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THE SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM -- SOME EARLY PROBLEMS AND RESULTS

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16. ABSTRACT

The origination of the Solar Heating and Cooling Commercial Demonstration Program by the Energy Research and Development Administration and the subsequent activities of the Marshall Space Flight Center of the National Aeronautics and Space Administration in the technical evaluation of proposals, contracts definitions, and program management details are defined and discussed.

During the period from initial site selection to present, a significant amount of experience has been gained which should be published to assist others in avoiding these problems. The significant problems are summarized in both technical and management aspects of the program.

It is concluded that the program has significantly stimulated additional solar effort by the program participants. It is also concluded that the use of conventional construction industry organizations with design/competitive bid procedures and standards has maintained a cost effective program.

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THE SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM – SOME EARLY PROBLEMS AND RESULTS

INTRODUCTION

This report presents a summary of the effort by both the Energy Research and Development Administration (ERDA)[1] and the National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC), personnel who attempted to define and implement, in a short time, an energy program of national urgency that had no precedent in Government-Industry relationships and procedures. Many individuals from ERDA and MSFC have contributed significant amounts of personal time to structure and implement this program, and their contributions are recognized and appreciated.

DISCUSSION

The Commercial Solar Heating and Cooling Demonstration Program was initiated by ERDA Program Opportunity Notice (PON) [1] in October 1975. The overall program currently calls for approximately yearly releases of PON's over a 4 year period. The second PON [2] was released in October 1976, and the selection process is now being completed by ERDA. MSFC, which had participated in earlier solar heating and cooling activities, was asked by the ERDA to perform technical evaluation of the approximately 300 responses to the PON for the first and second years. ERDA used the results of the MSFC technical evaluation in addition to other criteria in selecting the demonstration sites for the first and second year.

Following the first year selectior by ERDA of the 32 winning sites in March of 1976, MSFC was asked by ERDA to define a contractual relationship for each site that was unique in government contractual procedures, and to manage the program through the successful operation of each site. The contract relationship was expected to have the following characteristics:

[1]ERDA was absorbed by the newly formed Department of Energy (DOE), Oct 1, 1978.

a. Cost sharing — In most cases, the Government would provide the major funding for the design and installation of a solar system into each site. Each site owner/team would receive the reduced utility cost of the project, plus the intangible return of public relations and pioneering industry experience. The maximum degree of cost sharing was desired.

b. Cost effectivity — The program was aimed at installing available solar components with existing Heating Ventilation and Air Conditioning (HVAC) industry standard hardware and procedures. If these government contracts were significantly over-funded by either inaccurate cost estimates or unnecessary requirements, then the new solar industry could and would be initiated with a cost bias that would require years to overcome and achieve competitive cost with conventional energy.

c. Contract requirements workable with small business — Several of the selected sites were proposed by organizations with no experience with government contracts. All aspects of the contracts therefore had to be applicable and workable with small organizations and individuals with no government contract experience.

d. Cost effective installation of the performance measuring sensors and Site Data Acquisition System (SDAS) — The PON reference stated that the Government might provide hardware to measure the solar system performance at any site. The decision was made by ERDA to supply each site for a period of time with the performance measuring sensors and equipment to record and transmit the performance data to a central computer processing site. Figures 1 and 2 show the equipment and its operation while References 3 and 4 provide definitive details.

e. Maximize the success probability of each site — It is believed that providing assistance to each site (both technical and management) significantly increases the success probability of each site. Some of the methods used were developed in the space program and others utilized conventional construction industry procedures.

f. Utilize conventional construction industry procedures, standards, and terminology — The PON specified the participation of professionally qualified architects and engineers. Therefore, the entire program must be structured to utilize and operate within the "construction" industry procedures, terminology, and standards. In addition, the project must conform to all applicable local codes and the Interim Performance Criteria of Reference 5.

The MSFC personnel assigned to prepare the contract documents (and essentially define the program structure and procedures) recognized that previous management experience with space related development projects was not adequate for this unique conventional industry program. Therefore, a conference was arranged at MSFC in early March 1976 before the contract document preparation with representatives of the professional societies and industry organizations currently operating in the HVAC area of the related construction industry. The participating organizations were:

a. American Society of Heating, Refrigeration and Airconditioning Engineers (ASHRAE)

b. American Institute of Architects (AIA)

c. Mechanical Contractors Association of America (MCAA)

d. Sheet Metal, Airconditioning Contractors National Association (SMACNA)

The desired program goals and general plans to operate with conventional construction industry procedures were discussed with the representatives of these organizations.

The following specific points were discussed with representatives of the above organizations and their organization recommendations for the program were received for inclusion in the program:

a. Architect and engineer design procedures and standards

b. Project cost evaluation and control procedures

c. Competitive bidding procedures

d. Initial system operations and check out procedures.

The review of the program with the technical societies and industry associations provided invaluable insight into methods of accomplishing the desired program goals. It was decided to utilize the professional experience of selected members of the ASHRAE and the AIA in the actual program implementation. This permitted individuals with extensive industry experience to provide constructive technical peer group inputs and suggestions into each selected site and to permit a broader awareness and utilization of each project site experience. The major program elements were in general as follows.

Preliminary Design Review

This review was to be held at the project site. For some complex projects, one or two members of ASHRAE and AIA (selected by their National Headquarters) attended the preliminary and final design review to offer constructive suggestions. The purpose of the review was to discuss the project concept including:

a. Collector tilt angle, location, and size

b. Storage tank type, size, and location

c. Control procedures, operating modes, and control parameters

d. Performance variations for changes in collector, storage, and airconditioning or heating system

e. Project schedule

f. Planned Government furnished performance measuring instrumentation and Site Data Acquisition System (shown in Figures 1 and 2 and defined in References 3 and 4)

g. Required project design compliance with the Interim Performance Criteria [5] and all state and local codes.

Design Phase

The system configuration agreed to in the Preliminary Design Review is reduced to construction drawings according to industry practice. The appropriate performance sensors for the specific sites are defined by the Government. In coordination with the team member preparing the final construction drawings, the sensor installation details and procedures [3] are integrated into the final construction drawings.

Final Design Review

This review is conventionally called a 90 percent review. The purpose of this review is to approve the final and complete construction installation drawings and specifications prior to release for competitive biddings. These documents have been prepared in the design phase based on approved preliminary design and configuration. The estimated cost of the project is a significant review item as well as all system definitive details not approved conceptually in the preliminary review. The compliance of all elements of the project design with the Interim Performance Criteria [5] and all state and local codes is evaluated. Other specific review items are, for example, detailed checks of structural, electrical, and site drawings for technical adequacy, completeness, clarity for competitive bids, and project control during and after construction. The control system operating modes, operating parameter settings, and building installation locations are also evaluated in detail.

Competitive Bidding, Construction Contract Award, and Construction Phase

The complete and approved drawings and specifications permit the selection of an acceptable bidder on the basis of cost and defined task. This selection is done by the organization with whom the Government has contracted for the demonstration site. If no acceptable bids are received within the allocated project funds, then a design-to-cost exercise may be performed to reduce some element of the project scope so that an acceptable bid within the allocated project funds can be obtained by competitive bidding.

Acceptance Test Phase

Following completion of the construction phase, the solar energy system will be operated to evaluate the design conditions of the following:

a. Collector performance, flowrates, and flow uniformity

b. Storage device performance, heat loss, and internal plumbing adequacy

c. Transport system flow rates and heat loss

d. Airconditioner performance, C.O.P., air and water flowrates, flow balance, and distribution

e. Control system adequacy and operating parameter set points, and control stability

f. Heating system performance, air and water flowrates, flow balance, and distribution

g. Auxiliary or alternate heating/cooling system operation performance and automatic cut in

h. All pumps and fans electric power requirements.

During this operation, the performance measuring sensors and the Site Data Acquisition System are used to measure and record performance. A special "on site monitor" (OSM) is provided so that performance signals recorded in the Site Data Acquisition System can be read in engineering units at the site. Current program plans are for each site to have temporary use of an OSM for the period required to perform acceptance testing. Adjustments or changes to the system to achieve desired or optimum performance are made during this period.

Operational Phase

During this period, which may be up to 5 years, the Site Data Acquisition System records the performance and transmits these data to a central computer in Huntsville, Alabama. No change can be made to the system configuration in this period without MSFC/ERDA approval.

These program elements were used as a general guideline for each project; however, significant deviations were required on several sites due to the following:

a. The selected sites varied in project status from conceptual design, where all elements of the general program guidelines could be used, to several projects that were already complete and required only definition and installation of the performance measuring sensors and Site Data Acquisition System.

b. The site size/complexity and thus the proposed site team (the PON requested a site owner, an architect/engineer, and project manager) varied from large sites involving major national corporations with large supporting technical organizations (both architects and engineers) to small projects where one man served nearly all functions.

The contractual relation with all 32 selected sites was negotiated before June 30, 1976, and Table 1 defines the projects including cost and Table 2 presents the project status. The data of Tables 1 and 2 show that of the total program cost of 7.9 million, 2.1 million (or 26.9 percent) has been completely through the design and construction phase. Another 1.8 million (or 22.8 percent) is currently under fixed price construction contracts. The remainder of the project work valued at 4.0 million (or 50.2 percent) has not been advertised for competitive bidding.

In achieving the current program status, a significant amount of experience has been obtained by the program participants, both industry and government.

The condensed summary of the "lessons learned" information presented in this report is the first publication of this type of information over the entire program (individual papers on the technical aspects of several projects have been published).

The compilation of significant program experience is separated into technical design and management areas and is presented in Tables 3 and 4. The information is presented in general terms to show its possible impact for any other program and also to minimize its identification with any specific project and thus preclude any possible reflection on any firm or individual.

In addition to the problems/solutions information contained in this report, it was decided to collect additional program data concerning financial and recommended program changes from each of the site owners as well as architect and/or engineer. A joint committee of the ASHRAE and the AIA Research Corporation prepared a questionnaire and discussed the answers to these questions with each respondent. The results of this questionnaire have been reduced to a draft report by the joint ASHRAE and AIA Committee. The report is expected to be published very soon and be available through ASHRAE, AIA, and government sources.

CONCLUSIONS

The overall goal of the Government solar heating and cooling program is to stimulate the creation of an industry that will ultimately provide solar heating and cooling systems competitive with conventional powered heating and cooling systems without Government funding support. The commercial solar heating and cooling demonstration program has contributed to this overall goal in the following areas:

a. Public visibility and access — The Mount Rushmore Site and the Florida Visitors Center together will be visited by over 50 000 people per day during peak season. It is projected that over 2 000 000 people per year will visit the 32 sites selected in the first year.

b. Project experience and design data dissemination — The project reports, including as-built drawings, installation, operation and maintenance manuals, are to be provided to the National Technical Information Center for public access.

c. The initial meeting in March of 1976 with industry and technical associations provided invaluable inputs into the program structure. A major product of this meeting was precluding aerospace procedures or terminology from being initiated in a program where it was not appropriate or desired. A second meeting was held in March 1977 with the same previously mentioned organizations and also the President and representatives of the Solar Energy Industry Association. A review of what has been accomplished in this program was performed, and an effective communication procedure was established between NASA and the technical/industry organization. Periodic reviews with these organizations and possibly others are planned for the future.

Some of the early demonstration projects have long economic "pay back periods" defined as the cost of the project divided by cost of energy saved. However, many of the commercial organizations involved in the program have expressed firm intentions of pursuing additional efforts in solar heating and cooling as a result of participation in the PON Program. The demonstration program therefore has developed a "multiplier effect." Based on expressed stated intentions of many site participants, the multiplier effect can be as high as 5 to 10 where for each dollar of Government funds in the program between 5 to 10 dollars of non-government funds may be introduced into solar heating and cooling. The stimulated applications vary from additional applications of solar heating and cooling to manufacture and or distribution of solar heating and cooling products such as collectors, storage devices, and control devices. An observation of the program has been the successful utilization of architects and engineers experienced in the conventional construction industry to design successful solar heating and cooling projects. The conventional industry design and competitive bid procedures have resulted in cost conscious design and construction in the program.

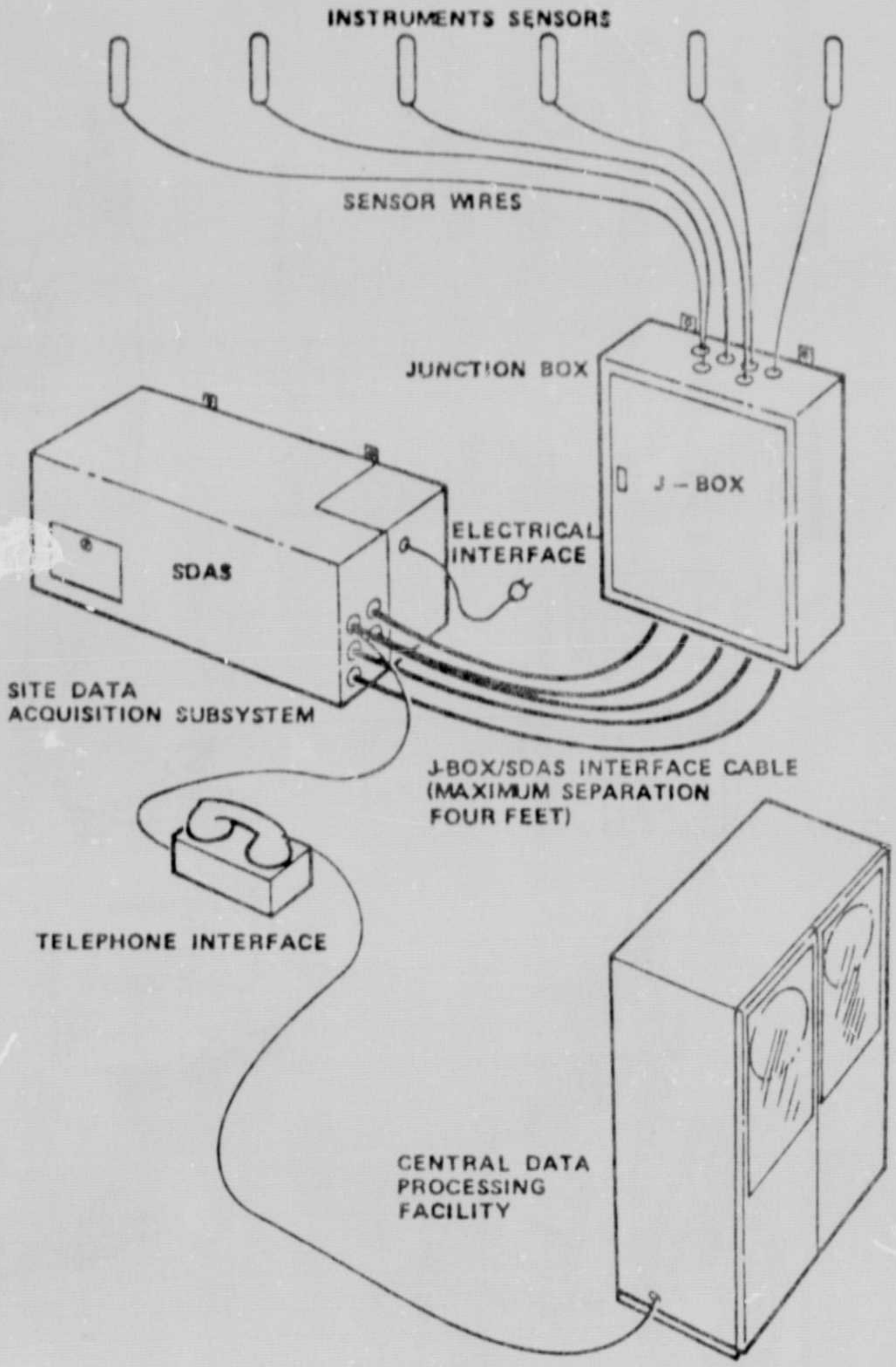

Figure 1. Site data acquisition system.

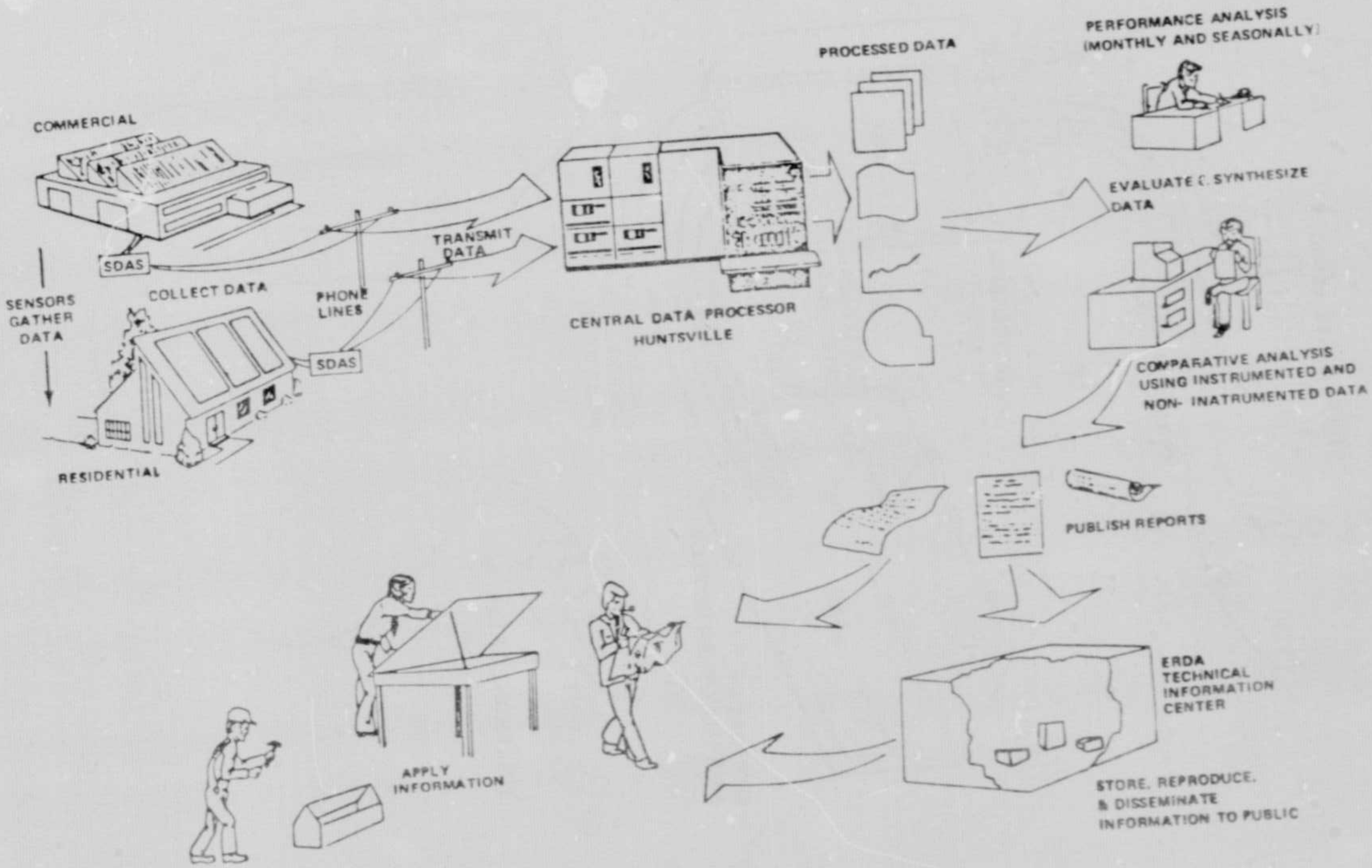

Figure 2. Sensor to user data system.

TABLE 1. PROJECT INFORMATION SUMMARY

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Holiday Inn Hotel at St. Thomas, U.S. Virgin Islands	13 000 ft^2 Northrup Tracking Concentrator	Solar heated water reduces load on existing oil fired boiler-absorption A/C	None	Existing 1000 Ton Carrier	$ 411 447
Mt. Rushmore Visitor's Center Rapid City, SD	2000 ft^2 Lenox	Solar heated water operates absorption cycle A/C or air H_x to reduce load on existing conventional electric A/C or oil boiler	3000 gal	3-3 Ton Arkla	$ 228 200
Rademaker Corp. Louisville, KY	195 ft^2 — Air-Solaron 240 ft^2 — Liquid-SDI	Combination air and liquid system both heating bldg. Liquid system also heats water.	110 ft^3 rock 560 gal water	N/A	$ 20 729
Blakedale Professional Center Greenwood, SC	954 ft^2 — PPG Liquid Collectors	Heating and hot water system	5000 gal	N/A	$ 52 616
Memorial Hospital Charlotte, NC	3950 ft^2 — GE Liquid Collectors	Heating and hot water system	6000 gal	N/A	$ 204 515
Baltimore Community Center Baltimore, MD	3100 ft^2 — Revere Collectors	Solar assisted heat pump system and hot water	20 000 gal	N/A	$ 150 345

TABLE 1. (Continued)

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Terrell E. Moseley Lynchburg, VA	410 ft^2 — Locally Shop Fabricated Collector	Solar assisted heat pump system and hot water	1200 gal	N/A	$ 15 630
Ferguson Corp. (Thr-Rift Inn) Annapolis, MD	2325 ft^2 — Southwest Ener-Tech. Inc. Flat Plate	Solar heated water reduces load on existing electric boiler which supplies water to the rooms and laundry	3500 gal	None	$ 75 545
Loudoun County Vocational School Leesburg, VA	1225 ft^2 — Southwest Ener-Tech. Inc. Flat Plate	Solar heated water reduces load on existing electric boiler which supplies water to the classrooms, laboratories, and restrooms	1500 gal	None	$ 56 336
Ingham County Medical Care Facility Okemos, MI	10 000 ft^2 — Revere or Equiv. Flat Plate	Solar heated water reduces load on the oil fired boiler which supplies water to the rooms, kitchen, and laundry	5000 gal	None	$ 336 700
Iris Images, Inc. Custom Film Processing Lab. Mill Valley, CA	640 ft^2 (net) Site Fabricated Flat Plate — Filon Glazing, Sunburst and SDI Absorber Plates	Solar heated water reduces load on existing gas fired boiler which supplies water to film processors and restrooms	360 gal	None	$ 35 154

TABLE 1. (Continued)

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Work Wear Corp. (Red Star Indust. Laundry) Fresno, CA	6720 ft^2 — Ying Mfg. Flat Plate	Solar heated water reduces load on existing gas fired boiler which supplies water to the laundry	12 000 gal	None	$ 165 000
Scattergood Schl. West Branch, IO	2500 ft^2 — Solaron	Solar air collectors for hot water and heating an 8000 ft^2 gymnasium — furnishes 75 percent of heating load	1250 ft^2 rock bin	N/A	$ 76 289
Lake Valley Fire House — Tahoe Paradise, CA	352 ft^2 — Western Energy Flat Plate Liquid Collector	Solar system to provide heating and hot water for a fire house	2000 gal	N/A	$ 4726
LSU Field House Baton Rouge, LA	5700 ft^2 — Lennox Honeywell Liquid Collector	Solar system to provide heating and hot water to a 101 200 ft^2 field house	20 000 gal	N/A	$ 258 225
Radisson Hotel St. Paul, MN	4752 ft^2 — Lennox-Honeywell Liquid. 3744 ft^2 Air.	Combination air and liquid collectors for heating and hot water	8000 gal	N/A	$ 360 000
Tempe Union High School Tempe, AZ	20 000 ft^2 — South West Standard Water Collectors	Heating for 264 000 ft^2 school plus hot water	47 000 gal	N/A	$ 692 100

TABLE 1. (Continued)

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Fire Station Kansas City, MO	2808 ft^2 Solaron Air Collectors	Heating for 6000 ft^2 fire station	1400 ft^3	N/A	$ 131 829
Kalwall Warehouse Manchester, NH	1700 ft^2 Vertical Wall (Kalwall) Panels for Passive Heating	Kalwall fiberglass insulated panel let sunlight into warehouse for passive heating	concrete floor and warehouse contents	N/A	$ 28 600
Environmental Center — San Francisco, CA	1800 ft^2 — Liquid Chamberlain Collector Plus Passive	Solar system will supply 57 percent of heat for a 55 000 ft^2 office bldg.	3000 gal	N/A	$ 138 866
Telex Communications Mfg. Plant, Blue Earth, MN	12 000 ft^2 of Liquid Collectors. Mfg. by Solar Corp. of Am.	Liquid Solar Corp. collectors will heat the 97 000 ft^2 manufacturing plant	22 000 gal	N/A	$ 350 000
Office Building Stamford, CT	3108 ft^2 of Liquid Collector by Sunworks	Sunworks liquid collectors to heat a 25 000 ft^2 office building	9000 gal	N/A	$ 335 000
Office Building Silver Spring, MD	1700 ft^2 — Liquid Collectors Mfg. by KTA	A heating system for a 22 264 ft^2 office building	4000 gal	N/A	$ 49 016

TABLE 1. (Continued)

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Florida Visitor Center I95 at GA border	2700 ft^2 Northrup Tracking Concentrator	Heating and cooling with solar heated water, conventional electric A/C for auxiliary and off peak chilled water, oil furnace for heat back up	6000 gal hot 4000 gal cold	25 Ton Arkla	$ 280 000
Radian Corp. Austin, TX	350 ft^2 — Northrup Tracking Concentrator	Heating and cooling with solar heated water, conventional electric A/C and gas heater for auxiliary	1500 gal	3 Ton Arkla	$ 32 205
El Camino School Irvine, CA	5000 ft^2 — Owens-Illinois Evacuated Glass Tube	Solar heated water supplements existing gas fired boiler to produce hot water for either cooling or heating	None	100 Ton Arkla	$ 247 500
RKL Controls Lumberton, NJ	6000 ft^2 — Sunworks Double Glazed Selective Coating Flat Plate	Solar heated water for collector is used for either heating or cooling. Electric for auxiliary heating or cooling. Mini computer controlled proportional flow and system operation. This is entirely new factory being built.	30 000 gal hot 20 000 gal cold	2-25 Ton Arkla	$ 541 605

TABLE 1. (Concluded)

Project Location	Collector Area/Type	Project Description	Storage	A/C	Government Funds
Alabama Power Montevallo, AL	2450 ft^2 PPG Flat Plate Liquid Collector With Reflectors	Solar assisted conventional heating, air conditioning and domestic hot water heating system for a 17 000 ft^2 office building.	8000 gal hot water 8000 gal chilled water	25 Ton Arkla	$ 279 179
Reedy Creek Utilities (WDW) Lake Buena Vista, FL	3840 ft^2 Modular Concentrator Collector	Solar assisted conventional heating, airconditioning, and domestic hot water heating system for a 5120 ft^2 bldg.	6000 gal hot water 10 000 gal chilled H_2O	25 Ton Arkla	$ 344 747
Trinity University San Antonio, TX	16 080 Northrup Tracking Concentrator Collectors	Solar assisted conventional heating, airconditioning, and domestic hot water system for 284 928 ft^2 area served.	40 000 gal	350 Ton Arkla	$ 1 100 000
Olympic Engr. Richland, WA	6000 ft^2 G.E. Flat Plate Collector	Solar assisted conventional heating, airconditioning, and domestic hot water system for a 14 400 ft^2 office	9000 gal hot water 2000 gal cold	25 Ton	$ 634 000
Miami County Library Troy, OH	2000 ft^2 Owens-Illinois Evacuated Glass Collectors	Solar heating system with provision for adding solar cooling for a 23 200 ft^2 library	5000 gal	N/A	$ 272 925
				TOTAL	$ 7 909 109

TABLE 2. PROJECT STATUS SUMMARY

Project Location	Status Summary	Major Problems	Operational Date
Holiday Inn Hotel St. Thomas U.S. Virgin Islands	Both preliminary and final design reviews completed. Selected installation contractor has installed 90 percent of collectors and solar system plumbing. Performance measuring sensors being installed with data acquisition system.	Shipping damage to collectors	May 1977
Mt. Rushmore Visitors Center Rapid City, SD	All collectors and plumbing completed and leak checked. Cooling tower delayed due to severe winter. Performance sensors and SDAS to be installed in May. Checkout test in May, acceptance test in June.	Severe winter delayed construction	August 1977
Rademaker Corp. Louisville, KY	Both air and liquid system are operational. A freeze-up on liquid system shut this down one month in January and part of February.	— Freeze of liquid system. — Algae in tank. — Collector glazing problem. Replaced by manufacturer.	September 15, 1976
Blakedale Professional Center Greenwood, SC	Became operational in October 1976. Later model collectors now have failed. Storage system revised. Performance measuring system being installed.	Collector cover problems. Replaced with later model by manufacturer.	October 1, 1976

TABLE 2. (Continued)

Project Location	Status Summary	Major Problems	Operational Date
Charlotte Memorial Charlotte, NC	System becomes operational April 20, 1977	None	April 20, 1977
Baltimore Comm. Center Baltimore, MD	Bids are being prepared now. System planned for operation in October 1977, but April 1978 more realistic.	None	November 1977
Terrell E. Moseley Lynchburg, VA	The system has been in operation since November 1, 1976. No system problems have been experienced.	None	November 1, 1976
Ferguson Corp.	— The design review completed. — Bids are being evaluated. — Possible redesign to cost.	None	August 1977
Loudoun County	— The design review completed. — All hardware ordered. — Construction has started.	None	July 1977
Ingham County	— The preliminary and final design reviews completed. — Design is out for bids.	None	December 1977
Iris Images	— The design review completed. — System was operating since July 1976 without sensors. — Sensor installation began in March and now about 90 percent complete. — SDAS installation scheduled for April 20, 1977	Freeze damage to collectors	July 1976

TABLE 2. (Continued)

Project Location	Status Summary	Major Problems	Operational Date
Work Wear Corp.	— The preliminary and final design reviews completed. — System installation about 75 percent complete.	None	June 1977
Scattergood School West Branch, IO	Preliminary and final design reviews completed. Installation is to be completed in April 1977.	Difficulty in aligning collectors.	May 1977
Lake Valley Fire House — Tahoe Paradise, CA	Design reviews completed. System installation completed November 1976. System operational but having heat loss problems. SDAS installation will help find source of heat loss.	Storage tank too large for collector storage area. Large heat loss.	May 1, 1977
LSU Field House Baton Rouge, LA	A preliminary design review has been held. The final design has been held up because of excessive cost estimates. Contractor is redesigning to cost.	None	January 1, 1977
Radisson Hotel St. Paul, MN	No design reviews have been held. Contractor is having administrative problems.	None	July 1979
Tempe Union High School Tempe, AZ	Design reviews are complete. Collector supports are in place with collectors to be mounted in July 1977.	None	November 1977

TABLE 2. (Continued)

Project Location	Status Summary	Major Problems	Operational Date
Fire Station Kansas City, MO	Design reviews are complete. Installation starts July 1 with a completion date by end of 1977.	None	April 1978
Kalwall Warehouse Manchester, NH	Sensors have been installed and SDAS was installed April 15, 1977. Passive system is operating.	None	September 1, 1976
Environmental Center — San Francisco, CA	No design reviews have been held.	None	February 1978
Telex Comm. Mfg. Plant Blue Earth, MN	A preliminary design review has been held. High cost estimates caused redesign to cost exercise. Final design review is to be held in May.	None	September 1977
Office Building Stamford, CT	A preliminary design review has been held with final design review scheduled in May. Approval has been given for purchase of collector steel supports.	None	October 1977
Office Building Maryland National Park — Silver Spring, MD	This project has stopped due to a shading problem. An alternate site or relocation of collectors under evaluation.	None	Unknown

TABLE 2. (Continued)

Project Location	Status Summary	Major Problems	Operational Date
Florida Visitors Center I-95 at GA border	Acceptable bid received in redesign to cost exercise. Construction and installation under way. Desired performance data output to State of Florida for educational purposes under discussion with ERDA.	Initial design had excessive cost (bids)	September 1977
Radian Corp. Austin, TX	Project construction/installation complete and acceptance test under way. First to receive SDAS.	— Project delayed by sensor delivery and SDAS checkout. — Severe winter delayed construction	April 1977
El Camino School Irvine, CA	Competitive bids on construction/installation received and under evaluation.	Project delayed due to design changes.	August 1977
RKL Controls Lumberton, NJ	Final design review successfully completed project under construction by owner personnel.	Severe winter delayed site preparation	September 1977
Alabama Power Company Montevallo, AL	Final design review is scheduled for April 1977. Installation of hardware began in January. The system is scheduled for operation with the next heating season.	None	October 1977

TABLE 2. (Concluded)

Project Location	Status Summary	Major Problems	Operational Date
Reedy Creek Utilities (WDW) Lake Buena Vista, Florida	All design reviews are complete. Installation began in April 1977.	Control system redesigned to stop pump cycling due to variable cloud cover and type of collector used.	August 1977
Trinity University San Antonio, TX	The system is instrumented. Acceptance test is scheduled in April 1977.	None	May 1977
Olympic Engr. Co. Richland, WA	Design reviews are completed. Installation of hardware began in November 1976.	Construction problems and cost escalations	May 1977
Miami County Library Troy, OH	The final design review has been held. Installation and test of system are scheduled for completion in April 1977 with the system operation by next heating season.	None	September 1, 1977

TABLE 3. SUMMARY OF SIGNIFICANT TECHNICAL/DESIGN PROBLEMS AND SOLUTIONS FOR THE SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM — FIRST YEAR — TO DATE

Problem	Solution	Discussion
Liquid storage tank internal plumbing design minimized or eliminated stratification and associated benefits.	Diffusers are designed on all incoming lines to minimize flow velocity at terminal point. Either baffles or separation and direction prevents cold return flows short circuiting to hot exit pickup points.	This problem was initially discovered in operation of MSFC solar house. Reference 6 presents some design considerations and alternates.
High thermal losses from buried storage tanks due to wet insulation.	Storage concept rebuilt with better ground water drainage, location above water table.	Below grade storage tank locations have significantly higher performance risk. Avoid if at all possible or use waterproof insulation type.
Glycol/water mixture found to be too low during freezing weather and freeze-up of system.	Higher concentration of glycol added, automatic water makeup precluded without specific gravity continuous measurement or check.	Water-glycol system designs need extensive failure mode evaluation and design consideration.
Pressure relief valve failed to open due to freezing.	Relief valve relocated to non-freezing location and vent line relocated.	Water-glycol system designs need extensive failure mode evaluation and design consideration.

TABLE 3. (Concluded)

Problem	Solution	Discussion
Pumps and fans cycled frequently during start up and shut down due to control system instability.	Time delay added to thermostats and control set points altered.	Significant solar energy can be lost (not collected) due to control system stability particularly with variable cloud cover. Both computer simulation and experimental checks need to be made.
Corrosion or algae build-up in liquid storage tank and transport system.	Proper corrosion inhibitors used after evaluation of fluids and metals also biocide added to control algae	The corrosion aspect may well be the major long term problem of the program. Few site teams have the specialized qualifications to analyze the corrosion potential, condition, or solutions.
Drain-down collectors systems retained enough water to cause freezing problems	Air lines added to prevent "water trap" in drain-down lines.	This system requires good failure mode analysis of design and review of finished construction condition.
Glass breakage during non-operating periods with high solar energy incidence.	System design recommendation in manufactures installation manual changed to avoid "boil off mode" during period where solar heat not required by system. Manufacturer evaluating other approaches and is providing application support/ recommendations for each site.	Extensive evaluation test performed by MSFC and manufacturer to evaluate problem and fixes.

TABLE 4. SUMMARY OF SIGNIFICANT MANAGEMENT PROBLEMS, AND SOLUTIONS FOR SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM

Problem	Solution/Discussion
Construction bids and costs often exceed the amount negotiated in Government-site contract for this activity.	The problem can be caused by (1) inflation in constructed cost since negotiation of Government-site contract (approximately one year), (2) inadequate project definition detail for accurate Government or site cost estimate, and (3) project scope change since negotiation due to more accurate detail information or test. The solution can be (1) redesign project to cost and rebid, (2) site owner assume additional cost or portion, and (3) Government assume additional cost or portion. Corrective action to minimize this problem is (1) more accurate project definition at negotiation, (2) use conventional industry inflation/contingency cost in initial cost projections, and (3) accurate, complete drawing/specs and competitive bidding.
Communication problems between project designers and solar component suppliers.	The newness of the industry requires extremely close coordination between solar component producers and the project designers on a technical and financial basis. If local laws require competitive bids on collectors then this should be performed very early in the project so that the selected design can be properly integrated into the system design, and the component supplier can participate fully in all project phases.
Transportation damage to several types of collectors.	The solution is in part better communication between the carrier and collector suppliers. More appropriate packing will probably evolve.
Site owner/designer cost and problems associated with Government required reports, approval procedures, and financial procedures.	Regardless of the intent and steps taken to minimize this problem area, the ASHRAE-AIA joint survey found this to be still a major problem. ERDA has made major efforts to minimize and explain the financial aspects. NASA has reduced reporting requirements to one page letter with photo when appropriate.

REFERENCES

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4. Thermal Data Requirements and Thermal Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program, NBSIR 76-1137, August 1976.

5. Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings, NBSIR 76-1187, November 1976.

6. Humphries, W. R., Hewitt, H. C., and Griggs, E. I., "Fluid Manifold Design for a Solar Energy Storage Tank," NASA-TM-X-64940, June 1975.

APPROVAL

THE SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM – SOME EARLY PROBLEMS AND RESULTS

By Robert L. Middleton

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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