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SOLAR HEATING AND COOLING

TECHNICAL DATA AND SYSTEMS ANALYSIS

Center for Environmental and Energy Studies

The University Of Alabama In Huntsville

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SOLAR HEATING AND COOLING

TECHNICAL DATA AND SYSTEMS ANALYSIS

PROGRESS REPORT

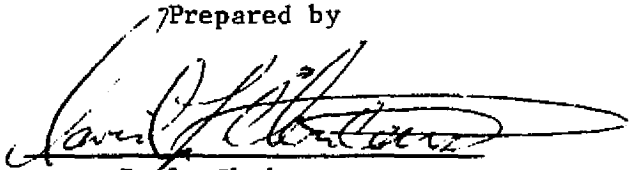
CONTRACT NAS8-31293

Submitted to

National Aeronautics & Space Administration
Marshall Space Flight Center, Alabama

(Summary for Period October 1974 - August 1975)

Prepared by



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SEPTEMBER 1975

PREFACE

Studies, experiments and operational programs in applying solar energy for climate control in buildings have been conducted for a number of years by industrial, educational, and governmental organizations. With the enactment of the Solar Heating and Cooling Demonstration Act of 1974 (PL93-409), the NASA Marshall Space Flight Center and The University of Alabama in Huntsville recognized the pressing need for compiling and organizing a variety of information concerning solar energy heating and cooling and related technology into useable formats and data handling systems.

A collection of data on climatic conditions and topographical features of various sites; economic factors from all sections of the nation, including fuel and energy costs; coupled with architectural techniques, properties of construction materials, and selected parameters for both conventional and solar energy heating and cooling equipment are required to perform analyses of development requirements for solar energy equipment and related applications in various systems and subsystems. This is particularly true if a viable industry and marketable hardware is to be developed according to the intent and stated objective of the Solar Heating and Cooling Demonstration Act.

Efforts are now underway, as described in this status report, to provide resource and input material for a computerized system which will allow cross correlation, access, and ready retrieval of all pertinent data and conditions necessary for systems analysis and development of information packages to meet the needs of program management, developers, and potential users of solar energy heating and cooling equipment. This new tool will hopefully be applied to meeting our critical needs for new energy sources.

ABSTRACT

The activities described herein were accomplished by The University of Alabama in Huntsville under Contract NAS8-31293 with the Marshall Space Flight Center (MSFC), National Aeronautics and Space Administration. Overall technical direction was provided by Mr. Donald R. Bowden (COR), Manager of the MSFC Solar Heating and Cooling Task Team. Computer formating and data acquisition was under the direction of Mr. John F. Pavlick, Chief of the Mission and Operations Branch, Preliminary Design Office, Program Development.

The prime goals of the contract are basically three-fold. The first goal was to gather the expertise and available knowledge of solar energy research and demonstration projects, solar heating and cooling equipment manufacturers, interested educators, knowledgeable consultants, and industrial organizations into complete, easy to use, quickly retrievable packages.

The second goal was to identify pertinent parameters for conducting systems analyses of solar heating and cooling applications. These included specific evaluations of topography, architectural design, conventional and solar heating and/or cooling equipment, thermal properties of construction materials, geographic economics, energy costs, and overall economic considerations.

The third, and on-going effort, is to acquire specific data in the identified parameters for inclusion in a computer data bank using the Marshall Information Retrieval and Data System (MIRADS) developed by NASA-MSFC. This effort requires the development of format, indexing and entry techniques to allow ready accessibility and utilization of the gathered data. This broadly based approach is needed to develop a systematic method to aid in making decisions and determine the most cost-effective development program for solar heating and cooling systems.

ACKNOWLEDGEMENTS

This report has been prepared by a solar energy research team of the Center for Environmental and Energy Studies, The University of Alabama in Huntsville, as an interim summary of on-going progress under NASA Contract NAS8-31293. David L. Christensen is the Principal Investigator of the research study. Major contributors to the project and to 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, the efforts of the NASA-MSFC Contract Monitor, Mr. Donald R. Bowden, Manager of the Task Team, has provided valuable contributions to the overall research approach. Mr. John F. Pavlick, Chief, Mission Operations Branch, is likewise closely monitoring the current efforts to provide a viable computerized data system which is needed for overall systems analysis.

The special consulting services of Professor George O. G. Lof, Colorado State University, and Dr. J. A. Duffie, Director of the Solar Energy Laboratory, University of Wisconsin-Madison, were also invaluable to the research efforts. Both Dr. Lof and Dr. Duffie visited Huntsville during March and April 1975 to provide advice and consulting support.

Many members of the NASA-MSFC Solar Heating and Cooling Task Team made their time available for helpful discussions and cooperative efforts. Special acknowledgement is given to Mr. John M. Price, Mr. Robert L. Middleton, and Mr. Sidney Johnston for their encouragement and support on this research program.

The University of Alabama in Huntsville also wishes to acknowledge the assistance and valuable contributions made by numerous other individuals and to express thanks for the cooperation of various government agencies, industries, universities, technical societies, and other organizations.

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I. INTRODUCTION AND BACKGROUND

NASA Contract NAS8-31293 was initiated in October 1974 for the performance of "Solar Heating and Cooling Technical Data and Systems Analysis". The initial period of performance was from October 23, 1974 through December 31, 1974 for the amount of $5,998.00. Four basic tasks were specified in the contract as follows:

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. Utilizing the capabilities of the UAH Center for 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 University of Alabama in Huntsville continued work under Contract NAS8-31293 without a change in the original estimated cost. The purpose of this extension (Amendment 2 to the contract) was primarily to complete certain tasks then underway, including surveys and technical data review.

Amendment 3 to the contract was required to include the following task to the initial statement of work:

5. Provide in-depth analysis and support in the areas of solar energy systems, collection and storage systems, energy transport concepts and data development.

The performance was, therefore, extended through April 30, 1975 at an additional contract cost of $3,000.00 with Amendment 4. This effort required the use of specialized seminar and consulting activities. Accordingly, both Dr. George O. G. Lof, Professor of Engineering at Colorado State University and Dr. J. A. Duffie, Director of the Solar Energy Laboratory at the University of Wisconsin, provided their expert services at meetings in Huntsville during the period of March 31 through April 4, 1975. The UAH coordinated these meetings and performed related contractural activities during the period.

COMPLETED CONTRACT ACTIVITIES

During the period October 1974 through February 1975, primary emphasis was given to the collection, evaluation and synthesis of technical data related to solar heating and cooling systems. Detailed contacts were made with organizations involved with these systems and technical reports and packages were provided to the COR and other NASA personnel as directed.

A considerable amount of the total effort was applied to support of program planning efforts related to systems analysis. Many documents were reviewed and technical data packages developed to aid in the accomplishment of program objectives. Likewise, questionnaires were developed and telephone and mailing contacts made to gather pertinent information.

Specific examples of program activities and accomplishments are given below:

- Presentation Material - Data packages, including narrative and visual materials, were developed and delivered to NASA. These data were needed for presentation and briefings. Also, a large

number of slides containing technical, historical, and program information have been provided to NASA for duplication and use. (See Letter Progress Report dated 11-19-74 for additional information).

- Data Sources - A listing of data sources has been compiled and submitted to NASA for reference (See Attachment A). These sources have been and are being contacted as required to meet the contract objectives. The AIA Research Corporation data package includes detailed information concerning various solar heating and cooling projects and a complete set of information was provided to MSFC.
- Solar Collector Data - Letters and technical data forms were forwarded to 101 firms identified as manufacturers of solar collectors. (See Attachment B). Information now ready for incorporation into the data format sheets has been received from 30 of these manufacturers as of 7-15-75. Data has been received from:

  1. Corning Glass Works
  2. CSI - Solar Systems Division
  3. Energy Systems, Inc.
  4. FAFCO, Inc.
  5. Fun & Frolic, Inc.
  6. Garden Way Laboratories
  7. General Electric
  8. Hitachi America, Ltd.
  9. International Environment Corp.
  10. J & R Simmons Construction Co.
  11. Owens-Illinois
  12. Piper Hydro
  13. PPG Industries

14. Revere Copper and Brass, Inc.
15. Reynolds Metals Company
16. Sol-R-Tech, Inc.
17. Solar Energy Digest
18. Solaron Corp.
19. Solar Energy Research Corporation
20. Solar Power Corporation
21. Solar Systems, Inc.
22. Solar Water Heater Company
23. Southeastern Systems, Inc.
24. Steelcraft Corporation
25. The Stolle Corporation
26. Sun Source
27. Sun Systems, Inc.
28. Sun Water Company
29. Sun Works
30. Sundu Company

Three copies of all solar collector data have been provided to the NASA COR in the form of a Data Handbook. All listings are made alphabetically and an index is included for reference purposes. This material is being updated on a continuing basis.

- Solar Energy Heating and Cooling Systems - A detailed survey of solar energy heating and/or cooling projects throughout the United States was performed and a listing of these projects was developed. A letter and data format (Attachment C) was forwarded to 142 locations to obtain detailed systems and sub-systems data about these projects. Some 50 projects are now described in the information received from the selected sources and the data can be utilized to provide a broader baseline for systems analysis of various types of Solar HVAC Systems. This effort will continue to support the site selection elements of the overall program.

• Seminars and Consultant Support - Dr. George O. G. Lof of Colorado State University and Dr. J. A. Duffie of The University of Wisconsin have been involved in research and development of solar energy systems and applications for many years. Their services were provided to MSFC during a series of meetings held in Huntsville in late March and early April of 1975. Emphasis was placed on both the practical aspects of solar energy conversion and storage and system simulation using computer models. Additional seminars of this type are planned with other experts in the future. Also, The University of Alabama in Huntsville worked closely with members of the MSFC Solar Task Team during the Southeastern Conference on Application of Solar Energy held in Huntsville during March 1975. Some 50 technical papers from researchers throughout the country were given at this conference. A short course was also held at UAH during this period with Dr. Erich Farber of the University of Florida lecturing on "Solar Energy Fundamentals and Applications" and Dr. Jesse Denton of the University of Pennsylvania covering "Solar Power Systems".

• Other Related Activities - Numerous other research, liaison and coordinating activities have been performed related to the overall contract scope of work. Pinpointing of various parameters on a national map for display of data was performed, as well as evaluations of MSFC computer programs for compatibility with various types of solar energy and other data for format purposes. Likewise, selected lists of architectural, engineering and other industrial organizations with interests in program participation were provided to MSFC upon request. Particular emphasis has been placed on developing selected bibliographies and source lists for such areas as solar radiation requirement, selected coatings and materials for solar absorbers, and general bibliographies on all phases of solar heating and cooling systems. A detailed review and report on

selected environmental data for Huntsville-Madison County was also developed with UAH funds and a quantity of copies were provided for use by MSFC.[1]

1. Christensen, D. L., "Selected Environmental Data for Madison County, Alabama," Center for Environmental and Energy Studies, The University of Alabama in Huntsville, 1975.

II. CURRENT CONTRACT ACTIVITIES

Data describing climatic conditions, architectural details of homes, office buildings and manufacturing buildings, the details of building sites and their surrounding area, solar and conventional systems and components cost and performance parameters, and fuel and energy costs and availability data are required for conducting system analyses of solar heating and cooling applications. This type of data is necessary 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 to determine their marketability.

The following work statements, covering a period of performance from May 1, 1975 through July 31, 1975 was added to NASA Contract NAS8-31293 as Amendment 5 and this work is now being performed by The University of Alabama in Huntsville:

1. Acquire climatic data covering all areas of the U. S. sufficient to establish averages and extremes. This data will include, but not be limited to, temperature, humidity, wind velocity and direction, cloud cover, solar insolation, and atmospheric contamination.
2. Acquire architectural data sufficient to describe typical, and in selected cases, specific descriptions of buildings throughout the U. S. This data will cover all major classes of buildings, such as residential commercial, public, and manufacturing and such sub-divisions as may exist. In general, construction blueprints of buildings will constitute an adequate description.

3. Acquire building site data sufficient to describe the topography of selected areas and specific locations. This data will include sufficient information on adjacent structures to allow assessment of wind and sun exposure to be made.
4. Acquire data on conventional and solar heating and cooling systems, subsystems, components and piece parts sufficient for performance evaluation, and design work.
5. Acquire data on the thermal properties of construction materials and on buildings as described above, sufficient to allow thermal loads analyses to be conducted for selected combinations of building site location, building type, and heating and cooling system type.
6. Determine the most likely sources for collection of cost data of heating and cooling systems (industry literature and handbooks, surveys, completed studies, universities, etc.). Uniform data formats will be prepared and data collected accordingly. Each item on which data is collected will be examined to determine the technical parameter(s) to be used as the cost dependent variable(s) in the Cost Estimating Relationship (CER's).
7. Cost data will be collected from any applicable sources. Data is required for all systems, subsystems, and components that will enter in a systems analysis of both conventional and solar heating and cooling systems. Data will be required on the costs of design as required, procurement, installation, operations, and maintenance. This will include data on labor costs, component lifetimes, replacement or repair costs, etc. For some items it will be necessary to collect costs differentiating between complexities,

types, etc. (i.e., in the case of solar collectors separate CER's will be developed for various glazing techniques, etc.). Other considerations in reduction and normalization of the data will include addressing inconsistencies between year dollars, fee, production rates (learning and rate effects), state of the art, historical versus estimate data, man-year definition, geographical differences between labor rates, etc.

Detailed formats have been developed based on the level of detail necessary to insure flexibility and effectiveness in the final analyses. During this development period, numerous information sources have been identified and a large amount of data has already been acquired. Each of the task areas (climate, equipment, architecture, economics, etc.) are discussed in detail in the following sections of this report, and activities to date are included.

CLIMATIC DATA - TASK 1

TASK OBJECTIVES

To collect atmospheric, solar radiation and environment data and organize it for use in simulations and evaluations of solar energy in various forms. Arrange the data in easily accessible formats.

APPROACH

Review available sources and determine the availability and present format of atmospheric observational data. Develop load sheet formats for optimum access to the data. Determine specific locations and regions of primary interest and establish priorities. Make quality evaluations of the data whenever possible to estimate reliability of results.

ACTIVITIES AND PROGRESS

Telephone conversations with Dr. N. B. Guttman of the National Climatic Center (NCC), Ashville, North Carolina, determined that weather data tapes are available for about $60 to $70 per reel. One reel would contain about 10 years of hourly surface records for any years before 1965 and 3-hourly records for years subsequent to 1965. Solar radiation data (hourly) with some weather data (format yet to be determined) will be available in about 4 months due to data rehabilitation activities. The NCC plans to correct the radiation data and develop a new format with clouds and wind data from standard surface data formats and new radiation data format. The first locations available will be Phoenix, Albuquerque, and Washington, D. C. An extensive literature search related to measurement of solar radiation was conducted by UAH through RSIC and submitted to MSFC. Related bibliographies are now being prepared for review.

Data format requirements were discussed with the Technical Co-ordinator and proposed formats for hourly data, monthly summaries by

hours, and a combined monthly, seasonal and annual format was submitted for review and comments.

The proposed formats are being tested with data for Nashville, Tennessee, and some minor changes have been identified for more efficient compilation of the data. However, final approval for the formats are needed before all available data is entered. Preliminary estimates indicate approximately 607 man hours of effort would be required to enter ten years of published data into the format sheets for one location.

At a meeting with the Technical Coordinator on 6 June, it was determined that a dual approach for loading in the climatic data is being considered (tape to tape, and also entry of NCC Summary Reports into the format sheets).

The following electronic tape data was received by UAH and submitted to MSFC on June 9, 1975:

1. A data tape from the University of Wisconsin with 8 1/2 years of hourly radiation and abbreviated weather data for Madison, Wisconsin (and several other locations with shorter periods of record) was developed from NCC tapes for computer simulations at the Solar Energy Laboratory. The tape is 7 track, BCD, 556 BPI, even parity. Instructions for use of the tape were included.
2. Three reels of daily Insolation Data in card-deck format No. 480 with reference manual from the National Climatic Center (NCC), Ashville, North Carolina.
3. One reel of hourly surface weather data for Nashville, Tennessee (since 1965) in deck format No. 144 from NCC.

• Climatic Data Available for Each Time Interval - The National Climatic Center (from which all of our present published data for Madison, Wisconsin and Nashville, Tennessee is acquired) provides hourly data for total horizontal solar radiation, total diffuse radiation, and precipitation (for the preceding hour). At every third hour interval sky cover, ceiling height, visibility, weather, dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, wind direction, and wind speed are provided. The 06 hour was chosen to include the following daily summary data (as the depth of snow on the ground is only measured at 06 am): maximum temperature for the day, minimum temperature for the day, heating degree days for the day, cooling degree days for the day, snow or ice depth on the ground, total precipitation for the day, total snowfall of ice pellets for the day, hours of sunshine for the day, sky cover from sunrise to sunset, and sky cover from midnight to midnight.

• Available Radiation Data - At the present time, there are approximately 88 pyranometer stations which measure Total Horizontal Solar Radiation (Direct Horizontal plus Diffuse Radiation) operating in the United States. Of these 88 stations, approximately 21 have readily available hourly Total Horizontal Solar Radiation data that is either not completely processed and available, or contains data for only a limited number of years. Only 7 stations give Normal Incident Solar Radiation data, which is used along with the Total Horizontal Solar Radiation data to calculate the Diffuse Radiation. Plans are being formulated by NOAA to measure Diffuse Radiation directly with a shading ring on a Total Horizontal Pyranometer at a number of stations.

UAH efforts have been quite successful in locating new solar radiation data. Twelve additional stations in the Southeastern U. S. and eight additional ones in California, all currently operating, have been identified, as well as 40 more which operated from a period of a few months to over 10 years, but are not currently operating.

The quality of many of these records should justify their incorporation into the computer data bank. If it is decided to collect the new data and build a comprehensive solar radiation data bank, the project could be much larger than now envisioned. Some of the custodians may provide the data gratis, while some may want reimbursement for the data. Any costs of acquiring the data would appear to be small compared to the work of checking it for quality and organizing it for easy access. From results thus far, it appears that the total project would be well worth the costs.

- WBAN and International Station Numbers - Spaces for both the WBAN station number were included in the identification record of the Hourly Weather Data Format submitted to MSFC. These station numbers are the only climatic station numbering systems in general usage and most weather stations in the United States, including the military, use this system. The longitude and latitutde will be entered to identify and cross-relate the location of any weather station.

Presently, climatic data is being entered from selected data tapes; however, published climatic data from other sources can be loaded in the MSFC data bank using the load sheet formats developed by UAH.

RECOMMENDATIONS

Solar radiation data has a relatively short history, especially in its practical application. Therefore, its reliability is suspect and it should be used with caution. All data on solar radiation readily available from the National Climatic Center has been ordered. Other sources of data should also be investigated, especially those that can provide data that has been used in practical applications. The recommended procedure is as follows:

1. Request data from the National Climatic Center that is not in their readily available package. This has been done.

2. Contact manufacturers of solar radiation measuring instruments to obtain the names of buyers of this equipment over the past five (5) years. These buyers are being contacted for data that could be made available.
3. Contact other sources of climatic data (see listing below), such as utility companies, universities and research centers, agricultural locations, military installations, and other organizations.

Air Quality Stations (AQS)

Agricultural Experiment Station (AES)

Army Air Base (AAB)

Army Air Field (AAF)

Auxiliary Air Force Base (AAFB)

Air Force Base (AFB)

Airport (APT)

Coast Guard Station (CGS)

Field Test Station (FTS)

Firetower (FT)

Fleet Weather Central (FWC)

Forest Service (FS)

Industrial Station (IS)

International Airport (IAP)

Marine Corps Air Facility (MCAF)

Marine Corps Auxiliary Landing Field (MCALF)

Meteorological Research Station (MRS)

Naval Auxiliary Air Station (NAAS)

Naval Air Facility (NAF)

Naval Station (NS)

Power Generating Station (PGS)

Solar Energy Research Station (SERS)

Television Station (TS)

University Station (UNS)

Utility Station (UTS)

Weather Bureau Office (WBO)

Weather Service Station (WSS)

Wind Energy Research Station (WERS)

All available data should be evaluated to determine its usefulness for data bank entry. However, this effort would represent an undertaking which could not be completed under the present contract amendment (Amendment 5).

Solar radiation data and hourly surface weather data, for locations of interest to MSFC, are being ordered on magnetic tape from the National Climatic Center (NCC), Asheville, North Carolina, for merging into a new data format for computer storage and retrieval. A survey is underway to locate and identify solar radiation data not stored at NCC to publish a listing of all such data which may be valuable information for proposed solar energy projects. This material is being consolidated into a source book which will be forwarded to the COR when completed.

ARCHITECTURAL DATA - TASK 2

TASK OBJECTIVES

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

APPROACH

Data Acquisition Forms to acquire the necessary architectural data for any building have been developed and submitted to the Technical Coordinator. The basic input element for the format sheets incorporates the external dimensions of any building and the physical properties of its construction materials. The structural components of the building such as walls, floors, windows and roofs are identified separately and are assembled as building blocks to describe the total building. The format structure does not limit the values of the linear dimensions of the building components, nor does it limit the number of components. Consequently, the developed formats have the capability for describing buildings of any size, shape and fenestration using any type of construction materials.

ACTIVITIES AND PROGRESS

A coordinate system of identification has been developed to identify any wall of a building. That wall is then examined in detail, including all dimensions, construction materials, etc. This process is followed for each exterior and interior surface, each ceiling and floor, and each space on a given level. Roofs and underground levels are included. Any space within the total building structure can thus be described by numerical definition. For example, a closet, a stairway, a kitchen, an office or a workshop can acquire a numerical position for a total building concept. An office can be assigned "space number one". All scheduled activities for this space which affect the thermal loads of "space one" can be obtained for any hour of any day. For a total thermal load analysis of

a building, the concept is to look at the building as a space containing many spaces. An analysis can also be made of the total building thermal load versus the total of each individual space. A flow chart graphically explaining this approach has been developed and submitted for review.

TYPICAL SOURCES OF INFORMATION

The following information sources have been reviewed to aid in data gathering and format development. Other sources are being investigated.

1. Carrier Technical Development Program, Cooling Load Estimates (survey, estimating data, load estimates) copyright 1962, Carrier Air Conditioning Company.
2. Procedure for Determining Heat and Cooling Loads for Computerized Energy Calculations (logorithms for building heat transfer sub-routines) compiled and published by the Task Group of Energy Requirements for Heating and Cooling, Refrigerating and Air Conditioning Engineers, Inc. Edited by Metin Lokmanhekim, copyright 1971, by ASHRAE, 345 East 47th Street, New York, New York 10017.
3. Guide for Calculation of Electric Space Heating and Cooling, Tennessee Valley Authority, Darwin Marketing Division, revised March 1975.
4. ASHRAE Proposed Procedures for Simulating the Performance of Components and Systems for Energy Calculations, Second Edition. Edited by W. F. Stoecker; copyright 1971 by ASHRAE, 345 East 47th Street, New York, New York 10017.
5. Architectural Graphic Standards (Sixth Edition). Authors: Charles G. Ramsey and Harold R. Sleeper. Edited by Joseph N. Boaz (AIA).

6. Handbook of Air Conditioning, Heating and Ventilating; copyright 1959 by the Industrial Press, 93 Worth Street, New York. Edited by Clifford Strock.

7. Energy Systems Optimization Program: Its Descriptive and Comparative Analysis, compiled data by Ben E. Fulbright (Urban Systems Project Office), Lyndon B. Johnson Space Center, Houston, Texas. S. L. Ferden and R. D. Stallings, Applied Mechanics Department, Lockheed Electronics Company, Houston, Texas.

8. Computer Program for Analysis of Energy Utilization in Postal Facilities, Volume I, prepared by General American Research Division, General American Transportation Corporation, Niles, Illinois. Data compiled by Metin Lokmanhekim, Robert H. Henninger, James Y. Shih and Charles C. Groth.

9. Southern Standard Building Code, 1973 Edition, Southern Building Code Congress International, Birmingham, Alabama.

10. Evaluation of Heating Loads in Old Residential Structures, Dept. of Housing and Urban Development, Report No. HUD-HAI-7, Hittman Associates, Inc., January 1974.

11. Residential Energy Consumption Single Family Housing Final Report, Dept. Housing and Urban Development, Report No. HUD-HAI-2, Hittman Associates, Inc., March 1973.

PROBLEM AREAS

No significant problem areas have been identified to date other than the large amount of information required for detailed systems analysis of a variety of architectural designs.

RECOMMENDATIONS

Typical site locations and buildings might be selected and used to test the proposed method of data gathering and entry at an early date. This would help identify problem areas, clarify definitions and enhance overall systems evaluations techniques.

SITING DATA - TASK 3

TASK OBJECTIVES

Acquire building site data sufficient to describe the topography of selected areas and specific locations.

APPROACH

Review available data and contact various sources to determine site factors such as:

- Orientation of building
- Predominant sun angle and wind direction
- Ground elevation
- Height of neighboring buildings
    - o Sunlight blockage
    - o Wind breaks
- Surface conditions of surrounding topography
- Vegetation
- Building construction
    - o Reflectance and absorption
    - o Sunblocking overhangs
    - o Rain protection

These data will be considered in relation to the time of day and the time of year.

PROGRESS AND ACTIVITIES

Formats have been developed and submitted that consider major terrain features, differences in surface materials on all sides, shadows produced by overhangs and adjacent buildings (or other extraordinary architectural design), seasonal topographical variances, traffic density changes and other related site parameters.

TYPICAL INFORMATION SOURCES

1. Residential Energy Consumption Single Family Housing, Dept. of Housing and Urban Development, Report No. HUD-HAF-2, H. Hittman Associates, Inc., January 1974.
2. City Planner's Office, Huntsville, Alabama

HEATING AND COOLING EQUIPMENT - TASK 4

TASK OBJECTIVES

Acquire data on conventional and solar heating and cooling systems, subsystems, and components sufficient for performance evaluation.

APPROACH

Survey manufacturer's literature and handbooks, ASHRAE data books, manufacturer computer programs, governmental and industrial studies and surveys to establish formats for entering data. Establish source lists and contacts for gathering data.

ACTIVITIES AND PROGRESS

A major effort has been made to develop data formats adaptable to computer inputs for heating, ventilating and cooling (HVAC) equipment, including identification and economic information for conventional HVAC and solar HVAC systems, subsystems and components.

Surveys of data sources of commercial equipment from the Thomas Register, ASHRAE data books, The Encyclopedia of Associations and Societies, and other publications, such as The Heating and Air Conditioning Journal and Actual Specifying Engineer have been completed. The surveys have provided a base for an extremely large input of potential information. An effort is now underway to locate data banks already in existence and preliminary contacts have been established with several commercial equipment sources.

Contact with Automatic Programs for Engineering Consultants, Inc. (APEC) has also been established. The NECAPS (formerly called the Post Office) computer program is being studied by APEC. Their intent is to evaluate, simplify and shorten run time, and make this program available to industry.

Letters have been sent to various sources to determine which computer programs related to HVAC systems are available. The first of these were sent to companies listed in the Heating Piping Air Conditioning - InfoDex 74, which have software programs available. There has been a reasonable response to the letters and an abstract type report on all programs for which data are available is being prepared.

The Air Conditioning & Refrigeration Institute (ARI) has provided a complete book of their standards and listings of all units certified by ARI. All major air conditioning companies are represented and each one is being contacted to obtain data (some 61 companies). Many of these companies also manufacture heating equipment so additional data can be obtained with the same request.

Contact with a local manufacturer of HVAC equipment (Martin Industries) has been fruitful and we expect to gain more information from this source as they have been very cooperative. A listing of other manufacturers in this area is being prepared for related contacts.

A sample matrix to provide standard equipment classifications has been completed. It is suggested that these industry recognized standards be utilized for each group of equipment.

The quantity of product information related to solar systems, subsystems and components continues to grow at an accelerated pace. The data on hand has been greatly expanded by researching a variety of potential sources. Some 147 systems installations have been identified, ranging from residential to heavy commercial and process applications. The number of identified solar collector manufacturers has grown to 96.

The "Energy Sources and Equipment for Heating, Ventilating and Cooling (HVAC)" Table 1, provides the basis for the systems data sheets which may be used to describe total solar, solar with conventional augmentation, or con-

Table 1 - Energy Sources and Equipment for Heating, Ventilation and Cooling (HVAC)

	Energy Sources	Heating Conversion Subsystems	Controls Subsystem	Thermal Storage Subsystem	Cooling Conversion Subsystem	Fluid Distribution (Ventilation)
Conventional HVAC Systems	Utility Sources • Electricity (Line) • Gas (Line) • District Steam • District chilled water On Premise Storage • Oil (Tank) • LPG (Tank) • Coal • Wood Prime Mover Standby Power	Boilers Furnaces Radiant Heaters Unit Heaters Heat Pumps	On - Off Modulated Hybrid	Domestic Hot Water Tank	Absorption Compression Dehumidification Evaporative Heat Pumps	Ducting • Ducts • Plenums • Blower/Motors • Diffusers Piping • Pipes/Tubes • Pump/Motors Terminal Devices • Heat Exchangers
Solar HVAC Systems	Solar Insolation • Diffuse Radiation • Direct Radiation Conventional Sources • Auxiliary Equip.	Solar Collectors • Flat Plate • Concentrating • Structural Auxiliary Equip. • Conventional	Unique to Solar HVAC	Sensible Heat (Specific Heat) Latent Heat (Heat of Fusion)	Unique to Solar Cooling	

ventional systems. The chart is also to be used as a check list to assure that provisions are made for each function required. The systems data sheets basically give overall systems operational and efficiency data and identify each unit subsystem. The unit subsystem data are then found by referencing the data package prepared on these items. This same work-breakdown process is followed to the component level, as required.

Information presently available indicates that there are very few off-the-shelf systems for combined solar heating and cooling systems, but a few engineered systems concepts are in existence which require on-site construction of various items. For example, each storage system will need to be treated as a collection of components assembled into a storage systems design.

Complete collectors and absorber plates are readily available (but still expensive). A few "for solar only" control systems are available at this time. ARKLA units are now being used by many researchers for solar powered air conditioning and an improved model is now being considered for manufacturing. Some 19 projects have been identified as users of the ARKLA unit in a recent issue of Professional Engineer magazine (August 1975).

DISCUSSION AND GENERAL COMMENTS

HVAC equipment data is generalized up to a point and then becomes unique to methods used by industrial firms to express other than standard operations. Since there are multiple variables which affect the efficiency ratios of heating equipment, there are also many ways of expressing the variance of heat output of a unit system. This same statement is true for cooling systems (and many package systems are heating and cooling); however, much more data is available for analysis of cooling systems.

No vendor data has yet been encountered related to combustion heating systems, evaluating heating output to ambient air conditions, even though

this has a considerable effect on the heat delivered to a conditioned area. This effect is minimal when combustion air is drawn from ambient direct to a combustion chamber, but becomes meaningful when combustion air is drawn from the conditioned area and must be accounted for in the infiltration air heat loading. The worst condition is encountered in the coldest weather when the system is likely to be at capacity load. It is apparent from data available on heating equipment, that without further investigation and refinement in the methods by which equipment is rated, there can be no real quantitative evaluation of energy usage for heating. The formulae used for years for gas furnace efficiencies and for calculating annual energy requirements do not reflect a true condition, when compared to direct electric heating applications. The formulae were revised for electric heating by inserting a constant (fudge factor). The constant accounts for heat gain from a multiple of sources not accounted for in the equations used to evaluate direct combustion heating units and are suspect, with the real efficiency being lower than claimed.*

TYPICAL SOURCES OF INFORMATION

Thomas Register

Industrial Catalogs

Architectural Handbooks

Consultants - Surveys

Open Literature - Publications

Actual Specifying Engineer

Mechanical Engineering Journal

Heating and Air Conditioning Journal

Direct Industrial Contact

* Reference article by R. L. Dunning, Manager, Energy Utilization Project Power Systems Planning, Westinghouse Electric Corp., June 1974, Refrigeration Service & Contracting

THERMAL LOADS DATA - TASK 5

TASK OBJECTIVES

Acquire data on the thermal properties of construction materials sufficient to allow thermal loads analyses to be constructed for selected combinations of building sites, types, and heating and cooling systems.

APPROACH

A format has been developed to enter all thermal characteristics using standard tables provided by industry or any other available source.

RECOMMENDATIONS

Useful and complete tables for thermal properties of construction materials are contained in the Heating Ventilating Air Conditioning Guide (ASHRAE) 1958, Chapter 9 (beginning on page 169). These should be used as the standard source of information although certain special cases may be located to augment the basic source material.

OTHER INFORMATION SOURCES

1. Evaluation of Heating Loads in Old Residential Structures, Dept. of Housing and Urban Development, Report No. HUD-HAI-7, Hittman Associates, Inc., January 1974
2. ECUBE Program - Energy, Equipment, Economics Program of American Gas Association

ECONOMIC DATA - TASKS 6 & 7

TASK OBJECTIVES

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

APPROACH

Develop format sheets for entering all pertinent economic data by investigating literature, existing computer programs, government and university studies, statistical compilations, etc., and acquire data as needed for analyses.

ACTIVITIES AND PROGRESS

The basic formats for entering economic data have gone through several revisions. They now include broad geographical descriptions of areas corresponding to available Federal Power Commission and climatic data, as well as state and county breakdowns. Available data is being gathered that gives an accurate picture of the economic health of the area, availability of selected fuels, and cost to the retail customer (to the county level, if possible).

Separate cost data formats are being developed for electricity, gas (manufactured and natural), fuel oil, and coal. Economic factors influencing initial and maintenance costs and life cycles for facilities and equipment have been identified and included in the formats.

A list of 103 major utility distributors has been compiled for the continental United States, including their phone numbers.

At present, the majority of information available on fossil fuels gives wholesale rates only. Data obtained from the Federal Power Commission

(FPC) is given for nine geographical areas and then for the 48 continental states, but includes no retail cost data, which is essential for a detailed systems analysis.

Retail electrical rates for TVA customers and immediately adjacent areas were obtained in a meeting with Ed Hall and Marcus Wilson of TVA on June 11, 1975. Nationwide retail electrical rates have been obtained from the Federal Power Commission, and represent the rates as of January 1, 1974.

TYPICAL INFORMATION AND SOURCES

1. Typical Electric Bills - 1974 Federal Power Commission Report R 84 is published annually by the FTC. This report provides data on typical electric bills for residential, commercial and industrial customers in all areas of the country. Residential charges at four consumption levels are provided for cities over 2,500 (over 6,000 cities). Industrial and commercial charges are given at four consumption levels for cities of over 50,000. Some 1,330 different utilities were included in the 1974 report. TVA also provided photocopies of residential rate structures for several major utilities, as well as a table comparing TVA rates with those of seven southeastern utilities.

2. Union Wage Rates: The Building Trades - Published by the Bureau of Labor Statistics Annual Report. 1968. This report provides hourly union wage rates in 68 cities representing all geographic areas of the country for classifications of building trades. It also provides an overall average rate for building trades in general, the figure which was used in this report.

3. Moody's Guide to Public Utilities provided source material for electric companies serving more than 250,000 customers.

4. Statistical Abstract of U. S. has numerous data presented in table form that will allow information to be obtained quickly and accurately. This document is being extensively used for data research.

5. TRACE computer program on air conditioning economics developed by The Trane Company, LaCrosse, Wisconsin, provides a format to follow for comparative cost analysis of equipment.

6. F. W. Dodge provides building information with a breakdown of areas. Will possibly serve as a complete source on building information.

7. Economic Report of the President is full of information on employment, income and energy that will provide useful data for the economic format.

8. Sept. 1974 MEGASTAR - published as a result of NASA Grant NGT 01-003-044 by the Auburn School of Engineering. It provides information on projected consumption of energy, production trends and technology trends.

9. Sept. 1973 TERRASTAR - published as a part of same grant as MEGASTAR but earlier. Gives information on consumption by sector, unpredictable price influences and energy resources.

10. The Applicability of the Residential Energy Consumption analyses to various geographic areas - Nov. 1973 HUD. This report breaks down fuel consumption by heating types according to geographic regions. It also contains information on the percentages of air conditioning in the various regions.

RECOMMENDATIONS

Specific utility rate schedules can change very quickly so the latest data available from the FPC (1973) should be entered to give a relative base from which to work. A uniform rate of increase could then be applied to all geographic areas for various time periods.

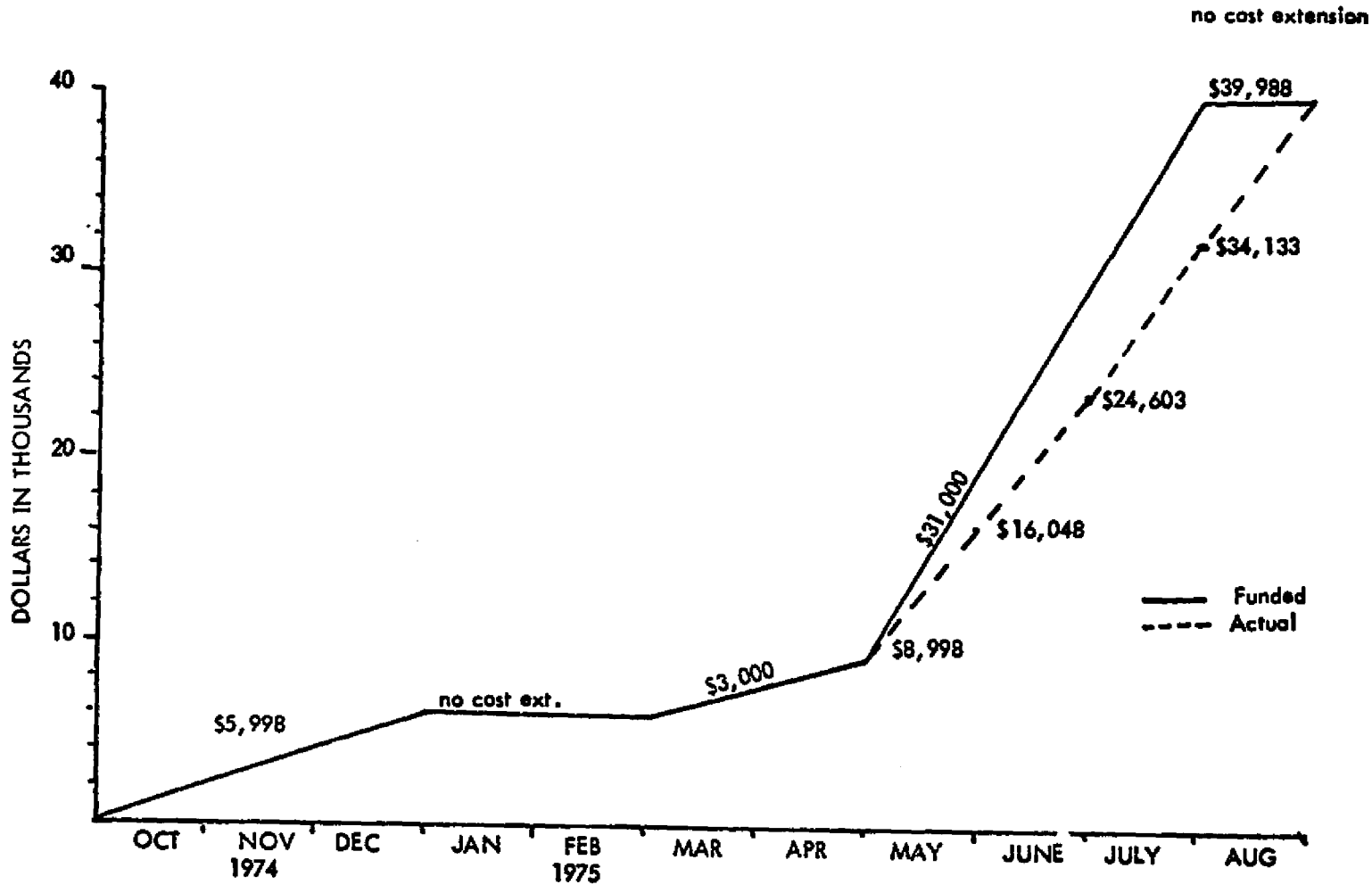
Prime economic data to the sub-state level is being obtained from many local Chambers of Commerce and their state headquarters are being contacted to gain guidance in the data acquisition efforts.

Trend projections on fuel status are being obtained from governmental agencies such as the National Bureau of Statistics and the Federal Energy Administration and from other sources such as MEGASTAR and TERRASTAR.

CONTRACT EXPENDITURES

Original funding for the contract was $5,998 for October through December 1974. A no-cost extension was proposed and approved for January and February 1975. An additional $3,000 for the months of March and April was approved to pay for consultant support and seminars. Amendment 6, initiated in May of 1975 and continuing through August, was in the amount of $31,000, and funded the data acquisition tasks. This task has been extended through December 1975 in the amount of $40,000.

CONTRACT NAS8-31293 EXPENDITURES
OCTOBER 8, 1974- JULY , 1975
(PROJECTION FOR AUGUST 1975)



ATTACHMENT A
SELECTED DATA SOURCES FOR SOLAR ENERGY HEATING AND COOLING (HARDWARE AND PROGRAMS)

Data Source	Description	Status	Comments
A. D. Little, Inc.	Solar Climate Control Project includes technical, economic, and marketing studies.	Phase I Completed Phase II Underway	Part of a large ($1.4 million) multi-client study with international participation.
Atomic Energy Commission (Now ERDA)	Solar Energy Bibliography (TID-3351). $10.00 from MTIS.	Issued by AEC in December 1974, 218 pages plus 138 page index.	Good reference on overall solar energy R & D programs.
AIA Research Corporation	Design of Solar Heated and Cooled Buildings.	Complete sets of solar oriented Architectural Data.	Useful for Architectural Building Site, Orientation, tThermal Data, etc. Copies provided to MSFC.
Arizona State University	Compiled listing of Solar and Wind energy products, plans and services.	Data is periodically updated and available.	Review of data is in process.
Energy Primer Portola Institute	200 pages (1974)	Several sections including 24 page book review on Solar Energy	Available for $4.50 from: Whole Earth Truck Store, 558 Santa Cruz Ave. Menlo Park Co. 94025
Energy Research and Development Agency (ERDA)	Mailing lists are being prepared (National Plan for Solar Heating and Cooling).	Various letters and requests for information and forms are soliciting interest in program.	Separate mailing list for solicitations of Residential Demonstrations being developed by HUD. UAH formats can accomodate input data from ERDA, HUD and other sources.
Environmental Action of Colorado 1100 14th St Denver, Col. 80202	620 page Solar Directory (1974) including product and project inventory. Available for $20.00	Planned as yearly publication.	Uses Computerized format. Handy reference in selected areas. Review of data is in process.

Data Source	Description	Status	Comments
Federal Energy Administration Office of Energy Statistics	Survey of Solar Collector Manufacturing Activity CY 1974	Some 45 responses received from telephone survey	Survey results are available.
	Survey of Solar Energy Projects of the Federal Government (dated January 1975)	Some 14 agencies now funding 171 solar energy projects for $25.3 million (period of FY 74-75)	Draft copy available and provides a useful overview of federal government activity.
Library of Congress (Attn: J. Glen Moore)	Survey of all solar energy equipment and related services	First letter survey requests information by May 1, 1975	Activity initiated by Congressman Mike McCormack on 3-28-75.
NASA-MSFC Solar Task Team	Letter surveys for potential bidders list and industrial briefing questionnaires	Responses are being received and processed	Data being [illegible] and updating planned for performance summaries.
The University of New Mexico	Bibliography with abstracts on Solar Thermal Energy Utilization 1957-74; 2 Volumes	Issue date of November 1974 with periodic updates	Available for $37.50. Good use of key word index and as a source for program activities. MSFC has copy.
Popular Science Magazine	Compiled listing of 33 sources for products and plans in the March 1975 issue	Meetings held between Editor of Popular Science and MSFC	Contact made for exchange of information on continuing basis.
Shurclift, William 19 Appleton Street Cambridge, Mass. 02138	Survey of Solar Heated Buildings. $7.00 post paid.	Ninth edition covers 135 buildings	Copies available and data being reviewed.
Solar Energy Digest	Distributes newsletter	Published monthly by W. B. Edmondson, P. O. Box 17776, San Diego, California	

Data Source	Description	Status	Comments
Solar Energy Industries Association	Newsletters and Industrial Directory and Buyers Guide available	Industrial Exposition held May 27-29, 1975	Membership data available. Performance warranty and related data on hardware and related programs has been requested.
Solar Energy Intelligence Report	Report published twice monthly by Business Publishers, Inc., P. O. Box 1067 Silver Springs, Md. 20910	Trial Copies available	Subscription rate $75.00 per year for 24 copies.
Solar Energy Technology (Annotated Bibliography)	547 entries of last five years of material	Available for $18.00	Order from: Ocean Engineering Information Service, PO Box 989, La Jolla, Ca. 02038.
University of Alabama in Huntsville	Letter survey made of 96 collector manufacturers	Detailed technical and cost data received by 30 solar collector manufacturers	Handbook data provided to NASA-MSFC under Contract NAS8-31293. Data ready for entry into computer formats.
UAH	Survey of 137 building projects underway for systems and sub systems analysis	Survey in progress. Data received for 48 projects through 7-15-75.	Data available for entry into computer formats.
UAH	Preparation of selected data and reading lists	Bibliography and reading lists in progress	See attached selected bibliography from the International Solar Energy Society.

ATTACHMENT A - BIBLIOGRAPHY

INTERNATIONAL SOLAR ENERGY SOCIETY
AMERICAN SECTION
12441 Parklawn Drive
Rockville, Maryland 20852

SOLAR ENERGY, OTHER SOURCES OF ENERGY

some choices to buy
where to order
cost

SOLAR SCIENCE PROJECTS...D.S. Halacy, Jr.; Scholastic Book Services, 900 Sylvan Ave., Englewood Cliffs NJ 07632. $0.75. Projects for building solar cookers, solar stills, solar ovens, solar water heaters, solar motors, solar radios.

ENERGY PRIMER...Portola Institute; Whole Earth Truck Store, 558 Santa Cruz Ave., Menlo Park CA 94025. $4.50. A comprehensive new book about renewable sources of energy - solar, water wind, and biofuels. The focus is on small-scale systems which can be applied to the needs of the individual, small group, or community.

SOLAR ENERGY DIGEST...edited by William B. Edmondson (monthly newsletter); Solar Energy Digest, P.O. Box 17776, San Diego CA 92117. $27.50/year. Reports developments in applications and technology; meetings, courses, and conferences; new products and publications; manufacturers.

CLOUDBURST: A Handbook of Rural Skills & Technology; Book People, 2940 Seventh St., Berkeley CA 94710. $4.50. Plans for several types of water wheels, a windmill, a solar dryer, and other items of interest to those who want to build this kind of thing.

PRODUCING YOUR OWN POWER...edited by Carol Hupping Stoner; Rodale Press, Inc., Book Div., Emmaus PA 18049. $8.95. Handbook on how to build or erect windpower plants, harness small water power sites, heat and cook with wood, make methane gas, heat water and space with solar energy, combine alternative energy systems, conserve energy in existing structures, and find the required hardware and supplies.

DIRECT USE OF THE SUN'S ENERGY...Farrington Daniels; Ballantine Books, Inc., 457 Hahn Rd., Westminster MD 21157. $1.95, paperback. By far the best available introduction to the subject. Covers all aspects of solar energy research and application; without stressing mathematical or engineering details, describes the full range of work on solar collectors, cooking, heating, agricultural and industrial drying, distillation, storage of heat, solar furnaces and engines, cooling and refrigeration, photochemical conversion, photo and thermoelectric conversion, and many other uses of solar energy.

SOLAR HEATED BUILDINGS: A Brief Survey (8th Edition, March 1975)...William A. Shurcliff, 19 Appleton St., Cambridge MA 02138. $7.48 ppd. Lists and describes 119 buildings that did exist, do exist, or are expected to exist very soon; houses, schools, commercial buildings that are partially or fully solar heated.

WINDMILLS AND WATERMILLS...John Reynolds; Praeger Publishers, Inc., 111 Fourth Ave., New York NY 10003. $12.50. Actual mechanics of wind and water mills. Traces development of the watermill from the 1st century B.C. and the windmill from the 10th century. Describes mills used to grind wheat, mustard seed and maize; extract oil; crush rocks, saw lumber.

THE COMING AGE OF SOLAR ENERGY...D.S. Halacy, Jr.; Harper & Row, Inc., 10 East 53rd St., New York NY 10022. (1973) $7.95. An overall view, past, present, and future.

SOLAR ENERGY, TECHNOLOGY AND APPLICATIONS...J. Richard Williams (1974); Ann Arbor Science Publications, Inc., P.O. Box 1425, Ann Arbor MI 48106. $9.95 ($6.95, soft cover). Brief, inclusive overview, with estimates of present costs; good introduction for those with some science or technical background.

ENERGY, ENVIRONMENT AND BUILDING...Philip Steadman (1975); Cambridge University Press, 32 E. 57th St., New York NY 10022. $14.95. Compendium on solar energy, wind power, small scale water power; includes over 100 pages of bibliographies and appendices; lists solar hardware manufacturers.

ENERGY FOR SURVIVAL...Wilson Clark (1974); Doubleday & Co., Inc. 277 Park Ave., New York NY 10017. $12.50. Energy sources today, yesterday, prospects for the future; "total" energy systems, electricity from nuclear fission, geothermal energy, hydrogen, solar energy, wind energy; extensive information source and guide to sources.

DESIGN WITH WIND...Douglas R. Coonley; Total Environmental Action, Church Hill, Harrisville NH 03450. $7.00, soft cover. Investigates the creative uses of the wind that are possible with proper building design; includes the results of wind tunnel tests on scale models and discusses the potential energy available in the wind and ways of utilizing that energy.

SUN AT WORK...newsletter of Association for Applied Solar Energy (now International Solar Energy Society), Volumes 1-11 (1956-1966); Microforms International Marketing Corp., 380 Saw Mill River Rd., Elmsford NY 10523 (Hard Copy only) Complete set $50.00; $5.00 per volume.

ALTERNATIVE SOURCES OF ENERGY NEWSLETTER...ASE Newsletter, Route 2, Box 90 A, Milaca MN 56353. $6.00/year. (four times a year) Information exchange; source of continuing information on all aspects of renewable energy sources.

Pamphlets from: Total Environmental Action, Church Hill, Harrisville NH 03450
Solar Energy Hardware...Annotated listing of over 70 manufacturers and distributors of solar energy equipment. $5.00
Wind Energy Hardware...Three pages listing sources of wind energy equipment. $2.00

Bibliographies from: Total Environmental Action, Church Hill, Harrisville NH 03450. $1.00 each
Solar Energy Books...18
Wind Energy...39
Energy Conservation...45
Brace Research Institute Publications...15
Architectural & Engineering Design...35
Designing for Solar Radiation on Building Surfaces...17
Solar Heating: Domestic Hot Water and Swimmign Pools...42

WIND ENERGY BIBLIOGRAPH:..,Windworks, Box 329, Rt. 3, Mukwonago WI 53149. A 100-page guide that includes wind data sources, home building, where to buy, parts and whole, conference proceedings and associations. $3.00.

SOLAR ENERGY: A Bibliography...U.S. Atomic Energy Commission (1974); National Technical Information Service, Springfield VA 22151. ($10.60) TID-3351.

HOW TO DESIGN AND BUILD A SOLAR SWIMMING POOL HEATER...Francis de Winter; Copper Development Association, 405 Lexington Ave., New York NY 10017. Free. The physics, economics and construction techniques of building a solar pool heater out of copper. The how-to-do-it details are very complete.

SOLAR ENERGY WARM AIR HOUSE HEATER...Aden B. Meinel and Walter B. Meinel; Helio Associates, Inc. 8230 E. Broadway, Tucson AZ 85710. $5.00. Simple do-it-yourself plans for collector construction, various configurations of collector placement and rock- or water-filled plastic bottle heat storage. Designs readily adaptable to mobile homes.

Plans from: Brace Research Inst., Macdonald College of McGill University, Ste. Anne de Bellevue PQ H9K 3M1 Canada. $1.00 each + 25¢ handling:
How to Build A Solar Water Heater...(1973) Do-it-Yourself Leaflet L-4
How to Heat Your Swimming Pool Using Solar Energy...(1973) Do-it-Yourself Leaflet L-3
How to Make a Solar Still...(Plastic covered) Do-it-Yourself Leaflet L-1
Simple Solar Still for the Production of Distilled Water...(1967) Technical Report T-17. Simple solar distillation unit designed primarily for use in service stations to provide water for automobile batteries (Normal operating conditions: av. three liters per day produced)
Plans for a Glass and Concrete Solar Still...(1972) Technical Report T-58
Solar Steam Cooker...(1972) Do-it-Yourself Leaflet L-2
How to Make a Solar Cabinet Dryer for Agricultural Produce...(1973) Do .t-Yourself Leaflet L-6

SOLAR HEATER FOR SWIMMING POOL...Soltech Industries, 6702 Marilyn Dr., Huntington Beach CA 92647. $3.00. Brief plans for copper tubing, aluminum sheets, wood frame and Plexiglass cover.

HOME HEATING SOLAR HEAT PANELS...*Solar Concepts, P O Box 462, Independence CA 93526. $6.95.* Plans for simple do-it-youself air heating collector system.

HOT WATER...Hot Water, 350 E. Mountain Dr., Santa Barbara CA 93108. $2.00. Simple diagrams on how to build a variety of solar water heating collectors.

ILLUSTRATED SOLAR ENERGY GUIDE OF FLAT-PLATE COLLECTORS FOR PRACTICAL HOME APPLICATION...E I & I Associates, P O Box 37, Newbury Park CA 91320. $2.00. Diagrams on how to plumb various domestic water heating systems.

PLANS FOR A SOLAR WATER HEATER...$5.00
and *PLANS FOR A SOLAR AIR HEATER*...$5.00 Solar Energy Engineering, P O Box 17177, Orlando FL 32810

Plans from: Zomeworks Corp., P O Box 712, Albuquerque NM 87103
Drum Wall Plans...(1974) $5.00
Beadwall Plans...(1974) $15.00
Solar Water Heater Plans...(1974) $5.00

LIVING WITH THE SUN, Volume 1...AASE; Microforms Internatl. Marketing Corp., 380 Sawmill River Rd., Elmsford NY 10523. $10.00. Sixty plans selected from the entries in the 1957 International Architectural Competition to Design a Solar-Heated Residence.

SOLAR HOUSES AND SOLAR HOUSE MODELS, 2nd Edition...Harry E. Thomason; Edmund Scientific Co., 150 Edscorp Bldg., Barrington NJ 08007. $1.00, booklet

SOLAR HOUSE PLANS...Harry E. Thomason; Edmund Scientific Co., 150 Edscorp Bldg., Barrington NJ 08007. $10.00

SOLAR HOUSE PLANS II-A...Harry E. Thomason and Harry Jack Lee Thomason, Jr.; Edmund Scientific Co., 150 Edscorp Bldg., Barrington NJ 08007 $24.95.

SOLAR HOUSE PLANS...Henry Mathew, Rt. 3, Box 768, Coos Bay OR 97420. $10.00. Plans of the Coos Bay solar heated home; one of the examples that contradicts the assumption of impracticability of solar heating in northern homes.

SOLAR ENERGY FOR PACIFIC NORTHWEST BUILDINGS...John S. Reynolds (1974); The Center for Environmental Research, School of Architecture & Allied Arts, University of Oregon, Eugene OR 97403. $3.00.

FUTURE ENERGIES...R. Meador; Ann Arbor Science Publishers, Inc., P O Box 1425, Ann Arbor MI 48106. $1.95, paper cover. Summary of present state-of-the-art of solar applications, as well as of fusion energy, geothermal, t 'al and water power.

ADVANCED SOLAR ENERGY TECHNOLOGY...Advanced Solar Energy Technology Newsletter, 1609 West Windrose, Phoenix AZ 85029. $60/year.

HANDBOOK OF FUNDAMENTALS...(1972) $33.00
and *HANDBOOK OF APPLICATIONS*...(1974) $42.00, ASHRAE (Sales Dept.), 345 East 47th St., New York NY 10017. (*Applications* includes Chapter 59, "Utilization of Sun and Sky Radiation for Heating and Cooling Buildings," John I. Yellott)

SOLAR ENERGY APPLICATIONS, A Bulletin...ASHRAE (Sales Dept.), 345 East 47th St., New York NY 10017. $10.00 (includes 12-page paper "Storage of Solar Heating/Cooling", Maria Telkes)

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SOLAR THERMAL ENERGY UTILIZATION 1957-1975...Energy Information Center, Technology Application Center, The University of New Mexico, Albuquerque NM 87131. $37.50 per set; quarterly update service $50 per ye 2100 references. Contents: Volume I, Development, Solar Radiation, Material Properties, Components, Space Heating and Cooling, Process Heat; Volume II, Power Generation, Author Index, Corporate Source Index, Permuted Keywork Index, Permuted Title Index. Quarterly update service surveys the latest literature.

AN ASSESSMENT OF SOLAR ENERGY AS A NATIONAL RESOURCE...NSF/NASA Solar Energy Panel (1972); Supt. of Documents US Government Printing Office, Washington DC 20402. $1.20. #3800-00164.

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PartI: Technical Sessions, March 21 & 22, 1973. $7.50. PB 223-536
Part II: Panel Sessions, March 23, 1973. $4.25 PB-235-483
US Dept of Commerce, Natl. Technical Information Service, Springfield VA 22151

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SOLAR ENERGY THERMAL PROCESSES...J.A. Duffie and W.A. Beckman, Oct. 1974; John Wiley & Sons, Inc., One Wiley Dr., Somerset NJ 08873. $16.95. How to understand and predict the performance of solar collectors and solar photo-thermal systems for heating and cooling buildings, for heating water and air; include transient analysis of collectors and computer modelling, materials properties and the fundamentals of the relevant aspects of radiative and convective heat transfer. Comprehensive and coherent treatment for professionals, and especially for engineers. Can be used as text for graduate or advanced undergraduate engineering course.

SOLAR COOLING FOR BUILDINGS...ed. by Francis deWinter (Los Angeles, 1974) NSF/RANN Workshop; Supt. of Documen US Government Printing Office, Washington DC 20402. $3.00. Includes complete texts of all prepared papers and also the questions raised and answers given during discussion periods. #3800-00164.

THE DEVELOPMENT OF A SOLAR-POWERED RESIDENTIAL HEATING & COOLING SYSTEM...NASA/George C. Marshall Space Flight Center (May 1974); Technology Utilization Office, NASA Code KT, Washington DC 20546. #M-TU-74

NEWSLETTER...Senator Mike Gravel, U.S. Senate, Washington DC 20510. Free.

SOLAR ENERGY AND SHELTER DESIGN...Bruce Anderson (1973); Total Environmental Action, Church Hill, Harrisville NH 03450. $7.00. Introduction to principles and problems; analyzes ways of collecting and using solar energy; includes description of most past solar projects.

CRITERIA FOR THE PRELIMINARY DESIGN OF SOLAR-HEATED BUILDINGS...E.M. Barber and D. Watson (1974); Sunworks, Inc., 669 Boston Post Rd., Guilford CT 06437. $10.00. Manual for architects and builders; practic installation advice.

ALTERNATIVE ENERGY SOURCES IN BUILDING DESIGN...Albert J. Davis & Robert P. Schubert, PO Box 499, Blacksburg VA 24060. $5.00. Focuses on criteria for an energy conservative design and prerequisites for the utilization of alternative sources of energy; deals with both low technology and more industrially sophisticated design in the realms of solar energy, wind energy and organic fuels.

Publications from: Solar Energy Laboratory, University of Florida; Engineering Information & Publications Office, 331 Joseph Weil Hall, University of Florida, Gainesville FL 32611.
Practical Applications of Solar Energy...E.A. Farber & Reed (1956) L-83 50¢
Domestic Solar Water Heating in Florida...Hawkins (1947) B-18 $1.80
Solar Energy--Conversion and Utilization...E.A. Farber (1969) T-439 75¢
Design and Performance of a Compact Solar Refrigeration System...E.A. Farber (1970) T-457 $2.30
The Direct Use of Solar Energy to Operate Refrigeration and Air-Conditioning Systems...E.A. Farber (1965) TPR-15 50¢

SOLAR ENERGY...Franklin M. Branley (1957); Thomas Y. Crowell Co., 666 Fifth Ave., New York NY 10019. $3.9 Includes all phases of solar energy; written on a junior high school level.

SOLAR ENERGY FOR MAN...B.J. Brinkworth (1973); John Wiley & Sons, Inc., One Wiley Dr., Somerset NJ 08873. $9.95. Has been suggested as a text for a technical course on solar energy at the undergraduate science level, supplemented by Farrington Daniels' *Direct Use of the Sun's Energy* (see page 1).

REPRINT SERVICE International Solar Energy Society, American Section

Dr. Jay Shelton, a Director of the American Section, ISES, has selected articles of general interest, namely some papers dealing with fundamentals and applications of flat-plate collectors. Articles will be reproduced photo-offset from journals and will be corner-stapled. Prices are postpaid; include payment with order. Send to:

Reprints, American Section, ISES
c/o Dr. Jay Shelton
Physics Department
Williams College
Williamstown MA 01267

This address is for reprints only; do not direct inquiries or other correspondence to Dr. Shelton.

Item No.	Description	Price
1.	*Solar Energy Utilization for Heating and Cooling*, J.I. Yellott, Chapter 59, *ASHRAE Handbook and Product Directory, 1974 Applications* Volume. Summary of current practice, including many details and a substantial section on the availability and characteristics of solar radiation at the earth's surface.	$1.00
2.	*The Performance of Flat-Plate Solar-Heat Collectors*, H.C. Hottel & B.B. Woertz, *Trans. ASME 64*, pp. 91-104. A classic paper on the physics of flat-plate collectors. *The Derivations of Several "Plate-Efficiency Factors" Useful in the Design of Flat-Plate Solar-Heat Collectors*, R.W. Bliss, Jr., *Solar Energy* 3 (4), 55-64 (1959). *Thermal Resistance of the Tube-Plate Bond in Solar-Heat Collectors*, A. Whillier, *Solar Energy* 8 (3), 95-98 (1964).	3 papers $1.00
3.	*Cost of House Heating with Solar Energy*, G.O.G. Löf & R.A. Tybout, *Solar Energy 8 (3)*, 253-278 (1973).	$1.00
4.	*A Naturally Air-Conditioned Building*, H.R. Hay & J.I. Yellott, *Mechanical Engineering* January 1970, 19-26. *Solar Houses: Heating & Cooling Progress Report*, H.E. Thomason & H.J.L. Thomason, Jr., *Solar Energy* 15 (1) 27-39, (1973). *The Use of Solar Energy for Space Heating--MIT Solar House IV*, C.D. Engrebetson, *Proceedings of the UN Conference on New Sources of Energy* 5, 159-169 (1961)	3 papers $1.00

Volumes on solar energy and windpower of the *Proceedings of the United Nations Conference on New Sources of Energy* (1961) have been reprinted by the United Nations and are available from: United Nations Publications, Rm. LX-2300, New York NY 10017. If prepaid, postage is included in prices, as listed below:

Vol. 4	Solar Energy I: Engines, Electric Power, Availability, Materials	$20.00
Vol. 5	Solar Energy II: Heating	16.00
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On a trial basis, the ISES, American Section, is distributing these volumes at reduced prices: Vol. 4 @ $16.50; Vols. 5,6,7 @ $13.50 each, postpaid, if payment is included with order. Send to: Reprints, American Section, ISES, c/o Dr. Jay Shelton, Physics Dept., Williams College, Williamstown MA 01267. Do not use this address for any inquiries or correspondence; use for reprints orders only.

Back issues of *Solar Energy: The Journal of Solar Energy Science and Technology*, official journal of the International Solar Energy Society (formerly the Association for Applied Solar Energy), are available from: Microforms International Marketing Corp., 380 Saw Mill River Rd., Elmsford NY 10523.

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Please note that the International Solar Energy Society has not officially approved this list of references, nor does it necessarily recommend any title herein as authoritative. There are many publications in the subject area of renewable sources of energy and their applications, too many to list in a few pages. The reference list has been compiled to respond specifically to the many requests for information that are received in the office of the American Section, ISES.

April 1975

ATTACHMENT B

SOURCES FOR MANUFACTURING AND SALES - SOLAR ENERGY COLLECTORS

This attachment is comprised of three lists. The first is an overall list of solar energy collector manufacturers and/or sales organizations. Second, a list of manufacturers of solar energy collectors primarily designed for swimming pool heating. The third list is of manufacturers of solar HVAC systems that provide domestic hot water heating and space heating and cooling.

SOLAR ENERGY COLLECTORS-MANUFACTURERS, EXPERIMENTERS AND SALES OUTLETS

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

2. Aluminum Company of America
   1501 Alcoa Building
   Pittsburg, PA 15219
   Attn: William F. Lewis
   (412) 553-2748

3. Arizona Solar Enterprises
   6719 E. Holly St.
   Scottsdale, AZ 85257
   Attn: Mr. Walters
   (602) 945-0512

4. Beutel's Solar Heater Co.
   1527 N. Miami Ave.
   Miami, FL 33136
   Attn: Orvar Lindstrom
   (305) 371-1426

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

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

7. Coleman Solar Service
   8900 NW 34th Ave.
   Miami, FL 33136
   Attn: Mr. Gay
   (305) 233-1999

8. Corning Glass Works
   Houghton Park C7
   Corning, NY 14830
   Attn: Jim Murry, Manager Special Projects
   (607) 972-9000

9. CSI
   Solar Systems Division
   12400 49th St. N
   Clearwater, FL 33520
   Attn: L.H. Sallen, President
   (813) 577-4489

10. D & J Sheet Metal Company
    10055 NW 7th Ave.
    Miami, FL 33150
    Attn: Jake Sticher
    (305) 757-7033

11. Daystar
    41 Second Ave.
    Burlington, MA 01803
    Attn: Clifton Smith, V.P. Marketing
    (617) 272-8460

12. Dome East Corporation
    325 Duffy Ave.
    Hicksville, NY 11801
    Attn: Jeff Thomas
    (516) 938-0545

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

14. E & K Service Co.
    16824 74th Ave. NE
    Bothell, WA 98011
    Attn: James Ewbank
    (206) 486-6660

15. Ecotechnology
234 Barbara Ave.
Solana Beach, CA 92075
Attn: Daryl Pettus
(714) 755-8361

16. Edwards Engineering Corporation
101 Alexander Ave.
Pompton Plains, NJ 07444
Attn: James Campbell
(201) 835-2808

17. Emerson Electric Company
8100 W. Florissant St.
St. Louis, MO 63136
Attn: William Nusbaum, V. President
(314) 553-2000

18. Energy Conservations Systems of Colorado Springs, Inc.
327 W. Vermijo
Colorado Springs, CO 80903
Attn: Peter O. Wood, President
(303) 475-0332

19. Energy Converters, Inc.
2501 N. Orchard Knobb Ave.
Chattanooga, TN 37406
Attn: Mr. Rhodes
(404) 375-2503

20. Energy Design Associate, Inc.
3003 19th Dr. NE
Gainsville, FL 32601
Attn: Richard Rodgers, Director of Research
(904) 377-7883

21. Energy Systems, Inc.
634 Crest Drive
El Cajon, CA 92021
Attn: C.L. Caster
(714) 440-4646

22. Environmental Energies, Inc.
21243 Grand River
Detroit, MI 48219
Attn: B. O'shea, President
(313) 533-1985

23. FAFCO, Inc.
138 Jefferson Dr.
Mental Park, CA 94025
Attn: Freeman Ford
(905) 321-6311

24. FESCO
Falbel Energy Systems Corporation
472 Westover Rd.
Stamford, CT 06902
Attn: Gerald Falbel, President
(203) 357-0626

25. Fiberglass Engineering Company
10223 Residency Rd.
Manassas, VA 22110
Attn: James D. Morris
(703) 361-1200

26. Fred Rice Production, Inc.
SAV Solar Heater (New Zealand)
6313 Peach Ave.
Van Nuys, CA 91411
Attn: Frederick Rice
(213) 786-3860

27. Free Heat
P.O. Box 8934
Boston, MA 02114
Attn: Edward Kunz, President
(617) 247-1769

28. Fun & Frolic, Inc.
P.O. Box 277
Madison Heights, MI 48071
Attn: Edward Konopka, President
(313) 399-1560

29. Future Systems, Inc.
12500 W. Cedar Rd.
Lakewood, CO 80228
Attn: Bill Thompson, Director of Corporation Communications
(303) 989-0431

30. Garden Way Labs
P.O. Box 66
Charlotte, VT 05445
Attn: Dr. Douglas Taff, Director
(802) 425-2147

31. General Dynamics
2361 S. Jefferson Davis Highway
Suite 1112
Arlington, VA 22202
Attn: W. Ruhe
(202) 785-6500

32. General Electric
P.O. Box 8661
Room 8036
Building 8
Philadelphia, PA 19101
Attn: D.L. Kirkpatrick
(215) 962-4926

33. General Industries
2238 Moffett Dr.
Fort Collins, CO 80521
Attn: John Hensley, General Manager
(303) 493-1688

34. Grumman Aerospace
Energy Program Plant 25
Bethpage, NY 11714
Attn: Don Stein, Commercial Sales
(516) 575-9186

35. Halmac Company
2414 Makiki Heights Dr.
Honolulu, HI 96822
Attn: L.M. Judd, Jr., President
(808) 533-6464

36. Halstead Industries, Inc.
Halstead & Mitchell Div.
P.O. Box 1110
Scottsboro, AL 35768
Attn: Otto Nussbaum
(205) 259-1212

37. Helio-Dynamics, Inc.
518 S. Van Ness
Los Angeles, CA 90020
Attn: Truman Temple, President
(213) 384-9853

38. Hitachi Chemical Company America, Limited
437 Madison Ave.
New York, NY 10022
Attn: H. Aburatani, Manager
(212) 838-4804

39. Hittman Associates, Inc.
9190 Red Branch Rd.
Columbia, MD 21045
Attn: Dr. Curran, Sr. Staff Consultant
(301) 730-7800

40. Honeywell, Inc.
Systems and Research Center
2600 Ridgeway Parkway
Minneapolis, MN 55413
Attn: Roger Schmidt, Manager Solar Pilot Plant
(612) 378-4078

41. I.B.M.
Building 965-2
Department 725
Essex Junction, VT 05452
Attn: Dick Pratt, Staff Engineer
(802) 769-0111

42. Illinois Institute of Technology
Institute of Gas Technology
3424 S. State St.
Chicago, IL 60616
Attn: Dr. Lavan, Associate Professor Department of Mechanics
(312) 567-3189

43. International Environment Corporation
129 Halsted Ave.
Mamaroneck, NY 10543
Attn: Richard Rothschild, President
(914) 698-8130

44. International Solar Heating, Inc.
Route 1 Box 319 A
Brandywine, MD 20614
Attn: George Gaydos
(301) 888-1267

45. International Solarthermics Corporation
Box 397
Nederland, CO 80466
Attn: Bob Strickland, V. President of Administration
(303) 258-3272

46. Intertechnology Corporation
100 Main St.
Warrenton, VA 22186
Attn: Norris Beard, Director Marketing Operation
(703) 347-7900

47. Isle Engineering, Inc.
7177 Arrowhead Rd.
Duluth, MN 55811
Attn: John Isle, President
(218) 729-6858

48. Itek Corporation
Optical Systems Division
10 Maguire Rd.
Lexington, MA 02173
Attn: Norm Groalick, Engineer
(617) 276-2000

49. J & R Simmons Construction Co., Inc.
2185 Sherwood Dr.
S. Daytona, FL 32019
Attn: John Simmons, Vice President
(904) 767-6367

50. Johnson Diversified, Inc.
2340 Queen Ann St.
Merritt Island, FL 32952
Attn: Stan Johnson, President
(302) 452-5545

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

52. Materials Consultants, Inc.
2150 S. Josephine St.
Denver, CO 80210
Attn: Dr. J.D. Plunkett, President
(303) 722- 8258

53. Motorola, Inc.
New Venture Dev.
4039 E. Raymond St.
Phoenix, AZ 85040
Attn: Dr. I. Lesk, Manager of Solar Program
(602) 244-5511

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

55. Northeastern Solar Energy Works, Inc.
112 West 34th St.
Suite 916
New York, NY 10001
Attn: Louis Varon, President
(212) 524-2474

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

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

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

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

60. Phoenix of Colorado Springs, Inc.
P.O. Box 7246
Colorado Springs, CO 80933
Attn: Douglas Jardine, President
(303) 633-2633

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

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

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

64. Raypak, Inc.
3111 Agoura Rd.
Westlake Village, CA 91359
Attn: Mr. Boniface
(213) 889-1500

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

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

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

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

69. Shelly Radiant Ceiling Company
8110 North St. Louis Ave.
Skokie, IL 60076
Attn: William Shelley, President
(312) 675-8899

70. Shultz Field Enterprises Solar Utilities Company
11404 Sorrento Valley Rd.
Suite 112
San Diego, CA 92121
Attn: Jack Shultz, Owner
(714) 452-8822

71. Skytherm Process & Engineering
2424 Wilshire Blvd
Los Angeles, CA 90057
Attn: Harold Hay
(213) 389-2300

72. Sol-R-Tech, Inc.
The Trade Center
Hartford, VT 05047
Attn: John Devries, Vice President
(802) 295-9343

73. Sol-Therm Corporation
7 W. 14th St.
New York, NY 10011
Attn: I. Sittenfeld
(212) 691-4623

74. Solar Corporation
9620 Royalton Dr.
Beverly Hills, CA 90210
Attn: Hal Meier, President
(213) 276-6372

75. Solar Dynamics, Inc.
4527 E. 11th Ave.
Hialeah, FL 33013
Attn: Mr. Chester, Vice President
(305) 688-4393

76. Solar Applications, Inc.
2200 E. Washington St.
Phoenix, AZ 85034
Attn: Robert E. Hopp, Vice President
(602) 244-1822

77. Solar Energy Company
P.O. Box 69-B
Norland Branch
Miami, FL 33169
Attn: Mr. Balmer
(305) 233-0711

78. Solar Energy Components, Inc.
1605 Cocoa Blvd.
Cocoa, FL 32922
Attn: Walter Autry, President
(305) 632-2880

79. Solar Energy Development, Inc.
1437 Alameda Ave.
Lakewood, OH 44107
Attn: Nicholas Macron, President
(216) 221-3500

80. Solar Energy Digest
Equipment Division
P.O. Box 17776
San Diego, CA 92117
Attn: Bill Edmondson, Owner
(714) 277-2980

81. Solar Energy Products Company
121 Miller Rd.
Avonlake, OH 44012
Attn: Frank Rom, President
(216) 933-5000

82. Solar Energy Research Corporation
1228 15th St.
Denver, CO 80202
Attn: James Wiengard, President
(303) 573-5499

83. Solar Energy Systems
1243 South Florida Ave.
Rockledge, FL 32955
Attn: Roy C. Mealee, President
(305) 632-6251

84. Solar Equipment Corporation
P.O. Box 327
Edision, NJ 08817
Attn: John Cotsworth, President
(201) 549-3800

85. Solar Physical Corporation
1350 Hill St.
El Cajon, CA 92020
Attn: Jack Hedger, President
(714) 440-1625

86. Solar Systems, Inc.
1802 Dennis Dr.
Tyler, TX 75701
Attn: Mr. Jim Eftes, Owner
(214) 592-5343

87. Solarway
P.O. Box 217
Redwood Valley, CA 95470
Attn: Ben Piraino, General Manger
(707) 485-7616

88. Solergy, Inc.
150 Green St.
San Francisco, CA 94111
Attn: Ronald Smith, President
(415) 398-6813

89. Stampco, Inc.
4549 St. Augustine Rd.
Building #13
Jacksonville, FL 32207
Attn: R.C. Decker
(904) 737-6144

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

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

92. Suhay Enterprises
2112 W. Oak
Burbank, CA 91506
Attn: Frank L. Suhay
(213) 846-6245

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

94. Sunearth, Inc.
Box 99
Milford Square, PA 18935
Attn: Howard S. Katz, President
(215) 536-8555

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

96. Sunsource
9570 West Pico Blve.
Los Angeles, CA 90035
Attn: Edward London, General Manager
(213) 271-7248

97. Sunwater Company
1112 Pioneer Way
El Cajon, CA 92020
Attn: Ed Smith, President
(714) 440-3151

98. Sunworks, Inc.
669 Boston Post Rd.
Guilford, CT 06437
Attn. Everett M. Barber, President
(203) 453-6191

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

100. Thomason Solar Homes, Inc.
6802 Walker Mill Rd. SE
DC 20027
Attn: H. Thomason
(301) 336-0009

101. Ying Manufacturing Corporation
1940 W. 144th St.
Gardena, CA 90249
Attn: Mr. Yu, Vice President
(213) 770-1756

School of Graduate Studies
And Research

Center for
Environmental Studies

The University
Of Alabama
In Huntsville

P.O. Box 1247
Huntsville, Alabama 35807

The University of Alabama in Huntsville is preparing source materials related to solar energy conversion systems and subsystems. This effort is funded by the State of Alabama and by NASA Contract NAS8-31293 in support of the Solar Energy Heating and Cooling Demonstration Act of 1974.

As your organization is a manufacturer or supplier of solar collectors, we request your cooperation and assistance in this effort. The results of this survey effort will be made available to participants. Please indicate any restrictions or limitations for dissemination of data provided by your organization.

Attached is a Data Sheet for gathering basic information concerning solar collectors. Please complete the appropriate blanks and add any comments or additional information of potential interest. I would appreciate two copies of any available literature or brochures concerning your products and capabilities for the UAH and NASA Technical Information Files.

Thank you for your assistance in supporting our research efforts.

Sincerely,

David L. Christensen
Research Associate

DLC:sr

Enclosure: Data Sheet

SOLAR COLLECTOR DATA SHEET

Date: _____

Source Data:

Name of Manufacturer or Dealer: _____
Street Address: _____
City, Town, Zip Code: _____
Key Contact: _____
Telephone: ( ) _____

Design Data:

Type Collector: _____
Collector Name: _____ Model or Part No. _____
Type Fluid Used: _____
Type Additives Required: _____
Fluid Flow Rate : _____
Physical Dimensions: (L _____, W _____, H _____, Dia. _____)
Active Absorber Area: _____
Weight: (Dry _____, Operational _____)

Materials:

Outer Cover Plate: _____
Inner Cover Plate: _____
Other Cover Plate: _____
Cover Plate Coating: _____
Absorber: _____
Absorber Coating: _____
Base Plate: _____
Edge Enclosure: _____
Insulation: _____

Manufacturing Data:

Number Produced: _____
Production Capability (Units/Year): _____
Years in Production: _____
Warranty: _____

Installation and Operational Data:

Collector Mounting Position(s): _____
Type Moisture Removal: _____
Type Instrumentation: _____
_____

Performance and Test Data:

Energy Collection Rate (BTU/Hr. - ft^2): _____
Collector Efficiency (% and Curves): _____
Test Report Number(s): _____
Test Certifying Agency: _____

Economic Data:

Cost Per Collector Unit

Wholesale: _____ Retail: _____ Installed: _____

Quantity Discounts: _____

Application Data:

Location	User
_____	_____
_____	_____
_____	_____
_____	_____

Reference Material (Please Attach):

Design Drawing Number: _____
Specification Number: _____
Installation Drawing No.: _____
Maintenance and Repair Report No.: _____
Environmental Test Report No.: _____
Other: _____

Comments:

ATTACHMENT C

SOLAR ENERGY HEATING AND COOLING PROJECTS

This attachment presents results of a detailed survey of solar energy heating and/or cooling projects located throughout the United States. The package consists of four parts: sample letter mailed to 142 locations, enclosed data sheet, a listing by state of identified projects with a symbol explanatory page, and a list of the locations that responded to the inquiry.

School of Graduate Studies
And Research

Center for
Environmental Studies

The University
Of Alabama
In Huntsville

P.O. Box 1247
Huntsville, Alabama 35807

May 2, 1975

Dear

The University of Alabama in Huntsville is preparing source materials related to solar energy conversion systems and components for use in a technical data bank. As your organization is involved in this field of endeavor, we request your cooperation and assistance in this effort. The results of this survey effort will be made available to participants. Please indicate any restriction or limitations for dissemination of data provided by your organization.

Attached is a Data Sheet format for solar energy heating and cooling systems. Please complete the appropriate blanks and add any comments or additional information of potential interest. I would appreciate two copies of any available literature or brochures concerning your program activities.

Attached is a listing of solar collector manufacturing and sales outlets which may be of interest to you.

Thank you for your assistance in supporting our research efforts.

Sincerely,

David L. Christensen
Research Associate

DLC:sr

Enclosures

DATA SHEET

Solar Energy Heating and Cooling Systems

Basic Elements of Building/Application:

Type (Residence, Commercial, Test, Other): _____

Title: _____

Location: _____

Size (floor area): _____

Number of Floors: _____

Date Completed or Planned Date: _____

Operational Period: _____ to _____

Responsibility Data:

Information Contact: _____

Address, Telephone: _____

Architect: _____

Designer/Engineer: _____ / _____

Owner/Sponsor: _____ / _____

Design Data:

Collectors:

Manufacturer: _____

Type Collector: _____

Operating Fluid: _____

Total Area: _____

Location/Orientation/Tilt: _____ / _____ / _____

Storage:

Type/Medium: _____ / _____

Volume: _____

Location: _____

Heating: Type: _____

Capacity (BTU/hr.): _____

Cooling: Type: _____

Capacity (BTU/hr.): _____

Hot Water: Type: _____

Capacity: _____

Control System: Operational Description: _____

_____

Instrumentation: _____

_____

Overall System:	% Total	Storage Capacity (days)
Solar Heated:	_____	_____
Solar Cooled:	_____	_____
Hot Water:	_____	_____

Auxiliary Energy Source: _____

Related Equipment Req. (Cooling towers, etc.): _____

_____

Total Electric Power Req. (Watts): _____

System Cost (Installed): _____

Certifications, Testing, or Industrial Standards Used: _____

_____

References (Articles, etc.): _____

_____

_____

Comments/Drawings/Photos/Data: _____

_____

_____

_____

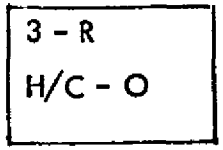
_____

ATTACHMENT C

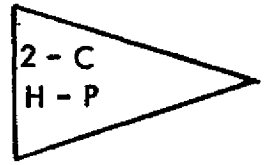
SYMBOL DEFINITIONS

Symbol	Meaning
R	Residential
C	Commercial
R/D	Research and Development
H	Solar Heating Only
H/C	Solar Heating and Cooling
P	Planned
O	Operational
No.	Corresponding reference in that state in the Survey Book

EXAMPLES



3 - Third reference in that state
R - Residential
H/C - Heated and Cooled
O - Operational



2 - Second reference in that state
C - Commercial
H - Heating Only
P - Planned

Attachment C

Identified Projects by State

State	R	C	R/D	H	H/C	P	O	Total
Alabama	-	-	2	-	2	1	1	2
Arizona	2	-	1	1	2	-	3	3
California	5	2	1	4	3	3	5	8
Colorado	18	6	5	22	4	6	23	29
Connecticut	4	-	-	2	2	1	3	4
Delaware	-	1	1	2	-	1	1	2
D. C.	4	-	-	-	4	-	4	4
Florida	1	-	1	2	-	1	1	2
Georgia	-	2	-	1	1	2	-	2
Illinois	1	2	-	2	-	1	2	3
Kansas	-	-	1	1	-	-	1	1
Maine	2	-	-	1	-	-	2	2
Maryland	1	1	-	1	1	-	2	2
Massachusetts	2	1	-	3	-	1	2	3
Michigan	-	1	2	1	2	2	1	3
Minnesota	2	3	-	2	3	2	3	5
Missouri	-	3	-	3	-	3	-	3
Nebraska	1	1	-	-	2	-	2	2
Nevada	1	1	-	1	1	1	1	2
New England	1	-	-	-	1	1	-	1

State	R	C	R/d	H	H/C	P	O	Total
New Hampshire	4	1	1	3	3	2	4	6
New Jersey	-	1	-	1	-	-	1	1
New Mexico	14	4	5	17	5	13	10	23
New York	-	5	1	5	1	5	1	6
Ohio	2	-	1	2	1	1	2	3
Oregon	1	-	-	1	-	-	1	1
Pennsylvania	2	2	1	4	-	2	3	5
Rhode Island	-	-	1	-	-	1	-	1
Texas	1	-	-	-	-	1	-	1
Vermont	3	2	-	4	1	4	1	5
Virginia	1	4	-	3	2	4	1	5
West Virginia	1	-	-	1	-	1	-	1
Wisconsin	1	-	-	1	-	1	-	1
Total	75	43	24	91	41	61	81	142

Letters and technical data forms were forwarded to 142 selected sources for information concerning different solar energy projects. Information has been received from about 49 of the projects as of July 15, 1975. Typical sources of information who have responded are:

1. AAI Corporation
   P. O. Box 6767
   Baltimore, Md. 21204

2. Dr. J. Douglas Balcomb
   University of California (LASL)
   Los Alamos, N.M.

3. Dr. Al Caselia
   Sangamon State University
   Springfield, Ill

4. Carleton Granbery, Fred Dubin,
   Everett Barber (FAIA)
   Guildord, Conn.

5.-22 Dublin-Murdock-Bloome Assoc.PC.
   Consulting Engineers and Planners
   New York, NY.

23. Richard T. Dunean, Jr.
   Westinghouse Electric Corp.
   Baltimore, Md.

24. Energy Conservation Systems, Inc.
   Colorado Springs, Colorado

25. Environmental Consulting Service
   Boulder, Colorado

26. Flack & Kurtz
   Consulting Engineers
   Ner York, NY.

27. Glave, Newman, Anderson & Assoc.
   Richmond, Virginia

28. Grassy Brook Village, Inc.
   Brookline, Vermont

29. Harrison Fraker - Architect
   Princeton, NJ

30. Intertechnology Corp.
   Warrenton, Virginia

31. Jackson & Son - Consultant
   Colorado Springs, Colorado

32. R. H. Kula - Director of Planning
   Community College of Denver
   Denver, Colorado

33. Henry Mathew - Individual
   Coosbay, Oregon

34. Ohio State University
   Fairgrounds, Ohio

35. Powell Brothers, Inc.
   South Gate, Ca.

36. P P & L Co.
   Allentown, Penn.

37. Sandia Laboratories - Solar
   Energy Systems
   Albuquerque, NM.

38. Norman B. Saunders
   Weston, Mass.

39. R. G. Schmitt - Consultant
   Strongsville, Ohio

40. Paul Shippee
Livermore, Col.

41. Solar, Inc.
Ashland, Neb.

42. Sol-R-Tech
Hartford, Vt.

43. Southern California Gas Co.
Loa Angeles, California

44. Richard Speed
Solar Tech. Corp.
Denver, Col.

45. Warren Stetzel (Raven Rocks)
Beallsville, Ohio

46. Sunstructure, Inc.
Ann Arbor, Mich.

47. Thomason Solar Homes, Inc.
Washington, D. C.

48. Dr. Roland Winston
Argonnenationa Lab
Argonne, Illinois

49. David Wright - Architect
Santa Fe, N.M.