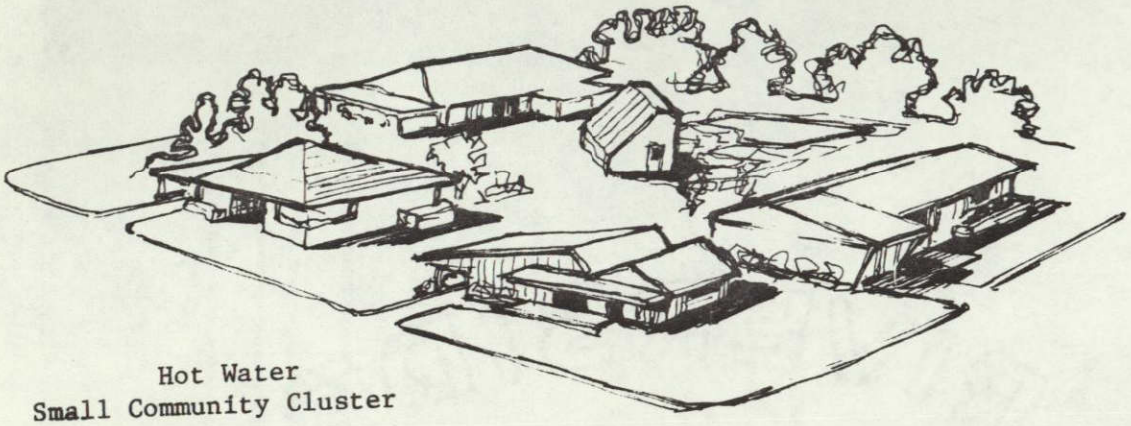
FIGURE 5

LAYOUT PLAN OF SOLAR ENERGY HEATING MODULE



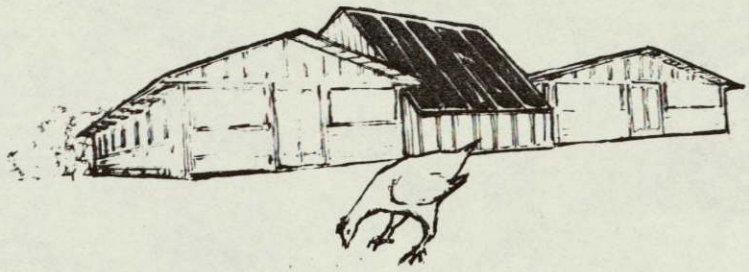


Heating and Hot Water
Single Family Residence

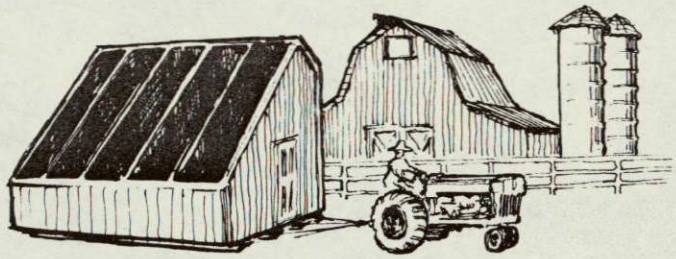


Hot Water
Small Community Cluster

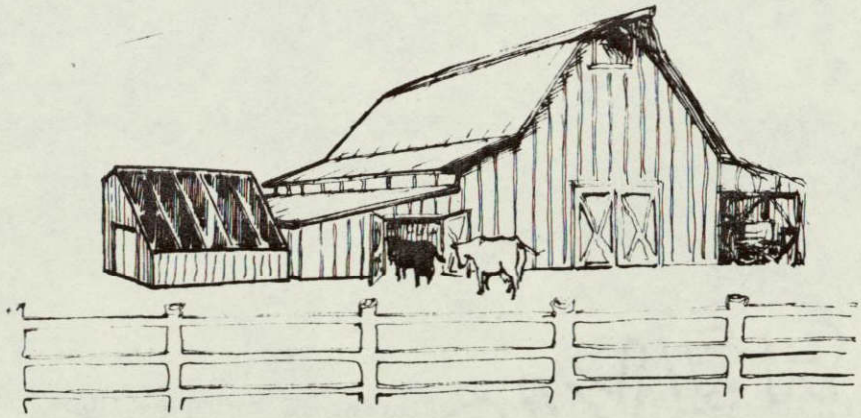
Hot Water
Mobile Home Park Laundry



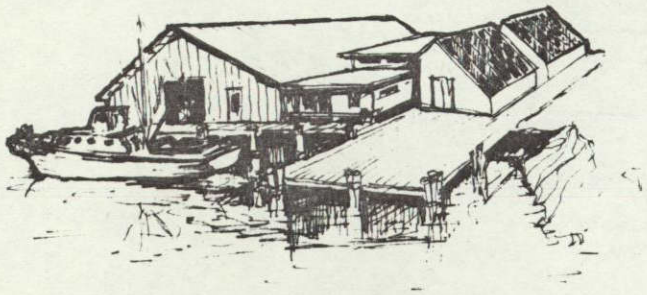
Space Heating
Chicken Brooders



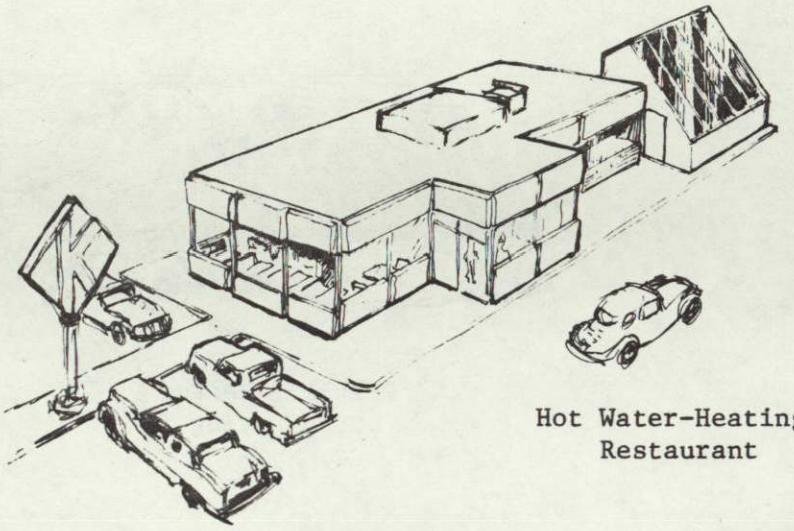
Portable Heater
Crop Drying



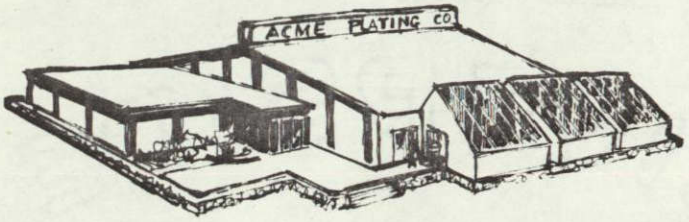
Hot Water
Dairy Operations



Hot Water
Canning Operations

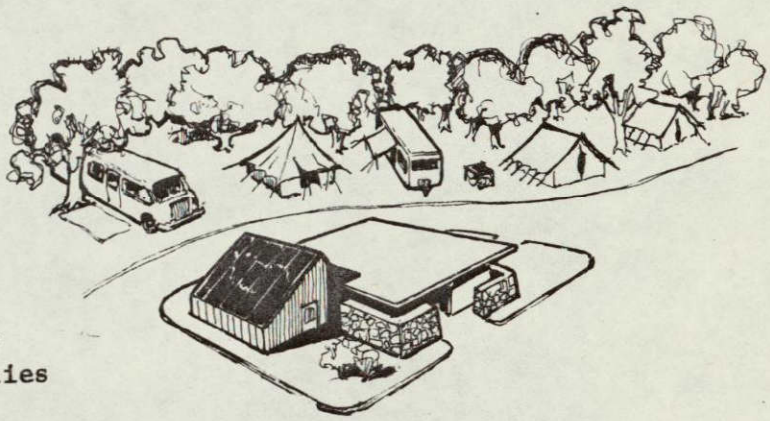


Hot Water-Heating
Restaurant

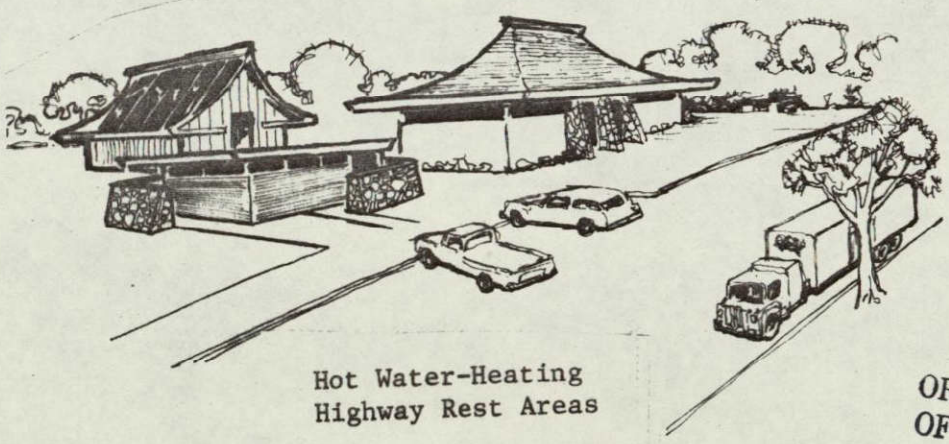


Hot Water
Plating-Film Processing

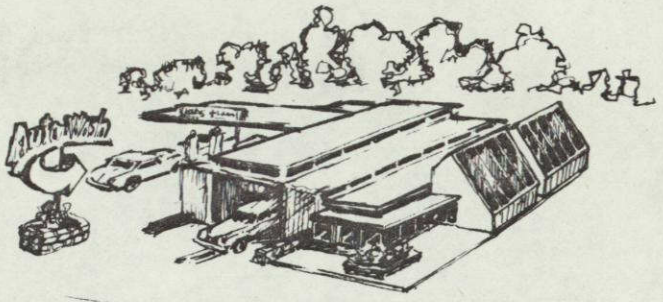
Hot Water-Pool Heating
Motel-Hotel



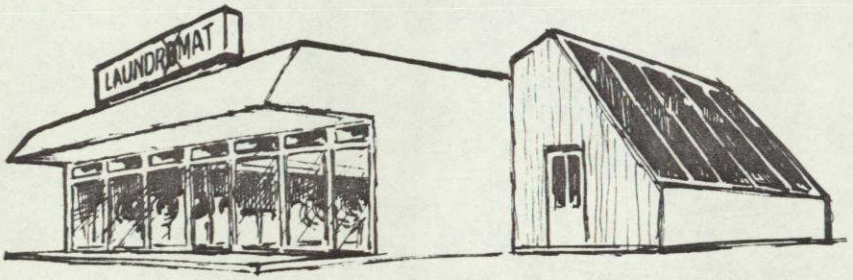
Hot Water
Camper Facilities



Hot Water-Heating
Highway Rest Areas



Hot Water
Automobile Washing Facility



Hot Water-Heating-Drying
Automatic Laundry Facility

REFERENCES

1. Bell, R. S., "Preliminary Listing of Solar Radiation Measuring Equipment".

2. Breithaupt, W. G., Redstone Arsenal Solar Radiation Data, May-October 1976 (UAH Technical Note).

3. Carter, E. A., R. E. Wells, B. B. Williams, "Catalog of Solar Radiation Data Sources", May 1976.

4. Carter, E. A., S. A. Greenbaum, A. M. Patel, "Listing of Solar Radiation Measuring Equipment and Glossary", July 1976.

5. Carter, E. A., R. E. Wells, B. B. Williams, "Solar Radiation Observation Stations with Complete Listing of Data Archived by the National Climatic Center, Asheville, North Carolina, and Initial Listing of Data not Currently Archived", November 1976.

6. Carter, E. A., W. G. Breithaupt, C. S. Dahagam, A. M. Patel, "Catalog of Solar Radiation Measuring Equipment", April 1977.

7. Christensen, D. L., E. Stuhlinger, "Executive Summary of the National Solar Energy Workshop - ERDA Division of Solar Energy and State Energy Offices", July 1976.

8. "Proceedings of the National Solar Energy Workshop of the ERDA Division of Solar Energy and the State Energy Offices held in Huntsville, Alabama, May 19-21, 1976", edited by D. L. Christensen, October 1976.

9. Solar Heating and Cooling Technical Data and Systems Analysis - Contract NAS8-31293 - Progress Report, June 1976.

10. Solar Heating and Cooling Technical Data and Systems Analysis - Contract NAS8-31293 - Presentation Charts, September 12, 1976.

11. Solar Radiation Research and Related Projects in Support of National Solar Energy Goals - Progress Report, January 1 - March 31, 1977.

ATTACHMENTS

ATTACHMENT A - Abstracts of Solar Energy Systems Simulation Programs

ATTACHMENT B - Solar Energy Collectors - Manufacturers, Experimenters, Sales Outlets

ATTACHMENT C - Preliminary Draft of Data Base User's Guide Brochure

ATTACHMENT D - Recommendations for MSFC Solar Energy Control Form and Equipment Draft - February 1976

ATTACHMENT E - MSFC Solar Energy Slide File Users' Manual

ATTACHMENT F - Total Energy Slide Package

ATTACHMENT G - Address List of Radiation Data Sources

ATTACHMENT H - UAH Solar Energy Activities - Summary

ATTACHMENT A

ABSTRACTS OF

SOLAR ENERGY SYSTEMS SIMULATION PROGRAMS

QUESTIONNAIRE INSTRUCTIONS

1. Program Identification: In the upper left hand corner of the form in the space provided, type the name of the solar energy systems analysis program.

2. Code: In the upper right hand corner of the form in the box provided, do not type anything.

3. Date: In the box provided type the date of the day of filling out the questionnaire.

4. Source - Address - Key Contact - Phone: In the space provided type the name, division and mailing address of company or institution. Also type name of the person or office and telephone number to be contacted for further information.

5. Application Area: In the space provided type the area of program application.

6. Program Status: In the space provided, type answers to questions listed:

   a. Program Language: The name of computer language used in the program described.

   b. Computer Specification: Required machine specifications, in order to run the program described.

   c. Input Requirement: Input requirement for the program described to perform the described analysis.

   d. Output of Program: Computer output information of the program described.

   e. Program Limitations: Any limitations on the program applications.

7. Cost: In the column provided, type answers to questions listed:

   a. Purchasing Cost ($): The updated cost ($) of the program described.

   b. Leasing Cost ($/year): The updated cost ($/year) of lending the program described.

   c. Delivery Time (Days): The time period (days) required to deliver the program described after receiving the order.

8. Abstracts: In the space provided, type the abstracts of the program described above. Add more pages if needed.

Summary Matrix
of
Simulation Program Capabilities

Program Name	Program Language	Source	System Mod.	System Generic	Load Calc.	Tech. Perf. of Solar Component	Econ. Eval.	Sys. Perf.	Cost
TRNSYS	FORTRAN	U. of Wisc.	X		X	X		X	$200
F-CHART	FORTRAN	U. of Wisc.		X	X	X	X	X	$100
SOLRI	FORTRAN	A. D. Little		X		X		X	$1000
MINISHAC	APL	IBM/Huntsville		X			X	X	
CERES	APL	IBM/Huntsville					X		
CAP	APL	IBM/Huntsville					X		
LOCKHEED	FORTRAN	LOCKHEED/ Huntsville		X				X	Government Development
SHACSAC-1	FORTRAN	Charles Stark Draper Lab, Inc.		X	X	X	X	X	
SIMSHAC	FORTRAN	Colorado St. University	X		X	X		X	
SOLSYS	FORTRAN	Sandia Lab NM	X		X	X		X	Government Development
SUN	FORTRAN	Berkeley Solar Group CA		X	X	X		X	
SOLAR-LASL	HYBRID/ FORTRAN	Los Alamos SCI Lab		X	X	X		X	Government Development
SOL COST	FORTRAN	IBS - Washington	X		X	X	X	X	$70/Serv.

Program Identification	Code
TRNSYS	
	Date 11/1/76

Source - Address - Key Contact - Phone

Solar Energy Laboratory (608) 263-1589
University of Wisconsin
Engineering Research Building
Madison, Wisconsin 53706 Attention: Thomas Freeman

Application Area

Solar Energy Thermal Performance Simulation

Program Status

Program Language	FORTRAN IV
Computer Specification	~35K Words Core
Input Requirements	Hourly card images of meteorological data (solar radiation and ambient temperature)
Outputs of Program	User specified thermal performance data printed and/or plotted at user specified intervals.
Program Limitation	Presently limited to solar energy thermal processes.

Cost

Purchasing Cost ($)	$200	Delivery Time (Days)	10 days
Leasing Cost ($/year)			

Abstracts TRNSYS, a program for simulating the dynamic thermal behavior of transient systems, is a general program for solving sets of differential and algebraic equations which describe solar energy systems. It is based on a modular approach which enables the user to readily simulate a wide variety of systems. The program consists of component models (for collectors, controls, storage tanks, heat exchangers, furnaces, building loads, integrators, recorders, etc.) and an executive routine.

The designer selects his components and the design parameters describing the components, and specifies in a simple fashion the way in which the components are interconnected. The whole process is analogous to specifying an experimental system. The designer also selects the information he wants from the simulation, again in a manner analogous to a physical experiment, and includes the appropriate instrument components in his simulation.

A-3

Program Identification	Code
F-CHART	
	Date January 7, 1977

Source - Address - Key Contact - Phone

Solar Engineering Laboratory
University of Wisconsin - Madison, WI 53715
Attention: Patrick J. Hughes
Phone: (608) 263-5626

Application Area

Economic analysis and thermal analysis for heating and hot water application of solar energy. Air systems and liquid systems can both be simulated. Built-in system optimization routine available.

Program Status

Program Language	FORTRAN II
Computer Specification	Compatible with any digital computer
Input Requirements	Maximum input requirements are 38 parameters regarding solar system, building, geological, climatological and economic data.
Outputs of Program	Optimized collector size, thermal analysis showing percent solar per month, economic analysis showing savings by solar energy utilization
Program Limitation	No cooling application. Load calculation of one-zone model is used.

Cost

Purchasing Cost ($)	$100.00	Delivery Time (Days)	1 week
Leasing Cost ($/year)	N/A		

Abstracts

Program available to anybody. Program is written in interactive mode. Consulting fee is required for complete program set-up, if needed. Basis of this program is F-CHART method developed by extensive solar hot water and heating application simulations via TRNSYS program by Duffie/Beckman group. User must supply data at the terminal by simply typing "yes" or "no" to given questions (38 questions are built-in). Easy to use for non-technical personnel. Computation time is short, and usually costs not more than $2.00/run. Weather data for 126 cities throughout U.S. and Canada are built in. Additional weather data can be easily incorporated.

A-4

Program Identification	Code
SOLR1	
	Date Nov. 16, 1976

Source - Address - Key Contact - Phone

Arthur D. Little, Inc. (617) 864-5770 X 887
20 Acorn Park
Cambridge, Massachusetts 02140 Attention: Richard Merriam

Application Area

Simulation of solar heating and cooling systems.

Program Status

Program Language	FORTRAN
Computer Specification	IBM 370
Input Requirements	Specially prepared weather tape containing hourly weather parameters.
Outputs of Program	Energy balances on monthly basis. Percent solar, storage losses, collection efficiency
Program Limitation	Uniform temperature thermal storage, one-zone building model.

Cost

Purchasing Cost ($)	$4,000	Delivery Time (Days)	10 days
Leasing Cost ($/year)			

Abstracts

Program only available to sponsors of all Phase I Solar Climate Control Project (present cost = $7,500). Dynamic model, predicting hourly energy flows between system components and transient temperatures within residence. Components modeled include various types of collectors, storage, heat-actuated air conditioner, heat pump (including solar-assist model), building, controls, pumps, heat exchangers, downstream meter heater, conventional residence and HVAC system. Weather data includes dry bulb, wet bulb, humidity, wind, solar flux components.

A-5

Program Identification	Code
MINISHAC	
	Date November 16, 1977

Source - Address - Key Contact - Phone

IBM/Huntsville
Research Park
Huntsville, Alabama 35805
Attention: J. E. Irby and J. M. Nash
Phone: (205) 837-4000

Application Area

For heating and hot water application only. Based on F-CHART method. Percent solar, operating cost for initial site/system selection.

Program Status

Program Language	APL (A Program Language)
Computer Specification	IBM-370
Input Requirements	System baselines, site characteristics (weather, economics, sybsystem characteristics, load, modification to system baseline
Outputs of Program	Long term overall system economics, site selection, system and site matching.
Program Limitation	No cooling application. Load calculation of one-zone model

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Abstracts

A part of IBM/Huntsville unified simulation capability system analysis program for solar heating and cooling. Philosophy based on F-CHART method. Very similar to F-CHART program of the University of Wisconsin. Weather and economic data of 112 sites are pre-programmed. Access to the program by general user is not known.

Program Identification	Code
CERES	
	Date November 16, 1976

Source - Address - Key Contact - Phone

IBM/Huntsville - (205) 837-4000
Research Park
Huntsville, Alabama 35805
Attention: J. E. Irby and J. M. Nash

Application Area

Applicable for hot water, heating and cooling application. Generates system merit factor (SMF) which serves as basis for all performance comparison and grades. Final link to tying technical economic, and performance factors together.

Program Status

Program Language	APL (A Program Language)
Computer Specification	IBM-370
Input Requirements	Conventional and auxiliary energy requirements generated by TRNSYS/SOLAR system simulator. Local utility rates, capital costs, and other economic data (insurance, tax, etc.)
Outputs of Program	System Merit Factor (SMF). Initial investment payback period.
Program Limitation	No built-in collector system optimization.

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Abstracts

CERES (Comprehensive Economic Recovery Evaluation System) is a part of IBM/Huntsville's Unified Simulation Capability System Analysis Program. It is comprised of two major routines: performance analysis and consumer economics. For a given solar design and site with actual local climatological data, heating/cooling requirements are generated by simulation code (TRNSYS/SOLAR). Then, economic data (initial cost, insurance, tax, inflation rate, maintenance cost, etc.) are entered together to produce SMF factor, cost comparison (solar/conventional) and sensitivity analysis to changes in design parameters/economic conditions.

A-7

Program Identification	Code
CAP	
	Date November 16, 1977

Source - Address - Key Contact - Phone

IBM/Huntsville
Research Park
Huntsville, Alabama 35805
Attention: J.E.Irby and J.M.Nash

Phone: (205) 837-4000

Application Area

Provides market penetration of a particular solar system or group of systems. There are nine market sectors (single family, multiple family, commercial, school, etc.) providing best potential benefit of money spent in solar applications.

Program Status

Program Language	APL (A Programming Language)
Computer Specification	IBM-370
Input Requirements	System Merit Factor (SMF) from CERES ROUTINE,
Outputs of Program	Regional market capture (dollar value of solar systems utilized)
Program Limitation	Only works with other economy analysis programs (FCHART, MINISHAC, CERES, SOLAR, TRNSYS, etc.)

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Abstracts

CAP (Capture Analysis Program) uses two sets of relationships; the first represents probable percent penetration of a market sector (9 sectors are considered) as a function of SMF. (This data provided by A. D. Little, Inc.) The second represents market capture (dollars spent in solar application) as a function of market penetration level. (This data provided by NSF phase 0 studies). CAP is operational via interactive terminal. Changes in system performance affects SMF and therefore affect regional impact directly.

A-8

Program Identification

Lockheed-Huntsville
Solar Heating & Cooling Simulation

Code

Date 12/9/76

Source - Address - Key Contact - Phone

Lockheed Missiles & Space Co. (205) 837-1800 X 353
4800 Bradford Dr. N. W.
Huntsville, Alabama 35807
Attention: Paul O. McCormick

Application Area

Solar Heating and Cooling of Residences

Program Status

Program Language	FORTRAN
Computer Specification	None - Has run on IBM 7094, 1109, EAI 8400
Input Requirements	Weather data (daily) Building heat loss and gain parameters Solar components: characteristics and sizes
Outputs of Program	Hourly and daily energy collected, used (solar & auxiliary), storage temp., electrical power for pumps and blowers.
Program Limitation	Uses lump node analysis for building loads & response to heat input.

Cost Not for sale. It is available (as are all programs developed under government funding) through normal channels.

Purchasing Cost ($)		Delivery Time (Days)	
Leasing Cost ($/year)			

Abstracts

The program obtained widespread publicity because of the association with the NASA demonstration; a number of investigators have expressed a desire to use the program for their particular applications. However, due to the specialized application for which it was written, the program has limited use as a general purpose solar systems simulation program.

Ref: "Modifications to the Lockheed-Huntsville Solar Heating and Cooling System Simulation Program", P. O. McCormick, July 7, 1975 (NSF/RANN/SC/C-898/HR/95/2)

A-9

Program Identification	Code
SHACSAC-1	
	Date. 29 October 1976

Source - Address - Key Contact - Phone

The Charles Stark Draper Laboratory, Inc.
555 Technology Square, Cambridge, Massachusetts 02139
David R. Fairbanks, MS 37, (617) 258-1422

Application Area

Solar heating and cooling systems analysis for System #1; repetitive simulations with varied parameters, to find sensitivities and/or minimum life-cycle system cost.

Program Status

Program Language	Fortran IV G
Computer Specification	IBM 360/75 or equivalent
Input Requirements	Fixed parameters initialized internally, do loops added for parameter variations; National Climatic Center weather tape.
Outputs of Program	System values each time step, plots, summary printout of costs, energies, performance factors.
Program Limitation	Special purpose program for System #1 only.

Cost

Purchasing Cost ($)	Undefined	Delivery Time (Days)	Undefined
Leasing Cost ($/year)	Undefined		

Abstracts

First of a series of programs, each for a specific solar HVAC system arrangement, using minimized computer time. Generates internal or uses external building load timelines, simulates system transient behavior for one year using hourly weather data and imposed control strategy, accumulating energies. Determines annualized first installed costs, maintenance costs, energy costs, and total life-cycle costs. System #1 is for a two-pipe building using unitary heat pumps. Execution time for a one-year simulation at one-hour time steps is 0.6 minutes with 550K region, or 1.0 minute with 150K region.

A-10

Program Identification	Code
SIMSHAC	
	Date January 4, 1977

Source - Address - Key Contact - Phone

Dr. Gearold R. Johnson
Mechanical Engineering Department
Colorado State University
Fort Collins, CO 80523

Application Area

Dynamic simulation for performance analysis of solar heating and cooling applications.

Program Status

Program Language	FORTRAN
Computer Specification	CDC6000, CYBER 70, IBM-370
Input Requirements	Component descriptions, parameters and connecting geometry building thermal characteristics, weather data.
Outputs of Program	Tables of system performance, temperature and flow rate for most critical system components.
Program Limitation	Designed specifically to simulate CSU solar house demonstration.

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Abstracts

SIMSHAC (Simulation Model for Solar Heated And Cooled building)
Program can be obtained by requesting a documentation from CSU. Special features of this program include a model of the enclosure (building, etc.) for determining heating and cooling requirements by using actual weather data. Three types of solar radiation data can be used; a) deterministic, b) random simulation model based upon cloud cover, and (c) actual tabulated data. This program is not as modular as TRNSYS but some degree of flexibility does exist for systems similar to CSU solar house.

A-11

Program Identification	Code
SOLSYS	
	Date January 6, 1977

Source - Address - Key Contact - Phone

M. W. Edenburn (505) 264-5678
Solar Energy Div. 5717
Sandia Lab.
Albuquerque, NM 87115

Application Area

Program is developed for simulating the transient preformance of solar energy systems.

Program Status

Program Language	FORTRAN IIT
Computer Specification	CSC 6600 Scope 3.3
Input Requirements	Solar system configuration. Thermal load requirements. Weather data.
Outputs of Program	Dynamic characteristic of solar systems. Energy saved by solar.
Program Limitation	Maximum 80 components; no economic analysis.

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Available from:
Argonne Nat. Lab. Computer Code Dissemination Center

Abstracts

SOLSYS consists of a component routine library (fluid handling components), an information routine library (weather data, coding and heating requirements, etc.), a control-component subroutine library (controller of thermostat, flow switches, etc.) and an executive program which handles input and output and calls on subroutines. SOLSYS is flexible in changing configuration modification; components parametric studies are easily performed.

A-12

Program Identification	Code
SUN	
	Date June 6, 1977

Source - Address - Key Contact - Phone

Charles S. Barnaby
Berkeley Solar Group
1815 Francisco Street
Berkeley, CA 94703

Application Area

Very primitive and inexpensive estimation of solar energy system performance for hot water and heating application.

Program Status

Program Language	FORTRAN IV
Computer Specification	CSC 6400
Input Requirements	Averaged weather data. Solar system component parameters, building loads parameter.
Outputs of Program	Echo of all inputs, monthly printout of system behavior during a typical day. Annual summary printout with monthly and yearly totals.
Program Limitation	Solar system model is simpel; no economic analysis; no cooling application.

Cost

Purchasing Cost ($)	Not known *	Delivery Time (Days)	Not known
Leasing Cost ($/year)	Not known		

*Program available through contact with Berkeley solar group.

Abstracts

SUN is developed to provide an inexpensive simulation program. Main components are a building without mass, a flat plate collector, a heat exchanger and an isothermal storage tank. Basic theory is based on Lin and Jordan.

A-13

Program Identification	Code
SOLAR - LASL	
	Date January 6, 1977

Source - Address - Key Contact - Phone

Hugh S. Marray and James P. Shipley
Los Alamos Scientific Lab.
Los Alamos, NM 87544 (505 667-5061

Application Area

Dynamic modeling of building and energy system (solar with conventional) to systematically examine dynamic behavior of entire system to different control system configurations.

Program Status

Program Language	Hybrid analog/digital
Computer Specification	Digital computer
Input Requirements	Solar system characteristics, detailed building description, statistical climatological data.
Outputs of Program	Basis for dynamic energy balance on building air, flow logic, sensor behavior and other control logic data.
Program Limitation	No optimization capability for system design and economic evaluation, generic code.

Cost

Purchasing Cost ($)	N/A	Delivery Time (Days)	N/A
Leasing Cost ($/year)	N/A		

Abstracts

This program is designed specifically for a system analysis of the National Security and Resources Lab (60,000 ft^3 concrete structure). Contains particularly detailed HVAC modeling. Control logics are emphasized. To minimize computation, reduced system approach is used with good results.

A-14

Program Identification	Code
SOLCOST	
	Date January 6, 1977

Source - Address - Key Contact - Phone

Charles E. Hansen (202) 628-1470
International Business Service
1010 Vermont Ave. N. W., Suite 1010
Washington, D. C. 20005

Application Area

Residential solar heating and cooling; provides optimal collector system of life cycle cost analysis and building load calculation.

Program Status

Program Language	FORTRAN IV
Computer Specification	CDC, IBM, UNIVAC
Input Requirements	Historical weather data; physical description of building; solar system data; financing data.
Outputs of Program	Cost, optimum collector area, storage tank size, load type, payback period, rate of return, cash flow, life cycle cost analysis.
Program Limitation	No detailed solar performance simulation possible.

Cost

Purchasing Cost ($)	N/A *	Delivery Time (Days)	XXX
Leasing Cost ($/year)	XXX	approx. $70/service	

*Soon will be available via CYBERNET and EEIS networks.

Abstracts

SOLCOST is a public domain computer design program written for residential solar heating and cooling simulations. Statistical weather data is used to minimize computer time. Provides four analysis options; a) standard solar analysis for optimum collector system characteristics and cash flow; b) Collector Trade Analysis for selecting collector type and size; c) financial analysis for system performance and life cycle cost analysis and, d) passive structure analysis for load requirement estimates for passive solar applications.

A-15

Program Identification	Code
Solar Weather	
	Date 6 November 1976

Source - Address - Key Contact - Phone

Sungineering Co.
Stafford Rd.
Wales, Massachusetts 01081
Attention: Dr. Michael McClintock Tel. (617) 353-2222

Application Area

Weather data input for Solar Energy Simulations

Program Status

Program Language	Fortran	
Computer Specification	Program requires at least 20 K usable storage	
Input Requirements	No. of years of wx. data No. of months of wx. data Latitude of wx. data	Time of day of min. temp. Slope for incident radiation Azimuth for incident radiation Time of day of max. temp.
Outputs of Program	Probability of sequence info. Occurence frequency info. Best length of week.	Occurrence distribution info. The most probable week. Hourly breakdown of week.
Program Limitation		

Cost

Purchasing Cost ($)	465.00	Delivery Time (Days)	10 days
Leasing Cost ($/year)	N/A		

Abstracts

Solar Weather is a 600-card Fortran program having the ability to analyze any number of years of weather data for a particular month. The analysis results in a typical "week" representative of that month. Twelve of these weeks may be strung together to form a typical year.

The program has been designed to fulfill a twofold purpose. The first purpose being to typify the weather that occurs over an extended period of time, thus best representing the weather of the past and very probabaly of the future. The second purpose is to save costly computer time when one is using weather data as an input to any computer simulation.

Verification simulations were done resulting in differences of less than 7% when compared with other methods of weather data input. Savings in computer time were in the 75% range.

A-16

Program Identification

SOLAR WATER HEATER FT 12

Code

Date 6 November 1976

Source - Address - Key Contact - Phone

Engineering Faculty,
University of Malaya,
Kuala Lumpur 22-11
Attention: Dr. K. S. Ong

Application Area

Water Heating

Program Status

Program Language	Fortran
Computer Specification	IBM 1130
Input Requirements	Varied to suit
Outputs of Program	Varied to suit
Program Limitation	Thermosyphon- flow solar water heater

Cost

Purchasing Cost ($)		Delivery Time (Days)	
Leasing Cost ($/year)			

Program not commercially available as yet. In process of updating.

Abstracts

To evaluate thermal performance of natural - convection (thermosyphon-flow) solar water heaters.

A17

ATTACHMENT B

SOLAR ENERGY COLLECTORS -

MANUFACTURERS

EXPERIMENTERS

SALES OUTLETS

COLLECTOR CLASSIFICATION	ABSORBER	HEAT TRANSFER FLUID	COST RANGE - $/Ft^2						
			4	4.01 - 7	7.01-10	10.01-13	13.01-18	18.01-25	25
FLAT PLATE	NON-METALLIC	LIQUID	8,16,17 37,44,144 157,174	85			55		
		AIR							115
	METALLIC	LIQUID	57,62	46,96 106,168 193	35,64,67, 90,91,95, 136,153, 175,180, 181	25, 61,76,92, 114,187	4,5,6,7, 12,19,105, 107,109, 117,184	50,87, 155,178,	
		AIR		22,111, 113,123, 132	45,72, 91,173, 181	119,154			
CONCENTRATOR	METALLIC	LIQUID				158,166	66	66	2

MANUFACTURERS OF SOLAR ENERGY COLLECTORS

1. AAI Corporation
   P. O. Box 6767
   Baltimore, MD 21204
   Attn: I. R. Barr
   (301) 666-1400

2. Alpha Designs, Inc.
   1014 Vine St., Suite 2230
   Kroger Building
   Cincinnati, OH 45202
   Attn: Miroslav Uroshevich
   (513) 621-1243

3. Aluminum Company of America
   1501 Alcoa Building
   Pittsburgh, PA 15219
   Attn: Bill Foster
   (412) 553-3185

4. American Heliotherm, Inc.
   3315 South Tamarac Drive
   Suite 360
   Denver, CO 80237
   Attn: George Eldridge
   (303) 773-6085

5. American Solar King Corp.
   6801 New McGregor Highway
   Waco, TX 76710
   Attn: Brian D. Pardo
   (817) 776-3860

6. American Solar Power, Inc.
   5018 West Grace St.
   Tampa, FL 33607
   Attn: Paul W. Arnold
   (813) 879-4943

7. Ametek
   1, Spring Avenue
   Hatfield, PA 19440
   Attn: John Bowen, Manager
   (215) 248-4600

8. Aquasolar, Inc.
   1234 Zacchini Avenue
   Sarasota, FL 33577
   Attn: G. J. Zella
   (813) 366-7080

9. ASG Industries
   P. O. Box 929
   Kingsport, TN 37662
   Attn: Patty Stewart
   (615) 245-0211

10. Astro Solar Corp.
    744 Barnett Dr.
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    Attn: Dick Dawley
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11. Aztec Solar Corp.
    P. O. Box 272
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    Attn: Jay Lipeles
    (305) 628-5004

12. Berry Solar Products
    P. O. Box 327
    Edison, NJ 08817
    Attn: Calvin C. Beatty
    (201) 549-3800

13. Beutel's Solar Heater Co.
    1527 No. Miami Ave.
    Miami, FL 33136
    Attn: Orvar Lindstrom
    (305) 885-0122

14. Brown Manufacturing Co.
    P. O. Box 14546
    Oklahoma City, OK 73114
    Attn: Russell Brown, Pres.
    (405) 751-1323

15. D. W. Browning Mfg. Co.
    475 Carswell Ave.
    Holly Hill, FL 32107
    Attn: Ike Johnson
    (904) 252-1528

16. Burke Rubber Company
    2250 So. 10th St.
    San Jose, CA 95112
    Attn: Larry Schader
    (408) 297-3500

17. Calmac Manufacturing Corp.
150 So. Van Brunt St.
Englewood, NW 07631
Attn: John Armstrong
(201) 569-0420

18. Capital Solar Heating, Inc.
376 No. W. 25th St.
Miami, FL 33127
Attn: Ronald Saifman
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19. Chamberlain
845 Larch Avenue
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Attn: Charles Franke
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20. Columbia Chase Corp.
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21. Consumer Energy Corp.
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22. Contemporary Systems, Inc.
68 Charlonne St.
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Attn: John Christopher
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23. Corning Glass Works
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Corning, NY 14830
Attn: Jim Murry, Manager
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24. CSI
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Clearwater, FL 33520
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(813) 577-4489

25. D & J Sheet Metal Company
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Miami, FL 33150
Attn: Jake Sticher
(305) 757-7033

26. Daystar
41 Second Ave.
Burlington, MA 01803
Attn: Clifton Smith, V.P.
Marketing
(617) 272-8470

27. Dynatherm Corporation
Marble Court off Industry Lane
Cockeysville, MD 21030
Attn: A. Streb, V. P.
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(301) 666-9151

28. E & K Service Company
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Bothell, WA 98011
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29. Emerson Electric Company
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30. Energy Applications, Inc.
830 Margie Dr.
Titusville, FL 32780
Attn: Napoleon P. "Nap" Salvail
(305) 269-4893

31. Energy Conservations Systems
of Colorado Springs, Inc.
327 W. Vermijo
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Attn: Peter O. Wood
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32. Energy Converters, Inc.
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33. Energy Design Associates, Inc.
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34. Energy Systems of America, Inc.
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35. Energy Systems, Inc.
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Attn: C. L. Caster
(714) 440-4646

36. Environpane, Inc.
348 No. Marshall St.
Lancaster, PA 17602
Attn: Joe Bond
(717) 299-3737

37. FAFCO, Inc.
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Mental Park, CA 94025
Attn: Freeman Ford
(415) 321-3650

38. Falkner, Inc.
6121 Alden Road
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39. Federal Energy Corp.
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40. Fern Engineering Co., Inc.
20 Perry Ave.
Buzzards Bay, MA 02532
Attn: Phillip Levine
(617) 759-7529

41. Fiberglass Engineering Co.
10223 Residency Road
Manassas, VA 22110
Attn: James D. Morris
(703) 361-1200

42. Flagala Corp.
9700 West HIghway 98
Panama City, FL 32401
Attn: H. G. Swicord
(904) 234-6559

43. Florida Solar Power, Inc.
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Tallahassee, FL 32301
Attn: W. P. Malloy
(904) 224-8270

44. Fun & Frolic, Inc.
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45. Future Systems, Inc.
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Director of
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46. Garden Way Labs
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47. General Dynamics
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48. General Electric
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49. General Energy Devices, Inc.
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Attn: E. D. Salsman
(813) 586-1142

50. Grumman Aerospace
Energy Program Plant 25
Bethpage, NY 11714
Attn: Gregg Knowles
Solar Group
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51. Gulf Thermal Corp.
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52. Halmac Company
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53. Halstead Industries, Inc.
Halstead & Mitchell Div.
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Attn: Otto Nussbaum
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54. Heliotherm Inc.
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Lenni, PA 19052
Attn: John Rodenhauser
(215) 459-9030

55. Hitachi Chemical Company
America, Limited
437 Madison Avenue
New York, NY 10022
Attn: H. Aburatani, Mgr.
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56. Honeywell, Inc.
Systems and Research Center
2600 Ridgeway Parkway
Minneapolis, MN 55413
Attn: Roger Schmidt, Mgr.
(612) 378-4078

57. Ilse Engineering Inc.
7177 Arrowhead Road
Duluth, MN 55811
Attn: John Ilse
(218) 729-6858

58. Illinois Institute of Technology
Institute of Gas Technology
3424 S. State Street
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Attn: Dr. Lavan
Associate Professor
Department of Mechanics
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59. Independent Living, Inc.
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Suite 205
Doraville, GA 30340

60. Industrial Erectors, Inc.
21877 Euclid
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61. International Environment
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President
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62. Intertechnology Corporation
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Marketing Operation
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63. Itek Corporation
Optical Systems Division
10 Maguire Road
Lexington, MA 02173
Attn: Norm Groalick
Engineer

64. J&R Simmons Construction Co., Inc.
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S. Daytona, FL 32019
Attn: John Simmons
Vice President
(904) 767-6367

65. Kalwall Corporation
1111 Candia Road
Manchester, NH 03105
Attn: Keith Harrison
Vice President
(603) 627-3861

66. KTA Corporation
12300 Washington Avenue
Rockville, MD 20852
Attn: Dr. W. E. Tragert
(301) 468-2067

67. Largo Solar Systems, Inc.
2525 Key Largo Lane
Fort Lauderdale, FL 33312
Attn: Ronald T. Hannivig
(305) 583-8090

68. Libbey Owens Ford
811 Madison Ave.
Toledo, OH 43695
Attn: Jerry Smith
(419) 247-3731

69. Lo-K Medallion Systems, Inc.
P. O. Box 188
Bellmont, NC 28012
(704) 825-5357

70. Martin Marietta Aerospace
Mail # 1610
Denver, CO 80201
Attn: R. L. Hulstrom
(303) 794-5211

71. Mathews Systems, Inc.
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Gainesville, FL 32602
Attn: Dinh Khanh
(904) 376-5222

72. McArthurs, Inc.
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Attn: W. M. McArthur
(704) 245-7223

73. McDonnell Douglas Astronautics Co.
5301 Bolsa Ave.
Huntington Beach, CA 92647
Attn: R. W. Holley
(714) 960-1301

74. Miller Associates, Thermal Div.
A Div. of Hill Bros., Inc.
3501 N. W. 60 St.
Miami, FL 33152
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(305) 693-5800

75. National Plastics, Inc.
Lab Sciences Division
604 Park Drive
Boca Raton, FL 33432
Attn: Joseph Cariseo
President
(305) 392-0501

76. National Solar Co.
2331 Adams Dr. N. W.
Atlanta, GA 30318
Attn: J. B. Franklin
(404) 352-3478

77. National Solar Corp.
Novelty Lane
Essex, CT 06426
Attn: Anthony Easton
(203) 767-1644

78. Northeastern Solar Energy Works, Inc.
112 West 34th Street
Suite 916
New York, NY 10001
Attn: Louis Varon
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(212) 564-1776

79. Northrop, Inc.
302 Nichols Drive
P. O. Box 452
Hutchins, TX 75141
Attn: Harold Hammer, Vice President of Marketing
(214) 225-4291

80. NRG Limited
901 Second Ave. East
Coralville, IA 52241
Attn: David Simms
(319) 354-2022

81. Oak Ridge Eng. and Assoc.
110 Peach Rd.
P. O. Box 3016
Oak Ridge, TN 37830
Attn: Vernon Hockman
(615) 482-5290

82. Owens-Illinois
P. O. Box 1035
Toledo, OH 43666
Attn: Richard E. Ford
Marketing Manager
(419) 243-1015

83. P. R. Distributors
1232 Zacchini Avenue
Sarasota, FL 33577
Attn: John Pickett, Owner
(813) 958-5660

84. Penrod Enterprises
P. O. Box 1047
Cape Giradeau, MO
Attn: Robert Penrod
(314) 334-3258

85. People/Space Company
259 Marlboro Street
Boston, MA 02116
Attn: Robert Shannon, Partner
(617) 261-2064

86. Pet-Craft Assemblies
Solar Division
430 Dayton Boulevard
Melbourne Village, FL 32901
Attn: Jack C. Houck
(305) 724-1393

87. Piper Hydro
2895 E. LaPalma
Anaheim, CA 92806
Attn: James Piper, Pres.
(714) 630-4040

88. Polyset, Inc.
7 Summer St.
Manchester, MA 01944
Attn: John M. Bradley
(617) 526-1992

89. Powell Brothers, Inc.
5903 Firestone Blvd.
South Gate, CA 90280
Attn: Hayward Powell
Vice President
(213) 869-3307

90. PPG Industries, Inc.
One Gateway Center
Pittsburgh, PA 15222
Attn: Meil M. Marker
Manager
(412) 434-3552

91. R-M Products
5010 Cook Street
Denver, CO 80216
Attn: Donald P. Erickson
(303) 825-0203

92. Raypak, Inc.
31111 Agoura Road
Westlake Village, CA 91359
Attn: Mr. Boniface
(213) 889-1500

93. Refrigeration Research, Inc.
Solar Research Division
525 N. 5th Street
Brighton, MI 48116
Attn: Frank Rockwell
Chief Engineer
(313) 227-1151

94. Research Eng. Man. Co.
5285 N. Red Rock Dr.
Phoenix, AZ 85018
Attn: Mr. McLister
(601) 959-0761

95. Revere Copper and Brass, Inc.
Solar Energy Department
P. O. Box 151
Rome, NY 13440
Attn: William Heidrich, Mgr.
(315) 338-2401

96. Reynolds Aluminum
5th Cary Street
Richmond, VA 23261
Attn: Chester H. Holtyn
(804) 281-2000

97. Reynolds Metal Company
2315 Dominguez Street
Torrance, CA 90508
Attn: D. Louding
Plant Manager
(213) 328-7421

98. C. F. Roark Welding &
Engineering Co., Inc.
136 North Green St.
Brownsburg, IN 46112
Attn: Gary Wilson
(317) 852-3163

99. W. R. Robbins & Son
1401 N. W. 20th St.
Miami, FL 33142
Attn: T. S. Simone
(305) 325-0880

100. Rocky Mountain Air
Conditioning
5010 Cook St.
Denver, CO 80216
Attn: Don Erickson
(303) 825-0203

101. Seigfried, Inc.
510 So. Lansing
P. O. Box 3365
Tulsa, OK 74120
Attn: Robert Troy
(918) 587-4105

102. Semco, Inc.
1091 S. W. 1st Way
Ft. Lauderdale, FL
Attn: David B. Aspinwall
(305) 565-2516

103. SES, Inc.
#1 Tralee
Industrial Park
Newark, DE 19711
Attn: R. O. Johnson
Marketing Manager
(302) 731-0990

104. Shelly Radiant Ceiling Company
8110 No. St. Louis Ave.
Skokie, IL 60076
Attn: William Shelley
President
(312) 675-8899

105. Simons Solar Environmental Systems, Inc.
24 Carlisle Pike
Mechanicsburg, PA 17055
Attn: Earle Simons
(717) 697-2778

106. Sol-R-Tech, Inc.
The Trade Center
Hartford, VT 05057
Attn: John Devries
Vice President
(802) 295-9343

107. Sol-Ray
Div. of Unit Electric Control, Inc.
130 Atlantic Dr.
Maitland, FL 32751
(305) 831-1900

108. Sol Tex Corp.
P. O. Box 1124
Houston, TX 77001
Attn: Mr. Cunningham
(713) 522-1781

109. Sol-Therm Corporation
7 W. 14th Street
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Attn: I. Sittenfeld
(212) 691-4632

110. Soltrax, Inc.
720 Rankin Road N. E.
Albuquerque, NM 87107
Attn: B. Eisenstadt
(505) 344-3431

111. Solar Comfort Systems
4300 East-West Highway
Bethesda, MD 20014
Attn: David Bervmer
(301) 951-0095

112. Solar Controls
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Clearwater, FL 33515
(813) 443-5004

113. Solar Development, Inc.
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West Palm Beach, FL 33407
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(305) 842-8935

114. Solar Dynamics, Inc.
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(305) 688-4393

115. Solar Electric
403 So. Maple
West Branch, IA 52358
Attn: C. E. Sewell
(319) 643-2598

116. Solar Energy Company
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117. Solar Energy Components, Inc.
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118. Solar Energy Development, Inc.
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119. Solar Energy Equipment
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120. Solar Energy, Inc.
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Attn: Frank Rum
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121. Solar Energy Products Company
121 Miller Road
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Attn: Frank Rom
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122. Solar Energy Products, Inc.
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(904) 377-6527

123. Solar Energy Research Corporation
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124. Solar Energy Resources Corp.
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125. Solar Energy Systems
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126. Solar Energy Systems, Inc.
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127. Solar Equipment Corporation
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128. Solar-Eye Products
(American Solar Heat Corp.)
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129. Solar Fin Systems
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Attn: Webster Felix
(904) 824-3522

130. Solar Heating & Air
Conditioning Systems
13584 49th St.
Clearwater, FL 33520
Attn: C. H. Breckenridge
(813) 577-3961

131. Solar Heating Systems Corp.
151 John Downey Dr.
New Britain, CN
Attn: Alvin Trumbull
(203) 244-2164

132. Solar Inc.
P. O. Box 246
Mead, NB 68041
(402) 624-6555

133. Solar Industries of Florida
P. O. Box 9013
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Attn: G. W. Laird
(904) 768-4323

134. Solar Industries, Inc.
100 Captain Neville Dr.
Waterbury, CN 06705
(203) 244-2000

135. Solar Industries, Inc.
Monomouth Airport Industrial Park
Farmingdale, NJ 07727
Attn: Donald G. Harter
(201) 938-7000

136. Solar Innovations
412 Longfellow Blvd.
Lakeland, FL 33801
Attn: Bill Fenton
(813) 646-5071

137. Solar Kinetics, Inc.
147 Parkhouse
Dallas, TX 75207
Attn: Joe Hutchinson
(214) 747-6519

138. Solar Manufacturing Co.
10 Connecut Lake Rd.
Greenville, PA
Attn: Jake McClelland
(412) 588-2571

139. Solar One Ltd.
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Virginia Beach, VA 23451
Attn: Ernest Scofield
(804) 422-3262

140. Solar Pool Heaters of Southwest Florida
901 S. E. 13th Place
Cape Coral, FL 33904
Attn: Ward Morissey
(813) 542-1500

141. Solar Products
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Attn: J. Grady
(603) 635-2118

142. Solar Products
1001 Laguna Dr.
Venice, FL
Attn: Harry Drehouse
(813) 488-4408

143. Solar Products Sun-Tank, Inc.
614 N. W. 62nd St.
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Attn: H. J. Houtkin
(305) 756-7609

144. Solar Research Systems
3001 Red Hill Ave. I-105
Costa Mesa, CA 92626
Attn: Dr. Joseph Farber
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145. Solar Sun, Inc.
235 W. 12th St.
Cincinnati, OH 45210
(513) 241-4200

146. Solar Systems, Inc.
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Belmont, NC 28012
Attn: Robert Kincaid
(704) 825-8416

147. Solar Utilization Systems
2716 Marion Ave.
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Attn: Juan Repollet
(212) 367-9529

148. Solar Water Heater Co.
P. O. Box 341872
Coral Gables, FL 33165
Attn: W. V. Morrow, Pres.
(305) 221-4611

149. Solar Waterheaters of Newport Richey
540 Palm Meadows
Newport Richey, FL 33552
(813) 848-2343

150. Solarmatic
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220 W. Brandon Boulevard
Brandon, FL 33511
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(813) 247-5848

151. Solaray Corp.
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Attn: Judd Lawrence
(808) 533-6464

152. SOLARCOA
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Long Beach, CA 90807
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(213) 426-7655

153. Solargenics, Inc.
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Attn: David Collins
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154. Solaron Corp.
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155. Solar Systems, Inc.
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156. Solartec Corp.
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San Diego, CA 92111
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157. Solarway
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158. Solergy, Inc.
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159. SOLTRAX, Inc.
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160. SOLUS, Inc.
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President
(713) 681-1224

161. Southwestern Systems, Inc.
P. O. Box 5508
Yuma, AZ 85364
Attn: William S. Mitchell
(602) 782-9174

162. Space Age Service
North Old Dixie Highway
Route #1 Box 260
Titusville, FL 32780
Attn: Floyd W. Blum
(305) 267-5970

163. Spectra Energy Systems, Inc.
1210 Camino Rio Verde
Santa Barbara, CA 93111
(805) 964-5584

164. SSP Associates
704 Blue Hill Road
River Vale, NJ 07675
Attn: Jed Schaiman
(201) 391-4724

165. State Industries, Inc.
Ashland, TN 37015
Attn: Jim Harding
(800) 251-8170

166. Steelcraft Corporation
Environmental Design
Division
P. O. Box 12408
Memphis, TN 38112
Attn: Gary Ford
President
(901) 452-5200

167. Stolle Corporation
1501 Michigan Street
Sidney, OH 45365
Attn: E. G. Beck
Vice President
(513) 492-1111

168. Suhay Enterprises
2112 W. Oak
Burbank, CA 91506
Attn: Frank L. Suhay
(213) 982-0372

169. Sun Century Systems
P. O. Box 2036
Florence, AL 35630
Attn: Jack L. Graves, Jr.
(205) 764-0795

170. Sun Power Corp.
P. O. Box 16963
Orlando, FL 32811
Attn: C. Jack McCommon
(305) 876-2237

171. Sun Powers Systems Ltd.
1024 W. Maude Ave.
Suite 203
Sunnyvale, CA 94086
(408) 738-2442

172. Sun Systems of America
P. O. Box 10336
Jacksonville, FL 32207
Attn: Truett George, Jr.
(904) 389-0493

173. Sun Systems, Inc.
P. O. Box 155
Eureka, IL 61530
Attn: Dr. Y. B. Safdari
President
(309) 467-3632

174. Sundu Company
3319 Keys Lane
Anaheim, CA 93804
Attn: A. J. Meagher
(714) 828-2873

175. Sunearth, Inc.
P. O. Box 337
Green Lane, PA 18054
Attn: Howard S. Katz
President
(215) 568-8151

176. Sunsav, Inc.
250 Canal Street
Lawrence, MA 01840
Attn: Peter Ottmar
President
(617) 686-8040

177. Sunsearth, Inc.
669 Boston Post Road
Guilford, CT 06437
Attn: Everett M. Barber
President
(203) 453-6591

178. Sunseeker Systems, Inc.
P. O. Box 3323
Tampa, FL 33601
Attn: Robert W. Ellis
Vice President
(813) 223-1787

179. Suntap, Inc.
42 E. Dudley Town Rd.
Bloomfield, CT 06002
(203) 243-1781
Mailing Address:
P. O. Box 1902
Hartford, CT 06101

180. Sunwater Company
1112 Pioneer Way
El Cajon, CA 92020
Attn: Ed Smith, President
(712) 440-3151

181. Sunworks, Inc.
Div. of Enthone, Inc.
P. O. Box 1004
New Haven, CT 06508
Attn: Edward Jones
(203) 934-6301

182. Systems Technology, Inc.
P. O. Box 337
Shalimar, FL 32579
Attn: William S. Cronk
(904) 863-9213

183. T. D. Bross Line Construction
Company
42 E. Dudley Town Road
Bloomfield, CT 06002
Attn: Mr. Theodore Bross
President
(203) 243-1781

184. Thermal Collector Co.
19 Ravenwood Rd.
Peabody, MA 01960
Attn: William H. Neve
President
(617) 531-8881

185. Unitspan Arch. Systems, Inc.
9419 Mason Ave.
Chatsworth, CA 91311
Attn: Abe Grossman
(213) 998-1131

186. Universal Solar Company
1802 Madrid Ave.
Lake Worth, FL 33461
Attn: R. Gerhardt
(305) 586-6020

187. Universal 100 Solar Energy Systems
Div. of Southern Lighting
501 Elwell Ave.
Orlando, FL 32803
Attn: Kevin Drew
(305) 894-8851

188. Wallace Company
831 Dorsey St.
Gainesville, GA 30501
(404) 534-5971

189. Werner Industries, Inc.
P. O. Box 1466
Eau Gallie, FL 32935
Attn: Peter Werner
(305) 254-7611

190. Western Energy, Inc.
454 Forest Ave.
Palo Alto, CA 94302
Attn: Norman Rees
(415) 327-3371

191. Wilcon Corp.
3310 S. W. 7th St.
Ocala, FL 32670
Attn: K. T. Wilson
(904) 732-2550

192. Wilcox Manufacturing Co.
13375 U. S. 19 No., 62nd St.
Pinellas Park, FL 33565
Attn: C. M. Wilcox
(813) 531-7741

193. Ying Manufacturing Corp.
1940 W. 144th Street
Gardena, CA 90249
Attn: Mr. Yu
Vice President
(213) 770-1756.

194. Youngblood Co., Inc.
1083 N. W. 36th St.
Miami, FL 33142
(305) 635-2501

ATTACHMENT C

PRELIMINARY DRAFT OF DATA BASE USER'S GUIDE BROCHURE

DATA BASE USER'S GUIDE

INTRODUCTION

The Solar Heating and Cooling Projects Office at the NASA Marshall Space Flight Center in Huntsville, Alabama, has been developing a Data Base to support the systems analysis of solar heating and cooling systems. The effort supports ERDA in its work to create a viable solar energy industry.

The purpose of the Data Base is to supply the analyst with the information he needs to study the potential performance of a typical solar heated and/or cooled building anywhere in the conterminous United States. Parametric data collected for the user includes detailed climatological data, information on typical architectural designs in various parts of the country; conventional and solar equipment performance and costs; names and addresses of equipment manufacturers; the most current residential and commercial utility rates available for electricity, natural gas, fuel oil and coal; and general economic data. Thus, specific analyses of individual buildings under local climatic conditions can be carried out and a macro-economic overview can be obtained of the regions in the U. S. where the solar heating and cooling of buildings can be expected to have the most beneficial market impact.

In recent months, there has been a change of emphasis in the types of data being collected for the data base. In addition to the very specific information needed for detailed systems analysis, more generalized data and climatic averages for F-CHART (developed by the University of Wisconsin) and similar computerized systems simulation programs are also being computed or collected. For example, life cycle cost analyses based on variously rising inflation and utility rates can now be performed to produce bottom-line figures for "dollars and fossil fuel saved" and "payback period" for simulated solar energy systems.

Two new files have been developed in response to this change in emphasis: the Primary Solar Data File and the Design Applications File. The Primary Data File has been developed to supply climatic and utility cost data in a concise package for an F-CHART user for any community in the U. S. The Design Applications File complements this information with federal, state and private solar energy project information which describes actual buildings already designed and constructed to the local climatic conditions. Thus a user can see with what designs others have responded to a given set of conditions. They can then evaluate the predicted and actual performance of the system based on operational data. Also, subsystem and system level performance can be reviewed and the particular application's success can be judged.

This user's guide will first describe the contents of the individual files in the Data Base and then elaborate on what information can be generated from the comparative and constructive use of the data.

Any questions regarding permission to access the MSFC Data Base should be addressed to Mr. Andrew G. Kromis at (205) 453-1759 (FTS 872-1759). Technical inquiries pertaining to difficulties accessing the Marshall Information Retrieval and Display System (MIRADS) should be addressed to Mr. Everett Dailey at (205) 453-0384 (FTS 872-0384). Inquiries concerning the content and quality of the data should be addressed to Mr. Jeremy Goddard at (205) 895-6257 (FTS 872-0380).

1. PRIMARY SOLAR DATA FILE

Sources: The National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), Universities, the Federal Power Commission (FPC), Public Service Commissions, and Utility Companies.

Frequency of Updates: As updated or improved data is available.

The Primary Solar Data File has been set up in response to the requirements of F-CHART and other programs needing abstracted information. The file is a compilation of data which can separately be found in other files in the Data Base. It is hoped that the tailoring of the information to these computer simulation programs will simplify procedures and increase the rate for the gathering and use of climatic and utility rates required for economic analyses of solar energy applications in any and every commuinty in the contiguous United States.

Both English and metric units have been used in the presentation of the data. Cooling degree days are entered to a base of 65°F (18.3°C) since most available information is computed on this rather than on the 75°F base which is actually more realistic in the cooling mode (based on thermostat settings). Dry bulb temperature, dew point temperature, and relative humidity are all entered so that the data may be used without using an algorithm conversion process to supply the program's specific humidity-related parameter.

Some of the older programs use Cloud Cover Masking Factor and Percent Possible sunshine to estimate the insolation available at the simulated site. Both these factors have been included along with the insolation figure interpolated or measured by the NOAA network and available from the standardized SOLMET format climatic tapes. Ground water temperature, based on the inlet conditions for solar water heating systems, is necessary for the computation of the energy needed to raise the water temperature to that required for domestic use. Monthly average wind velocity and prevailing direction are also entered. Not all programs use wind information but a passive solar architectural design certainly needs to have these factors known; areas of high average winds will also affect the performance of local solar energy systems. The average wind chill factors can also be calculated.

Utility rates are a particularly critical area of need. Every effort is being made to expedite the gathering and entry of up-to-date rate schedules. In the Primary Data File, the rates for residential and commercial electricity, natural gas, coal and fuel oil can be found in common units: dollars per million Btu, or per million kiloJoules. The rates may not include the fuel adjustment rate changes which vary within short periods of time. However, the file can be used to compare climatically-influenced differences and to compare utility rates on an "apples with apples" basis. For the most up-to-date economic analysis, the user should resort to contacting the utility companies serving the locality of concern or the data base research team at UAH.

2. DESIGN APPLICATIONS FILE

Sources: Department of Housing and Urban Development, surveys by The University of Alabama in Huntsville, Federal Agencies, etc.

Frequency of Updates: New entries made as additional project information is made available.

The Design Applications File is organized to complement the Primary Data File. Where the latter presents data on meteorological, geological and utility rates for various locations throughout the contiguous U. S., the Design Applications File presents information on specific projects that have been designed, built, and operated to the climatic conditions existing at the site. Thus, the user, having noted the climatic parameters of a locality, can interrogate the Design Applications File for a typical project in that specific area, review the expected and actual performance of the solar energy system and thus determine whether or not it performs to its design specifications.

In this way, the user may profit by the mistakes made by previous designers in their considerations related to various design parameters. Also, one may obtain information about projects using, say, air systems, or cooling systems, and be able to learn whether or not they appear in the areas of interest for related projects; if they do not, an investigative study of the comparative efficiencies of similar designs in dissimilar geographical situations might be made.

The Design Applications File presents the solar energy subsystems and total system performance with the initial and operational costs. Where all the site data is available, the break-even point for the solar system at current utility rates and at several inflation and fuel rate increases per year can be calculated. The system economics, potential savings, and payback periods can also be evaluated.

The prime emphasis of the file is on commercial projects; this reflects the particular concern of the National Aeronautics and Space Administration in the national solar heating and cooling demonstration program. Residential applications will also be entered, expecially those of particular significance such as cooling projects. It is not expected, obviously, to include every supplemental solar hot water system in the nation.

3. AUTOMATED MONTHLY REPORT FILE

Sources: Site Data Acquisition Systems (SDAS) data processed in Huntsville, Alabama; monthly summaries.

Frequency of Updates: As data is processed and entered.

Data from the Site Data Acquisition Systems (SDAS) at each instrumented solar demonstration site are collected and processed in Huntsville. The parameters measured by the SDAS follow the recommendations of the NBS.

The Automated Monthly Report File incorporates the monthly performance summaries for the instrumented sites in the demonstration network. Figure 1 outlines the Central Data Processing System (CDPS) structure and data flow. Figure II lists the parameters gathered and computed in Huntsville before the monthly summaries are entered into the Data Base.

4. CLIMATIC ATLAS FILE (GRAPHIC)

Sources: Climatic Atlas of the U. S. (NWS/NOAA)

Frequency of Updates: As the source is updated.

The Climatic Atlas File is a graphics file printing maps of the U. S. in six different sizes. The file has an overlay capability: it will print latitude and longitude grids on the U. S. map and overlay contours of temperatures, relative humidity, heating degree days, solar radiation, etc. It can be harnessed usefully to judge the areas of optimum solar energy markets based on the climatic parameters affecting system performance. Figure III shows some sample printouts from the graphics file.

The file complements the Weather File which uses detailed information collected by the NES and NOAA.

5. WEATHER INFORMATION FILE

Sources: NWS/NOAA SOLMET Tapes

Frequency of Updates: Annual

The Weather Information File contains weather station identification numbers and period of record information, heating and cooling degree days, and monthly and annual insolation averages. The SOLMET tapes developed by NOAA are entered; an extensive effort has been made by NOAA to estimate solar irradiation data for more sites than those where direct measurements are being made. These estimates are chiefly made by converting the tenths of the cloud cover masking factors and the percent possible sunshine (which are "measured" at each site), into a calculated daily solar irradiation figure in (Btu/ft^2) or (kJ/m^2). There is also a project underway to interpolate the solar irradiation that would be measured at a given site by taking the recordings of sites close by and, with mathematical models, attempting to achieve an accurate figure. The hourly SOLMET data is very suitable for the University of Wisconsin TRNSYS simulation program; it will also produce monthly averages for use with F-CHART, MINISHAC and other systems performance/cost simulation programs using such "averaged data".

6. UTILITY RATES FILE

Sources: Federal Power Commission, Utility Companies, and Public Service Commissions

Frequency of Updates: Upon discovery or notification of rate schedule changes

Utility rates are among the most critically needed of all the parameters collected for the Data Base. They change almost daily due to fuel

FIGURE I

CENTRAL DATA PROCESSING SYSTEM STRUCTURE AND DATA FLOW

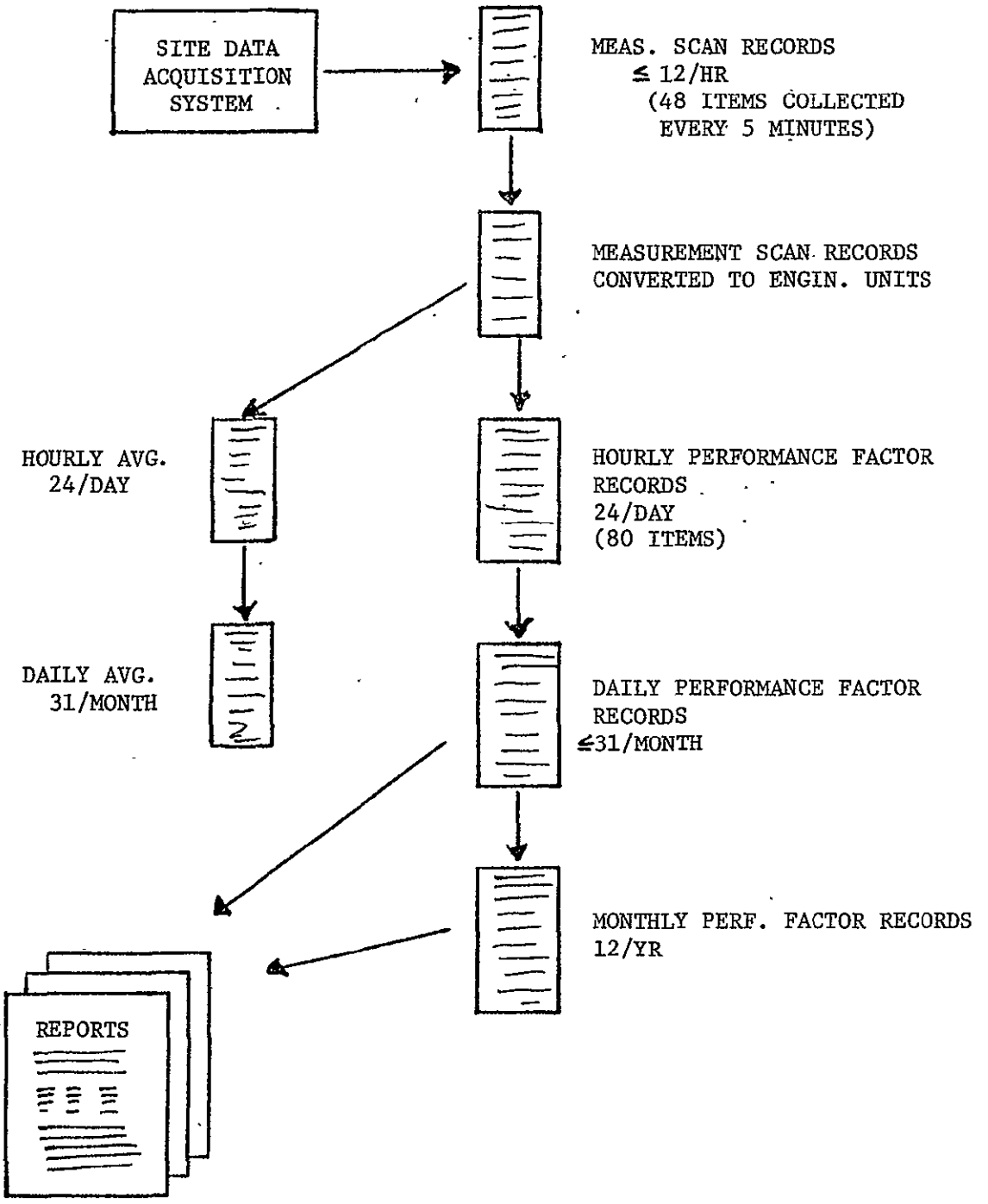


Figure II

Output Data on Demonstration Site Performance from CDPS Computations

Solar Energy Incident
Solar Energy Collected
Collection Heat Loss
Collector Efficiency
Collector Operating Point
Collection Efficiency
Solar Energy Delivered to Storage
Solar Energy Delivered from Storage
Change in Stored Energy
Storage Heat Loss
Solar Energy Delivered to Loads
ECSS Operating Energy
ECSS Coefficient of Performance
ECSS Efficiency
Hot Water Load
Solar Energy for HW Load
Solar Fraction of HW Load
Operating Energy for HW
Auxiliary Energy for HW
Auxiliary Electric Fuel Energy for HW
Auxiliary Fossil Fuel Energy for HW
Electric Energy Savings for HW
Fossil Energy Savings for HW
Space Heating Load
Solar Energy for Space Heating Load
Solar Energy Fraction of SH Load
Operating Energy for SH
Auxiliary Heat Energy for SH
Auxiliary Electric Fuel Energy for SH
Auxiliary Fossil Fuel Energy for SH
Electric Energy Savings for SH
Fossil Energy Savings for SH
Boiler/Furnace Efficiency
Heat Pump Load
Heat Pump Operating Energy
Heat Pump Coefficient of Performance
Space Cooling Load
Solar Energy for SC Load
Solar Energy Fraction of SC Load
Operating Energy for SC
Auxiliary Heat Energy for SC
Auxiliary Electric Fuel Energy for SC
Auxiliary Fossil Fuel Energy for SC
Electric Energy Savings for SC
Fossil Energy Savings for SC
Vapor Compression Equipment Load
Vapor Compression Equipment Operating Energy
Vapor Compression Equipment Coefficient of Performance
Absorption Chiller Load
Absorption Chiller Thermal Input Energy
Absorption Chiller Operating Energy
Absorption Chiller Coefficient of Performance
Ambient Temperature
Building Temperature
Total Load
Total Operating Energy
Total Auxiliary Energy
Total Energy Consumed
Total Electric Energy Savings
Total Fossil Energy Savings
Solar Energy Fraction of Load
System Performance Factor
Heat Rejected

Figure III

NORMAL TOTAL HEATING DEGREE DAYS , MARCH (BASE 65)

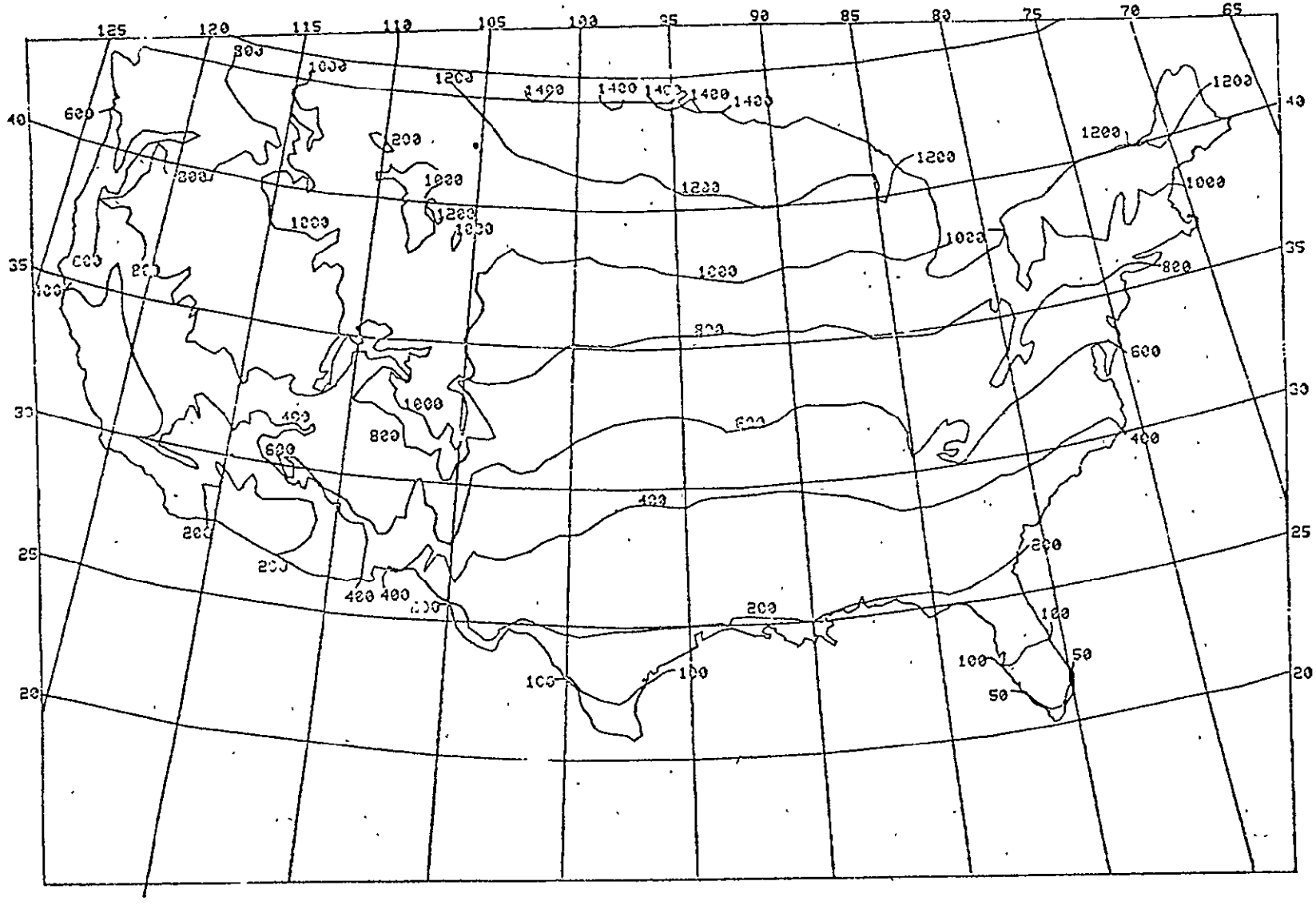


Figure III (contd)

MEAN DAILY SOLAR RADIATION (LANGLEYS)

MARCH

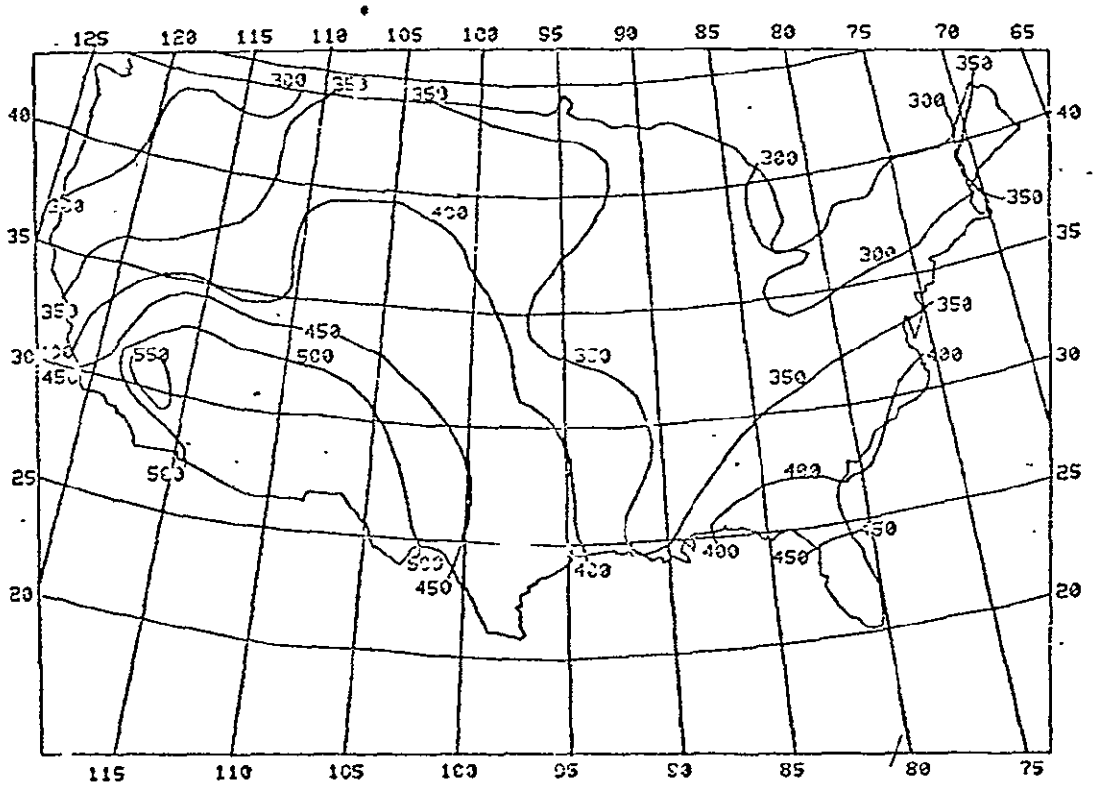


Figure III (contd)

NORMAL DAILY AVERAGE TEMPERATURE (^{O}F), MARCH

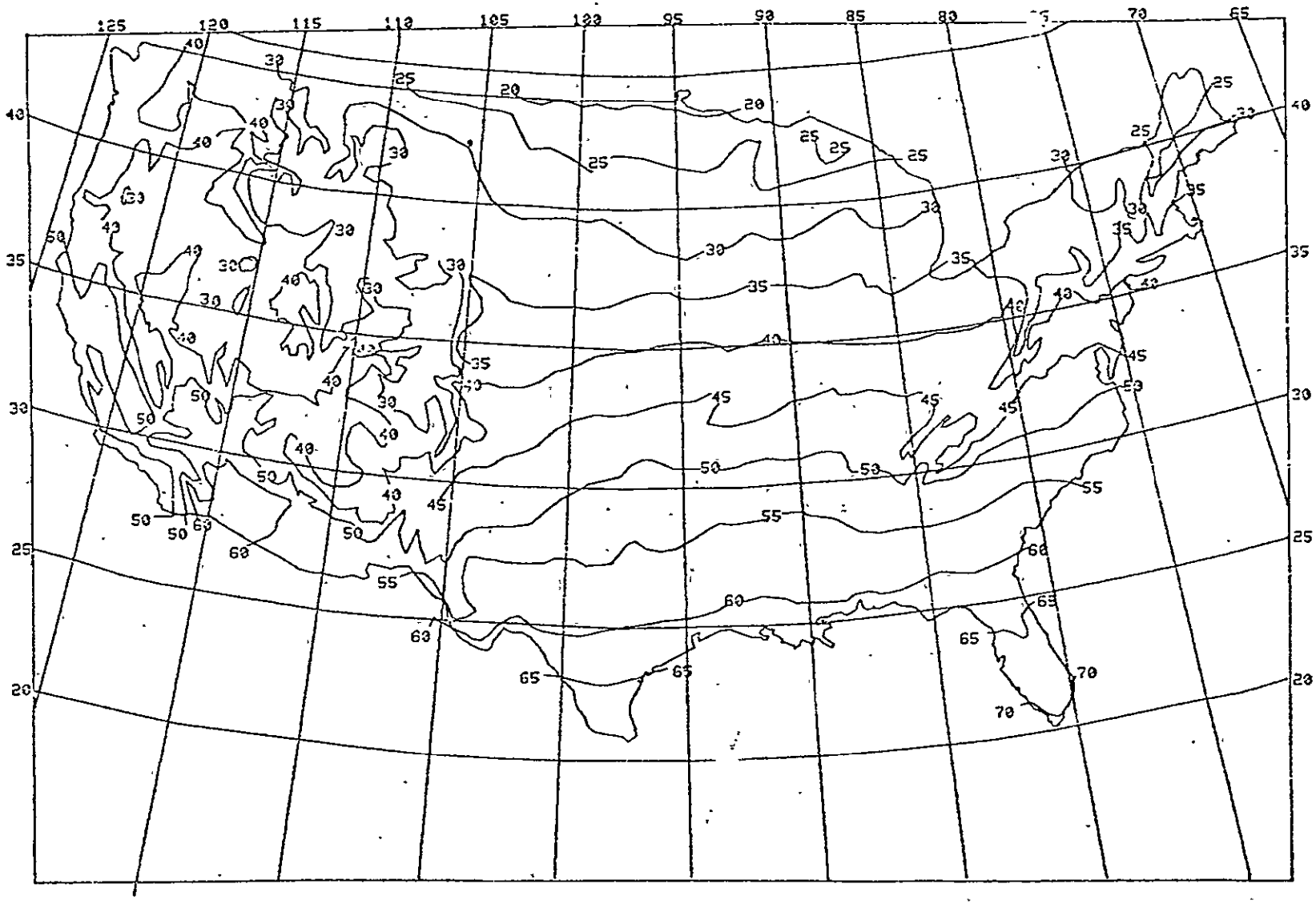
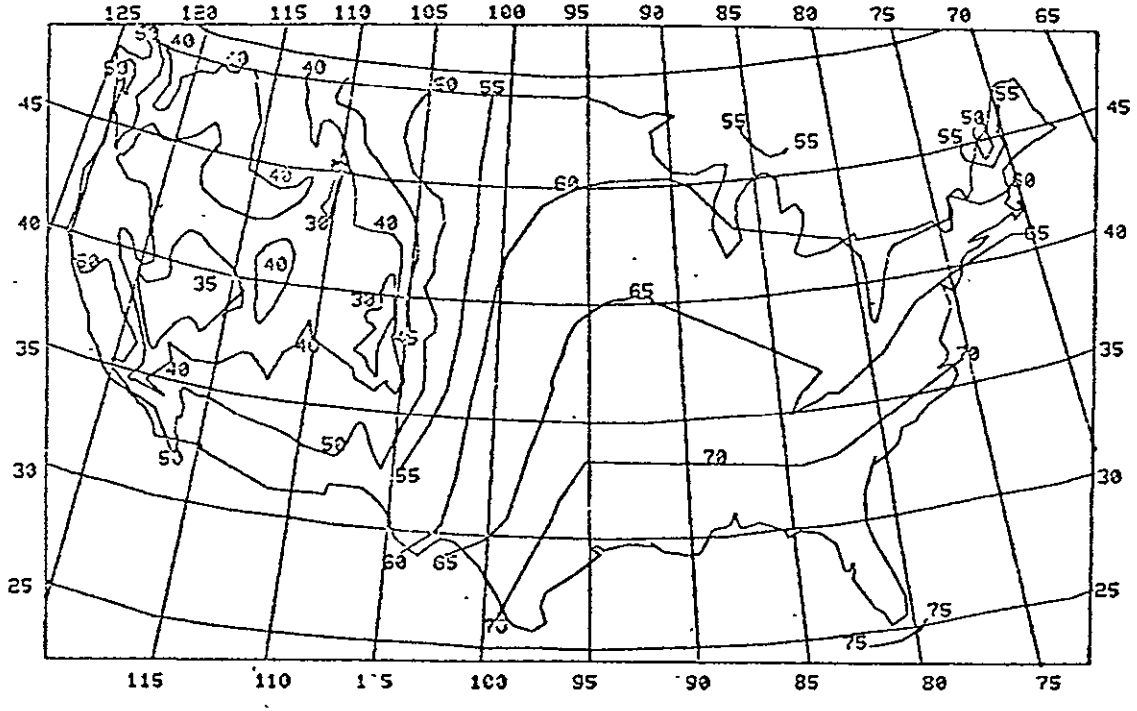


Figure III (contd)

MEAN DEWPOINT TEMPERATURE (^{0}F),
JULY



adjustment modification, while the Standard Base Rate may not change for 18 months or more. The UAH receives notification of these frequent rate schedule changes from the F.P.C., the states' Public Service Commissions and from many of the actual utility companies; such changes are entered almost immediately into the data base.

Where applicable, the rates are entered in the step-function form used by the utility companies, although many utilities are now converting to a "straight-line" costing. This allows the systems analyst to find the exact cost of the energy required for a house designed to certain climatic and consumption conditions. The utility companies, moreover, all seem to use differing cut-off points for the step-function rate so that is is necessary to develop an equal consumption point for price comparisons between the cost of service from various companies.

The definitions of the rate categories themselves also vary from company to company, for example, the "industrial power" rate for one company might cover all customers with demand over 200 kw while a second company might use the same nomenclature for industrial demands useability of the utility rates information.

7. FUEL COST AND QUALITY FILE

Source: Federal Power Commission

Frequency of Updates: As the information is obtained from the F.P.C.

The data in the Fuel Cost and Quality File is macro-economic in nature and deals with the input energy to the power stations. The file not only details the cost and quality of the fuel delivered to the utility plants, but also the amount.

The data provides the capability for predicting increases in utility rates. Examination of the long-term increase or decrease in supply will also show the expansion or otherwise of electrical power use and consumption in the vicinity.

A third factor to be considered is the pollution emissions from the steam plants, i.e.; low sulfur low-emission coal costs more. Consumer rates are thus affected indirectly by the quality of fuel used in the plant.

8. UTILITY OPERATING STATISTICS FILE

Sources: Federal Power Commission publications

Frequency of Update: Annual

The Utility Operating Statistics File contains information on the power generating capacity and the operating expenses of individual utility companies. Thus, the operating costs of large power stations can be compared on a "performance per dollar" basis. Their cost increases can be compared in both maintenance and operations. With the Fuel Cost

and Quality File, their overall cost and performance efficiencies can be examined. Differing methods for power generation can also be compared, and their corresponding costs of building and operation.

The File is to be used primarily as a macro-economic tool, but can be useful in the cost and performance analysis of the impact of large solar power stations.

9. TYPICAL ELECTRIC BILLS FILE

Source: "Typical Electric Bills" - F.P.C.

Frequency of Update: Annual

The "Typical Electric Bills" publication has residential-rate information on all U. S. communities over 2,500 population and commercial-rate information for cities over 50,000 population.

The file is designed as a quick-reference guide to national utility rates; a user can find the location of interest and compare a monthly bill for, say, 1000 kWh in that community with the cost of 1000 kWh anywhere else in the land. Thus, one is able to compare "apples with apples" in performing the economic analysis. Having pinpointed the area showing most promise for his study, the user can then go to the Utility Rates File for an accurate printout of the actual step-function costs of the rates involved.

The file presents rates for residential use, and for commercial and industrial demand rate use. It should also be possible to obtain a "ball park" figure for the price of operation in a large representative number of communities.

10. ARCHITECTURAL GRAPHICS FILE

Source: Architects, Consultants, American Institute of Architects, etc.

Frequency of Update: Not applicable

Entered into this graphics file from the blueprints are such items as plan and elevation views and plumbing diagrams. The user can overlay the various printouts to analyze the typical routing of hot water piping or conditioned air ducting, for example.

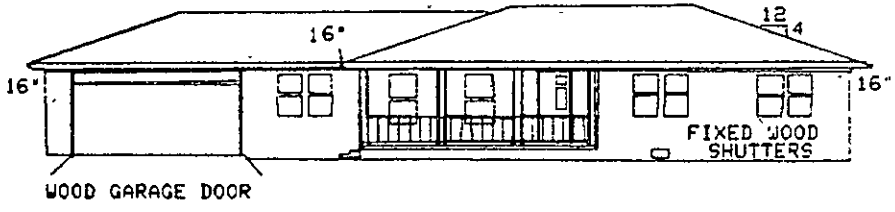
Dimensions of walls are given so that the user may calculate floor and wall areas, surface to volume ratios, and the optimum installation of insulation for the house design. He may also want to examine roof pitch, orientation and area for solar collection installation. All these factors and more can be determined from the graphic presentations. Figure IV displays typical printouts.

Figure IV

RANCH HOUSE 1524 SQ. FT.

HUNTSVILLE, ALABAMA

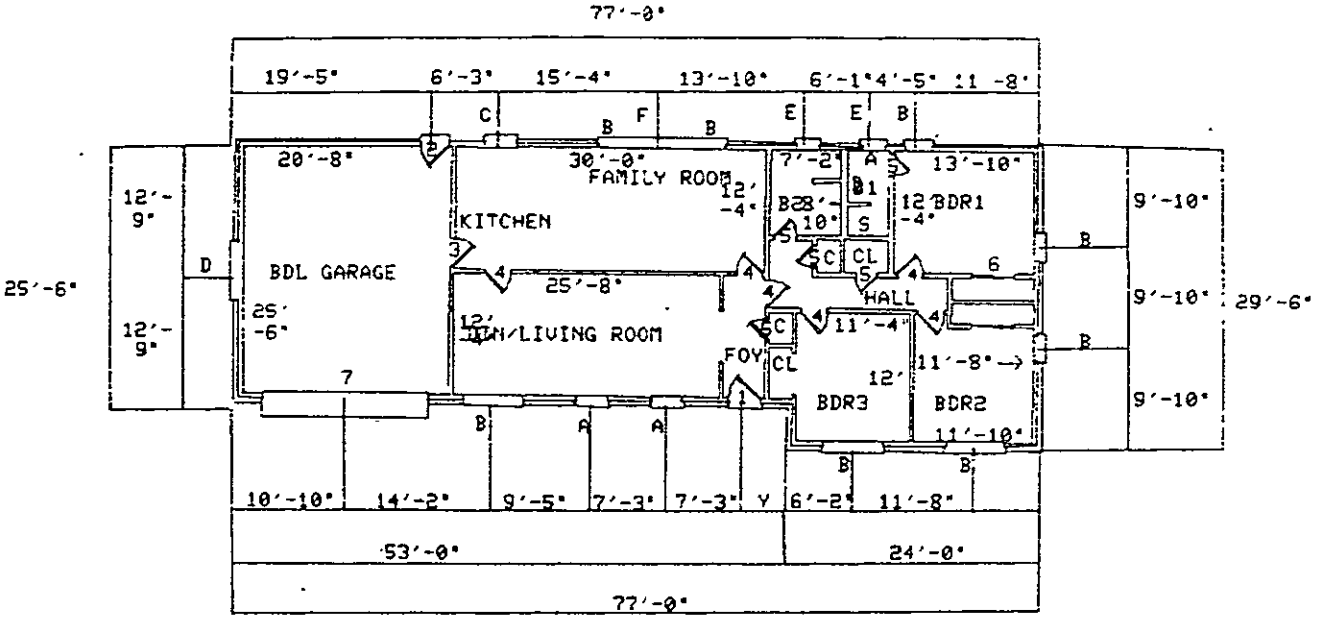
FRONT VIEW (17-F)



FRONT ELEVATION

Figure IV (contd)

RANCH HOUSE
HUNTSVILLE, ALABAMA
1"-F



BATHROOM DIM:
A. 4'-6"
B. 8'-10"
Y. 4'-1"

11. LOADS CALCULATIONS FILE

Source: Manual J - American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

Frequency of Update: Not applicable

This file was entered directly from the ASHRAE Manual J. Accordingly, it includes the heat transfer calculations and data for all common building materials. The inclusion of this document into the Data Base offers the user an advantage in obtaining information of this type when performing a detailed system analysis of the total building. It may also help a system designer in the calculations related to sizing HVAC equipment.

12. MANUFACTURER'S SURVEY FILE

Source: Manufacturers, Thomas Register, Libraries, Redstone Scientific Information Center (RSIC), Air Conditioning Research Institute (ARI), Association of Home Appliance Manufacturers (AHAM), etc.

Frequency of Update: Whenever additions or deletions are necessary.

The Manufacturer's Survey (MS) File has a listing of all manufacturers of HVAC equipment, both conventional and solar. A manufacturer will have a multiple listing if he makes more than one category of HVAC product.

The M.S. File is designed to be used closely with the Equipment File. The M.S. File displays the manufacturer's name, address, contact name, etc., along with the types of equipment the firm produces. Thus, a user can query the file for a product and obtain pertinent information concerning all manufacturers involved.

13. EQUIPMENT FILE

Source: Manufacturers, Thomas Register, AHAM, Energy Research and Development Administration (ERDA)

Frequency of Update: Whenever revisions are necessary.

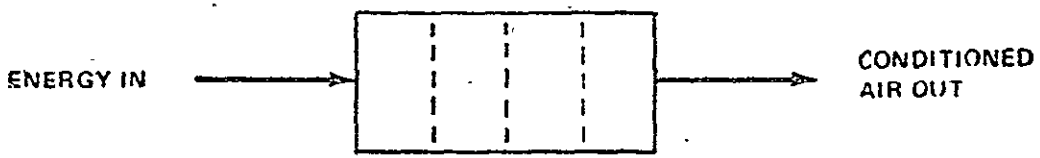
The Equipment File is organized as Figure V. System information is entered with coded references to the subsystem equipment used to build the system. Subsystems are used to enter physical and performance data on conventional and solar equipment and fall into the following categories:

1. Converter
2. Heat Exchanger
3. Storage
4. Chiller
5. Controls

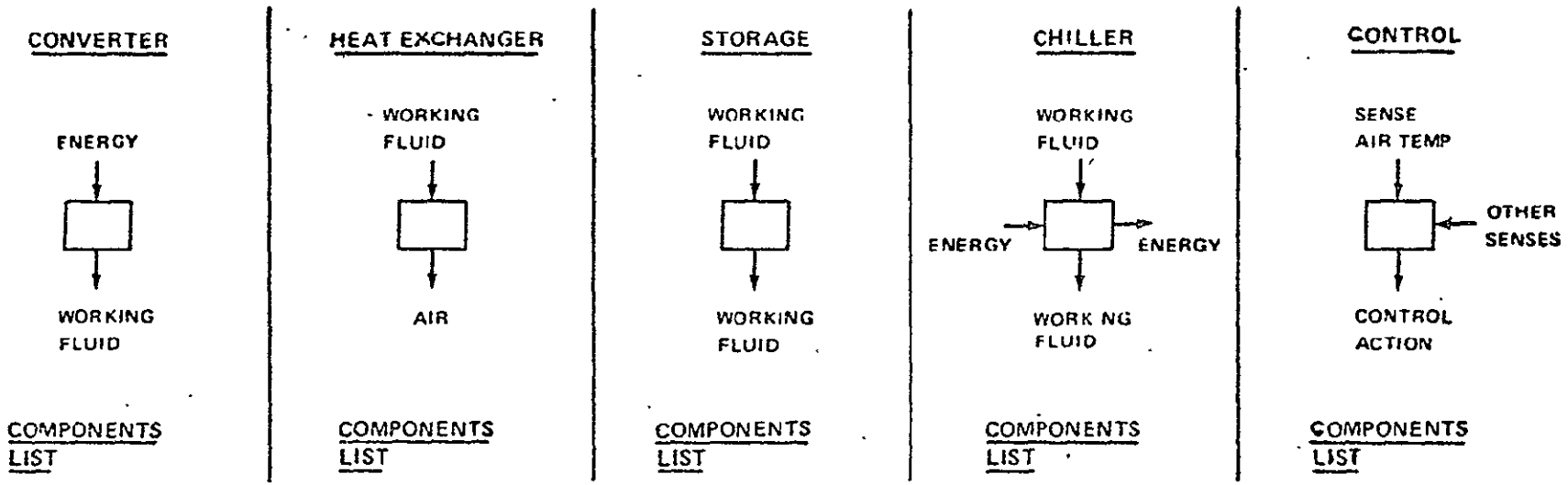
Figure V

EQUIPMENT DATA BREAKDOWN

SYSTEM



SUBSYSTEMS



In addition to this information, querying the converter subsystem file for "solar collector" will allow a graphic printout of the NBS performance curve of the particular solar collector of interest using format in both English and metric units.

The data base enables the performance curves of several different collectors to be overlaid for comparison purposes and cna also show the latest available retail and wholesale costs of the collector and other types of equipment. These primary factors, performance and cost, allow the system analyst to size various systems most cost-effectively to meet the thermal demands of the conditioned building as based on available fuel rates.

14. HEATING APPARATUS AND PLUMBING FIXTURES FILE

Source: Thomas Register, Association of Home Appliance Manufacturers (AHAM), Plant Engineering Directory, Manufacturers, etc.

Frequency of Update: As researched and available; annual catalogs

This file constitutes a survey of the heating and plumbing industry with regard to the size, type and extent of business activity.

15. AIR CONDITIONING AND REGRIGERATION EQUIPMENT FILE

Source: Thomas Register, AHAM, American Refrigeration Institute (ARI), Plant Engineering Directory, Manufactureres, etc.

Frequency of Update: As research and available; annual catalogs

This file is a survey of the air conditioning and refrigeration equipment industry with regard to the size, type and extent of business activity.

16. ECONOMICS FILE

Source: Statistical Abstracts and other Compilations of data by the Department of Commerce

Frequency of Update: As the information becomes available; chiefly annual updates.

The Economics File contains statistical economic information for the use of the systems analyst interested in the macro-economic impact of the heating and cooling of buildings by solar energy. Census information, tax structure, income and financial information, gas and coal production and reserves and other vital statistics as compiled by the Department of Commerce and other federal agencies are entered.

17. INCOME, EMPLOYMENT, AND FINANCES FILE

Source: State Labor and Employment Offices, Federal Reserve Banks

Frequency of Update; Monthly notifications

The I.E.F. File, used in conjunction with the Economic file, can indicate where sufficient incomes are available to provide the capital outlay involved in the installation of solar equipment. This file also gives a state-by-state economic profile describing the regions which should consider solar heating and cooling installation based on financial considerations. This factor, tied in with the climatic and utility cost data, can help to identify the prime market areas for solar equipment.

18. HOUSING STARTS FILE

Source: Department of H.U.D.

Frequency of Update: Annual Publications

The file contains information on those multi-unit residential buildings which have been started, which are under construction, or which have been completed within the last year.

19. RESIDENTIAL ALTERATION AND REPAIR

Source: Department of H.U.D.

Frequency of Update: Annual Publications

The Residential Alteration and Repair File contains information on the expenditures made on residential maintenance and improvement for all types of housing improvements; it also gives a profile of the amounts being spent on such work. Thus, an inference can be made of the region's potential for solar energy retrofits.

20. H.U.D. STATISTICS

Source: Department of H.U.D.

Frequency of Update: Annual Publications

This file presents information on the status and funding of the HUD sponsored projects. It is not solely devoted to solar projects, but with the knowledge of the money being spent by HUD in various regions on housing development, the user can infer what efforts and funds can readily be redirected to solar energy applications.

21. SMSA MAPS

Source: Rand McNally

Frequency of Update: Not applicable

SMSA maps is a graphics file presenting names and maps of the Standard Metropolitan Statistical Areas used as the census units for much of the statistical data included in the Data Base files. (See Figure VI).

22. GEOGRAPHIC AREA MAPS

Source: Rand McNally

Frequency of Update: Not applicable

This file presents a map of each state with overlays of the counties, county codes and the SMSA's located in each state. (See Figure VI).

Figure VI

STATE OF FLORIDA

COUNTY BOUNDARIES

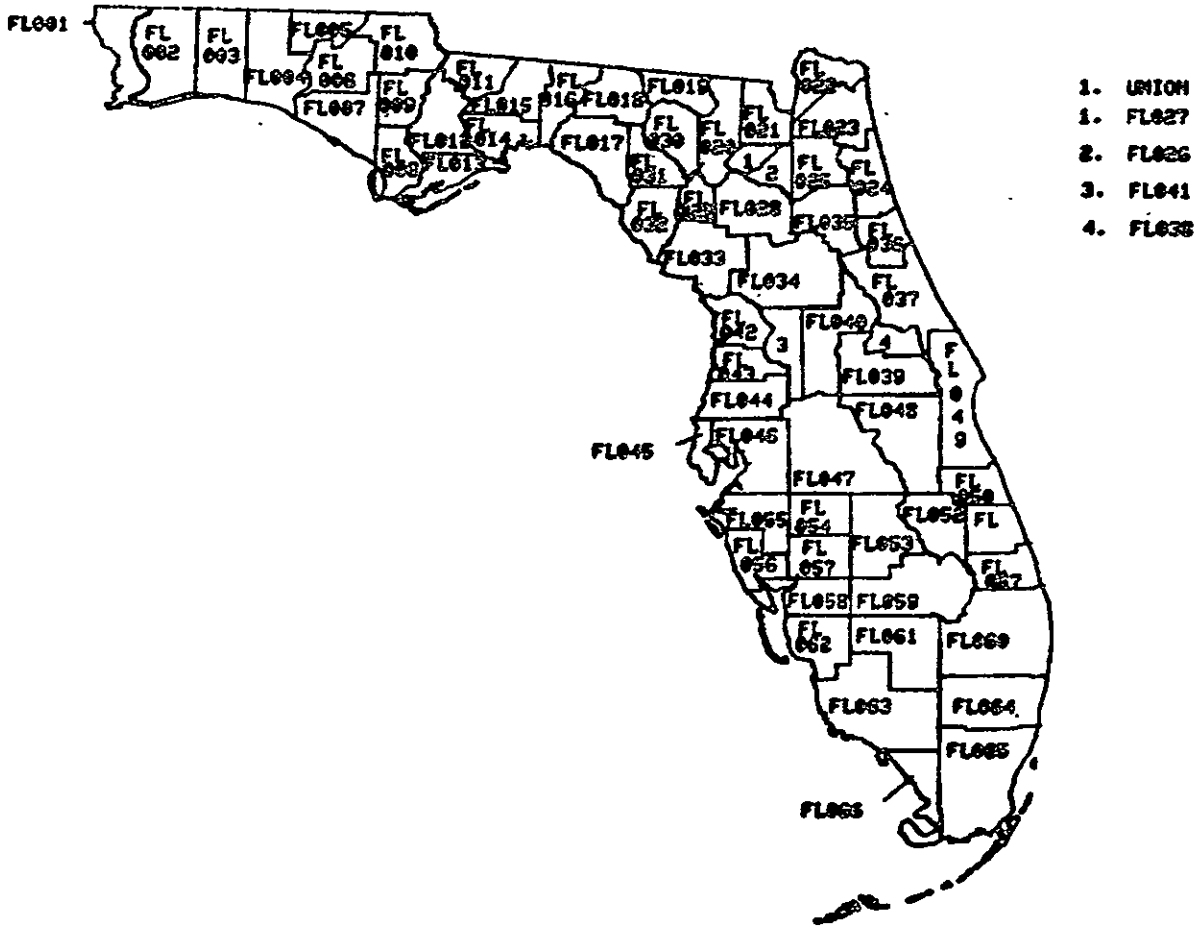


Figure VI (contd)

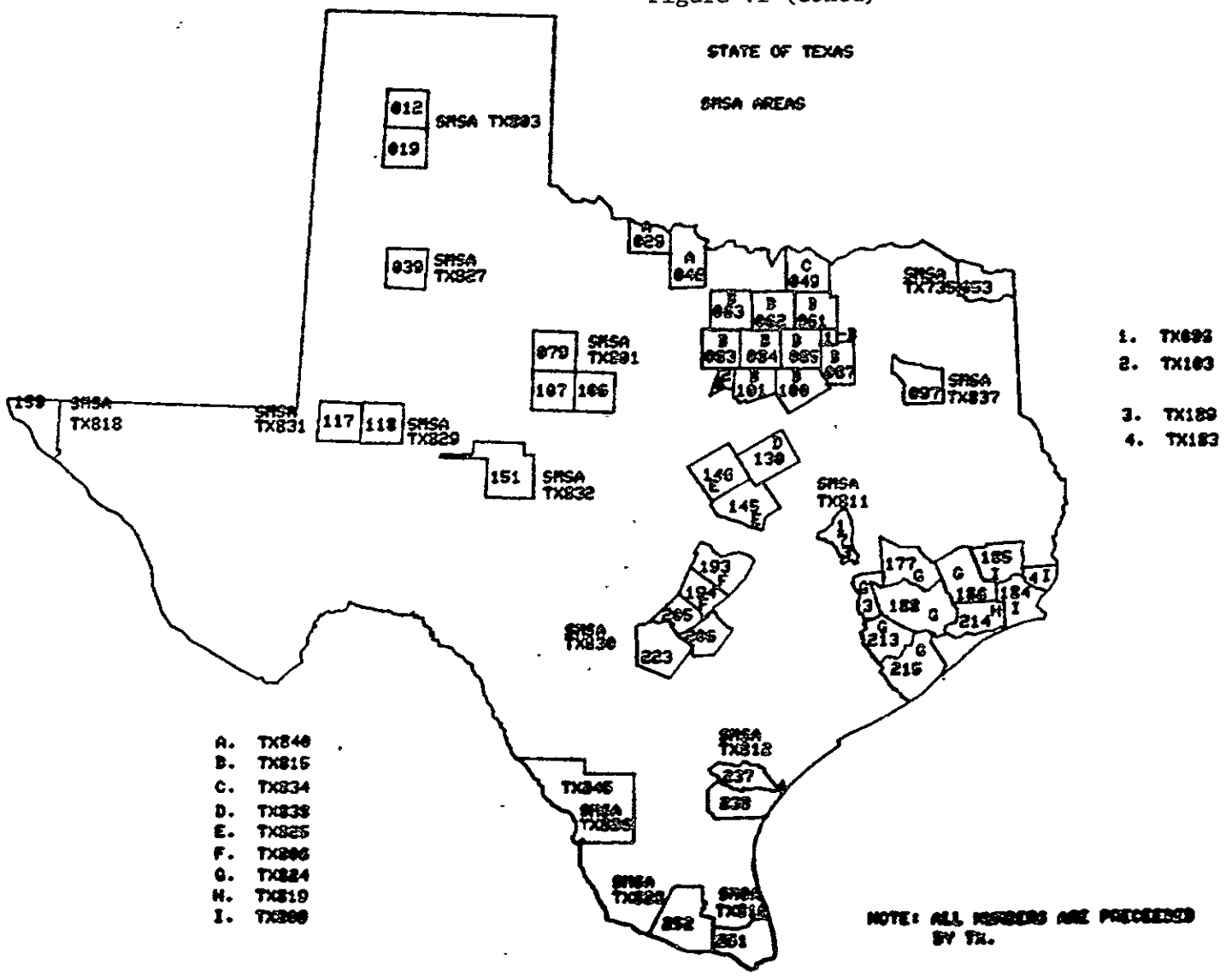
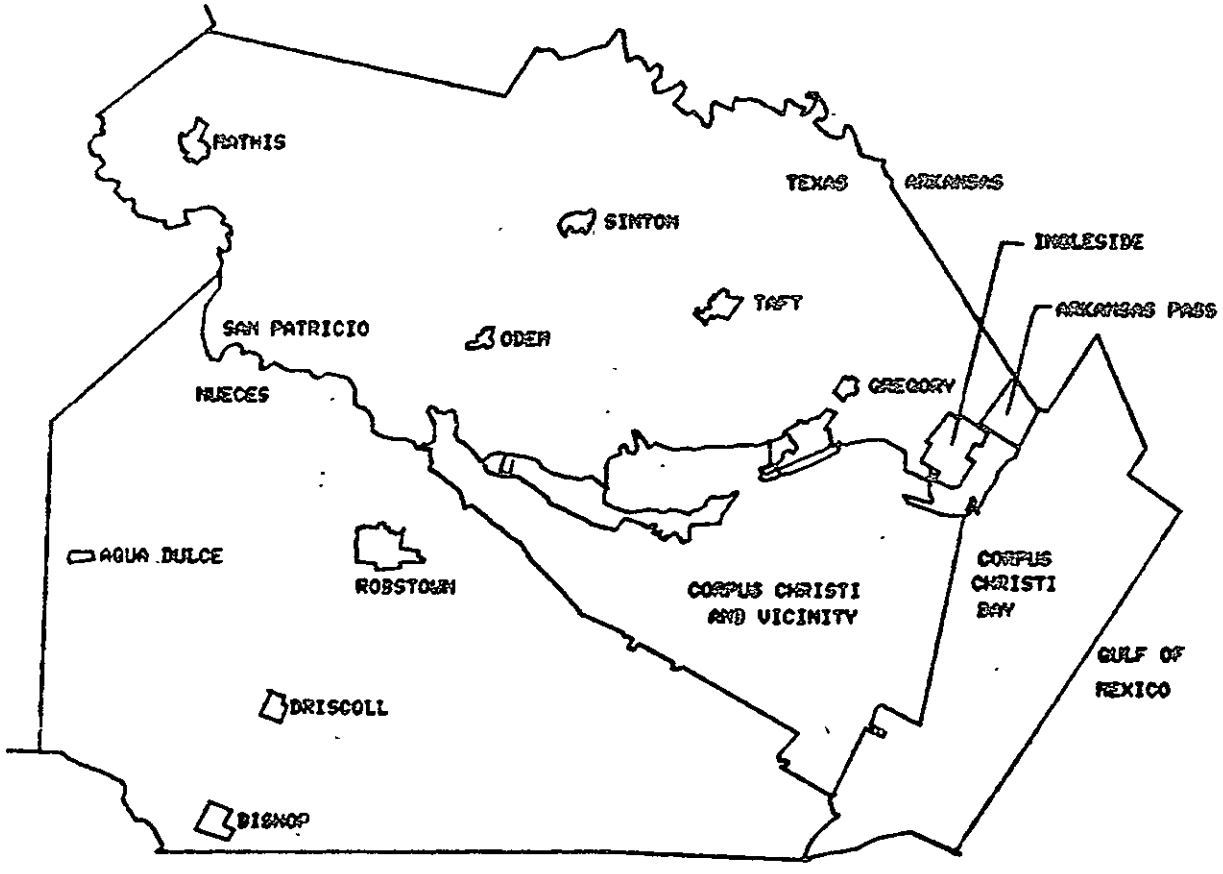


Figure VI (contd)

SMSA TX812 CORPUS CHRISTI, TEXAS



ATTACHMENT D

RECOMMENDATIONS FOR MSFC SOLAR ENERGY

CONTROL ROOM AND EQUIPMENT

INTRODUCTION

The purpose of this brief report is to offer recommendations on the use of the Marshall Space Flight Center, Solar Energy Control Room. A survey was conducted in January 1976 of the facility itself, the existing equipment, and the primary uses of the Control Room. The survey was conducted by representatives of The University of Alabama in Huntsville and its subcontractor, Spencer Graphic, Inc.

Emphasis was placed on making use of the equipment and visual aids that exist, with a minimum amount of new equipment being called for.

UTILIZATION PHILOSOPHY

The task facing the Marshall Space Flight Center's Solar Energy Task Team is not only that of helping developers of solar energy equipment reduce costs and raise efficiency; it includes spurring public acceptance of solar energy itself and a willingness to try something new.

The Control Room can be the hub of activity and the conter of interest. It lends itself well to small informal discussions, to full-blown and elaborate presentations, or as a showplace to stir interest and enthusiasm for solar energy and Marshall's programs.

It can be made an attraction for touring visitors by putting in small exhibits, models, and visuals explaining the principles of solar energy use. These exhibits should be of various levels of technological detail, so that they are of interest to the man-in-the-street as well as the knowledgeable engineer and scientist. The decor should be tasteful as well as functional. Solar Energy Task Team members must feel comfortable there, and equipment must be convenient and easy to use. A well-equipped control room must contain some relatively expensive equipment; it becomes yet more expensive when it lies unused. The survey revealed a great deal of expensive and idle equipment.

PRESENT EQUIPMENT

The Control Room has several versatile features. However, it appears that many are not being used to their potential or not at all. The following conditions existed at the time of the survey:

- 34 tracks for sliding, plexiglass display panels. 15 to 16 tracks were occupied, and only nine of these boards appeared to be in use.
- One wall-mounted 5' x 7' map of the United States. Not in apparent use.
- Two glass enclosed display cases - empty.
- Two viewgraph projectors used frequently.

- Telepro 3 x 4 and 2 x 2 slide projectors that lie unused. The 3 x 4 slides are expensive to make and are easily subject to damage.

- One 16 mm motion picture projector used rarely.

- Two ¼-inch tape recorders used rarely.

- Automatic Telepro control system for all rear screen projection equipment (except viewgraph projectors) with remote control at lectern. This very expensive equipment was not in working condition, and had not been used for years.

- Closed circuit television system including monitor mounted overhead and a large, rear-screen projector. The closed circuit system is rarely used and the expensive rear-screen projector is never used.

RECOMMENDATIONS

CONTROL ROOM DECOR - The Control Room should at all times depict something of the solar energy story and its vital contribution to the energy crisis solution. There are several immediate projects to improve the interior of the room itself.

First, a symbol that can be identified with the sun and its life force and energy should be adopted. Examples of several ancient sun signs are included in this report. A plaque or model of the emblem chosen should be prominently displayed and should appear on all MSFC visual material. A working model is proposed for the two glass front display cases. A light source will be placed in the top of the case to represent the sun. A light-metering device would then be placed to read directly the amount of light, or energy, received from the simulated sun. A series of filters that can be independently inserted between the light and the meter will represent the different forms of filtering conditions present in the earth's atmosphere. By changing the various filters, different cloud cover densities and their effect on solar radiation can be demonstrated.

The large map mounted at the end of the Control Room has a great deal of potential. A 35-mm projector can be mounted, unobtrusively, under the conference table. Slides could then be prepared to be projected fitting the map's dimensions. These slides could show the various solar radiation densities across the country, prevailing climatic conditions, locations of solar energy research projects, present energy use trends by area, energy costs by area, locations of solar energy equipment manufacturers, etc. The projector could be controlled by a standard remote switch by the speaker.

The sliding plexiglass panels are ideal for depicting schedules and milestones, especially changing ones. They can be quickly updated with tape and stick-on symbols, and the surfaces never wear out. More solar energy heating and cooling principles and equipment could be clearly and conveniently displayed on the plexiglass panels. They are large enough to be seen easily by anyone in the room.

TECHNIQUES - As mentioned previously, all visual material should display the

selected MSFC Solar Energy emblem. A pre-printed format can be used to prepare all viewgraphs and slides. This will give the presentations consistency, professionalism, and Marshall identity. Also, at no added expense or time, a color background can be used on viewgraphs and slides. It is not only more pleasing, but is also more restful to the eye. At very little extra expense, transparent multiple colors can be stuck directly to the viewgraphs the better to stress important points. All these recommendations are to improve the quality of the visual material and therefore the effectiveness of the presentation without appreciably increasing the time required for preparation.

One of the most vital and interesting projects in the Marshall solar energy effort is the Solar House. "Canned" presentations should be developed on several phases of this experiment - its history, equipment, various types of testing, practical knowledge gained, etc. These presentations could use slides, motion pictures, and closed circuit TV. The narration could be live or prerecorded. Many interesting tours of the Marshall facility could be conducted without ever leaving the comfort of the Control Room. This is especially practical during inclement weather.

The closed circuit TV could be used very effectively to give visual status reports of any project, and especially the Solar House. Using video tape, a presentation can be put together quickly to show up-to-the-minute progress or problems. A two-way sound system would enable the viewers to ask questions. These video-taped sessions could also be copied and exchanged with other centers or government agencies.

EQUIPMENT - It is recommended that much of the equipment behind the screens be removed. It takes up space and is not used. The automatic control equipment does not work, and might be costly to repair. There is also the problem of replacement parts and maintenance since the manufacturer is no longer in business. This is also the case with the large-screen television projector; its quality of resolution is far below that of the monitor in the Control Room itself.

The large slides for the 3 x 4 projector are costly to make, time consuming to mount and are subject to frequent damage. This size slide is not now in wide use, and the projector would at best see very limited use.

The viewgraph is a quick and effective visual aid. These projectors should remain as they are. The 16-mm movie projector is also a valuable asset; however, it is recommended that it be tied in with the automated system described in the following paragraphs.

MULTI-IMAGE SYSTEM - The multi-image system is manufactured by Wollensak and is distributed by the 3 M Company. It is a simple, cost effective, and versatile system that can be purchased in module form. A basic system can be added to as the need arises. It is fully automated, special effects, audio-visual package.

The basic units are a Wollensak Digi-Cue programmer, a Wollensak dissolver, a visual-sync recorder, a power pack, and two or more Kodak Carousels or Ektagraphic projectors. The basic capabilities of this system are as follows:

- Manual or automatic dissolves from one slide to another on the same screen with no dead space between slides.

- Automatic slide change using multiple screens.

- Automatic combination of slide with motion picture or any other electrically operated projection equipment.

- Audio can be recorded and an inaudible pulse placed on the tape which will change slides, start and stop any projector, turn on and off lights, etc.

In short, a complete presentation using combinations of visual effects on multiple screens and voice narration, with or without music, can be handled by just pressing the start button. The system can be stopped at anytime in the automatic mode for questions or group discussions, and then continued without disruption.

ATTACHMENT E

USERS' MANUAL

MSFC SOLAR ENERGY SLIDE FILE

USERS' MANUAL

SOLAR ENERGY VISUAL INFORMATION FILE

Prepared under NAS8-31293, Task 2

by

The University of Alabama in Huntsville

MSFC

SOLAR ENERGY DEVELOPMENT PROGRAM

INTRODUCTION

The Solar Energy Visual Information File is a valuable and versatile tool if used correctly and with just a little care. If it is not, the result will be missing or misplaced slides and viewgraphs and inevitable chaos. This brief Users' Manual will tell you what is available in the file system, and how to use it with a minimum amount of trouble and maximum results. There is a continuing effort to update the file with new and more pertinent visuals. Each month a revision sheet will be issued with the current status of the material in the file.

It is imperative that a control of some sort be maintained on the slides and viewgraphs and the visuals removed for use in speeches and presentations be returned to the file. The amount of duplicates are limited, and each slide that is missing puts one more hole in the effectiveness of an otherwise valuable solar energy information tool.

Those who have prepared the system and who will maintain it are available for any special assistance you may need, and are open to any serious suggestions on how to improve the system operation. Any requests for assistance should be addressed to Opal Tabor at The University of Alabama in Huntsville - 895-6358.

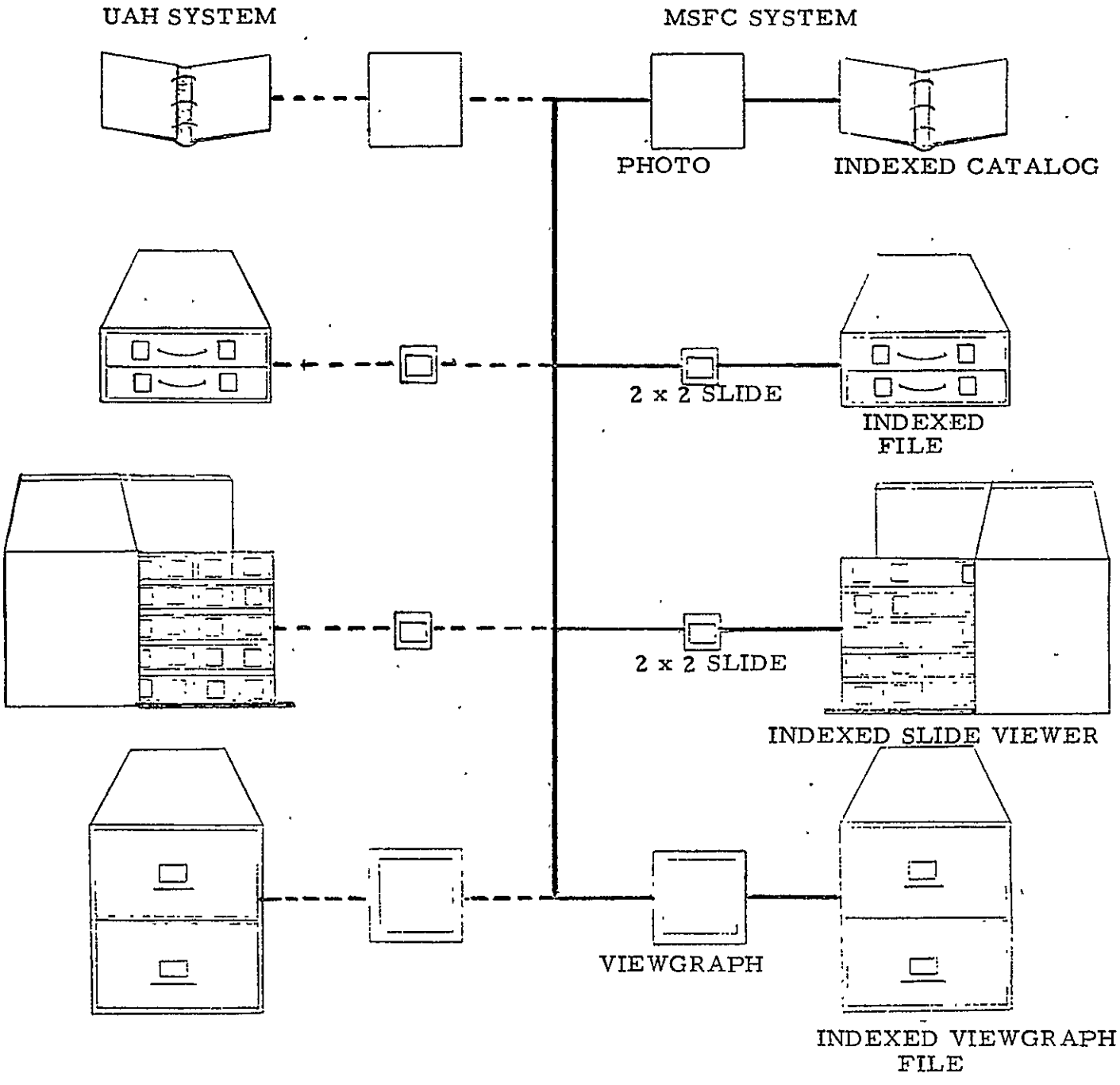
SYSTEM COMPONENTS

The system consists of stored and indexed slides and viewgraphs, a master file catalog with a photocopy and explanatory paragraph for each visual, and viewing stations (Figure 1). Most visuals exist in four forms, 2 x 2 slides, a viewgraph, an 8 x 10 black and white photo, and a color photo when possible. These visuals are cataloged and filed according to subject matter, and are numbered to reflect that subject matter. The numbering system is broken down into ten broad subject categories:

1. History
2. Available Systems (heating & cooling)
3. Available Subsystems
4. Solar Energy Projects (and testing)
5. New Concepts
6. ERDA Information
7. Energy Data
8. Environment and Climate
9. Solar Projects
10. Foreign Activities

These categories are further divided into subcategories as shown in Attachment A, Solar Energy Heating and Cooling Slide Catalog Reference File. Each visual has a number. The SE before the number indicates Solar Energy data. The first digit in the number indicates the broad

Fig. 1
SOLAR ENERGY VISUAL INFORMATION FILE FLOW



subject category, the second digit indicates the subcategory, and the third digit gives that particular slide's position in the group of slides.

> EXAMPLE: A slide numbered SE2-1-3, would depict Available Systems, (2) in the broad category; Hot Water, (1) in the subcategory, and it would be the third slide in that subcategory. The user can then flip through the catalog to that referenced spot and see a hard copy of the slide. Facing that photo would be a few facts about the visual. The system works the same way for 2 x 2 slides and for viewgraphs.

Note that subject category 9 includes Government-Funded Solar Demonstration Sites. This category is alphabetically divided into subcategories by states. The slides are filed by the location of the site rather than subject matter.

CONTROL PROCEDURES

It is immediately obvious that many slides will be in demand by more than one speaker simultaneously. Three 2 x 2 copies of each visual and one viewgraph have been provided. However, certain controls must be maintained to insure that slides and viewgraphs are returned to the files to be available for the next user. A log is provided to list the slides that are being removed from the files. After listing the slides or viewgraphs by number, write your name beside the list. After returning the slides, merely mark a large X through your list indicating that particular group of visuals has been returned.

IMPORTANT - Do not remove the hard copy photos from the Master File Catalog! This is your table of contents for the entire system. If a particular photo is needed, contact Opal Tabor at 895-6358 and she will provide one.

Every effort has been made to keep the process as simple as possible, but its success depends on the cooperation of every user.

NEW SLIDES

Many of you will find new slides that should be included in the system. Turn the visual over to Opal Tabor and she will process the numbering, captions, etc., and duplicate the necessary copies required for all the system components. You will also generate new slides on your visits to the various demonstration sites. To introduce these into the slide file, please use the following simple method:

1. Turn the exposed film over to Opal Tabor. She will have it processed and return a 4 x 5 copy of each to you.

2. From these 4 x 5 copies, you will choose those that should be in the system. Write three or four statements telling what the visual depicts, and return the chosen photos to Opal.

3. She will then assign a number to it, get the necessary 2 x 2 slides, viewgraphs, and hard copies made, and insert them into the library and catalog.

Those of you who use the system regularly will be the true judges of its effectiveness. Please offer your comments so that we may continue to improve the system and make it more operationally efficient.

SOLAR ENERGY HEATING & COOLING

SLIDE CATALOG REFERENCE FILE

These slides are listed in 10 basic categories with each category broken down into sub-categories.

SE 1 HISTORY

-1 Ancient to 1900
-2 1900 to 1970

SE 2 AVAILABLE SYSTEMS (HEATING & COOLING)

-1 Hot Water Only
-2 Heating Only
-3 Cooling Only
-4 Combined Heating & Cooling
-5 Hot Water & Heating
-6 Hot Water & Cooling
-7 Hot Water, Heating & Cooling
-8 Other (Costs)

SE 3 AVAILABLE SUB-SYSTEMS

-1 Air Collector
-2 Liquid Collector
-3 Storage
-4 Controls
-5 Instrumentation
-6 Other

SE 4 SOLAR ENERGY RESEARCH & DEVELOPMENT PROJECTS (& TESTING)

-1 MSFC (In-house)
-2 Other (By State)

SE 5 NEW CONCEPTS

-1 Line Focus Collectors
-2 Flat Plate Collectors
-3 Point Focus Collectors
-4 Architectural Renderings
-5 Power Plants

SE 6 PROGRAM INFORMATION

-1 General Information
-2 ERDA
-3 MSFC
-4 Other

SE 7 ENERGY DATA

-1 Energy Data (Solar)
-2 Energy Data (Overall)
-3 Energy Conservation
-4 Educational Aids

SE 8 ENVIRONMENT & CLIMATE

-1 Environmental Station - Instrument
-2 Environment & Climate

SE 9 SOLAR SITES & APPLICATIONS (By State)

- Commercial Demonstration Sites
-1 HUD Demonstration Sites (Residential)
-2 MSFC Development Test Sites
-3 Other

SE 10 FOREIGN

-1 Country
-2 Heating
-3 Cooling
-4 Industrial Process Heating
-5 Solar Distillation
-6 Hot Water

ATTACHMENT F

TOTAL ENERGY SLIDE PACKAGE

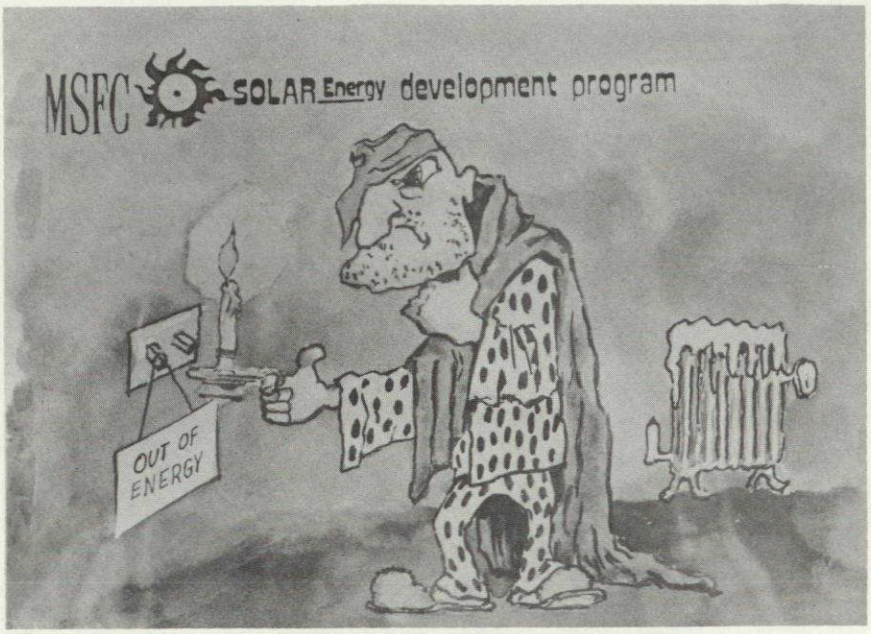
TOTAL ENERGY SLIDE PACKAGE

The slides developed for this package are designed to provide an "instant" presentation on the need for solar energy, the methods of solar energy utilization, other alternative sources of energy and the MSFC Solar Energy Development Program.

The package shown here provides the overview for slides devoted in more detail to the specific topics introduced here or for an expanded presentation, the user should consult the Slide Library itself.

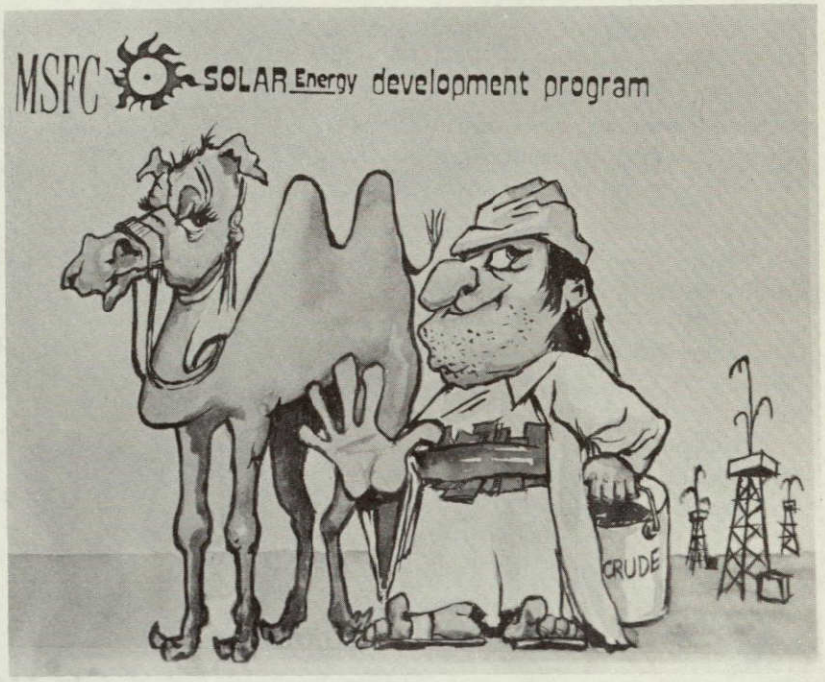
On the following pages, each slide is presented with a "transcipt" suggestion of those words which might accompany its presentation.

The energy problem facing the United States is bleak; it has already had a dramatic effect on our lives. Nothing affects our standard of living as much as the cost and availability of fuel and energy, and unless we change the present energy trends, our way of life as we know it today will be gone by the mid-1980's. We will no longer have a choice as to a standard of living, but will have to accept whatever the cost and availability of energy forces upon us.

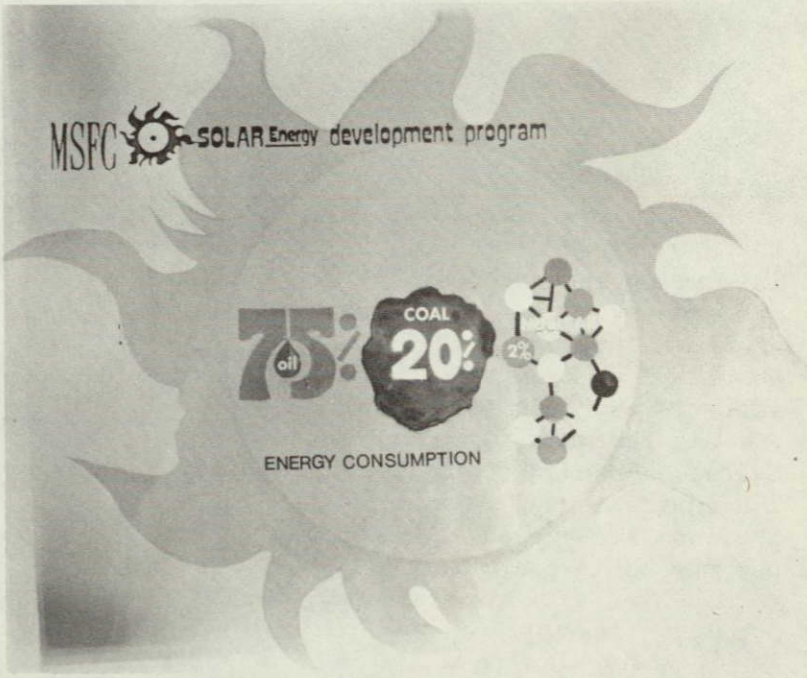


The present energy situation is the result of several factors. Firstly, there has been a dramatic increase in the demand for energy. In 1900, our energy use was the equivalent of 4 million barrels of oil a day. By 1950, 50 years later, it had risen to the equivalent of 16 million barrels a day. By 1970, the nation's energy demand was the equivalent of 32 million barrels of oil per day. At this rate of increase in the demand for energy, the United States would be consuming the equivalent of 64 million barrels of oil a day by the late 1980's.

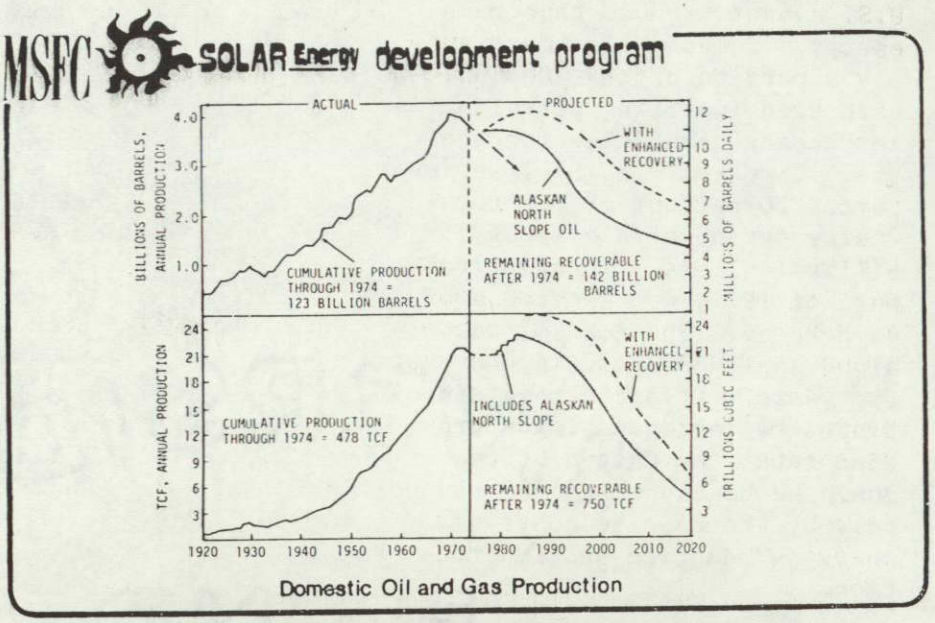
With our present technology the U.S. cannot produce that much energy. Someone else must supply a portion of that demand. We have been importing petroleum in increasing quantities for the past 10 years. In 1974, we imported 20 percent of our total energy demand at a cost of 25 billion dollars. In the first part of 1977, we imported over 45 percent. The cost of oil alone has quadrupled in the past two years. If our demand continues to increase at its present rate, the United States could be bankrupt by 1985 caused only by the massive costs of energy production and importation.



Another factor which must be considered is that the U.S. energy system relies most on the least plentiful domestic energy resources, and least on the most abundant ones. Seventy-five percent of the nation's energy consumption is based on oil and natural gas; these fuels are limited in quantity. It will be difficult to maintain even present production rates; before 1985, production of domestic oil and gas will begin to drop rapidly due to our dwindling supplies. The most abundant fossil fuel is coal, although it provides less than 20 percent of our current energy needs. Some experts estimate our coal reserves to be 10 times that of petroleum, but again, it is a fuel with a limit to its reserve. Nuclear power has vast potential, yet it presently provides about 2 percent of our total energy needs, and the most plentiful energy source, solar energy, supplies a negligible amount.

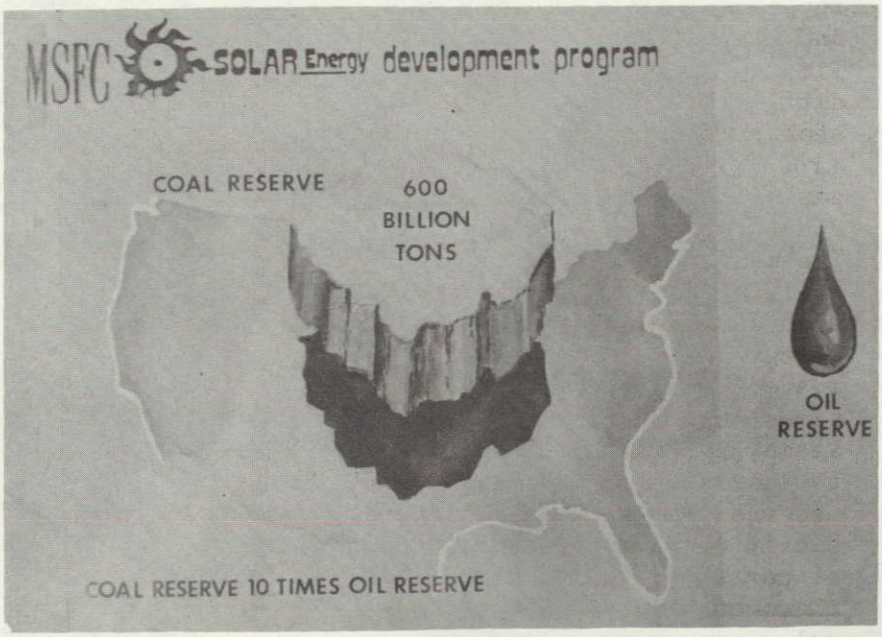


The exact amount of fuel sources available to us cannot be predicted. Certain assumptions must be made concerning undiscovered reserves and technology advancement for recovering and using these fuels. Most estimates of domestic reserves of oil and gas agree on one point; oil and gas cannot support our projected energy demands. Here is a comparison of our actual oil and gas production through 1974, and the projected production for the next 50 years. It shows an estimated total reserve of 142 billion barrels of oil and 750 trillion cubic feet of gas. Without some enhanced recovery techniques, the production will fall sharply by 1985. These recovery techniques require more research, but the extra fuel they produce will buy another 10 years of time - 10 crucial years that can be used to develop other energy sources.

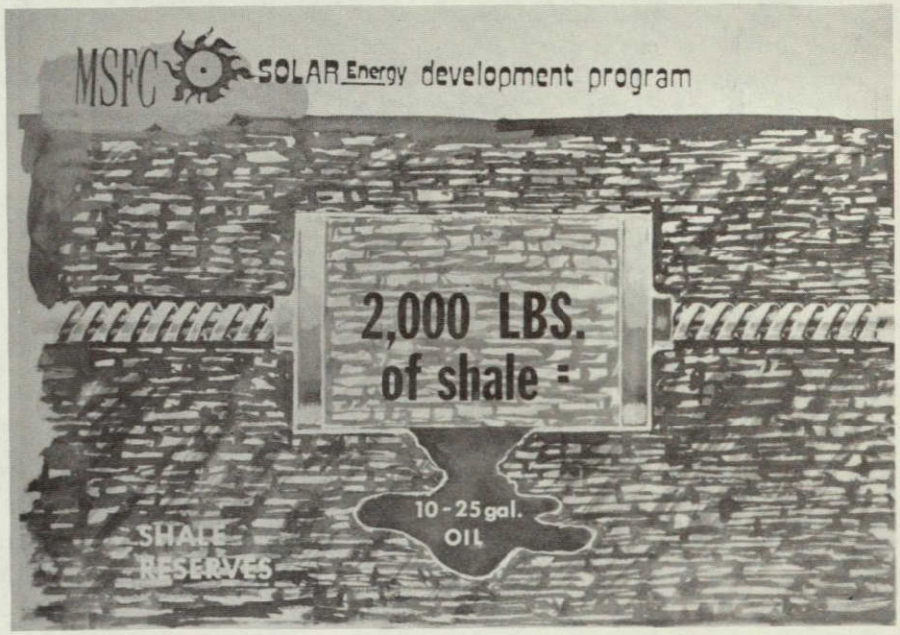


Domestic Oil and Gas Production

This slide shows the amount of coal reserves that are considered economically feasible to recover, about 600 billion tons. This estimate is about 10 times that of our oil reserves in equivalent energy. However, the ecological and environmental damage resulting from heavy coal recovery and use may be irreparable.

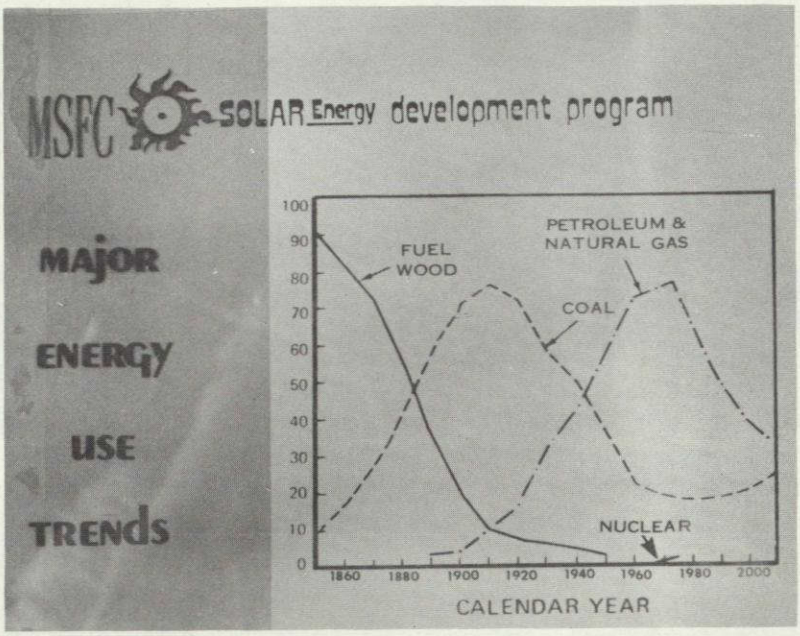


Shales vary considerably in their oil content and the technology has not been developed to make it economically sound to recover the more dilute shale. The shales have the potential of being equal to our oil well reserves in equivalent energy.

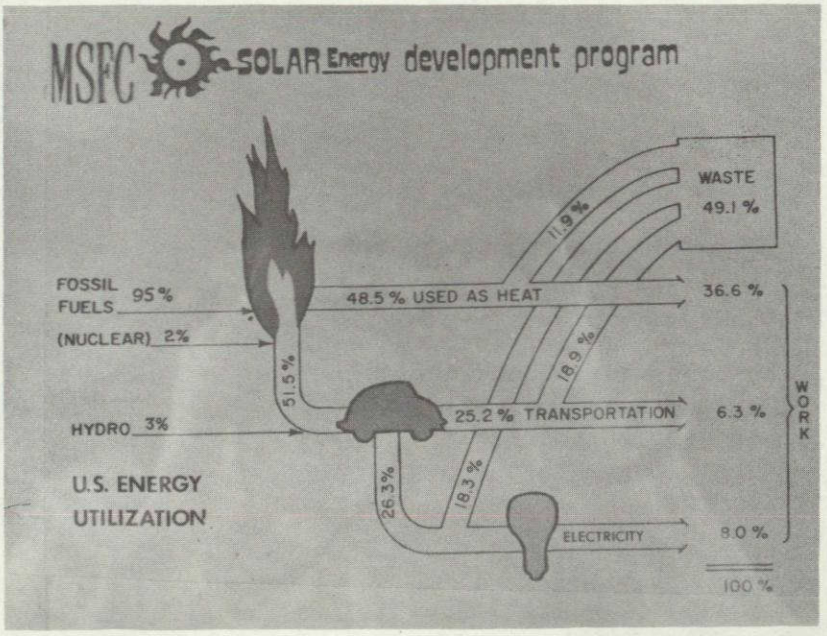


The future production and use of all these energy resources will pose some risks to our environment and our health. Strip mining has rendered thousands of acres of land almost useless and there is a strong anti-nuclear energy movement in our country. Science and technology can reduce the pollution and environmental damage if there is time to develop the safeguards along with the new sources of energy .

At the present time, 95 percent of our supply of energy is provided by fuels that are running out and there is no clear cut replacement. Trends in the past show that it has taken about 60 years from the point at which the change to a new energy source began and the point at which its use climaxed. Each time in the past a new energy source has been well developed by that time. Petroleum has reached that 60-year peak, but we have not developed our next energy source. The United States must change its energy dependence from limited fuel sources to unlimited fuel sources, and that change must be made more quickly than any similar change has been accomplished in history. We must buy as much time as possible for this change.



Up to now our lives have been based on cheap, readily available energy. It is estimated that we waste 49 percent of the energy we produce. So our first method of buying time is through energy conservation. We have slowed our speed limits; we have encouraged car pools. We have cut the thermostats down a little in the winter and up a little in the summer. Large amounts of waste heat from industrial and power generating processes which formerly were a problem are being recycled for useful purposes. The consumer's response to the national energy crisis has saved some gasoline, electricity and gas. Also, much can be done to help our short-term energy needs by concentrating certain technologies on enhancing the recovery techniques for oil, gas, and coal.



What are our choices? We can take whatever economic reduction the lack of energy forces on us and be satisfied with a lower standard of living--or we can use our energy more wisely through conservation and recycling and develop new sources of energy.

MSFC SOLAR Energy development program

Lower Standard of Living

&

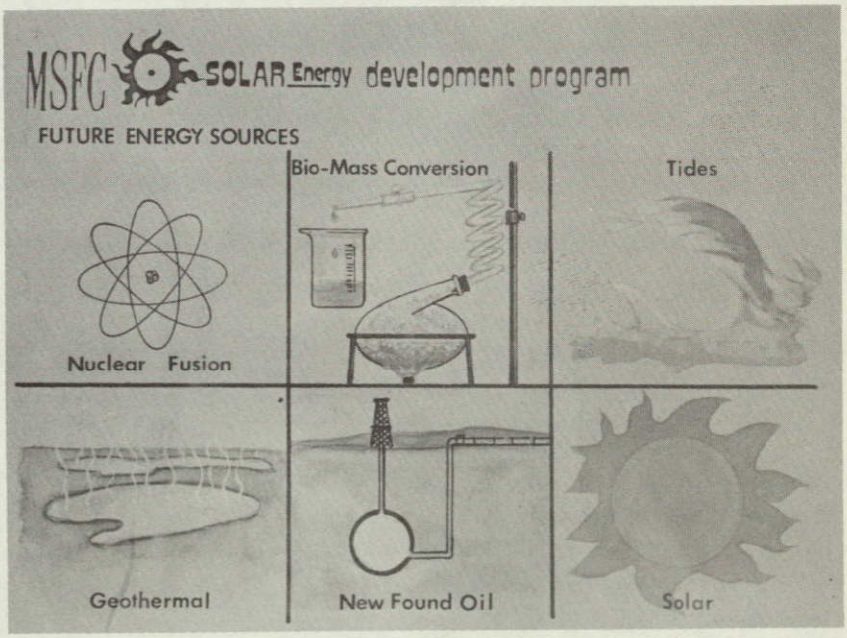
Economy Reduction

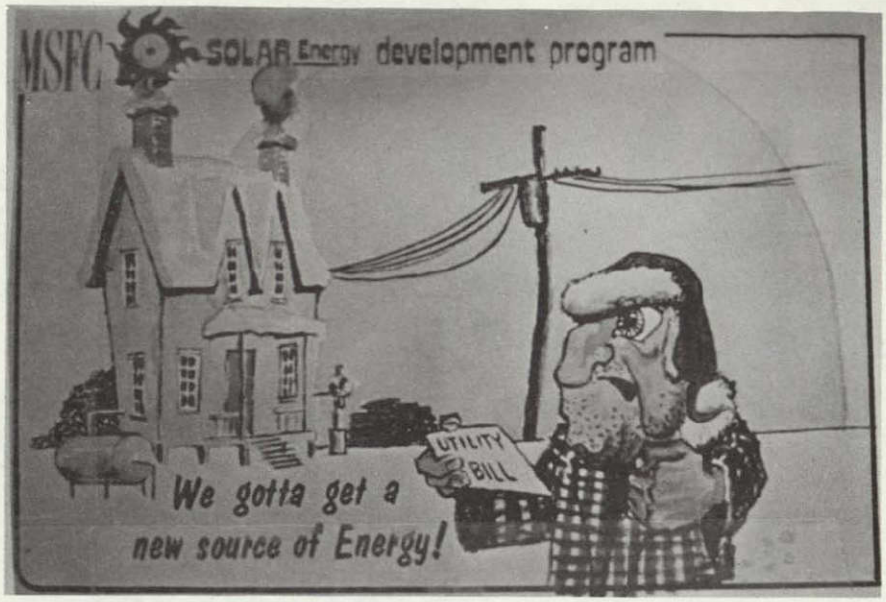
Use Energy Wisely

&

Develop New Sources of Energy

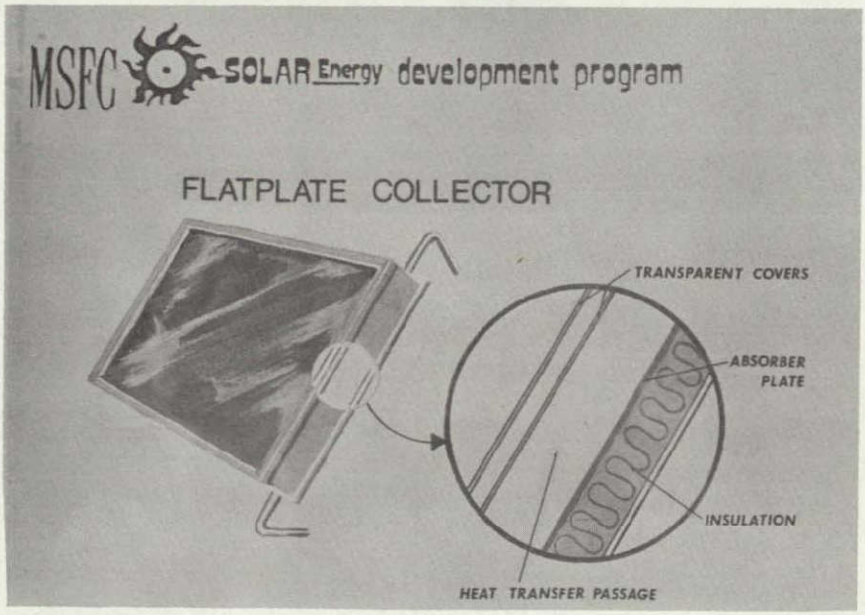
There are numerous unused and under-used energy sources available, nuclear fusion, biomass conversion, tides, geothermal and solar. All have their attendant problems in economics, technology and limits. The greatest potential is with solar energy. It is clean, unlimited, and free. It may be the world's prime energy source for all time to come. The technical problems associated with solar energy utilization are still substantial which is why we are going to work now to solve them.





WE NEED A NEW ENERGY SOURCE! Every second the sun throws off into space more energy than man has used since civilzation began. Even though only one two-billionth of this energy reaches the earth, this small fraction in three days provides as much heat and light as all our known reserves of coal, gas, and oil.

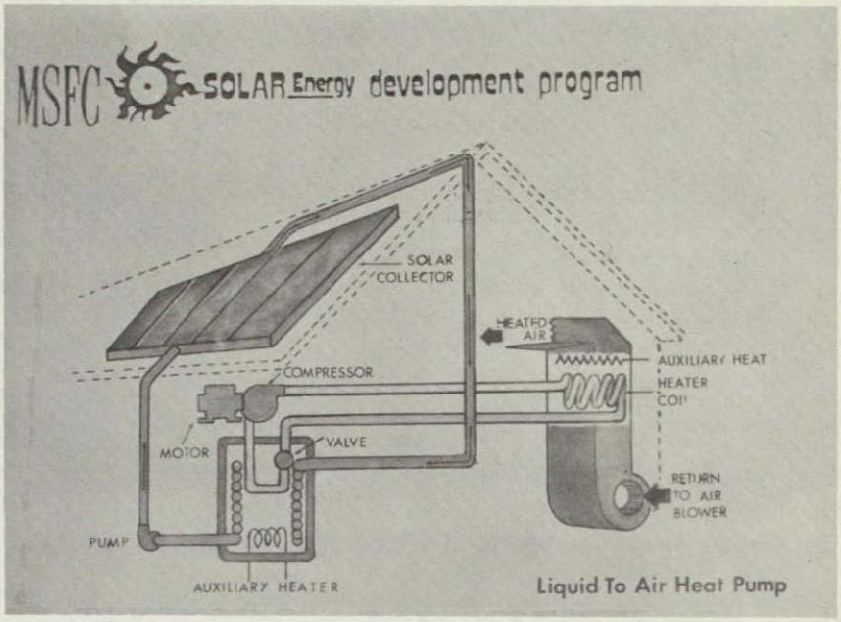
At the present time, solar energy can be used most effectively for heating water, in turn to heat buildings. The basic components of a solar heating system are collectors, heat storage containers, and a distribution system, but the heart of the system is the collector.



This is a basic flat plate collector. It consists of a heat transfer passage, an absorbing surface, one or two glass plates, and insulation. The collector may use a heat transfer liquid or a gas, usually air, to collect and transfer the heat. The absorber plate is coated to increase its ability to absorb the sun's energy. The coating may be an ordinary flat black paint or a more exotic selective coating.

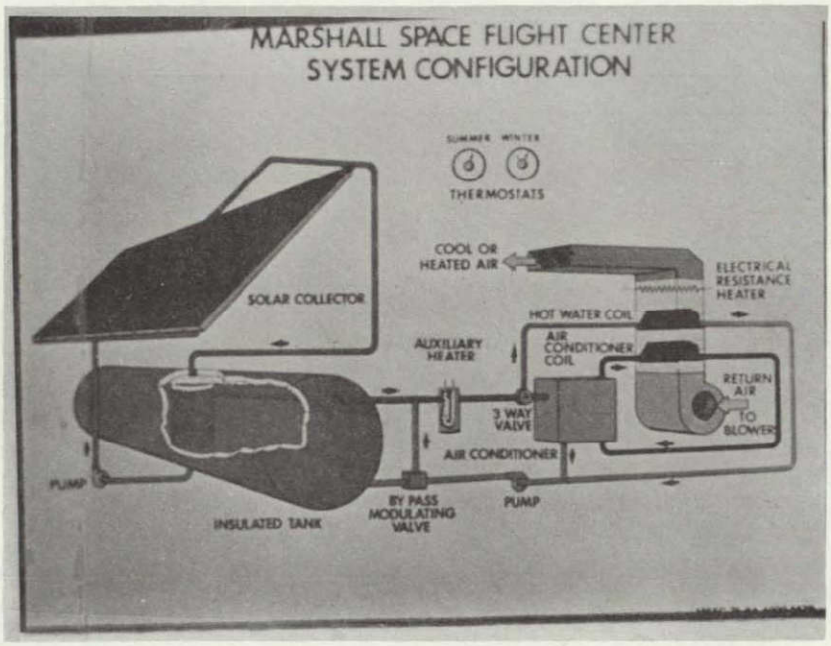
The efficiency of any collector is dependent on several variables: angle of the collector to the sun; whether the sun's rays are direct or diffuse; the type of absorber coating and insulation. However, most collectors on the market today can be considered to be about 35 percent efficient in year-round, every-day use.

The energy required to heat water for a home is 20 to 40 percent of the residential consumption. Using solar energy for this process would produce a substantial fuel saving. Shown is a typical system for heating and storing water for home space heating.

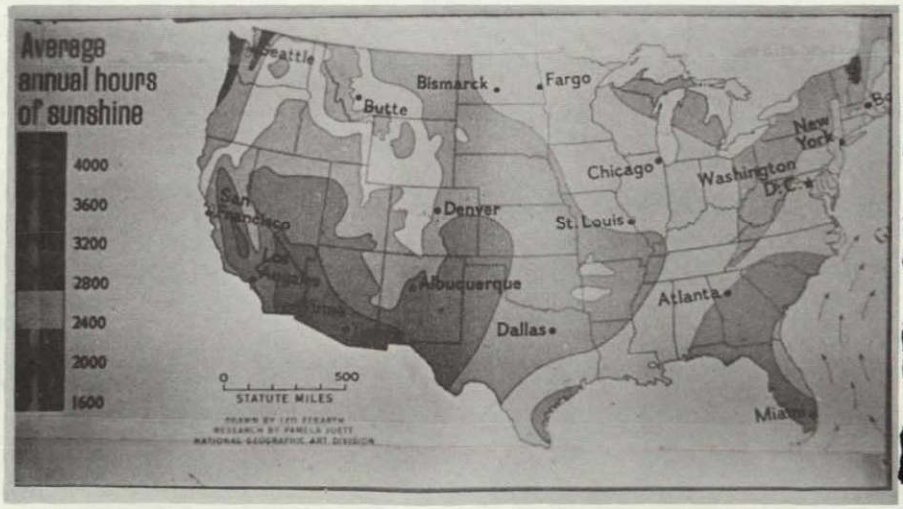


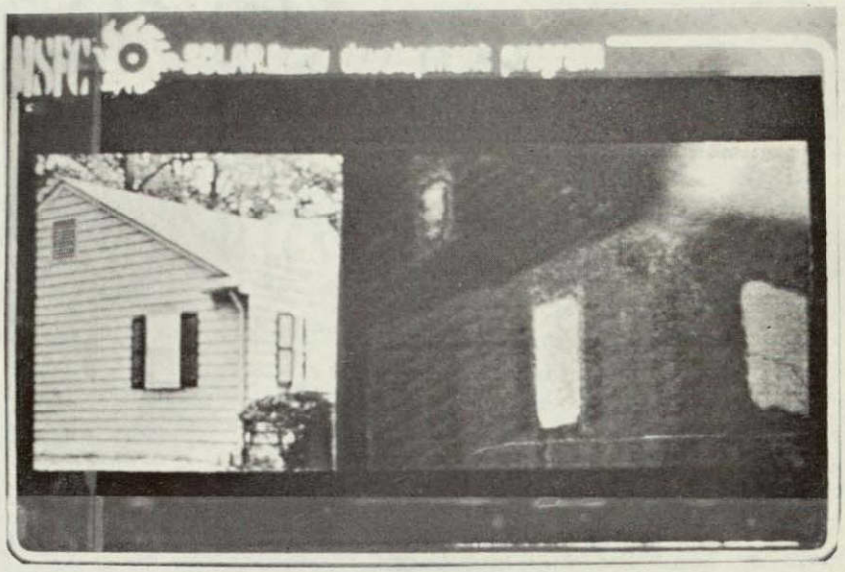
The second type of solar energy space heating system is an air system. The air from the collector heats reservoir of gravel or rocks. As the stored heat is needed, it is pushed from storage through the house by a forced air system.

Cooling by solar energy is still in a development stage, and is not yet efficient enough for residential use. However, several developmental projects are underway. One such project is at the Marshall Space Flight Center in Huntsville. This slide shows the basic schematic of Marshall's solar heating and cooling system. It is installed in a representative 2500 square-foot residential dwelling. The heating and cooling system produces 70,000 BTU per hour of heat during winter, and three tons of air conditioning for summer. The system stores sufficient energy for operation up to three cloudy days.



Now that we have examined the solar energy systems and equipment, let us look at the energy available. The amount of solar radiation or insolation available varies according to geographic area. This slide shows the concentration of solar radiation on an average day in the different areas. The radiation amount is influenced by such things as average cloud cover, wind currents, sun angle because of season, and other factors. Certain design considerations must be made in construction according to the radiation zone.

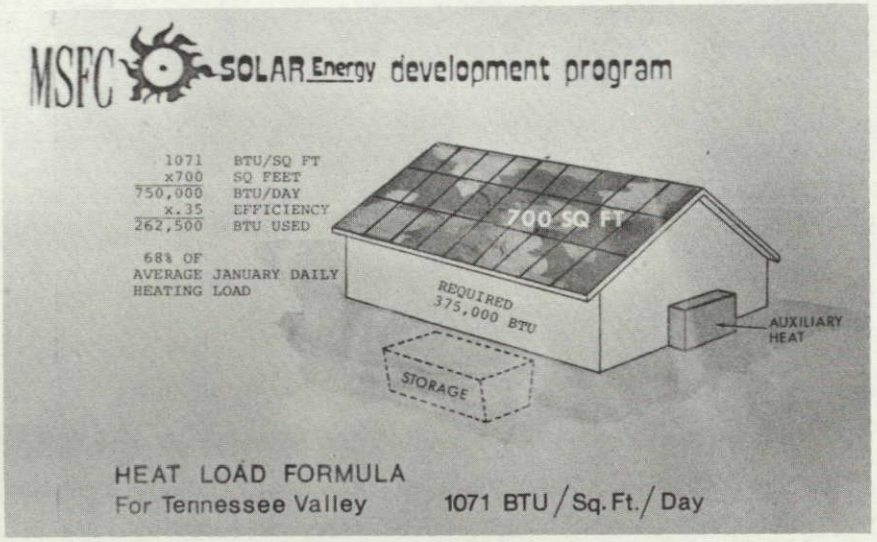




Just like any other heating and cooling system, solar energy systems are more efficient when used correctly. One of the first rules is "Insulate before you insolate." The heat produced must be conserved and protected. Inadequate insulation is one of the biggest factors in heat loss. This slide shows an infrared photograph to illustrate the building losing heat.

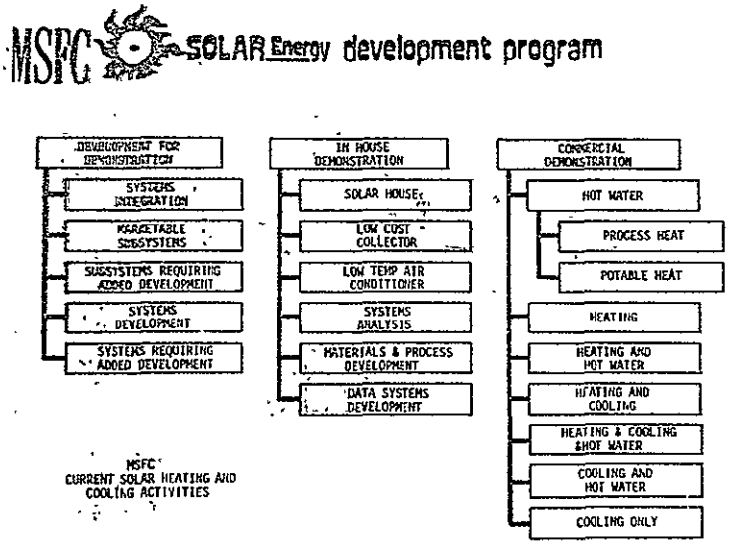
Another factor is life style. These rules should be observed--lower the thermostat at night and when the house is empty; do not waste hot water; keep outside doors and windows closed; and install storm windows and doors.

The amount of heating for a home that should be supplied by solar energy is also an economic factor. It depends on how much solar insolation is available, but also on the cost of installation of equipment, size of the house, cost of fuel in that particular area and other factors. This slide shows example using a typical house and conditions in the Tennessee Valley. The house contains 1400 square feet. For each square foot of living area, 275 BTU are required per day for heating. Therefore the daily heating load for the house on an average January day is 385,000 BTU. The ratio of roof area with the correct conditions for collectors to living space is roughly 1 to 2. So 700 square feet of collector could be installed on this 1400 square foot home. On an average January day, just under 1100 BTU of energy falls on each square foot of collector, giving us about 750,000 total BTU to the collectors. Assuming the collectors are 35 percent efficient, the system will produce 262,000 BTU for heating the home. This is approximately 70 percent of the heating load. The remainder would be provided by an auxiliary system such as a heat pump.

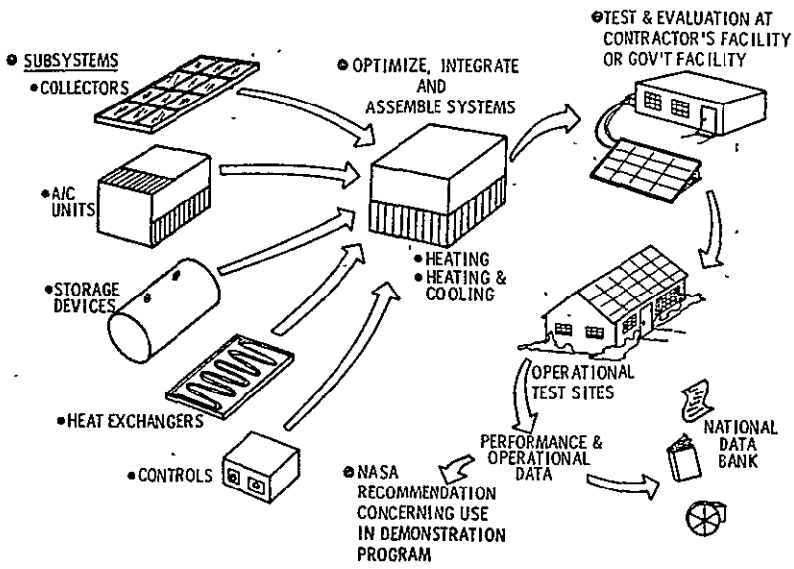


In adapting an existing structure to use solar energy, many components may be used without alteration. Existing domestic water heaters can be used to store hot water. Central forced air ducting can be used, and hot radiant systems can easily be integrated into solar heating systems.

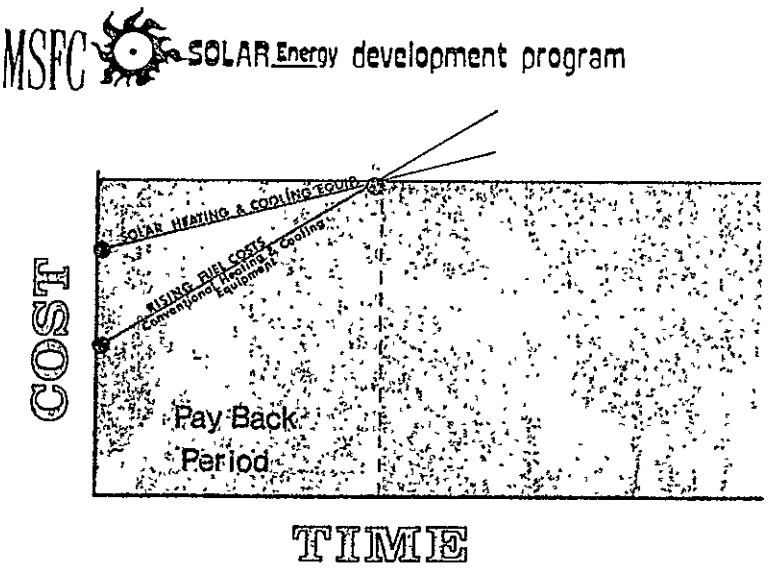
Many government agencies are encouraging and funding many solar energy projects. The specific role of the Marshall Space Flight Center is in equipment development--to raise the efficiency and effectiveness of solar energy equipment, and lower the costs. This slide shows Marshall's current solar energy heating and cooling activities. We are stimulating manufacturers by offering funds and technological expertise to help refine existing systems, develop systems that are in the R&D stage, and make equipment subsystems more compatible with each other and existing standard equipment.



Recently, MSFC began evaluating 308 proposals from industry in response to solicitations from the Energy Research and Development Administration (ERDA). As many as 20 contracts may be issued this year to support a wide range of projects including various combinations of solar heating, cooling and hot water systems in commercial buildings.



Right now the initial cost of solar energy heating and cooling equipment is higher than conventional equipment. The savings are in the use of fuel. This payback period is what we are working to shorten by improving the ease and cost of installing solar energy equipment, by improving mass production techniques and packaging, and by increasing efficiency and extending the life-times of equipment. We are investing a great deal of money, time and talent, but the payoff in terms of future fossil fuel and energy savings must be worht the inveatment.



ATTACHMENT G

ADDRESS LIST

OF

RADIATION DATA SOURCE

ADDRESS LIST

of

RADIATION DATA SOURCE OFFICES

ALABAMA

Agricultural Meteorological Station
Environmental Study Service Center
Auburn University
Auburn, AL 36830
ATTENTION: Mr. D. R. Davis, Meteorologist-in-Charge

Tennessee Valley Authority
River Oaks Building
Muscle Shoals, AL 35660
ATTENTION: Dr. T. L. Montgomery, Chief, Air Quality Branch

Commander, U.S. Army Missile Command
Redstone Arsenal, AL 35809
ATTENTION: Dr. O. M. Essenwanger, DRSMI-RRA

ALASKA

Smithsonian Radiation Lab
(See Smithsonian Under MD)

ARIZONA

Arizona State University
The Laboratory of Climatology
Tempe, Arizona 85281
ATTENTION: Robert W. Durrenberger

Mr. William L. Baily
Motorola Corp.
4039 E. Raymond Street
Phoenix, Arizona 85040

Desert Sunshine Exposure Tests, Inc.
Box 185
Black Canyon Stage
Phoenix, Arizona 85020

Northern Arizona University, Physics Dept.
Box 6010
Flagstaff, Arizona 86001
ATTENTION: William G. Delinger

CALIFORNIA

California State Resources
Dept. of Water Resources
Division of Resource Development
State Capitol
Sacramento, CA 95814
ATTENTION: Mr. James Goodrich

Munson, Mr. Delane
Hopkins Marine Station
Pacific Grove, CA 93950

San Diego State University
School of Engineering
San Diego, CA 92182
ATTENTION: Charles Morgan

COLORADO

Colonel Wallace E. Fluhr
Professor and Head, Department of Civil Engineers
United States Air Force Academy, Colorado 80840

National Radiation Laboratory/ERL-NOAA
Boulder, Colorado 80302
ATTENTION: Edwin C. Flowers

Kaman Sciences Corp.
P.O. Box 7463
Colorado Springs, CO 80433
ATTENTION: Doug U. Jardine, Phoenix Project

DELAWARE

University of Delaware
Institute of Energy Conversion
Newark, Delaware 19711
ATTENTION: Dr. Frederick A. Costello, Mechanical Engineering Dept.

FLORIDA

W. G. Jelen
IN-OMO-2
NASA-KSC, Data Branch
J. F. Kennedy Space Center, FL 32899

University of Florida Experiment Station
Quincy, FL

ILLINOIS

Dr. Thomas Van Heuklon
Department of Geography
Western Illinois University
Mocomb, Illinois 61455

KENTUCKY

TVA - See Alabama

MARYLAND

Goddard Space Flight Center
Greenbelt, Maryland 20771
ATTENTION: Mr. William Bandeen

Dr. H. E. Landsberg
University of Maryland
College Park, MD 20742

Smithsonian Radiation Biology Laboratory
12441 Parklawn Drive
Rockville, MD 20852

Dr. M. P. Thekaekara
Code 912 NASA/GSFC
Greenbelt, MD 20771

MASSACHUSETTS

Professor Samuel E. Johnson
Department of Biology
Clark University
Worchester, Massachusetts 01610

MICHIGAN

Dr. Dennis G. Baker
Assistant Professor of Meteorology
Department of Atmosphere and Ocean Science
2455 Haywood
Ann Arbor, Michigan 48105

Smith, Hinchman & Grylls Associates, Inc.
455 W. Fort St.
Detroit, MI 48226
ATTENTION: Mr. David C. Miller

NEBRASKA

Lambda Instruments Corporation
4421 Superior Street
P.O. Box 4425
Lincoln, Nebraska 68504

NEVADA

Dr. V. Smiley
Desert Research Institute
University of Nevada
Stead Campus
Reno, Nevada 89507

Dr. John Houghton
Department of Geography
University of Nevada
Reno, Nevada 89507

NEW MEXICO

Sandia Laboratories
Albuquerque, New Mexico 87115
ATTENTION: Eldon C. Boes, Energy Program Development Division 5711

NEW YORK

Atmospheric Sciences Research Center
State University of New York at Albany
1400 Washington Avenue
Albany, New York

Cornell University
Department of Agronomy
Ithaca, New York

Department of Environmental Conservation
Air Resources Division
50 Wolf Road
Albany, New York

Grumman Aerospace Corporation
Energy Programs, Plant 25
Bethpage, NY 11714
ATTENTION: K. Speiser

Dr. Rudolph Hollman
Senior Research Scientist
New York Ocean Science Laboratory
Drawer EE
Montauk, NY 11954

SUNY College of Environmental Science and Forestry
Department of Silviculture
Syracuse, NY 13210
ATTENTION: Mr. Richard A. Schwab

NORTH CAROLINA

National Climatic Center
Asheville, North Carolina 28801
ATTENTION: Dr. Nathan Gutman

Carolina Power & Light Company
P.O. Box 1551
Raleigh, NC 27602
ATTENTION: Mr. D. G. Wilder

Environmental Sciences Research Laboratory, EPA
Research Triangle Park, NC 27711
ATTENTION: Mr. Charles R. Hosler

NC/STRC
P.O. Box 12235
Research Triangle Park, N.C. 27709
ATTENTION: Mr. Leon Neal

OHIO

NOAA - See Colorado

SOUTH CAROLINA

South Carolina Agricultural Experiment Station
Clemson University
Clemson, SC 29631

Carolina Power & Light Company - See North Carolina

TENNESSEE

ASG Industries, Inc.
P.O. Box 929
Kingsport, TN 37662
ATTENTION: George H. Gose

TVA - See Alabama

TEXAS

Environmental Studies Service Center
Room 161, Bizzel Hall, TAMU
College Station, TX 77843
ATTENTION: Ray L. Jensen; Professor John Griffiths

VIRGINIA

Mr. I. L. Hamlet
NASA/Langley Research Center
Mail Stop 261
Hampton, VA 23665

Wallops Flight Center
Wallops Island, VA 23337
ATTENTION: J. Holland Scott or Robert L. Krieger

Intertechnology Corporation
100 Main Street
Warrenton, VA 22186

WASHINGTON

Professor Gaylon S. Campbell
Department of Agronomy
Washington State University
Pullman, Washington 99163

WISCONSIN

Solar Energy Laboratory
University of Wisconsin
Engineering Research Building
1500 Johnson Drive
Madison, Wisconsin
ATTENTION: Dr. Jack Duffy

ATTACHMENT H

UAH JOHNSON ENVIRONMENTAL & ENERGY CENTER

SOLAR ENERGY RESEARCH, DESIGN & TESTING ACTIVITIES

Johnson Environmental and Energy Center

The University Of Alabama In Huntsville

P O Box 1247
Huntsville, Alabama 35807

SOLAR ENERGY RESEARCH, DESIGN, AND TESTING ACTIVITIES

GENERAL

The Johnson Environmental and Energy Center at the University of Alabama in Huntsville is presently performing research, design, and testing activities and developing educational source materials on the University campus. These efforts are primarily supported by funds made available through the State of Alabama and under sponsored research contracts and grants with governmental and industrial organizations. All of the UAH programs, underway or planned, encourage and support participation by faculty, staff, and student members, as well as researchers from other institutions.

Local environmental parameters, materials testing data, and other information related to solar energy applications have been developed. Cooperative programs with industries, associations, and other institutions are also underway in such areas as instrumentation development, systems analysis, technical data handbooks, equipment testing, etc. A strong public interest in this field has also enhanced the expansion of these various projects.

Initial funding for the UAH-JEEC solar energy test facility was provided by State of Alabama revenue sharing funds amounting to $100,000 which were made available in June 1974. The facility now includes administrative and technical facilities (5,500 square feet), an atmospheric measurement station, test stands for solar collector performance analyses, and residential research facilities now being used for systems testing of solar and wind energy concepts and subsystems. Emphasis is being placed on the development of alternate energy sources and self-sufficient operation of mobile homes and modular structures.

TEST FACILITIES

The UAH-JEEC has established facilities for experimental and certification testing of solar energy components, subsystems and systems. Industrial researchers and firms in Alabama are now using these facilities to help advance the state of the art in solar energy applications, including gains in performance and reductions in cost. They are also being used to support industries from many other states where these kinds of unique and self-supporting testing capabilities are not available.

Particular emphasis is given to the side-by-side testing of various solar conversion systems to compare their relative efficiency, costs and applications.

The modular residential research facilities incorporate extensive use of energy conservation and "passive" solar energy techniques. "Bread-board" testing and system optimization studies combining solar, wind, and waste conversion are also incorporated to meet total energy requirements.

A digital data acquisition system is incorporated into the test facilities consisting of a 72 channel remote multiplex system utilizing a telephone terminal for input into the University's Univac 1110 Computer Complex. This data acquisition system is being expanded to include the addition of a computer and data storage system.

This unique research and test facility and program at The University of Alabama in Huntsville now supports a variety of research and development studies related to environmental and energy investigations and the application of solar and wind energy into combined systems. Likewise, energy conservation techniques and waste treatment systems for conversion to energy sources are being incorporated into this flexible approach for a practical matching of operational systems to "real world" environmental conditions. This is particularly needed in remote areas where alternate energy systems can more readily compete with conventional energy sources on an economic basis.

EDUCATIONAL ACTIVITIES

In the spring of 1975 the University of Alabama in Huntsville (UAH), in association with the Huntsville Area Technical Societies, sponsored a major short course and conference on solar energy applications for the benefit of industrial, university and governmental workers and homeowners. This five-day affair used the University and nearby hotel facilities and drew hundreds of attendees from throughout the United States. It also provided a focal point for solar energy research and applications within the southeastern region.

An annual conference has now been initiated as a result of this program with participation by southeastern and other universities, industries, and individuals.

In May of 1976, The Solar Energy Group of the UAH-Johnson Environmental and Energy Center coordinated a major workshop for the Solar Energy Division of the Energy Research and Development Administration. The workshop was needed to identify national meteorological and solar radiation data, acquisition and analysis. Moreover, members of ERDA, NOAA, NASA and the various state energy offices needed a forum to exchange information and formulate policies and planning activities to stimulate solar energy research, development, demonstration and commercialization programs to provide the United States with an expanded energy research capability.

The meetings and related tours to view solar energy test and operational sites in the Huntsville area were held over a three-day period with major activities centered at the Von Braun Civic Center and the Huntsville Hilton Hotel. Six sessions were held with emphasis on participation by all attendees in the workshops and on meeting the regional, as well as the national, and specific needs of the various states.

Detailed proceedings of both the first southeastern conference and the first national workshop with the state energy offices have been published by The University of Alabama in Huntsville. Follow-up activities are also underway as a result of these sessions and new programs are being planned.

The UAH-JEEC has also assisted in the organization and provides support to the Alabama Solar Energy Association, which is headquartered in Huntsville and now has some 500 members from throughout the state and across the country. This organization is a chapter of the International Solar Energy Society, American Section, and now uses the UAH-JEEC for facility support and a permanent mailing location for its membership activities.

A solar energy technical data and information room has also been established at JEEC for use by researchers. A comprehensive set of reference documents, charts, educational materials, test and operational data comprise this useful resource.

DESIGN AND DEVELOPMENT

The UAH-JEEC has performed research, design, engineering and development activities for numerous solar energy applications. The test facilities, including model studies, the overall layout, a materials and coatings test stand, solar collector test stands, residential research modules, solar radiation and environmental measurement facilities and wind conversion test stands were designed and developed under the direction of and with personnel from UAH-JEEC.

Instrumentation and data acquisition systems to monitor and control the test operations have been designed and developed with close support by industrial firms such as SCI Systems Incorporated of Huntsville.

Design improvements have been suggested to assist industrial organizations such as Halstead and Mitchell of Scottsboro and Sun Century Systems of Florence, Alabama. These solar collector manufacturers and others from throughout the United States have benefited from the varied design and testing experience of the UAH-JEEC Solar Energy Group.

The two residential research modules in the test facility incorporate "passive" solar energy conversion techniques through the use of extensive insulation and window area to the south side of the units. They function as test beds or "breadboards" to develop new solar energy systems incorporating advanced controls and to relate oyerall system performance to the subsystems operation.

The design team at UAH-JEEC has also supported the Alabama Space and Rocket Center solar energy activities, including design and development of a solar heated coffee demonstration and design of a solar heating module for display at the Center. This module is designed for "do-it-yourself" activities and can provide hot air and hot water for homes, crop drying, rest stations, chicken houses, workshops, etc. The structure can also serve as a storage area.

Other studies are underway, including hot air systems using solar energy, solar electric-mass transit systems, electrically powered commuter cars, and integrated systems incorporating solar, wind, and waste conversion techniques to provide the total energy needs of remote areas. In addition, design and engineering studies are underway to develop a "solar community" on the university campus which will aid in the research and development of longer-life and more energy efficient mobile and manufactured home demonstrations.

RESEARCH CONTRACTS

Besides the industrial research and testing performed for various organizations throughout Alabama and the United States, the UAH-JEEC Solar Energy Group has also provided contractual support to federal agencies on the National Demonstration Program for Solar Heating and Cooling. Under $373,000 in completed contracts from ERDA and the Marshall Space Flight Center of NASA (through 1976), the UAH-JEEC has performed national surveys for entry into a computerized data base used for systems analysis, developed a visual and educational system for management and lecture needs, performed research and published a "Listing of Solar Radiation Equipment and Glossary", and a compilation of "Solar Radiation Observation Stations" throughout the United States. Research programs are now committed for 1977, including new and extended contracts valued at some $300,000 in additional funding.

Other proposed and new programs should increase the 1977 (calendar year) contractual level of effort to $500,000.

The following research programs and tasks are now being performed:

NASA-MSFC (NAS8-31293)

Task 1 - National Survey and Data Base Development

Task 2 - Visual and Educational Aids Development and Support

Task 5 - Commercial Demonstration Design Review and Support

Task 6 - Solar Demonstration Program Module Development

ERDA - Solar Energy Division (EG-77-S-05-5362)

Task A - Solar Radiation Instrument Catalog (International Listing)

Task B - Solar Radiation Data Analysis (National Survey)

Tack C - Solar Radiation Network Guidelines (National Handbook)

Some 25 researchers are actively involved in these contractual programs.

SUMMARY

Since June 1974, the University of Alabama in Huntsville, Johnson Environmental and Energy Center (JEEC), solar energy program has supported the research efforts of 24 professional and administrative personnel, 52 graduate and undergraduate students, 28 consulting and other technical specialists, 20 subcontractors, and numerous commercial suppliers. Over $400,000 has been used in support of solar energy activities to date and some $500,000 is anticipated for calendar year 1977.

One of the key recommendations made at the National Solar Energy Workshop, which was coordinated by the UAH-JEEC under a grant from the Energy Research and Development Administration during May 1976, was for each state to designate and establish contact points to coordinate their solar energy activities. It was further suggested that the states develop task teams and centers to provide information dissemination and technical assistance to industries and users of solar energy systems. The UAH Johnson Environmental and Energy Center has been performing these same and related functions since early 1974 when Governor Wallace provided $100,000 in revenue sharing funds to the University.

An educational slide library and lecture materials have been developed under government contracts to support the National Solar Energy Demonstration Program. Likewise, solar equipment and instrumentation catalogs and solar radiation measurement and observation surveys have been completed. Local, regional and national workshops, conferences and seminars have been coordinated by the UAH-JEEC in support of solar energy research and applications and environmental source books and proceedings published.

The UAH-JEEC facilities are a focal point for testing and educational support of solar energy with many site visits from local, regional and national visitors and tour groups. Visitors from 34 states, Puerto Rico, Canada, Germany, and the United Kingdom have toured the UAH-JEEC solar energy facilities during the two years. About three-fourths of the total visitors have been from outside of Huntsville.

As funds are provided for meeting the additional operational needs of staffing, publication, testing and dissemination of information needed by the citizens of Alabama, the UAH Johnson Environmental and Energy Center can continue to function as a major solar energy center for this area.