~~H685~~

110537

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Federal Demonstrations Of Solar Heating And Cooling On Private Residences-- Only Limited Success

In response to the Solar Heating and Cooling Demonstration Act of 1974, the Department of Housing and Urban Development, in conjunction with the Department of Energy, established a program to demonstrate solar heating and cooling systems on private dwellings.

The program has had only limited success in demonstrating that solar heating is practical. Problems have hindered the development of definitive performance criteria for heating systems. Technology for solar cooling is not well advanced, and GAO believes that its demonstration would be premature.

This report recommends actions to better ensure the practical operation of demonstration systems, provide adequate information for developing performance criteria and improve program management. Due to problems developing solar cooling technology, the Congress needs to amend the act to permit demonstration of these systems only when its practical use can be shown.

110537

007204

EMD-79-55

OCTOBER 9, 1979

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-178205

To the President of the Senate and the
Speaker of the House of Representatives

AGC00912 AGC00823

This report provides an analysis of the residential solar heating and cooling demonstration program implemented by the Department of Housing and Urban Development for the Department of Energy. This report includes a perspective on the program, an evaluation of the success of the program in demonstrating solar heating systems, and a discussion on prospects for demonstrating solar cooling technologies.

AGC00027

Copies are being sent to the Director, Office of Management and Budget; the Secretary of Energy; the Secretary of Housing and Urban Development; and interested Members and Committees of the Congress.

AGC00022

NBS AGC00014

Comptroller General
of the United States

CW00010

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

FEDERAL DEMONSTRATIONS OF SOLAR HEATING AND COOLING ON PRIVATE RESIDENCES--ONLY LIMITED SUCCESS

D I G E S T

The 1973-74 Arab oil embargo and the growing realization that the Nation's fuel supplies are limited, prompted the Federal Government to undertake a program to demonstrate the feasibility of solar heating and cooling on private residences. The program was initiated in response to the Solar Heating and Cooling Demonstration Act of 1974. The act required that a national program be established to

--demonstrate the practical use of solar heating technology within 3 years,

--demonstrate the practical use of combined solar heat and cooling systems within 5 years, and

--determine and publish definitive performance criteria for solar heating and cooling components and systems to help establish accceptable effectiveness and safety levels.

The Energy Research and Development Administration initiated two programs, one for the residential dwellings and one for commercial buildings. Responsibility for the residential program was given to the Department of Housing and Urban Development for demonstrations on private homes and to the Department of Defense for Federal residences. This report focuses on the program implemented by the Department of Housing and Urban Development. 1/ Through fiscal year

---

1/GAO addressed that portion of the residential program managed by the Department of Defense in a report entitled "Solar Demonstrations on Federal Residences--Better Planning and Management Control Needed" (EMD-78-40, April 14, 1978).

1979, the program has obligated a total of $68.7 million, and has undertaken many solar heating demonstrations, plus a limited number of combined heating and solar cooling demonstrations.

GAO's review of the program disclosed that

--the program has had only limited success in demonstrating the practical use of solar heating systems;

--solar cooling technology is not ready for demonstration, thus the legislation needs to be amended to provide for demonstrations of this technology only when its practicality can be proven.

Additionally, GAO noted areas in which the program could have been more effectively managed.

PROGRAM HAS HAD ONLY LIMITED SUCCESS

GAO examined 20 operational demonstration projects containing 91 residential units and found that many projects were not successfully demonstrating the technical reliability of solar heating systems. Over one-half--52 percent--were either not working or experiencing continual operational problems. For example, the solar system on one project had not been operational for more than 2 weeks at a time, and leaks in the system repeatedly flooded the basement of the home on which it was installed. Only 31 percent of the units reviewed were maintaining reliable operations. Seventeen percent were not in operation long enough to assess their reliability. (See p. 13.)

These projects also have not clearly demonstrated the economic viability of solar heating systems. Data to determine the economics of the systems were difficult for GAO to obtain due to the poor performance of some projects and the short period in which the systems had been in operation. GAO was able, however, to obtain sufficient

economic data on three projects involving five units. According to Government and industry officials, solar energy systems would be considered economical by the public if the payback period--the time required for the energy savings to equal the cost of the system--were 8 to 10 years. Only one of the five systems could meet this criteria. The other four all had a payback of over 17 years. (See p. 15.)

The Department of Housing and Urban Development has recently taken actions to identify and correct operational problems with some of the projects, but such actions are not sufficiently comprehensive to ensure that all projects are performing correctly. In this connection, a contingency fund of $3 million has been established by program officials for the repair and replacement of defective systems, but has not been utilized. (See p. 16.)

The National Bureau of Standards is responsible for using data collected from the operating solar systems to develop performance criteria on efficiency, durability, strength, fire resistance, and safety. However, problems with the data collection equipment, together with the operational problems of the systems, have limited the performance data collected. Officials stated that the equipment has been corrected to improve the quality of the data, but that solar systems' operational problems still plague data collection. (See p. 18.)

To complicate matters, the data being collected and disseminated may not be sufficient to adequately develop the definitive performance criteria. A Department of Energy contractor collects the data and sends it in a summarized form to the Bureau. However, officials of the Bureau claim that basic, unsummarized performance data is critical to the development of the criteria and that without it criteria may be inadequate and delayed. (See p. 19.)

Program could have been more effectively managed

Neither the Department of Energy nor the Department of Housing and Urban Development adequately determined program goals and strategies by which to achieve an effective demonstration program, considering optimum program size, geographic dispersion, and mix of demonstrations. As a result

--the program has grown much larger than the Departments of Energy, and Housing and Urban Development originally anticipated; (see p. 21)

--program managers are unable to determine the extent to which the program is demonstrating solar heating systems in enough geographic areas; and (see p. 22)

--some promising solar heating applications have not received adequate attention. (see p. 24)

Additionally, a more effective program could have been attained had stricter criteria been used to limit the size of single-family demonstration projects and require builders to seek cost sharing opportunities with State and local governments. Stricter criteria limiting the size of single-family demonstration projects would have reduced the number of large projects, which have little benefit, and enabled more builders to participate in the program. Requiring builders to seek cost sharing opportunities with State and local governments could have reduced Federal expenditures for demonstration projects. GAO found that cost sharing opportunities existed but were not pursued.

NEED TO AMEND LEGISLATION FOR DEMONSTRATIONS OF SOLAR COOLING TECHNOLOGY

Solar cooling can be achieved through the use of active cooling systems or passive cooling principles. Active systems, which involve the use of solar collectors and moving components, have the most widespread

applicability, and have been the focus of Federal research and development efforts. However, active solar cooling technology has not advanced enough to permit reliable demonstration of these systems. The most critical problem is developing collectors which can achieve and maintain the high temperatures needed to operate cooling equipment. Department of Energy officials stated that this equipment must first be field tested before it can be demonstrated, and that such testing is not scheduled to begin until 1980. (See p. 40.)

Passive solar cooling principles are more advanced. These do not involve the use of solar collectors but rely primarily on architectural design. However, they work effectively only in a limited range of geographic locations. (See p. 41.)

Active solar cooling technology is expensive and has poor economic potential. The cost of equipment in the program is approximately $15,000 per system. At this level, assuming a moderate increase in electric rates, it would take 31 years for an average homeowner in Washington, D.C. to recover the cost of the solar cooling equipment. (See p. 42.)

Passive systems do not use high-cost equipment, but their economic potential is not readily determinable. Because they rely on the architecture of the residence to achieve a cooling effect, it is nearly impossible to segregate their costs from those of the residence. However, the Department of Housing and Urban Development believes passive systems may be economical in some regions of the United States. (See p. 42.)

Management's current plans

The residential solar heating and cooling demonstration program is into the final year authorized by the act, and the practical demonstration of combined solar heating and cooling technology was required by the end of the program. The Department of Energy requested $6 million for fiscal year 1979 to demonstrate systems containing

solar cooling technology; however, because of the problems with solar cooling technology, program managers do not plan to undertake demonstrations at this time. They believe that such demonstrations would not advance the acceptance of this technology. Current plans call for phasing out the program without demonstrating combined solar heating and cooling systems. (See p. 43.)

The Solar Heating and Cooling Demonstration Act of 1974 needs to be amended to provide program managers the flexibility to demonstrate solar cooling when its practicality can be proven. Legislation is currently being considered to extend the act for one year to permit additional time to develop and demonstrate combined heating and cooling technology. The imposition of new time constraints, however, could result in the demonstration of a technology which is still not practical. (See p. 43.)

CONCLUSIONS

GAO generally believes that demonstrations are an effective mechanism for advancing solar heating and combined solar heating and cooling technologies from research and development to the public marketplace. However, the demonstration of technologies which are not ready, or which do not function in a reliable and effective manner, will do little to advance the technology in the marketplace, and could jeopardize the future acceptance of solar energy systems as a replacement for conventional energy sources.

In order to have the maximum effect on the public acceptance of solar technology, actions need to be taken to correct the problems in the residential solar heating and cooling demonstration program. The operational problems experienced in many of the solar demonstration projects are preventing the program from demonstrating the practical use of solar heating technology. The practical demonstration of this technology

must be attained to convince the public that solar is an adequate substitute for conventional energy sources. Additionally, these operational problems are inhibiting the collection of performance data needed to develop definitive performance criteria for solar systems. The development of definitive performance criteria was mandated by the act, and are necessary to help ensure the efficient and safe operation of solar energy systems.

The Department of Energy and the Department of Housing and Urban Development need to determine the requirements for an effective demonstration program in regard to program size, geographic dispersion, and mix of demonstrations. These requirements should then be evaluated against the existing program structure to determine what and where demonstrations are necessary. If more demonstrations are deemed necessary to fully achieve an effective program, then program managers should take steps to ensure that large projects are minimized and the number of builders in the program maximized. In addition, actions should be taken to ensure that all cost-sharing opportunities are pursued.

Although the demonstration of combined solar heating and cooling technology is required by 1979, the technical and economic problems which confront solar cooling technology indicate that these demonstrations should not be undertaken at this time. The Congress, therefore, needs to amend the Solar Heating and Cooling Demonstration Act of 1974 to defer demonstrations of solar cooling. Legislation to amend the act should not include new time constraints for demonstrations of solar cooling technology, since time constraints could result in the demonstration of a technology which is still not practical. Program managers should be required to annually inform the Congress of the status of solar cooling technology, so that the Congress can authorize such demonstration when the technology can be shown to be technically and economically sound.

RECOMMENDATIONS

GAO recommends that the Secretary of Housing and Urban Development:

1. --Direct program managers to undertake an evaluation of the technical and economic adequacy of all demonstration projects funded. Such an evaluation should pinpoint those systems which are breaking down or performing poorly, and identify the respective technical problems.

--Once these systems are identified, require appropriate action be taken--~~including expenditures from the Department's contingency fund if necessary~~--to correct the problems.

2. --Require program managers to give priority attention to correcting those systems which are being monitored so that the definitive performance criteria mandated by law are not delayed.

3. --Require program managers to establish goals for an optimum program in terms of the number, location, and mix of solar demonstrations needed. The present program ~~should then be~~ evaluated against such ~~goals, and to the extent~~ additional demonstrations may be warranted to achieve a more effective program, develop an appropriate strategy to ensure success in meeting these goals.

4. --Establish stricter selection criteria for future demonstrations which would (1) allow for a larger number of builders to participate in the program, (2) limit large demonstration projects which have little benefit, and (3) ensure that such projects are reliable and economical.

5. --Establish procedures which will ensure that cost-sharing opportunities with State and local governments are pursued prior to the funding of projects and which ~~Such procedures should~~ require certification by applicants that cost-sharing possibilities were pursued.

GAO recommends that the Secretary of Energy:

--Monitor the Department of Housing and Urban Development's activities and provide assistance where needed to ensure that actions are taken to increase the effectiveness of the residential solar heating and cooling demonstration program.

--Require solar program managers to work with officials of the National Bureau of Standards to establish exactly what information is needed to develop adequate definitive performance criteria for solar systems on residential dwellings, and provide such information to Bureau officials responsible for developing the criteria as soon as possible.

RECOMMENDATION TO THE CONGRESS

Since active solar cooling technologies have not yet been developed to the point where they can be demonstrated successfully within the time frames established pursuant to the Solar Heating and Cooling Demonstration Act of 1974, GAO does not believe that the 1-year extension provided for in the Department of Energy's fiscal year 1980 authorization bill would be adequate. GAO therefore recommends that the Congress extend the requirements for combined solar heating and cooling demonstrations without imposing new time constraints. The Congress, instead, should require the Department of Energy to annually inform the Congress on the status of solar cooling technology, and provide an estimate of when the practical demonstration of these systems could be attained. When combined solar heating and cooling can be shown to be reliable and economical, the Congress could then consider imposing time constraints mandating demonstrations of this technology on the Department of Energy.

AGENCY COMMENTS

GAO obtained comments from the Department of Housing and Urban Development, the National Bureau of Standards, and the Department of Energy. The Department of Housing and Urban Development disagreed with the report, and expressed a number of concerns relating to GAO's evaluation of the demonstration projects, the Department's efforts to correct solar system problems, the effectiveness of the program's management, and the funding of large demonstration projects.

The National Bureau of Standards agreed that problems with information dissemination and development of definitive performance criteria did exist, but stated that efforts are underway which are helping to resolve the problems.

The Department of Energy agreed with the primary findings of the report.

The agency comments and GAO's evaluation are presented beginning on p. 31.

Copies of the letters commenting on a draft of this report are contained in the appendices.

Contents

ABBREVIATIONS

DOD	Department of Defense
DOE	Department of Energy
ERDA	Energy Research and Development Administration
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards

CHAPTER 1

INTRODUCTION

In the wake of the 1973-74 Arab oil embargo and the growing realization that the Nation's supplies of fossil fuels--particularly oil and natural gas--are limited, the Congress passed several pieces of legislation late in 1974 aimed at developing and demonstrating solar energy technologies so that these technologies eventually could become commercially available. 1/ In part, these laws gave the Energy Research and Development Administration (ERDA) 2/ overall responsibility for managing and coordinating a wide range of activities to ensure the successful and timely development and demonstration of solar energy systems.

One of the more aggressive and specific pieces of legislation was the Solar Heating and Cooling Demonstration Act of 1974. Not only did this act mandate a national program to demonstrate the use of solar energy to heat and cool buildings, but it also specified the objectives of the program, the time frame in which to accomplish these objectives, and the roles of various Federal agencies in the program.

The Solar Heating and Cooling Demonstration Act of 1974 has three primary objectives:

--Demonstrate the practical use of solar heating technology within 3 years (by the end of 1977).

--Demonstrate the practical use of combined solar heating and cooling technology within 5 years (by the end of 1979).

1/Public Law 93-409, Solar Heating and Cooling Demonstration Act of 1974, September 3, 1974.
Public Law 93-438, Energy Reorganization Act of 1974, October 11, 1974.
Public Law 93-473, Solar Energy Research, Development and Demonstration Act of 1974, October 26, 1974.
Public Law 93-577, Federal Nonnuclear Energy Research and Development Act of 1974, December 31, 1974.

2/The functions and responsibilities of ERDA were transferred to the Department of Energy (DOE) on October 1, 1977, pursuant to the Department of Energy Organization Act (Public Law 95-91, August 4, 1977). For simplicity, the former ERDA will be referred to as DOE throughout this report.

--Determine and publish definitive performance criteria for solar heating and combined heating and cooling components and systems to be used in residential dwellings, using data available from the demonstration projects.

DOE has overall responsibility for Federal solar demonstration efforts and assists the activities of other Federal agencies involved. DOE established two separate programs--the residential solar demonstration program and the commercial buildings solar demonstration program--in order to demonstrate the practical use of solar heating and cooling technology to both the residential and commercial sectors.

In administering the residential program, DOE relies primarily on the services of the Department of Housing and Urban Development (HUD) and the Department of Defense (DOD). DOE retains the overall program responsibility; however, these other departments have the implementation responsibility for the residential program. In this regard, HUD is responsible for carrying out the day-to-day activities of that portion of the program relating to demonstrating solar devices on private residences. HUD's role is to arrange for the installation of solar heating systems and combined solar heating and cooling systems in a substantial number of residential dwellings, and to provide for the satisfactory operation of such installations during the demonstration period. DOD has similar responsibilities in regard to arranging for the demonstration of solar heating systems on residential dwellings, but such dwellings are limited to those which are located on Federal or federally-administered properties.

The commercial buildings solar demonstration program is operated directly by DOE. Under this program, DOE provides funds to commercial enterprises, State and local governments, and other Federal agencies, such as the Postal Service and the General Services Administration, for the installation of solar equipment on office buildings, schools, restaurants, warehouses, and other commercial buildings.

In conjunction with these programs, the act called upon the services of the National Bureau of Standards (NBS) and the National Aeronautics and Space Administration (NASA). The act required NBS to assist in developing definitive performance criteria for solar heating and combined solar heating and cooling systems and components. In this connection, the act required that the solar systems installed under the program be monitored so that performance data can be collected and disseminated to aid in the development of such criteria. A performance monitoring system has been developed

for the program by NASA, and is being used in both residential and commercial buildings demonstrations to provide performance data.

All agencies involved in the national solar demonstration effort use funds provided by DOE to carry out their respective responsibilities pursuant to the Solar Heating and Cooling Demonstration Act of 1974.

Other initiatives to assist the commercialization of solar energy systems have been undertaken since the passage of the Solar Heating and Cooling Demonstration Act of 1974. Generally, these initiatives are aimed at providing incentives for, and removing potential barriers to, the use of solar energy systems. For example, the Energy Tax Act of 1978 (Nov. 9, 1978) provides tax credits to purchasers of solar energy systems to improve the economics of these systems. These initiatives, however, are geared to accelerating solar commercialization once their practicality, in terms of reliability and economic potential, have been proven. Consequently, the demonstration programs, which will show the practicality of solar energy systems to the public, are crucial to the success of the Federal Government's solar development activities.

PURPOSE OF THE REPORT

The national solar heating and cooling demonstration program is now into its fifth year. Since the inception of the program, demonstration projects have been funded in many areas of the country. Many of these projects are now operational, thus information is available to measure how successful the program has been in reaching its objectives.

Our report discusses the residential aspects of the national program primarily because residential solar heating applications are the closest to being widely accepted and because much of the solar industry has directed its attention to selling solar heating devices to homeowners. The report focuses primarily on HUD's efforts to demonstrate solar technology on residential dwellings. The following chapters present (1) a perspective on the operation of the residential solar heating and cooling demonstration program; (2) a discussion on the success of this program in demonstrating solar heating systems and developing definitive performance criteria, and the effectiveness of the program management; and (3) the current status of solar cooling technology, and a discussion on the potential success of

combined solar heating and cooling demonstrations. The results of our review of the DOD efforts to demonstrate solar heating and cooling technology on Federal residences were discussed in a separate report, "Solar Demonstrations on Federal Residences--Better Planning and Management Control Needed" (EMD-78-40, April 14, 1978).

SCOPE OF REVIEW

We reviewed information on a selected number of operational residential solar demonstration projects in order to determine each project's usefulness. We selected 20 demonstration projects representing 91 residential housing units in seven States--Colorado, Georgia, Montana, New Mexico, South Carolina, Utah, and Virginia. 1/ Our project selection was based on HUD data which showed a high concentration of operational projects in the Rocky Mountain region and in the southeastern States. We reviewed all the operational projects in the selected States.

Our review consisted of evaluating the economic viability and technical soundness of each project. In conjunction with reviewing the success of these projects, we also examined how effective the program is being managed, paying particular attention to the extent the program is meeting the intent of the Solar Heating and Cooling Demonstration Act of 1974. In this regard, we interviewed officials and examined records and documents at DOE, HUD, NBS, and NASA. We also met with a number of solar industry and university officials to obtain their insights and perceptions not only on the success of the existing program but also concerning the future direction of the program. In addition, we contacted State and local government officials in a number of States to obtain their perspective on various aspects of the program.

1/These 91 units represented approximately one-third of the housing units designated by HUD officials as being operational as of September 1, 1977.

CHAPTER 2

PERSPECTIVE

The primary goal of the HUD implemented residential solar heating and cooling demonstration program, hereafter referred to as the residential demonstration program, is to stimulate the development and use of solar heating and cooling technologies for residential dwellings. Approximately 15 percent of the Nation's energy consumption is used to meet the heating and cooling needs of residential dwellings. Since solar heating and cooling devices are already commercially available--although on a limited basis--a well conceived and executed demonstration program showing the public that these devices are technically sound and economically attractive could lead to their expanded use. Moreover, and perhaps more importantly, it could represent a significant step in making the transition to inexhaustible energy sources.

PROGRAM OVERVIEW

The objectives of the residential demonstration program are consistent with the mandates of the Solar Heating and Cooling Demonstration Act of 1974. These program objectives include:

--Demonstrating the practical use of solar heating technology in residential buildings by 1977, and the practical use of combined solar heating and cooling technology by 1979.

--Developing solar energy systems performance standards and criteria as a guide for the production and installation of such systems.

--Operating an information system for collecting, storing, reporting, and disseminating data:

--Identifying the necessary legislation, codes, and incentives to mitigate or eliminate legal or institutional restrictions which may discourage the development and use of solar energy systems.

To carry out these objectives, the program is divided into five key elements; four of these elements address the specific objectives mentioned above and the other provides HUD with management support services to help in the day-to-day management of the program. The following table shows each key element and its associated cost by fiscal year.

Obligations (note a) for the Residential Solar Demonstration Program (millions)

	Fiscal Year					
	1975	1976 (note b)	1977	1978	1979 (note c)	Total
Demonstration projects	$ -	$3.1	$15.0	$11.2	$ 4.2	$33.5
Performance criteria and standards	.2	.7	.3	.7	.5	2.4
Collecting and disseminating data	-	.9	.9	.4	5.0	7.2
Market development activities	-	1.8	2.1	5.3	.3	9.5
Program management	.4	1.4	2.6	6.7	5.0	16.1
	$.6	$7.9	$20.9	$24.3	$15.0	$68.7

a/DOE's obligation to HUD under interagency agreements.

b/Includes transition quarter.

c/Estimate.

KEY PROGRAM ELEMENTS

The actual demonstration projects are the most visible and costly element of the residential solar demonstration program. The other elements, also important to the program's overall success, are intended to contribute to the development of a viable solar energy industry. The following sections discuss the status of each key element.

Demonstration projects

The fundamental management strategy for carrying out this program element is to initiate several cycles or series of demonstration projects. Each cycle consists of a group of demonstration projects, located across the country, which attempt to show the effective use of solar energy systems.

Each succeeding cycle is intended to cover a wider spectrum of climatic regions and a broader range of solar applications over the preceding cycles, so that by the end of the program a broad cross-section of solar applications in various climatic regions will have been demonstrated. HUD officials believe each succeeding cycle will bring solar technology closer to commercialization. They expect the technology to improve and costs to decrease as the solar industry expands and homeowners and builders become familiar with the use of solar energy systems.

The approach used by HUD for funding demonstration projects is to allow each builder or developer to plan his own project, including the type of solar system to be used, location, and the number of housing units to be included. 1/ Projects are then selected and grants awarded for each cycle on a competitive basis. Although criteria for selecting the projects have changed somewhat from cycle to cycle, they usually include such factors as

--technical adequacy,

--cost,

--marketability of the house with the solar system, and

--the degree to which the project provides an unusual or unique opportunity to demonstrate a solar energy system.

Four cycles of demonstration grants have been awarded through September 1978. HUD has awarded grants for 482 demonstration projects which contain 11,915 dwelling units of various types, including mobile homes, single family dwellings, and various sizes of multi-family housing units. Virtually all grants have been for projects demonstrating the use of solar heating systems. The following table shows the cost, together with the number of projects and residential units covered, for each cycle.

1/HUD also initiated a small number of demonstration projects for which HUD selected the solar systems to be used. This approach, termed site-system projects, had limited success due to builder reluctance to install those solar systems selected and the approach was terminated after one cycle of demonstration grants. Builders generally preferred installing systems of their own choice.

Number and Cost of
Residential Solar Demonstration
Projects

	Date of award	Number of projects	Number of units	Cost (millions)
Cycle 1	1/76	67	185	$ 1.1
Cycle 2	10/76	102	1,411	3.9
Cycle 3	8/77	169	3,468	6.0
Cycle 4	3/78	48	2,002	2.6
Cycle 4a (note a)	9/78	96	4,849	5.8
Total		482	11,915	$19.4

a/Cycle 4a was an extension of cycle 4. HUD required all applicants for grants in cycle 4 to include certification that the solar collectors met HUD's minimum property standards for solar heating and domestic hot water systems. Many builders encountered difficulties in obtaining this certification. Consequently, HUD repeated this grant cycle.

According to HUD officials, approximately 4,800 demonstration units were operational as of June 1979.

In addition to funding demonstrations, HUD has set up a contingency fund in case problems arise which cause unanticipated major costs to the grantee or homeowner, such as replacing the collectors on the solar system or repairing damage caused by leakage from the solar system. Financial records indicate HUD has set aside over $3 million in this fund. As of the end of our review, no money had been expended from this fund for the repair or replacement of any solar systems in the program.

Other funds have been set aside under this program element to pay for HUD's solar hot water initiative which provides $400 grants to homeowners who install solar hot water systems. This initiative is limited to 10 eastern States where electricity costs are high.

Performance criteria and standards

Standards are important to solar energy systems for the same reasons they are important to other products and

services. They help assure acceptable levels of quality by setting criteria for strength, effectiveness, fire resistance, durability, and safety. Once established, they provide for possible enforcement through permits, inspections, and testing. The Solar Heating and Cooling Demonstration Act of 1974 called for the development of interim performance criteria within 120 days after the law was enacted, and later development of definitive performance criteria based on the use of the interim criteria and on findings from the demonstration projects.

In response to the act, HUD, in cooperation with NBS, developed interim performance criteria. These criteria provide guidelines for the design of solar energy systems for demonstration projects, and they are continually being evaluated by NBS as to their general applicability to current solar technology, and are updated when necessary. Publication of the definitive performance criteria are not expected until the end of the demonstration program late in 1979.

This program element goes beyond the mandate of the Solar Heating and Cooling Demonstration Act of 1974 to develop definitive performance criteria in that it includes (1) developing standards for solar equipment, (2) identification of laboratories capable of testing solar equipment, and (3) developing a certification process to ensure that the solar equipment used in the program meets existing standards. With respect to standards, HUD has published standards entitled "Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems," which specify materials and construction standards for solar systems purchased in connection with HUD programs. In addition, laboratories capable of testing solar equipment have been identified by HUD to test equipment according to the HUD standards. HUD is now requiring certification that the solar collectors used in the residential solar demonstration program conform to these standards.

Collecting, evaluating, and disseminating data

The collection and evaluation of data obtained from the solar demonstration projects and its dissemination to the public is an important element of the overall residential demonstration program. The activities being carried out under this program element are intended to enable the public, solar manufacturers, and builders to gain a better understanding of the technical soundness and economic viability of solar energy systems. The data being collected are to

be used in the development of standards for solar energy systems and in the formulation of recommendations for industry to follow in establishing product warranties and handbooks for consumers. Three types of data are currently being collected:

--Instrumented technical data.

--Non-instrumented technical data.

--Market acceptance data.

The instrumented technical data are accumulated through the use of automatic data processing equipment and provide details on the performance of solar collectors and systems under various climatic conditions. The data are being collected with an instrumentation package developed by NASA. HUD ultimately plans to have instrumentation packages installed in 100 residential projects in the program. Collected data are transmitted to a central facility in Huntsville, Alabama, to be correlated for future use. There are presently 37 instrumented monitoring systems in operation on residential projects.

Technical data on problems experienced by the builders at the project sites are being recorded manually. HUD, through the use of a contractor, collects such non-instrumented technical data for all the demonstration projects. Finally, data on the factors affecting market acceptance, such as aesthetics, are collected not only from the homeowners taking part in the demonstration projects but also from special surveys of the general public.

Another important aspect of this program element is the operation of the National Solar Heating and Cooling Information Center located in Philadelphia, Pa. The information center, which is operated by a HUD contractor, accumulates general information on solar energy developments and provides a contact point for public inquiries concerning solar heating and cooling. The center distributes solar documents and reports to the public upon request, and prepares formal responses to inquiries when necessary. The center also prepares films and documents related to the contruction and use of solar systems, conducts workshops, and presents exhibits on solar energy.

Market development activities

Building codes, zoning restrictions, interface between solar and conventional energy systems, solar warranties, and property taxes are all potential barriers to the widespread

use of solar energy. HUD currently has a number of efforts underway which are aimed at finding ways to remove these barriers. Such efforts include a number of projects with utilities to determine the best ways to resolve the interface problems between solar and conventional energy systems, and to remove barriers and constraints to solar use. These efforts have also resulted in the following publications:

--A study entitled "Selling the Solar Home," which details some preliminary findings on the selling of the solar homes in the demonstration program.

--A report entitled "Building the Solar Home," which explains some common problems facing builders when they install solar energy systems and ways to avoid these problems.

In most cases, these market development activities go beyond demonstrating solar energy systems and are aimed at developing a commercial market for solar energy.

Program management

The objective of this program element is to secure management services to assist HUD in carrying out the day-to-day operation of the program. In this regard, Boeing Aerospace Company was selected in early 1976 to provide general management support services under HUD's overall supervision. The contractor's responsibilities include monitoring ongoing demonstrations and providing technical assistance in reviewing proposals for new demonstrations. According to HUD officials, these continual management services are necessary because of limited manpower resources. Through fiscal year 1978 HUD has spent $9.6 million for these services.

In addition to the management services provided by Boeing, HUD has from time to time funded other projects to further assist in managing the program. For example, HUD has paid $386,000 for the development of a matrix which was intended to serve as a basis for determining the optimum geographic dispersion of solar demonstrations. HUD also uses solar energy consultants to foster better communication and understanding of the issues facing the successful introduction of solar energy applications into the housing industry.

CHAPTER 3

EVALUATION OF THE RESIDENTIAL SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

In evaluating the residential solar heating and cooling demonstration program, we focused our review on determining how successful the program has been in meeting the mandates of the Solar Heating and Cooling Demonstration Act of 1974 and whether the program was being effectively managed.

Generally, we found that the residential demonstration program has had limited success in meeting the mandates of the act. The demonstration of the practical use of solar heating technology does not appear to have been attained because many demonstrations are experiencing technical problems and other demonstrations, which appear to be working properly, are not very economical. We also found that little data on the performance of solar heating equipment has been disseminated, and the data which is being disseminated may not be sufficient to develop definitive performance criteria as required by the act.

In addition, we found that the program could have been more effectively managed if program officials had (1) adequately determined program goals and strategies by which to achieve an effective demonstration program, (2) limited the size of projects, and (3) required builders to seek cost-sharing opportunities with State and local governments.

The residential demonstration program, nevertheless, is not without benefits. The program has increased the visibility of solar energy as a heating option, and has given a number of builders and homeowners the opportunity to build and use solar heated homes. However, if the more significant problems are not corrected as soon as possible, the demonstration program--contrary to the intent of the act--could have a detrimental impact on the commercialization of solar heating systems by raising questions about solar's credibility and usefulness as an energy source.

SUCCESS OF THE PROGRAM IN MEETING MANDATES OF THE SOLAR HEATING AND COOLING DEMONSTRATION ACT OF 1974

The Solar Heating and Cooling Demonstration Act of 1974 contained various objectives. Among the most significant of these was to demonstrate the practical use of solar heating systems by the end of 1977. The act states:

> "It is therefore declared to be the policy of the United States and the purpose of this Act to provide for the demonstration within a three-year period of the practical use of solar heating technology * * *."

Although the act never defined the meaning of the term "practical use," the legislative history of the act disclosed that the Congress intended the program to demonstrate both the technical adequacy and economic attractiveness of solar energy systems. The following excerpt from the legislative history typifies the congressional concerns relating to the practical use of solar energy systems:

> "[The objectives of the act] include demonstrating the economic and technical adequacy of these heating and combined heating and cooling units * * * to show beyond any reasonable doubt that the economics of solar heating and cooling are attractive to private risk capital and the home buyer."

Additionally, another important objective of the act was to develop definitive performance criteria for solar heating systems. The Congress recognized that standards were needed to assure that solar equipment is safe and reliable, and mandated that definitive performance criteria be developed from the performance data which would be available from the demonstration projects.

In our review of the residential solar demonstration program, we found that these objectives were not fully met. The practical use of solar heating technology has not been successfully demonstrated. Many of the solar heating projects we examined were not performing reliably and may not be economical. We found that more action needs to be taken to improve the performance of these projects. In addition, problems in the collection and dissemination of performance data have occurred which may delay the publication of definitive performance criteria.

Many demonstrations are not technically reliable

In order to ensure that the best demonstrations were undertaken, HUD assembled panels to review all proposed projects. These panels, which consisted of Government and private industry officials with experience in solar energy systems, examined each project to determine its technical adequacy. The projects that were determined to be the best were then selected and funded. If there were any potential problems with the selected projects, a list pointing out weaknesses

in the solar energy system was prepared by the panel and sent by HUD to the selected grantees so that improvements could be made. HUD officials believe that this review procedure resulted in demonstrating the most technically sound solar systems available.

We examined 20 operational solar demonstration projects containing 91 residential units to determine if the solar energy systems were delivering sufficient amounts of heat when necessary. Sixteen, or 17 percent, of the units in our survey were not in operation long enough for us to determine their reliability. Of the remaining demonstration units, 28 units, or 31 percent, were maintaining reliable operation and according to the builders and residents of these demonstration units, the systems had been working reasonably well and had been providing energy when necessary. However, 47 solar units, 52 percent, were either not working or were experiencing problems while in operation.

Many of the problems that were being experienced were minor but of a continual nature, such as recurring leaks. Other problems, however, were more severe.

--In one project, the system failed to work properly during the first 4 months of operation due to faulty installation and problems with the controls. During that period the residents were without heat three times in January and February. In addition, when the system did work, dirt from a bin containing rocks used for storing heat was blown into the living quarters of the house. At the time of our review, the builder was taking action to repair the system.

--On one multi-family project, the paint from the collector came loose and plugged the collector's water distribution channels. Subsequently, the plugged lines froze, pipes broke, and the system had to be shut off. At the time of our review, the builder was negotiating with the manufacturer to replace the collectors.

--On another project, operational problems had plagued the homeowners from the time they purchased the home in January 1977. The entire system--consisting of both space and water heating--had not been operational for more than 2 weeks at a time and repeatedly flooded the basement of the home. Furthermore, the system would only supply small amounts of hot water. The entire system was still not operating correctly at the completion of our review in early 1979.

According to the homeowners, the problems were caused either by the inexperience of the builder in installing solar equipment or, in a few cases, defective equipment.

In commenting on the technical problems associated with the solar projects, HUD officials said that projects in the early grant cycles may be experiencing technical problems; however, they believed that projects awarded in the later cycles are more reliable and will perform at a level approaching that of conventional systems. At the time our review, most of these later projects were either under construction or were just completed and consequently the related systems' reliability could not be readily determined.

Many projects may be uneconomical

To convince the public that solar heating is an acceptable alternative to conventional heating sources, and thereby induce homeowners into purchasing solar heating systems, it is necessary to demonstrate that such heating systems are economically attractive. The public will not invest in solar energy unless it is in their economic interest to do so. Although there is presently no universal consensus as to what constitutes economical use of solar, many Government and industry officials have concluded that solar heating systems would be considered economically attractive by the public if the payback period--the time required for the energy savings to equal the cost of the system--were 8 to 10 years.

There was not enough information available on most of the projects we reviewed to determine if they were economically attractive. No information was available for most projects because (1) they had not been working reliably; (2) they had not been in operation very long; or (3) the backup heating system on the solar residences operated off the same gas meter as nonsolar residences, which made it impossible to determine energy savings attributable to the solar heating system. However, we were able to obtain sufficient economic information on three projects containing a total of five single-family homes. For these three projects, we determined that only one project met the economic criteria and would be considered economically attractive by consumers, as follows:

**Payback Periods (note a)
for Selected Projects
in the Residential Demonstration Program**

Demonstration project	No. of units	Solar system cost per unit	Energy replaced	Energy cost saved/yr.	Estimated payback period (years)
A	1	$10,400	electric	$785	9
B	1	12,000	natural gas	340	17
C (note b)	3	9,800	electric	0	never

a/Calculations assume no maintenance cost and 10 percent fuel cost escalation for the first 10 years and 5 percent thereafter.

b/This system used more energy than a comparable nonsolar house.

Since we were able to obtain economic data on only three demonstration projects, we could not fully determine the success of the program in demonstrating the economical use of solar heating systems. However, based on the economic criteria we used, the economic performance of these projects indicates that the program may be experiencing problems in demonstrating economical solar energy use. In commenting on our observations, HUD officials advised us that there probably are a number of demonstrations in the program that are not economical. They speculated, however, that with respect to demonstration C above, the poor economic performance may be attributed to some malfunction in the system of which the owner is unaware.

More action needed to correct existing problems

The Solar Heating and Cooling Demonstration Act of 1974 specified that HUD would retain responsibility for solar system failures. Section 5(d) of the act states: "The Secretary [of HUD] shall * * * provide for the satisfactory operation of such installations during the demonstration period." HUD officials told us that they expected some

technical problems to occur in the course of the program because of either (1) the inexperience of the builder installing the equipment or (2) defective equipment.

HUD has taken some recent actions to correct operational problems with the demonstration solar systems. HUD's procedures involve identification of problems through instrumented monitoring activities, contacts with grantees by HUD contractors, and correspondence from solar residents. After identification of operational problems, HUD officials contact the appropriate builder and attempt to get the builder to repair the system. If the problem is such that it cannot be repaired by the builder, HUD advised us that it will fund the cost of repairs. In this connection, HUD has established a contingency fund of about $3 million for use in repair and maintenance of demonstration solar systems.

HUD officials believe that their procedures are adequate to ensure reliable operation of the solar systems in the program. However, these procedures do not provide for review of all residential demonstration projects. Documents provided by HUD showed that follow-up of all projects was suggested by DOE because many systems are deficient and have failed to perform at reasonable levels. However, HUD officials decided to continue under their present procedures because they believed that a detailed review would result in unnecessary and unwarranted claims for repairs. Therefore, they do not plan to review all projects to seek out operational problems in the demonstrated solar systems.

In our opinion, HUD's procedures for identifying and correcting problem systems have not resulted in locating and repairing all such systems, and, as a result, need to be improved. We noted that a number of the demonstration projects we reviewed which were experiencing operational problems were not identified by HUD. For example, one project, which was not identified on HUD's list of problem systems, was so unreliable and expensive to operate and maintain that the solar resident was planning to replace the solar heating system and electric backup with a conventional natural gas heating system. Furthermore, we found instances where problems have persisted as long as a year without attempts by the responsible builders to fix the related systems. Consequently, we believe that a number of operational problems with the demonstrated solar systems exist of which HUD may not be aware.

Thus, it appears to us that a more detailed review of residential demonstrations projects is warranted to ensure that all projects operate at a satisfactory level and serve to promote the reliable use of solar energy systems. Funds to

correct those systems experiencing operational problems are available in HUD's repair and maintenance contingency fund. In our opinion, a detailed review and repair program, starting with the early demonstration cycles which are not as technically advanced as those in later cycles, would enable HUD to locate all demonstrated solar systems which are not practical. This would permit proper corrective action--repair, replacement, or removal of the system--to ensure that the practical demonstration of solar energy systems is attained.

Little data being disseminated on the performance of solar heating devices

The Congress recognized the importance of developing standards for solar energy to assure the public and businesses that solar equipment is safe, reliable, and can supply sufficient energy, and mandated by law that such standards be developed. Section 8 of the Solar Heating and Cooling Demonstration Act of 1974 states:

> "As soon as feasible * * *, the Secretary [of HUD], utilizing the services of the Director of the National Bureau of Standards * * * shall determine, prescribe and publish * * * definitive performance criteria for solar heating and combined solar heating and cooling components and systems to be used in residential dwellings, taking into account climatic variations existing between different geographic areas."

To meet this mandate, 100 of the solar energy systems in the residential program are to include an automated electronic monitoring system. The monitoring system was designed by NASA, and is being used by DOE in both the residential and commercial buildings demonstration programs. This system, using sensors located in different parts of the solar device, as well as inside and outside the home, will gather information on how well the solar device is working. This information is recorded by a data acquisition system at the project, and is transmitted daily to a central facility maintained by a DOE contractor (International Business Machines Corporation). For each monitored project, the contractor compiles the daily performance data into monthly performance reports. Copies of these reports are sent to NBS for the development of the definitive performance criteria. As of September 1978, 37 monitoring systems were collecting and sending data, while another 27 systems were in the process of being installed. According to program officials, the remaining 36 systems will be installed on selected demonstration projects recently awarded or on future projects.

In examining these monitoring activities, we found that while 37 of the systems were producing data, data from only 9 were being summarized and sent to NBS. According to DOE officials and their contractor, the data which were collected at the remaining 28 sites were not representative of what would be expected from normally operating solar systems. For example, in some cases data from the monitoring equipment showed no solar energy was being collected at the demonstration sites. According to officials involved in the data gathering, this situation occurred because of malfunctions in the monitoring equipment and in the solar equipment itself.

A DOE official told us that the problems relating to malfunctions in the monitoring equipment are now being resolved. The monitoring equipment has been readjusted in many of the systems. According to DOE officials and their contractor, 22 of the monitoring systems are now producing reliable information and monthly reports on these systems will be forwarded to NBS. These officials, however, were not as optimistic about the information they are obtaining from poorly performing solar equipment. They have had trouble getting builders to make changes to improve the performance of installed solar devices.

In addition to the limited amount of data that has been disseminated, there were indications that such data may not be very useful to NBS in developing performance criteria. According to NBS officials, certain data must be available on the performance of various parts of the solar system on at least an hourly basis in order for them to determine exactly how well a system and its components work. This would enable them to correlate the performance of the system against the variable intensity of sunlight throughout the day to more fully evaluate various solar energy systems and components. The automated electronic monitoring systems used in conjunction with the demonstration projects are designed to collect the data which NBS officials stated they need. The monitoring systems are currently measuring performance at various places in the solar energy system, and collecting this data at 5-minute intervals. These officials stated that this detailed data would permit them to adequately evaluate demonstration solar systems and develop performance criteria.

The detailed performance data gathered by the monitoring systems, however, is not provided to NBS for the development of performance criteria. NBS receives only the monthly reports on the performance of the demonstration solar systems from the DOE contractor. These reports summarize the detailed data on a daily and monthly basis, and NBS officials

did not find such data to be very useful. Since June 1978, NBS officials have been attempting to obtain from DOE the unsummarized data compiled through monitoring. On June 16, 1978, NBS sent to DOE a request detailing its data needs. The request, however, was denied because DOE officials believed the data requested by NBS are not necessary for the development of the definitive performance criteria. According to a DOE official, computer time would be needed and a software package developed to provide the data in the form requested by NBS. The official estimated that this would cost over $1 million.

NBS officials, on the other hand, believe such data to be critical to developing definitive performance criteria. Without the data, they told us, the publication of performance criteria will be unnecessarily delayed. They added also that the criteria would lack specificity in certain instances and that this limitation may adversely affect its usefulness.

PROGRAM COULD HAVE BEEN MORE EFFECTIVELY MANAGED

HUD program managers have made efforts to assist the eventual widespread acceptance of solar energy systems. Some of these management efforts have been relatively successful, such as the creation of the National Solar Heating and Cooling Information Center. However, in the demonstration of solar energy systems, the program could have been more effectively managed. We found that neither DOE nor HUD had

- --adequately determined program goals in terms of optimum size, geographic dispersion, and mix of demonstrations, and the strategies by which to achieve an effective demonstration program;

- --when selecting projects, used sufficiently strict criteria limiting the size of the project a given builder could undertake; and,

- --directed builders to seek cost-sharing opportunities with State and local governments.

Program officials pointed out that the urgency to meet the mandates established pursuant to the Solar Heating and Cooling Demonstration Act of 1974 prevented DOE and HUD from fully defining program needs before funding projects and caused them to use less rigid criteria than desired.

Program goals and strategies not adequately determined

Although the Solar Heating and Cooling Demonstration Act of 1974 mandates a program to demonstrate solar technology, it left many key program goals, such as size (number of units to be demonstrated), geographic dispersion (where the demonstrations should be located), and mix of demonstrations (which solar energy systems on what housing types should be demonstrated), and the strategies to achieve these goals, to be determined by program managers. In regard to program size, section 5(d) of the act states "* * * The Secretary [of HUD] shall arrange for the installation of solar heating systems * * * in a substantial number of residential dwellings * * *." Regarding program geographic dispersion, section 15(a) of the act states that projects be placed "* * * in a sufficient number of different geographic areas * * * to assure a realistic and effective demonstration * * *." The act made no mention of what specific types of solar systems should be demonstrated.

Program size

Early in the program, DOE undertook several efforts to determine the appropriate size for the program; however, the optimum size for the program was never established. In March 1975, DOE, in conjunction with HUD, published a "National Plan for Solar Heating and Cooling" which outlined three alternative program levels for the residential demonstration program. The following table shows the proposed number of housing units at each level.

Alternative Program Levels
Proposed by DOE in March 1975

	Number of units (note a)
Level I	350
Level II	1,000
Level III	2,000

a/Estimates include units for both the solar heating and combined solar heating and cooling portions of the demonstration program.

The report, however, stipulated that these figures were based on projected alternative funding levels for the program and that because of uncertain information about the cost of solar

energy systems as well as the effectiveness of early research and development efforts, the figures were subject to change.

Efforts to define the optimum size of the residential demonstration program were described in a report dated April 15, 1976, entitled "ERDA Solar Heating and Cooling Demonstration Program Structure." This report, prepared by the Economics and Analysis and Industrial Liaison Branch of the former Solar Division in ERDA, recommended that the residential program include 600 to 700 demonstrations totaling 2,900 to 3,400 residential dwelling units. However, these recommendations were never adopted as official program goals. According to HUD officials, the initial plans or subsequent recommendations were not followed because they felt it would be more advantageous to let the program size evolve, depending on such factors as response by builders, congressional interest, funding availability, and success of earlier demonstrations. Thus, the optimum size for the residential program was never established.

The present program, without the benefit of established program goals, has grown much larger then these initial estimates. As of early 1979, with demonstrations of combined solar heating and cooling yet to be initiated, the program has funded close to 500 demonstrations involving almost 12,000 residential dwelling units. According to HUD officials the exact program size may go higher than 12,000 units. Without determining the optimum size of the program, it appears that DOE and HUD have been funding projects with little or no consideration for how many demonstrations are necessary to effectively demonstrate solar heating systems throughout the country.

Geographic dispersion and mix of demonstrations

Two other key program goals which program managers failed to establish were (1) optimum location of the demonstrations and (2) most suitable types of solar systems to be demonstrated. Early in the program, HUD officials became aware of these issues and contracted with Arthur D. Little, Inc. to determine which solar energy systems need to be demonstrated and to recommend the most appropriate sites for the demonstrations. Arthur D. Little's study, published in May 1976, recommended that 240 different solar energy systems be installed in 600 housing units at 50 sites located throughout the country.

During the first cycle of awards, HUD officials tried to follow the criteria set forth by Arthur D. Little. However, according to HUD officials, most builders were not very responsive to the approach because they found the criteria too rigid. These officials told us that those builders who were willing to participate submitted unusually high cost estimates to undertake specific projects. As a result of the limited success of this approach, HUD officials changed their management philosophy. Instead of preselecting where the systems would be located and the type of systems to be demonstrated, HUD officials allowed the builder the flexibility to make such determinations when applying for a grant. Selections were then made by HUD officials based primarily on the technical soundness of the proposals.

According to HUD officials, this approach had the advantage of increasing the building industry interest and lowering the cost of installing solar energy systems. However, since this approach let the builders determine the location of the demonstrations and the types of solar applications to be demonstrated, it appears to have resulted in an inadequate geographic dispersion of demonstrations and a lack of emphasis on demonstrating certain useful solar heating options.

The act called for demonstrations to be located where they would achieve an adequate and realistic demonstration of solar energy systems. However, locations for demonstrations were determined by the builders and based on our review of these locations it is questionable whether an adequate geographic distribution of systems had been achieved. HUD's criteria for selection of demonstrations relied primarily on the technical soundness of the proposals and not upon geographic locations, and resulted in some areas of the country receiving a large number of awards while others were overlooked. Thus, many centers of large populations received only a few demonstrations and in some cases none at all. For example,

--the States of Colorado and Arizona are of approximately equal population and size, and have both been cited as prime candidates for early solar commercialization. However, builders in Colorado were awarded grants for 34 projects totaling $1.6 million while builders in Arizona received only three projects totaling about $120,000 and

--both Houston, Texas, and Las Vegas, Nevada, did not contain any residential demonstration projects, although both areas were selected by the Arthur D. Little study as areas warranting solar demonstrations.

HUD officials told us that areas which had a better developed solar industry fared better under HUD's project selection approach since builders in those areas already had some experience with solar energy systems and would accordingly receive higher scores when their projects were evaluated.

Another disadvantage from using this type of approach is that some potentially attractive or useful solar heating options may be overlooked by builders submitting proposals. For example, some passive solar energy systems, which contain no moving components and use architectural principles to achieve solar heating, are believed by many energy experts to be cost effective, yet only 86 out of the 11,915 demonstration units funded under the first four cycles of demonstrations incorporate any passive solar technology. The retrofit of existing homes with solar energy systems would also seem to be an important aspect of any demonstration program since the vast majority of people already live in homes without solar energy systems. However, we found that only 105 of the 11,915 dwelling units demonstrating solar energy systems are retrofit installations on single-family homes.

To get more builders involved in the program, HUD found it necessary to change its initial approach for funding demonstrations. We believe, however, HUD could have taken other steps to ensure that (1) the demonstrations were more uniformly distributed among various States and local population centers, thereby achieving optimum visibility by a representative portion of the population and (2) practical solar designs which were less popular among builders received proper attention. For example, HUD could have issued special requests to encourage proposals from specific geographic regions or for certain specific applications. HUD has taken some steps in this direction. HUD undertook a passive solar design initiative last fall, which resulted in grants for 162 passive solar projects, and has included passive designs in awards for its fifth cycle of demonstration projects in June 1979.

We believe DOE and HUD could have had a more effective program had they determined the optimum scope and mix of demonstrations, and directed the selection of projects to achieve these optimum goals. Because of the failure to adequately describe the program needs, the program does not appear to have achieved an optimum scope and mix of demonstrations. Consequently, although the program had funded almost 12,000 demonstration units, HUD officials believe additional demonstrations may be needed to make the program more effective and to adequately demonstrate all potentially promising solar designs.

Stricter selection criteria could improve program's effectiveness

Large single-family demonstration projects of questionable benefit

Solar demonstrations on single-family homes is of primary concern to the success of the program, since almost 70 percent of the Nation's population resides in single family homes. These demonstrations allow the public to view solar energy working in a familiar environment, and give home builders experience in installing and marketing homes with solar energy. However, in funding projects, HUD awarded grants for a number of large single-family projects which have little additional benefit, and which limited the distribution of projects and the number of builders participating in the program.

HUD established broad criteria defining small and large projects. In regard to single family dwellings, HUD categorized projects consisting of 1 to 5 dwellings as small and projects consisting of 6 to 25 dwellings as large. In soliciting proposals, HUD specified that large projects would be supported only if funds were available. Larger projects than those described above would also be considered but awarded only if they offered exceptional demonstration opportunities. According to HUD officials, smaller projects were to be emphasized in order to get as many builders as possible involved in the demonstration program.

In awarding funds for single-family demonstrations, HUD funded mostly small demonstrations. However, HUD did fund a number of large demonstrations, and in fact, through four cycles of demonstration grants, most of the single-family solar homes in the program were funded under these large projects as follows:

Comparison of Large and Small Projects

	Number of projects	Number of single family homes	Cost (millions)
Small projects	253	436	$3.5
Large projects	41	524	3.0
	294	950	$6.5

As a result of funding these large projects, most of the single-family homes in the program were built by a relatively small number of builders and were concentrated in a few geographic areas. In some instances, a builder would build as many as 25 to 35 single-family solar homes in one project using identical solar heating systems. For example, in one project costing $216,000 and consisting of 25 solar homes, we found that:

--all 25 houses demonstrated the same solar heating system;

--all 25 houses were located together in one subdivision of a development, and in many cases were next to each other; and

--no justification was given by the builder in either the grant proposal or in subsequent correspondence with HUD as to why a 25-unit demonstration would be more beneficial to the program than a single-unit demonstration.

In commenting on this matter, HUD officials told us that they had no predetermined quota for large versus small awards. They felt that large projects awarded were more than justified because the builders were enthusiastic about solar energy and funding these projects would result in a push for the solar industry.

HUD's funding of large demonstration projects appears to us to have been of questionable benefit. A large project may be beneficial in stimulating the local solar industry; however, we believe that such projects resulted in demonstrating the same system to the same segment of the population many times over. Additionally, such projects appear to be more in the nature of a subsidy to the builder than a demonstration project. Had HUD used stricter criteria limiting the size of demonstration project, the program may have been more beneficial. Program officials told us that some qualified applications had to be denied because there were inadequate funds. Limiting the size of the projects would have enabled HUD to fund more applicants and include more builders in the program. As the program now stands, less than 0.5 percent of the 95,000 home builders in the country have received a demonstration grant. In addition, limiting project size and including more builders in the program could have resulted in a better geographic distribution of projects and the demonstration of more types of useful solar heating applications. Limiting the size of demonstration projects also could have resulted in decreased Federal expenditures, or freed funds for other high priority work.

Cost-sharing opportunities not pursued

The Solar Heating and Cooling Demonstration Act of 1974 directed that priority be given to projects involving cost-sharing with State and local governments. Not only would cost-sharing decrease the Federal expenditures but would also increase the State or local government's interest in helping to commercialize solar energy systems. In this regard, section 15(c) of the act states:

> "Encouragement should be given in the conduct of programs under this Act to those projects in which funds, appropriated by any State or political subdivision thereof for the purpose of sharing costs with the Federal Government for the purchase and installation of solar heating or combined solar heating and cooling components and systems, are committed before or after the date of the enactment of this Act."

We found that although some demonstration projects were awarded to State and local governments, cost-sharing opportunities for private builders were not pursued. According to HUD officials, they did not seek cost-sharing from other government entities, but relied upon applicants to obtain cost-sharing. They added that if a project did contain State or local cost-sharing, it would be given special consideration in the selection process. However, there was no place on the application for grants to highlight the applicant's planned use of State or local cost-sharing, nor did the related instructions direct the applicant to seek cost-sharing in order to have the application receive special consideration. Builders and developers we contacted indicated they were unaware of any cost-sharing opportunities and a few told us they saw no need to seek cost-sharing since the Federal Government was paying for the entire demonstration. Consequently, applicants made little or no effort to obtain State or local government cost-sharing for their demonstration projects.

To determine the extent State and local governments would be willing to cost-share on demonstration projects, we contacted 13 State and 14 local governments. Officials of these State and local governments told us they were never contacted by anyone concerning cost-sharing in the program. Virtually all, however, expressed an interest in cost-sharing, and some even had funds available to use for the projects. Officials from four States and one local government told us they had funds available which could be used to cost-share in the projects, and in one instance a State official said

his State would be willing to cost share on a 50 to 50 basis for the demonstration projects. Thus, cost-sharing opportunities appear to have existed but were never pursued by HUD officials. Had these opportunities been pursued, the Federal Government's costs may have been reduced, which would have enabled the program managers to undertake additional demonstration projects with the available funds.

CONCLUSIONS

Our evaluation of the residential solar heating and cooling demonstration program disclosed a number of shortcomings. Among the most important are the following:

--Many solar heating demonstrations are experiencing technical problems and are breaking down. Even those demonstrations which appeared to be working properly may not be very economical.

--Little data on the performance of solar heating equipment is being disseminated because of malfunctions in either the monitoring equipment or in the solar devices themselves. Furthermore, data which is being disseminated may not be sufficiently comprehensive to develop suitable definitive performance criteria as mandated by law.

We believe these problems can seriously impair not only the success of the program but also the future use of solar energy, since they indicate to the public that solar heating systems easily break down or perform poorly. Accordingly, we believe these problems should be corrected as quickly as possible. In this regard, HUD has established a contingency fund for this purpose. By correcting these problems, DOE and HUD can assure themselves of a more effective program for demonstrating the practical use of solar energy systems.

In order to correct these problems, there is a need for HUD to first undertake an evaluation of all ongoing demonstrations. This evaluation should include an identification of technical problems causing the systems to break down or perform poorly. After identifying the systems with technical problems, appropriate action should be taken--including expenditure from the HUD contingency fund if necessary--to correct such problems. When undertaking such an evaluation and implementing corrective action, care must be taken to avoid making extensive corrections to those systems which even under proper operating circumstances will not demonstrate the economical use of solar heating. In those instances, program managers should give serious consideration to removing these systems or replacing them with systems

that are economical. Priority attention should be paid to correcting those systems being monitored so that the information necessary to develop definitive performance criteria is not further delayed.

In regard to the sufficiency of information being disseminated to NBS for the development of performance criteria, we believe DOE and NBS should work together and agree on exactly what type of information is necessary. Every effort should be made by DOE to ensure that NBS has sufficient information to develop suitable definitive performance criteria as mandated by law.

Additionally, we believe the program could have been more effectively managed had DOE worked with HUD toward developing program goals and strategies by which to achieve an effective solar heating and cooling demonstration program in regard to the program's size, geographic dispersion, and mix of demonstrations. Failure to develop adequate goals and strategies resulted in (1) the program being larger than originally anticipated, (2) demonstrations not being adequately distributed among States, and (3) potentially attractive applications being underemphasized in the program. We believe it would benefit both DOE and HUD to determine how many demonstrations are necessary, where they should be located and which applications should be demonstrated, so they could evaluate the present program and take corrective action where warranted. For example, passive energy systems--which appear underemphasized in the present program--are not only technically feasible but, according to many solar experts, cost-effective. Once DOE and HUD determine exactly how many passive solar systems should be demonstrated, they may find more demonstrations of passive solar systems are needed.

Finally, we found that the program could have been more effectively managed and reached a broader segment of the building industry if

--stricter criteria were used limiting the size of the demonstrations a given builder could undertake, and

--cost-sharing opportunities were pursued with State and local governments.

By using stricter selection criteria program managers could have involved more builders in the program. HUD needs to establish stricter selection criteria which will encourage the largest possible number of builders in future projects. Also, builders who participate in future projects should be required to seek cost-sharing opportunities with State and

local governments. Cost-sharing on projects would enable HUD to fund more demonstration projects with available funds.

RECOMMENDATIONS TO THE SECRETARY OF HOUSING AND URBAN DEVELOPMENT

In order to ensure that the demonstration of solar heating systems on residential dwellings is as effective as possible, we recommend that the Secretary:

--Direct program managers to evaluate the technical and economic adequacy of all demonstration projects funded. Such an evaluation should pinpoint those systems which are breaking down or performing poorly, and identify the related technical problems.

--Once these systems are identified, require appropriate action--including expenditures from HUD's contingency fund if necessary--be taken to correct the problems.

--Require program managers to give priority attention to correcting those systems which are being monitored so that the definitive performance criteria mandated by law are not delayed.

--Require program managers to establish goals for an optimum program in terms of the number, location, and mix of solar demonstrations needed. The present program should then be evaluated against such goals and, to the extent that additional demonstrations may be warranted to achieve a more effective program, develop an appropriate strategy to ensure success in meeting these goals.

--Establish stricter selection criteria for future demonstrations which would (1) allow for a larger number of builders to participate in the program, (2) limit large demonstration projects which have little benefit, and (3) ensure that such projects are reliable and economical.

--Establish procedures which will ensure that cost-sharing opportunities with State and local governments are pursued prior to funding projects. Such procedures should require certification by applicants that cost-sharing possibilities were pursued.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

In view of the solar heating and cooling oversight responsibility of the Department of Energy, we recommend that the Secretary of Energy:

--Monitor HUD's activities and provide assistance where needed to ensure that actions are taken to increase the effectiveness of the residential solar heating and cooling demonstration program.

--Require solar program managers to work with officials of NBS to establish exactly what information is needed to develop adequate definitive performance criteria for solar systems on residential dwellings, and provide such information to NBS officials responsible for developing the criteria as soon as possible.

AGENCY COMMENTS AND OUR EVALUATION

HUD, DOE, and NBS each provided comments on a draft of this report. These comments are discussed in the following sections.

HUD comments and our evaluation

HUD presented a number of concerns pertaining to the validity of our draft report. HUD's specific comments related to our evaluation of the economics of the demonstration projects, HUD's efforts to correct solar system problems, the effectiveness of the program's management, the funding of large demonstration projects, and portions of our report which needed updating.

Economics of solar demonstration projects

HUD did not agree that the economic viability of solar heating systems has not been clearly demonstrated in the program. HUD believes that we examined too few solar units to determine the economic value of the demonstration solar systems. Additionally, HUD believes that the 10-year payback period cannot be justified.

We recognize that our sample of projects was not large. We initially attempted to obtain a larger sample; however, the operational problems being experienced by the projects and the short time in which the projects had been operational

prevented us from locating a larger number of projects on which we could obtain economic data. The projects on which we did obtain information indicated problems in demonstrating economical solar use.

These projects, however, were not the only consideration given in reaching our conclusion that some projects may not be economical. We were able to support this conclusion with data obtained by other auditing techniques. For instance, during our review of data contained in the demonstration project applications which were submitted to HUD, we noted that many of the applicants had estimated a 20 year or longer payback period for their respective projects. Our conclusion was also supported--albeit to a lesser extent--by interviews with representatives of DOE, the solar industry, builders, universities, and State and local governments, during which these representatives shared with us similar observations and perceptions concerning the lack of economic viability of the projects.

Further, HUD has yet to present, either in its letter or in meetings with us to discuss our draft, conclusive data showing that the projects are demonstrating the economic practicality of solar energy. In fact, during one such meeting HUD officials stated they were surprised that we even found one project that would meet the 10-year payback period.

As to HUD's criticism of our use of a 10-year payback criteria, HUD pointed out that this criteria does not include many factors which HUD believes necessary to determine solar economics. We recognize that there are other methods to determine the economic viability of solar energy and that some of these may be appropriate under certain circumstances. However, with the information available to us during our review, determination of the payback period was the most reliable and informative measure of the economics of the demonstrated solar systems. We used a 10-year payback period because, from the evidence we obtained, it appeared to be a fair standard of public acceptance towards solar economics.

HUD believes that an analysis of solar economics should include a variety of other factors. We noted during our review that HUD was using cost per million Btu's (British termal units) produced annually by the solar system as an economic measure. HUD officials stated that this measure examines many of the factors they deem necessary for solar economics, and that solar systems would need to cost between $125 to $150 per million Btu's produced to be economical. However, through the first four grant cycles, the average cost of the solar systems in the program was $231 per million Btu's produced--well over HUD's economic measure.

Consequently, we believe that an evaluation of the demonstrated solar systems using any reasonable criteria will illustrate the same economic problems with the demonstrated systems and show that the program has had only limited success in demonstrating that solar is practical from an economic standpoint.

HUD's efforts to correct solar system problems

In regard to HUD's efforts to correct solar system problems, HUD maintained that no formal $3 million contingency fund had ever been established in the program for use in repairing demonstration solar systems. Our contention that such a fund exists was based on program documents and financial records which we examined during our review. One program document, for example, contained the following statement relative to this fund:

> "* * * a contingency fund is being provided in case problems develop which would cause unanticipated major costs to the builder or the customer."

In our review of the pertinent financial records we noted one account in which HUD had an unobligated balance of about $3 million. Funds had been placed in this account since the initiation of the program and, according to HUD program officials at the time of our review, these monies were to be held as a contingency fund for repair of demonstration projects. HUD has not been able to give us any other explanation as to the purpose of these funds. Consequently, we still consider the $3 million contingency fund to exist.

HUD disagreed also with our contention that it had not taken sufficient action to correct systems experiencing problems. HUD pointed out that it has expended about $520,000 for identification and repair of solar systems, even though it is HUD's position that industry must accept responsibility for mistakes and poor workmanship. We believe the $520,000 for identification and repair of solar systems is misleading. Most of these funds were routinely provided to contractors for surveying selected demonstration projects as part of their regular duties. Only a minor portion of these funds were spent to repair solar systems on nine projects. With respect to the question of who had responsibility for correcting problems, we agree that industry will ultimately have to accept responsibility for defects in materials and workmanship. However, in the case of these solar energy demonstrations, we believe HUD clearly has the responsibility to ensure that they operate satisfactorily, even if the systems have to be repaired initially using appropriated funds.

As noted in our report, section 5(d) of the Solar Heating and Cooling Demonstration Act of 1974 placed responsibility on the Secretary of HUD for the satisfactory operation of these demonstrations. We therefore continue to believe HUD needs to improve its procedures for identifying and correcting the operational problems which still exist. HUD's current procedures are not sufficiently comprehensive to ensure that all problems are identified and corrected.

Program management effectiveness

HUD did not agree with our evaluation that the program could have been more effectively managed. With regard to the failure to determine program goals and strategies, HUD argued that the Arthur D. Little, Inc., study contained HUD's program goals and strategy for optimum size, geographic dispersion and mix of demonstrations in the program. Additionally, HUD stated that the increased program size was a result of a changing congressional mandate, and that some geographic regions, specifically Las Vegas, Nevada, did not contain solar heating demonstrations because these areas were, instead, designated for solar cooling.

We believe a well-conceived, appropriately planned demonstration program should have well-defined goals and a carefully laid out strategy for achieving such goals, to serve as the basis for guiding the program and providing benchmarks against which program success can be evaluated. The Arthur D. Little study referred to by HUD was not followed in meeting these objectives. Although HUD attempted to pursue the goals and follow the strategies laid out in the study, that attempt proved to be a failure. As discussed in the report, HUD tried to follow the criteria contained in the study during the first cycle of solar demonstration awards but, according to HUD officials, this approach had to be abandoned for a number of reasons including a lack of responsiveness on the part of prospective builders of solar equipped residences.

HUD's contention that the program had grown much larger than ever anticipated as a result of increased funding from the Congress and a changing congressional mandate is not a totally accurate statement. It is true that for some years the Congress funded the program at an amount larger than requested in the administration's annual budgets. Our review of pertinent budget records disclosed, however, that the amount funded was approximately equal to the amount originally requested by the program managers prior to reductions by higher levels in DOE and the Office of Management and Budget during the budget review process. Thus, it is apparent that the Congress was simply restoring the funds that the program managers felt were necessary to carry out an effective demonstration program.

In regard to the changing congressional mandate, we recognize that on occasion, certain committees set targets to demonstrate more units than the number anticipated by program managers. Nevertheless, program managers failed to update their plans to incorporate these changes to reflect congressional desires and to ensure an effective program. Instead, emphasis appears to have been put on multi-family housing and larger projects in order to increase the program's size. Consequently, we still believe that, while there was some initial planning done, the program managers failed to establish suitable goals or a working strategy, either early in the program or later when the Congress desired more demonstrations than HUD originally planned.

HUD disagreed with our example of Las Vegas, Nevada as an area overlooked for solar demonstrations. HUD argued that Las Vegas was not picked as a demonstration site because it requires solar cooling. However, the report by HUD's consultant, which suggested Las Vegas as an appropriate place for solar demonstrations, listed this site to also incorporate solar hot water and space heating. In this connection, National Oceanic and Atmospheric Administration data shows that Las Vegas averages 30 to 90 days of minimum temperatures below 32 degrees Fahrenheit per year, the same as Washington, D.C. Consequently, Las Vegas requires substantial amounts of space heating, and a demonstration of solar heating in this area appears warranted.

Funding of large demonstration projects

HUD also did not agree with our conclusions on the number of and questionable need for large projects. HUD's figures showing large versus small projects differed substantially from our figures. In reconciling these figures, we found that HUD's figures included grants awarded under its passive solar initiative of last fall and its fifth grant cycle, which was awarded at the time the draft report was sent to HUD for comment. HUD did not fund any large projects under either of these awards. Consequently, while we still believe that too many large projects were funded under the earlier grant cycles, these more recent awards indicate that HUD is now placing greater emphasis on smaller projects. We have incorporated changes in the body of our report recognizing these recent initiatives.

In regard to the questionable need for large projects, HUD stated that large projects are necessary to study local building laws, codes, ordinances, and practices and their

effects on the practical use of solar heating and cooling for residences. HUD pointed out that small projects are not conducive to making such studies. HUD also asserted that the larger projects help stimulate mass production of solar equipment which will help eliminate dependence on foreign energy sources.

We remain convinced that the larger projects provided little additional benefit. We believe that a small project of 3 to 5 units could provide HUD with virtually the same information on building laws, codes, ordinances, and practices as would a 25-unit project, and at a much lower cost per project. By funding only small projects, HUD could have achieved a wider geographic dispersion of projects thereby giving residential solar applications greater exposure to the public and permitting HUD to obtain information on building laws, codes, ordinances, and practices from a larger number of locations. As to HUD's belief that large projects stimulate mass production, we noted that in the case of the large 25-unit project discussed in our report, the solar collectors were made in Israel. We, therefore, have difficulty rationalizing how this project served to stimulate mass production of solar equipment in this country.

Updating our report

HUD provided other information in its comments which we used to update the data contained in portions of our report. HUD commented that grants have recently been given for passive solar homes to increase the number of passive demonstrations. In addition, HUD apprised us that it has canceled its plans to demonstrate combined solar heating and cooling technology in fiscal year 1979. We verified this information and updated the report where appropriate.

NBS comments and our evaluation

NBS agreed that the data being obtained on the thermal performance of the solar systems was less than adequate for its use in developing suitable definitive performance criteria. However, NBS stated it now has access to other data to supplement the thermal data being collected, and accordingly NBS has been able to compensate for the lack of detailed data that it had previously requested from DOE. NBS also commented that coordination between DOE, DOE's contractor, and NBS has improved, and that the required criteria can be developed through continued improvements and expansion of these coordinated efforts. NBS now has scheduled publication of the definitive performance criteria for December 1979, although subsequent updating and revision will be required.

It appears from NBS' comments that progress is being made towards resolving the problems associated with the development of definitive performance criteria. However, in its comments, NBS indicated that improvements in the quality and quantity of thermal performance data are still needed, and that continuation and expansion of cooperative efforts are required. Consequently, we believe recommendations to HUD and DOE on the need to improve the performance of monitored solar systems and the coordination and cooperation between DOE and NBS are still valid to better ensure that suitable definitive performance criteria are developed in a timely manner.

NBS also provided the following other comments. NBS commented that not all of the data requested from DOE was required on a hourly basis. In addition, NBS noted that the monthly performance reports are widely distributed, but our draft indicated that only NBS receives them. We have changed the report to reflect these NBS comments. NBS also commented that HUD's development of standards, identification of laboratories capable of testing solar equipment, and development of a certification process was within the scope of section 8 of the Solar Heating and Cooling Demonstration Act of 1974, and not outside the scope as stated in our report. In our opinion section 8 of the act refers to the development of definitive performance criteria. Our discussion in the report is merely intended to point out that HUD had taken the initiative to go beyond section 8 by developing intermediate minimum property standards for solar energy systems. This is not intended to imply that HUD had exceeded its authority, since authority for HUD's development of standards rests in other legislation.

DOE comments and our evaluation

DOE acknowledged that many of the demonstration projects are encountering a wide variety of performance problems, and that the problems are extensive, thereby undermining the promotional objectives of the program. However, DOE pointed out that our evaluation of program management did not examine the conflicting objectives of the program, but rather concluded with a recommendation to require program managers to determine the number, location, and mix of demonstrations which would constitute an effective program.

In determining the elements of an effective solar demonstration program, we noted in our review that the planning for an effective demonstration program, and the establishment of program goals and strategies, were not adequate. Better planning would have taken into consideration conflicting objectives, and would have established the necessary requirements

for the program to be fully effective. Consequently, we recommended that the elements for an effective program be determined by HUD and DOE in order to provide the necessary benchmarks against which the current program could be evaluated and efforts initiated to better ensure the program's effectiveness.

DOE also provided comments similar to HUD's pertaining to large demonstration projects. Our evaluation of such comments was discussed previously on page 35.

CHAPTER 4

NEED TO AMEND LEGISLATION FOR DEMONSTRATIONS OF SOLAR COOLING TECHNOLOGY

The residential solar heating and cooling demonstration program is completing the final year authorized by the Solar Heating and Cooling Demonstration Act of 1974, and has now undertaken five demonstration cycles which have consisted primarily of solar heating systems. Consequently, the program still needs to demonstrate the practical use of combined solar heating and cooling systems in order to meet the final mandate of the legislation. However, DOE and HUD program managers are not currently planning to perform combined solar heating and cooling demonstrations within the legislated time frame due to problems with solar cooling technology, even though fiscal year 1979 funds were requested for that purpose.

We examined both the technical and economic status of solar cooling to determine if the practical demonstrations of combined solar heating and cooling systems could be attained. We found that active solar cooling systems, which are the most common and have the largest potential for use

--face many technical problems, as confirmed during early attempts by DOE and HUD to demonstrate such systems, and

--are extremely capital intensive, which makes such systems--even if they work properly--economically unattractive.

In our view, the state-of-the-art of active solar cooling systems is not sufficiently advanced to allow for their practical demonstration. If attempted, more serious problems may occur in this portion of the program than occurred in the demonstration of solar heating systems.

STATUS OF SOLAR COOLING TECHNOLOGIES

When the demonstration program was created in late 1974, the Congress recognized that solar cooling technologies were not as economically and technically advanced as solar heating systems. Accordingly, the act allowed the program managers two additional years in which to demonstrate the practical use of combined solar heating and cooling systems. The act

also authorized the program managers to undertake research activities in order to develop the necessary technology and expertise to successfully demonstrate these combined systems.

In response to this requirement of the act, DOE and NASA have initiated research and development (R&D) activities to develop various solar cooling technologies. These activities are currently focused on developing three active cooling technologies and a number of passive cooling principles. In addition, HUD has also funded a relatively small number of demonstrations of systems which contain active or passive solar cooling, in order to gain some practical experience with such systems. We looked at these demonstration projects and R&D efforts to determine the technical status and economic attractiveness of solar cooling systems.

Technical status

The three active solar cooling technologies on which DOE and NASA have undertaken R&D efforts are absorption cooling, rankine cycle cooling, and desiccant chilling. These three active solar cooling technologies, which use solar collectors and have moving components, appear to have the most energy savings potential due to their nationwide applicability and their compatibility with existing residential structures.

However, these technologies are not ready for practical demonstrations. According to DOE and NASA officials, none are ready for demonstration because of technical problems. One of the most critical problems, according to these officials, is developing collectors which can achieve and maintain sufficiently high temperatures. The temperatures needed to run solar cooling equipment range from more than 200 degrees Fahrenheit up to 700 degrees Fahrenheit. Typical flat-plate collectors used for solar water and space heating can usually obtain temperatures of only 180 to 200 degrees Fahrenheit under optimum conditions. Thus, new equipment must be developed and tested before solar cooling can be successfully demonstrated. Other components used in a solar cooling system, such as pumps and basic absorption cooling equipment, are for the most part readily available. However, program officials pointed out that certain of these components must still be engineered and adapted to work efficiently from solar energy. They expect many minor problems--such as those associated with transporting high temperature fluids--will be worked out as those systems are fully tested.

According to DOE and NASA officials, of the three solar cooling technologies receiving the most attention, absorption cooling, which operates under principles similar to conventional air conditioning, is the closest to commercialization. DOE officials hope they may be able to begin field testing some absorption cooling equipment during 1979. For the other technologies field testing is not planned until 1981 and will probably not be completed until 1983.

Current demonstrations of active solar cooling technologies verify that solar cooling is not ready to be widely demonstrated. At the time of our review HUD had funded 18 demonstrations containing solar cooling of which three were operational. We examined two of these demonstrations and found:

--On one solar cooling demonstration, the collectors burst, causing the system to leak badly during operation. Consequently, the system was redesigned and several major components replaced. This brought the total cost of this system to over $50,000. When we visited the project the builder was still having problems with a temperature controlling device.

--On the other project--a multi-family residence--the collectors had deteriorated and clogged the water lines. Four collectors and two heat pumps had to be replaced. At the time of our review the system was not working.

In both projects the failure was attributable either to the system's design or to faulty equipment, which suggest these technologies are not ready to be demonstrated on a large scale.

In addition to the R&D being undertaken by DOE and NASA on active systems, work is also underway on developing and understanding passive solar cooling technologies. Passive solar cooling systems minimize heat gain, maximize natural ventilation and dissipate day-time interior heat gain in order to keep a structure cool. Passive cooling principles include such features as large overhangs to block sunlight from entering a building. Passive solar cooling systems do not suffer from the performance problems experienced by active solar cooling technologies; however, DOE program officials told us there is still a need to fully understand the economics and applicability of these principles. For example, according to these officials, passive cooling systems appear to work only in areas of low humidity and high day-night temperature variations. This limits the systems' potential usefulness. Program officials believe more R&D

is needed to fully develop architectural principles in order to satisfy residential cooling needs in a broader number of applications. They recognize, however, that some applications may be worthwhile now.

Economic status

The demonstration of solar cooling technology which is clearly uneconomical would be contrary to the mandate of the Solar Heating and Cooling Demonstration Act of 1974 which requires the demonstration of "practical" systems. To undertake such demonstrations may even be detrimental to the overall program if the public, as a result of these demonstrations, views solar energy systems as uneconomical.

Active solar cooling technology is extremely capital intensive. The additional expense for solar cooling for a single family residence can run anywhere from $12,000 to $23,000. To illustrate from the few solar cooling projects already funded within the demonstration program, the average combined active solar heating and cooling system costs $23,000 whereas solar heating alone costs about $8,200. This difference of about $15,000, for the most part, is for additional and specialized components needed to achieve solar cooling. 1/

In addition to being capital intensive, most of the country can expect only a modest energy saving from using solar cooling equipment. For example, in the Washington, D.C., area, local utility officials told us that the average homeowner spends approximately $210 a year to cool a four bedroom residence. Even if the solar equipment provides most of the home's cooling needs, it is unlikely such an investment would pay for itself in a reasonable time. For example, assuming that a solar cooling system can meet 70 percent of a given home's cooling needs and that electricity will increase in price by 10 percent a year for the next 10 years and 5 percent thereafter, a $15,000 solar cooling system will require about 31 years to pay for itself.

Passive solar cooling systems do not share the same economic drawbacks of active systems since expensive technology is not required for their use. However, the economics of these systems is difficult to determine. For instance, the cost of window overhangs, which shade the house from the

---

1/For example, one demonstration which contained solar cooling cost $25,473, of which $11,520 was needed for special high temperature collectors and $3,000 for the cooling unit.

summer sun, is partially attributable to passive cooling designs and partially to the architecture of the building. Furthermore, program officials told us there is little information available concerning the efficiency of such systems. HUD believes there are some economical applications in certain regions such as the southwestern United States.

MANAGEMENT'S CURRENT PLANS

DOE and HUD officials recognize that demonstrating combined solar heating and cooling technologies would be risky because (1) the technology is not proven and (2) such systems do not appear to be economical. Consequently, they do not plan to undertake demonstrations of combined solar heating and cooling systems at this time, even though DOE requested $6 million for fiscal year 1979 demonstrations of solar cooling technology. HUD officials, instead, are now in the process of awarding grants for a fifth cycle of demonstration grants which are for solar heating systems only.

HUD officials stated that solar cooling demonstrations are not being attempted because of the problems with its use. They stated that the solar cooling equipment presently available is not advanced enough to permit reliable demonstration in the program. These officials agreed that they would be in conflict with the Solar Heating and Cooling Demonstration Act of 1974 by not performing demonstrations of combined solar heating and cooling technology. However, they believe that demonstrations of solar cooling at this time would not serve to advance the acceptance of this technology. Current plans now call for a phasing out of the residential demonstration program without the demonstration of combined solar heating and cooling systems.

Since the practical demonstration of combined solar heating and cooling technology cannot now be attained, a change in the Solar Heating and Cooling Demonstration Act of 1974 is needed to provide DOE and HUD the necessary flexibility to initiate such demonstrations in the future when combined solar heating and cooling technology can be proven to be practical. Past efforts have been made by DOE and HUD to extend the requirements for combined solar heating and cooling demonstrations, and although one piece of legislation was introducted in 1978 to extend the act 3 years, these efforts have not proved successful. In addition, H.R. 3000, DOE's fiscal year 1980 authorization bill, presently contains a provision to extend the Solar Heating and Cooling Demonstration Act of 1974 for 1 year. According to a report of the House Committee on Science and Technology, this extension is to allow DOE additional time to develop and demonstrate combined solar heating and cooling technology. In our opinion, however,

such an extension would not allow DOE the needed flexibility to determine the timing for such demonstrations. The development and economics of solar cooling technology are still uncertain and establishment of new time constraints may result in the demonstration of a technology which is still not practical.

CONCLUSIONS

Generally, we believe that demonstrations are effective mechanisms for advancing solar heating and cooling technologies from research and development to the public marketplace. However, care must be taken to assure that such technologies are ready for commercialization. The demonstration of technologies which are not ready will do little for future acceptance of solar energy systems as a replacement for conventional energy sources.

Solar cooling technologies, for the most part, do not appear ready for demonstration. In examining the technical and economic status of solar cooling systems, which would be part of any combined solar heating and cooling system, we found active systems to be the most common type with the largest potential for use. These types of systems, however, face many technical problems and are extremely costly. We doubt that these systems can be successfully demonstrated as being practical. For many of these systems, field testing is not scheduled to be completed until the early 1980s. On the other hand, passive cooling systems do not face serious technical problems and are not nearly as costly as active systems. However, passive cooling does not have the potential of active type systems, and the practical demonstration of passive cooling may be possible, only on a limited basis.

The Solar Heating and Cooling Demonstration Act of 1974 mandated the demonstration of combined solar heating and cooling technology by 1979. However, DOE and HUD have recognized the problems with residential applications of solar cooling, and are not planning to undertake combined solar and cooling demonstrations, even though fiscal year 1979 funds were requested for that purpose. We believe that the program managers have correctly decided to not demonstrate solar cooling. However, the Solar Heating and Cooling Demonstration Act of 1974 should be amended to permit these demonstrations to be undertaken at a later date when practical demonstrations of combined solar heating and cooling technology can be attained. The fiscal year 1980 authorization bill for DOE currently contains a provision to extend the solar cooling objectives of the act 1 year. We believe the Congress should favorably consider this extension; however, many problems

still confront the practical demonstration of combined solar heating and cooling systems within this time frame. In our opinion, the Congress should not impose a specific time constraint for these demonstrations at this time. Instead, the Congress should require DOE and HUD to annually inform the Congress of the status of solar cooling technology and provide an estimate of when the practical demonstration of combined solar heating and cooling technology can be attained. This information should give the Congress a better basis for authorizing demonstrations of the reliable and economic use of this technology.

RECOMMENDATION TO THE CONGRESS

Since active solar cooling technologies have not yet been developed to the point where they can be demonstrated successfully within the time frames established pursuant to the Solar Heating and Cooling Demonstration Act of 1974, GAO does not believe that the 1-year extension provided for in H.R. 3000, DOE's fiscal year 1980 authorization bill, would be adequate. We therefore recommend that the Congress extend the requirements for combined solar heating and cooling demonstrations without imposing new time constraints. The Congress, instead, should require the Department of Energy to annually inform the Congress on the status of solar cooling technology, and provide an estimate of when the practical demonstration of these systems could be attained. When combined solar heating and cooling can be shown to be reliable and economical, the Congress could then consider imposing time constraints on DOE mandating demonstrations of this technology.

AGENCY COMMENTS AND OUR EVALUATION

In the draft report we submitted to DOE and HUD for their comments, we stated that plans for residential solar heating and cooling demonstration program called for demonstrations of combined solar heating and cooling technology in fiscal year 1979. This statement was based on DOE's budget submission to the Congress and on discussions with program managers in late 1978 on the future direction of the program. Because of the problems we found with solar cooling technology we recommended that these demonstrations not be undertaken at this time.

However, in commenting on our draft report, both DOE and HUD advised us that their plans no longer include demonstrations of combined solar heating and cooling technology, and that the funds requested for fiscal year 1979 demonstrations

have been expended for other demonstrations. Consequently, since DOE and HUD took actions similar to those recommended by us, we revised our report to reflect the current plans and direction of the program.

APPENDIX I

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
WASHINGTON, D.C. 20410

ASSISTANT SECRETARY FOR
POLICY DEVELOPMENT AND RESEARCH

June 29, 1979

IN REPLY REFER TO

Mr. Henry Eschwege, Director
Community and Economic Development
Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

I am responding to your letter of May 23, 1979, transmitting for our information and comment a draft report to the Congress entitled "Federal Efforts to Demonstrate Residential Solar Heating and Cooling Systems -- Past Mistakes and Future Uncertainties." [See GAO note, p. 53.]

I appreciate the opportunity to review this document in draft. Unfortunately, we have found it to be inconsistent, inaccurate, based on outdated and incorrect information, and full of evaluative statements which are not supported by the data presented, let alone by the correct, timely data available from our program staff. I trust that before the document is provided to the Congress it will be completely rewritten to reflect the actual situation and the recommendations will be supported by the facts.

A few examples from the report will illustrate the lack of thoroughness of the review and as a result, the invalidity of the entire approach and the resulting conclusions.

1. The GAO draft report states "GAO found that solar heating demonstrations on single family dwellings were dominated by large projects." To date HUD has awarded a total of 588 grants for small projects and only 37 for large projects. This small to large project relationship does not support the statement that the program is dominated by large single family projects.

APPENDIX I

The statement is even more suspect when you consider that many of these 37 so called large projects are single buildings with several townhouse units.

2. The GAO draft report states that passive solar designs have not received adequate attention. One could argue as to what may be "adequate"; however, 293 grants have been awarded for passive buildings. The report never even mentions the Passive Design Competition or the fifth demonstration cycle, both of which were for passive houses.

3. The GAO draft report states "The residential solar heating and cooling demonstration program is scheduled to shift from demonstrations of solar heating technology to demonstrations of combined solar heating and cooling technology in order to meet the final mandate of the Solar Heating and Cooling Demonstration Act of 1974. Program managers plan to award $6 million in grants for demonstrations of combined solar heating and cooling technology in 1979. However, solar systems which use solar cooling technology are not ready for widespread demonstration.".

   This statement implies that HUD either does not understand the state of the technology or, worse, plans to proceed with a major demonstration in spite of the facts. Such an implication is unwarranted.

   The report does not recognize the testimony of Donald Beattie, DOE Acting Assistant Secretary for Conservation and Solar Applications, on January 27, 1978 before the House Committee on Science and Technology, in which he stated that meeting the milestone for cost-effective solar cooling systems in 1979 was not possible in single family housing. This testimony was

developed in conjunction with HUD and resulted in the introduction of HR 11088 on February 22, 1978 extending the cooling milestone by three years. The report recommends that Congress extend the cooling milestone without even recognizing that the relevant Congressional Committee initiated such an action over a year ago.

The report's statement that HUD was planning to fund a $6 million combined heating and cooling demonstration in 1979 failed to note that we have already made all of the FY 1979 awards. These awards were for passive solar homes.

4. The GAO draft report states "Some geographic areas have been overlooked. For example Houston, Texas, and Las Vegas, Nevada, were selected in a consultant's study as areas warranting solar demonstrations, but neither area has been included in the program."

The statement made is correct in that there are no demonstration houses in Las Vegas, Nevada. GAO review of the consultant's report was clearly inadequate; otherwise GAO would have found that Las Vegas was suggested as a city to demonstrate solar cooling systems. It seems at least questionable for GAO to state, on the one hand, that we should not demonstrate solar cooling, and on the other hand, question our geographic distribution when we do not demonstrate in an area that requires cooling.

In addition, the GAO draft report states that neither DOE nor HUD determined program goals and strategies by which to achieve an effective demonstration program, considering optimum program size, geographic dispersion, and mix of demonstrations. The consultant's report cited above by the GAO is indeed the document which outlines an optimum size, geographic dispersion and mix of demonstrations. It seems that, on the one hand, the consultant's report was used as a

basis for adverse comments, while on the other hand, GAO failed to recognize its existence in another section of your report.

5. The GAO draft report states that little action has been taken to identify and correct the operational problems which exist in the demonstration projects. It further states that program officials have established a $3 million contingency fund for this purpose, but have not yet used any of these funds.

No formal $3 million contingency fund has ever been established in the program. An estimate had been made early in the program on what it might cost if HUD had to repair systems. Since the principal objective of the HUD residential solar program is to encourage the development of a solar industry, we have taken the position that the industry must accept responsibility for mistakes and poor workmanship, and we require warranties against defects. In most cases, problems brought to our attention have been resolved by the builder, the system manufacturer, or the system installer. The statement that no funds have been expended for repairs of systems is also in error. As of approximately April 30, 1979 $518,060 has been expended in manhours and equipment in the identification and repair of systems which could not be repaired under warranty. The process of problem identification and repair, using Federal funds where necessary, is described in a memorandum sent to the Department of Energy.

The five points discussed above are our response to statements in which we feel GAO disregarded the facts as they exist. It is not intended to be an all inclusive list of factual errors. The purpose is to illustrate the need for a complete revision of the report.

In addition to the factual errors, there are a number of statements and

conclusions in the GAO draft report which reflect a lack of understanding of the program and its development.

Three examples of this lack of understanding are:

1. The GAO draft report states "GAO's review of these projects also showed that the economic viability of solar heating systems has not been clearly demonstrated." This statement is based on review of only five solar units out of the 4,824 units completed, and uses a criterion of "payback within a period of 10 years." Not only is the sample far too small to make such a sweeping statement, but the use of a 10 year payback as a criterion cannot be justified. Such a criterion assumes that the solar system has to be paid off because it has no economic value after this period. There is no recognition of the most important economic feasibility criterion for most home buyers -- is it cheaper to live in a solar house than to live in one heated with conventional energy sources? Such a criterion takes into consideration the cost of money, the cost of the system, the cost of the alternative conventional fuels, the amount of sunlight available, and many other factors.

Since one of the principal determinants of economic feasibility is the cost of the conventional fuel available, systems which compete with resistance electricity in the New York area are very feasible, while systems competing with controlled-price natural gas or with low-cost electricity (such as that supplied by the Tennessee Valley Authority or the Bonneville Power Administration) may not be feasible for many years. GAO fails to recognize that regionally varying fuel costs make it impossible to achieve economic viability in every part of the country.

2. The GAO draft report states "With respect to size, GAO noted that the program has grown much larger than ever anticipated." This is correct. When HUD commissioned the consultant's planning study discussed above, we were looking for the minimum program level possible which could provide the necessary exposure and data needed to achieve program objectives.

GAO failed to acknowledge or discuss the Congressional oversight hearings and therefore did not recognize the changing mandate to ERDA, DOE, and HUD. For example, the Administration requested a budget of $8.1 million for the residential program in FY 1977; the final amount appropriated to ERDA and transferred to HUD for FY 1977 was $21.5 million. In the legislative history of the FY 1977 ERDA authorization, the Senate Interior Committee stated:

"The Committee's recommendation for FY 1977 ERDA authorization for heating and cooling provides for the fulfillment of the requirements of Public Law 93-409. Under the budget requested by the Administration the trend line of the fiscal year 1977 plan leads to a 5-year total of about 1,300 residential units and 200 commercial units. This number of units is unacceptable to the Senate Interior Committee, and an authorization level has been approved which would provide for approximately 60 commercial and 350 residential demonstration awards to be made in fiscal year 1977."

The 1300 dwelling unit number would have been in accordance with the original plan and the consultants report cited earlier. The Committee changed from units to awards and suggested 350 residential awards in FY 77. While we have funded some 12,688 dwelling units throughout the program, we have only made 787 grants through the five year program. In fact, in FY 77 HUD made 271 awards, slightly less than estimated by Congress; however, it represented 4,879 units of housing. One award to a multifamily high rise building for the elderly, who we all agree need the benefits of lower energy

costs, may involve 200 dwelling units. This illustration shows that unit count cannot be the total measure of the size of the program.

3. GAO questioned the need for projects as large as 25 units in a given subdivision. This questioning results from a lack of understanding of the total HUD program.

The goals of the legislation were not just the demonstration of units of housing but rather the creation of a viable solar industry as part of the housing industry. In order to accomplish this goal Public Law 93-409 directed HUD, among other things, to study and investigate the effect of building codes, zoning ordinances, tax regulations, and other laws, codes, ordinances, and practices upon the practical use of solar energy. Many of the above factors, such as zoning ordinances, can only be explored by attempting to impact these ordinances with situations likely to occur in the private housing market. The limited number of larger projects were used to identify problems of zoning, sun rights and subdivision planning which could not have been identified with single-unit demonstrations.

In addition, Congress stated in Section P.L. 93-409 that mass production of solar equipment will help eliminate dependence on foreign energy sources. Mass production is helped significantly by larger projects by one manufacturer in one location.

These examples outline our problems with the GAO draft report; they by no means exhaust the numerous individual errors and misstatements of fact which occur throughout the report.

I am sure that upon closer review of the facts surrounding the Residential Solar Demonstration Program, GAO will significantly revise the recommendations to HUD, DOE and Congress. This being the case, I see no purpose in providing comments on the recommendations of the draft report at this time.

My staff is ready to provide any data you may need to successfully complete the rewrite of the report. We would appreciate the opportunity to comment on any revised report prior to its issuance.

Sincerely yours,

Donna E. Shalala

GAO note: Title of draft report was changed to "Federal Demonstrations of Solar Heating and Cooling on Private Residences--Only Limited Success."

APPENDIX II

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

8 JUL 1979

Mr. Henry Eschwege
Director, Community and Economic
Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in reply to your letter of May 23, 1979 requesting comments on the draft report entitled "Federal Efforts to Demonstrate Residential Solar Heating and Cooling Systems -- Past Mistakes and Future Uncertainties."

We have reviewed the enclosed comments of the Assistant Secretary for Science and Technology and believe they are responsive to the matters discussed in the report.

Sincerely,

Elsa A. Porter
Assistant Secretary
for Administration

Enclosure

[See GAO note, p. 57.]

APPENDIX II

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-3111

Mr. Henry Eschwege
Director, Community and Economic
Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

Thank you for your letter of May 23, 1979, requesting that the Department of Commerce review your proposed report to Congress entitled "Federal Efforts to Demonstrate Residential Solar Heating and Cooling Systems--Past Mistakes and Future Uncertainties." In response to your request, the staff of the National Bureau of Standards (NBS) who are working on the Residential Solar Demonstration Program reviewed your proposed report. Their comments follow. [See GAO note, p. 57.]

Lack of Performance Data (p.iii,18)*

The statement on p. iii of the proposed report, "problems with the equipment designed to collect performance data for use in developing the criteria, together with operational problems associated with the solar systems, have resulted in a lack of performance data being collected," is correct but applies primarily to thermal performance data. However, contractors for the Department of Energy (DoE) and the Department of Housing and Urban Development (HUD) are collecting other valuable technical performance (noninstrumented) data relating to the mechanical, safety, structural, durability/reliability and maintainability performance of solar heating and cooling systems and components. The NBS is evaluating these data, in addition to the thermal performance data, for possible use in the development of definitive performance criteria.

Detailed Thermal Performance Data (p.iii,19)

P.iii of the proposed report states that "officials of the National Bureau of Standards claim that the basic, unsummarized performance data is critical to the development of the definitive performance criteria and that without the data such criteria for solar systems will be inadequate and even further delayed." This sentence overemphasizes the usefulness of basic, unsummarized performance data. An explanation of this statement is given in the following paragraph.

On p. 19, the report indicates that "data must be available on the performance of various parts of the solar system on at least an hourly

*Page references were changed to correspond with those in this final report.

basis in order for them (NBS) to determine exactly how well a system and its components work." This statement is not totally accurate, since much useful information on system performance is also available from the daily and monthly performance summaries. In the NBS draft plan for using demonstration program thermal data to develop definitive performance criteria that was sent to DoE on June 16, 1978, a number of detailed studies of system and component thermal performance were proposed that would require the hourly performance data as input. In addition to these detailed studies, a number of other studies were proposed that would require as input the daily and monthly thermal data similar to that presented in the DoE data contractor's monthly performance summary for each site. Studies using the monthly performance data are currently underway at NBS.

Since February 1979, there has been a substantial increase in the amount of cooperation and coordination between NBS and the DoE contractor in regard to the identification of studies and the exchange of data which will be useful to NBS in the development of definitive performance criteria. It is apparent at this time that it would not be efficient for NBS to acquire the hourly data or the 5-minute data and reprocess them to make them suitable for performance criteria studies. It also appears that most, if not all, of NBS's needs for thermal performance data can probably be obtained by continuation and expansion of the above-mentioned cooperative efforts and by closer coordination of the technical studies planned by the DoE data contractor with those planned by NBS.

On page 18 the proposed report indicates that "the contractor compiles the daily performance data into monthly performance reports which are then sent to NBS ..." This statement implies that the monthly reports are sent only to NBS. Monthly reports are made available to all interested parties through the DoE Technical Information Center.

Performance Criteria and Standards (p.8-9)

Page 9 of the proposed report indicates that "this program element goes beyond the mandate of the Solar Heating and Cooling Demonstration Act of 1974 to develop definitive performance criteria in that it includes (1) developing standards for solar equipment, (2) identification of laboratories capable of testing solar equipment, and (3) developing a certification process to assure the public that solar equipment meets existing standards."

Section 8, paragraph 3 of Public Law 93-409, does require HUD to determine "procedures whereby manufacturers of solar heating and combined heating and cooling components and systems shall have their products tested in order to provide certification that such products conform to the performance criteria established under paragraph (1)." Accordingly, we believe the program elements cited above are necessary and are not outside the scope of this legislative mandate. The NBS has worked with HUD and DoE to assist them in identifying qualified laboratories for testing solar collectors in order that they could have some assurance that the

thermal performance data submitted by collector manufacturers for proposed demonstration program projects were obtained in accordance with established procedures (i.e., ASHRAE Standard 93-77). To our knowledge, HUD has not "certified" laboratories nor have they required certification of solar collectors used in the Residential Solar Demonstration Program.

The development of the "Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems," cited on page 9, was initiated by HUD in late 1975 as a result of a request by the Senate Select Committee on Small Business (May 1975 hearings).

Monitoring of Systems (p.30)

On page 30, it is recommended that "priority attention be given to those systems which are being monitored so that the definitive performance criteria mandated by law are not further delayed." We would also recommend that DoE, on a limited number of these sites, make all possible improvements in the data acquisition system and that additional sensors be installed to enhance the quality and quantity of the thermal performance data obtained.

Preparation of Definitive Performance Criteria

Based on discussions with HUD, NBS is planning to develop a definitive performance criteria document for residential solar heating and cooling systems by December 1979. This document will be a revision of the previous interim performance criteria document (NBSIR 78-1562) developed for HUD in November 1978. However, since adequate long-term (several years) performance data will not be available by the end of 1979, we have recommended to HUD and DoE that work be continued at least through FY 1982 to update and revise the definitive performance criteria document which is scheduled to be published in December 1979. The delays in demonstrating sufficient numbers of active solar cooling systems and passive heating and cooling systems also reinforce the need to continue performance criteria development work for several more years.

We appreciate the opportunity to comment on your proposed report. If you wish to discuss NBS's comments, please contact Mr. Robert D. Dikkers, Group Leader, Solar Technology, NBS (921-3285).

Sincerely,

Jordan J. Baruch

GAO note: Title of draft report was changed to "Federal Demonstrations of Solar Heating and Cooling on Private Residences--Only Limited Success."

APPENDIX III

Department of Energy
Washington, D.C. 20545

June 22, 1979

Mr. J. Dexter Peach, Director
Energy and Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Federal Efforts To Demonstrate Residential Solar Heating And Cooling Systems -- Past Mistakes And Future Uncertainties." Our views with respect to the text of the report and recommendations contained therein are discussed below.

The Department of Energy (DOE) acknowledges the primary findings in the draft report, that many of the demonstration projects are encountering a wide variety of performance problems, and that the problems are extensive and are undermining the promotional objectives of the program. The report does not, however, sufficiently address specific problems. It identifies several areas where program management was ineffective (e.g., inadequate goals, overly large effort, improper geographic dispersion, and a project mix bias towards multiunit demonstrations), but does not explore the constraints or the trade offs which were at issue when the decisive programmatic judgments were made. The report is critical of the program's geographic dispersion and mix, but it recognized that the underlying reason that some States received disproportionate demonstration support was that the program subordinated dispersion concerns to considerations of technical merit of the competing proposals. It then cites repeatedly that the most critical problem encountered by the program was that many demonstrated systems are neither technically reliable nor economic. The report does not attempt to weigh, or examine these conflicting objectives, but instead concludes with a recommendation to: "...require program managers to determine the number, location, and mix of solar demonstrations which would constitute an effective program."

While it is true that numerous multiunit projects reduce the diversity of specific solar designs which can be built, no offsetting consideration is given to the question of the market share of the large project developers

[See GAO note, p. 59.]

or to the economic advantages (per unit cost reductions) that can be realized through integrated projects. The recommendation that stricter selection criteria should be imposed to limit large projects is not analytically detailed in the report.

Similar areas where the report could be strengthened by a more penetrating treatment of the demonstration program record are: identifying the nature and the cost of the recommended performance correction measures; detailing the relationship between program failures, manda ted time-specific objectives, and intrinsic economic and technical limitations to active heating technology; and assessing the relationship between the failure to emphasize cost-sharing approaches and the urgency of externally imposed timing constraints.

The draft report concludes that "...demonstrations are an effective mechanism for advancing solar heating...technologies," but it notes that care must be taken to assure such technologies are ready and that demonstrations work properly; however, DOE would direct much more critical attention to the inherent tension between the imposition of timing deadlines and the effective demonstration of new technologies.

We appreciate your consideration of these comments in the preparation of the final report and will be pleased to provide any additional information you may desire. Comments of an editorial nature have been provided to members of your staff.

Sincerely,

Don C. Gestiehr

Donald C. Gestiehr
Director
Office of GAO Liaison

GAO note: Title of draft report was changed to "Federal Demonstrations of Solar Heating and Cooling on Private Residences--Only Limited Success."

(307080)

AN EQUAL OPPORTUNITY EMPLOYER

UNITED STATES
GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. GENERAL ACCOUNTING OFFICE

THIRD CLASS