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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Federal Demonstrations Of Solar Heating And Cooling On Commercial Buildings Have Not Been Very Effective

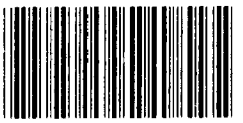
This report discusses the Department of Energy's solar demonstrations on commercial buildings program and focuses on the following questions:

--Are the solar heating and cooling projects on commercial buildings demonstrating practicality?

--How successful has data dissemination been?

--Has the solar demonstration program aided in developing a viable solar industry?

In general, GAO found that many of the projects are not operating properly and most are not cost effective. Data collection has been relatively slow, and it is doubtful that much of the information collected is reaching the target audience. Also, the Department of Energy does not know what impact its program is having in fostering development of the solar industry.



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

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

This report provides an analysis of the commercial buildings solar heating and cooling demonstration program implemented by the Department of Energy. The report includes a discussion of the objectives of the law authorizing the program and an evaluation of the success of the program in meeting those objectives.

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

Comptroller General
of the United States

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COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

FEDERAL DEMONSTRATIONS OF SOLAR HEATING AND COOLING ON COMMERCIAL BUILDINGS HAVE NOT BEEN VERY EFFECTIVE

D I G E S T

GAO reviewed the Department of Energy's program for demonstrating solar heating and cooling on commercial buildings and found that

--most projects funded under the program have not demonstrated that solar heating and cooling are practical,

--data dissemination has not been very successful, and

--the extent the program has aided in developing a viable solar industry is unknown.

MOST PROJECTS HAVE NOT DEMONSTRATED PRACTICALITY

As of July 1979, the Federal Government had spent over $44 million on 238 solar projects on commercial buildings. While these projects have provided invaluable hands-on experience for builders, installers, and others integrally involved with the program, most of the projects funded have not demonstrated that solar heating and cooling of buildings are practical--many of the projects were not operating properly and most projects were not cost effective.

Very few commercial demonstration projects were operating as designed. As of June 1979, only 104 of the 238 projects funded had been constructed and each project's related solar system started up. Of the 104 projects, 55 (or 53 percent) were either down, partially operating, or were being tested. Additionally, neither the Department of Energy nor the project owner knew how much energy many solar systems were contributing. Of those with data available, many were not providing the expected energy. (See p. 6.)

Most projects funded under the program are not economically viable. GAO's analyses showed that most projects were not expected to pay for themselves within the 3 to 5 years generally required by industry, and most projects had expected energy costs several times greater than the most expensive alternative fuel. (See p. 11.)

The program's failure to demonstrate practicality was largely attributed to the Department's lack of a definition of practicality, the absence of a strategy for supporting projects meeting that definition, and the Department's failure to emphasize cost-effective systems in choosing projects for support. Another factor was the Department's funding of projects based on sketchy design data contained in project proposals. (See pp. 9 and 14.)

DATA DISSEMINATION HAS NOT BEEN VERY SUCCESSFUL

The Department of Energy has established a data dissemination program to provide reliable, objective information to enable individuals and organizations to make decisions on the purchase and use of solar heating and cooling equipment. The data dissemination program cost for commercial demonstrations, through fiscal year 1979, exceeded $13 million. The benefits from this program thus far have been limited. Site data collection and analysis have been relatively slow, with only a few sites actually providing reportable data. Some sites will probably have no data collected. Additionally, it is doubtful that the information collected and disseminated primarily through the Department's Technical Information Center at Oak Ridge, Tennessee, is reaching much of the target audience. (See p. 20.)

EXTENT THE PROGRAM HAS AIDED IN DEVELOPING A VIABLE SOLAR INDUSTRY UNKNOWN

The Department of Energy had not translated its definition of what constitutes a viable solar industry into specific measurable

goals by which it could measure the industry's progress and develop strategies for stimulating the industry.

While the industry has grown considerably and the Department has implied in hearings and program documents that its program is generating private buying, GAO's analysis indicated the Department does not know what effects its program is having. GAO believes it is doubtful that the demonstration projects have stimulated much additional buying because most projects did not show solar energy systems to be practical. (See p. 27.)

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Because most solar projects on commercial buildings were not demonstrating that solar heating and cooling are practical and because of the large number of projects with operational problems which can serve as disincentives to the widespread use of solar energy, the Secretary of Energy should:

--Evaluate all solar demonstration projects on commercial buildings to identify the magnitude of each project's problems, what it would take to correct the problems, and the likelihood that the project will show solar to be practical. Action should be taken to correct the problems identified.

--Take specific actions to increase the likelihood of funding projects which demonstrate solar to be practical, thereby encouraging more use of solar heating and cooling. (See p. 16.)

To improve data dissemination, the Secretary of Energy should:

--Devise a means to determine the amount of energy being provided by each demonstration project. Such information is critical to evaluating the system's practicality and will also add meaning to manually collected data.

--Direct the Technical Information Center to expand its criteria for adding groups to its mailing list to ensure that more industry user groups are reached.

--Place greater emphasis on making user groups aware of the availability of data produced from demonstration projects. (See p. 25.)

Because the Department of Energy does not know whether its program is aiding in developing a viable solar industry, the Secretary of Energy should develop appropriate measurements to gauge the impact of its solar demonstrations on commercial buildings, and, if appropriate, develop alternative strategies or options, including legislative proposals, for encouraging the widespread use of solar on commercial buildings. The Secretary should present the options with probable costs and impacts to the Congress for its consideration in funding further solar programs. (See p. 32.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

Even with improvements to the program, GAO questions whether the demonstrations will promote widespread use of solar. In carrying out GAO's recommendations, the Secretary of Energy may be developing and reporting to the Congress alternative strategies for encouraging widespread use of solar heating and cooling of commercial buildings and for developing a viable solar industry. To the extent such strategies include new legislative proposals, the Congress will have to carefully weigh the costs and associated impacts of each such proposal in order to decide which are best for achieving the program's intended effect. (See p. 32.)

AGENCY COMMENTS

In its comments (see app. II), the Department of Energy agreed with GAO's recommendations with one qualification. In the Department's opinion, GAO's criticism of the economic viability of the demonstration

projects failed to take into account the intent of the Congress when it passed the Solar Heating and Cooling Demonstration Act of 1974. GAO, however, disagrees with the Department's interpretation of legislative intent.

The Department also suggested three additional recommendations concerning the premature nature of the demonstrations. GAO believes it has adequately covered the thrust of two of these recommendations and disagrees with the merits of the third.

The Department's comments and GAO's evaluation are presented beginning on page 17.

Contents

ABBREVIATIONS

DOD	Department of Defense
DOE	Department of Energy
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
MBtu	Million British thermal units
NTIS	National Technical Information Service
PRC	Planning Research Corporation
TIC	Technical Information Center

CHAPTER 1

INTRODUCTION

Recognizing that solar energy can help reduce the Nation's dependence on fossil fuels and that Federal assistance would speed up commercializing solar energy, the Congress passed the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409, September 3, 1974). The act was created to demonstrate the viability of solar energy as an alternative to conventional fuel sources and to encourage widespread use of solar. The Department of Energy (DOE) has overall responsibility for carrying out the provisions of the act.

This is our fourth report dealing with the solar heating and cooling demonstration programs. Two of our three previous reports dealt with solar demonstrations on military and private residences and discussed the limited success of these demonstrations in meeting the objectives of the act. 1/ In addition, our report on private residential demonstrations pointed out that solar cooling for the most part is not ready for demonstration because the technology is not well-advanced and is very expensive. The third report discussed, in part, the need for a comprehensive strategy and plan for guiding and integrating conservation and solar efforts for Federal buildings. 2/

Because of the problems noted in the earlier reports, we undertook this review of the commercial buildings demonstration program. Our purpose was to determine whether DOE had accomplished its objectives for the commercial buildings program. We focused our review on answering the following questions:

--Are the projects on commercial buildings demonstrating that solar heating and cooling are practical?

--How successful has data dissemination been?

1/"Solar Demonstrations on Federal Residences--Better Planning and Management Control Needed" (EMD-78-40, Apr. 14, 1978); "Federal Demonstrations of Solar Heating and Cooling on Private Residences--Only Limited Success" (EMD-79-55, Oct. 9, 1979).

2/"The Solar in Federal Buildings Program" (EMD-79-84, Aug. 10, 1979).

--Has the solar demonstration program aided in developing a viable solar industry?

PURPOSE OF SOLAR DEMONSTRATION PROGRAMS

The Solar Heating and Cooling Demonstration Act of 1974 mandated a major demonstration of solar heating technology in residential and commercial buildings by 1977, and the development and demonstration of combined solar heating and cooling technology in residential and commercial buildings by 1979. The Congress, in its deliberations on the bill to authorize appropriations to DOE for fiscal years 1980 and 1981, is considering a 1-year extension of the act.

One of the underlying objectives of the act is to stimulate creation of a viable solar industry. Demonstrations are supposed to help achieve this objective by showing that solar heating and cooling of buildings is practical, thereby stimulating demand. To promote early and widespread use of solar technology, the act directed that data on the demonstrations be disseminated to Government authorities, the building industry, the scientific and technical community, and the public.

The act gave the Energy Research and Development Administration the administrative responsibilities for the program. In 1977, these responsibilities were transferred to DOE pursuant to the Department of Energy Organization Act (P.L. 95-91, Aug. 4, 1977). 1/ The solar demonstrations are located on private and military residences and commercial and Federal buildings. While DOE has overall administrative responsibilities, programs for demonstrating solar systems on the various types of buildings have been run by different agencies, as shown on the following page.

1/For ease of expression we use DOE in this report to refer to both the Energy Research and Development Administration and DOE.

Program	Agency Conducting Program
Private residences	The Department of Housing and Urban Development (HUD)
[a/] Military residences	Department of Defense (DOD)
Federal buildings	Various agencies
Commercial buildings	DOE

[a/] DOE has evaluated its program and terminated joint efforts with DOD. DOD is carrying out a solar program under its military construction program.

According to DOE records, since the act's passage in 1974, over $286 million has been spent or obligated for the demonstration programs through fiscal year 1979.

COMMERCIAL BUILDINGS SOLAR DEMONSTRATION PROGRAM

DOE reports spending over $68 million for the commercial buildings program, of which over $44 million has been spent directly on projects.

The commercial buildings demonstration program is being carried out in a series of annual procurement cycles. The first cycle was announced in 1975. As of July 1979, four cycles had been completed, three emphasizing solar space heating and cooling systems and one emphasizing hot water systems. A fifth cycle emphasizing passive systems is nearing completion. According to DOE, negotiations are underway for funding 42 commercial buildings projects in this cycle.

In each cycle, DOE solicits proposals from the private sector and evaluates each proposal on its technical merits and the proposer's ability to carry out the project. From over 1,150 proposals, DOE has funded 214 projects; it has also assumed responsibility for 24 National Science Foundation projects. The number and dollar value of each type of system in the demonstration program are shown in the table on the following page.

DEMONSTRATION PROJECTS FUNDED
THROUGH JULY 1979

Type of solar system	No. of projects	Federal funding
Hot water	49	$ 3,919,333
Space heating	48	5,728,372
Space heating and hot water	87	14,107,042
Space cooling	1	809,767
Space heating and cooling	18	7,001,944
Space cooling and hot water	1	869,770
Space heating and cooling and hot water	34	11,868,365
Total	238	$44,304,593

SCOPE

We reviewed the relevant literature and interviewed solar equipment manufacturers, architects, engineers, and officials from solar industry associations as well as officials from DOE headquarters and their contractors. We also interviewed officials in project management offices in San Francisco, California; Chicago, Illinois; and Huntsville, Alabama. We reviewed documentation related to program management, such as program goal setting, strategy development, project selection and management, and data collection. We reviewed all commercial buildings demonstration projects by analyzing case files, status reports, and contracts, and by discussing the projects with project managers. We also visited projects and interviewed project site owners or their representatives.

CHAPTER 2

ARE THE SOLAR HEATING AND COOLING PROJECTS ON COMMERCIAL BUILDINGS DEMONSTRATING PRACTICALITY?

One of the purposes of the Solar Heating and Cooling Demonstration Act of 1974 is

> "to provide for the demonstration within a 3-year period of the practical use of solar heating technology, and to provide for the development and demonstration within a 5-year period of the practical use of combined heating and cooling technology."

While the solar projects on commercial buildings have provided invaluable hands-on experience for builders, installers, and others integrally involved with the program, most of the projects funded have not demonstrated the practicality of solar heating and cooling on commercial buildings as intended by the act. Many of the projects are not operating properly, and most projects are not cost effective.

WHAT DOES "PRACTICAL" MEAN?

Although the objective of the program was to demonstrate that solar systems are practical, neither the law nor DOE had defined "practical." A clear definition of practical seems necessary for both selecting projects and evaluating the program.

To define practical as intended by the Congress, we reviewed the legislative history of the Solar Heating and Cooling Demonstration Act of 1974. In discussing practicality, the Congress expressed two major concerns: technical feasibility and economic viability. For example, in discussing the legislation, the Congress stressed that both technical feasibility and economic viability were necessary to ensure success in the eventual public acceptance and adoption of solar energy systems. Discussions emphasized the importance of systems being reliable, durable, economical, and efficient. Thus, it is clear from the legislative history of the act that the Congress intended that solar demonstrations show both technical feasibility and economic viability to encourage widespread use of the technology in commercial buildings.

DO THE PROJECTS DEMONSTRATE THAT SOLAR HEATING AND COOLING SYSTEMS ARE TECHNICALLY FEASIBLE?

Solar industry officials and businesses we contacted agreed that technical feasibility for solar systems consists of two components: (1) capability to provide the energy expected and (2) reliability and durability.

Problems with providing expected energy

For many solar systems neither DOE nor the project owners knew how much energy the systems were contributing. However, of those systems with actual performance data available, many were not providing the expected energy.

DOE has collected performance data for a complete season from only 10 sites, 9 of which had expected energy data available for comparison. Only one system was providing close to the energy expected, four were providing close to half the energy expected, and four were providing less than half of the energy expected. The following table compares the expected energy contribution based on proposal data of the 10 solar systems to their actual contribution.

EXPECTED AND ACTUAL
GENERATION OF ENERGY BY
DEMONSTRATION SOLAR SYSTEMS

Type of project		Energy contribution (MBTU) (note a)		
BUILDING	SYSTEM	EXPECTED	ACTUAL	PERCENT
Warehouse	space heating	116	111	96
Restaurant	hot water	1403	847	60
Office building	space heating and hot water	32	18	56
Office building	space heating and cooling and hot water	437	227	52
University	space heating and cooling and hot water	2245	1140	51
School gymnasium	space heating and hot water	361	170	47
School	space heating	378	116	31
Laundry	hot water	2665	808	30
Office/warehouse	space heating	188	56	30
School	space heating and cooling	unknown	1059	unknown

a/ MBTU stands for 1 million Btus. Btu stands for British thermal unit and means the heat necessary to raise the temperature of 1 pound of water 1 degree Fahrenheit at or near its point of maximum density.

To provide greater insight into the extent to which the projects are meeting energy expectations, we contacted owners of 66 projects that had operated for over a month at the time of our review. Most of the owners did not know how much energy their systems were providing. Two owners had instruments on their systems and knew their systems were providing 75 percent or more of the amount proposed. Twenty-four (24) other owners guessed their systems were doing well. They based their guesses on utility bills for alternative fuels, the amount of time the solar system and back-up were running, or on their comparisons to other similar buildings' utility bills. Over half of the owners, however, would not hazard a guess as to how much energy their systems were providing because either they had no instruments and no data for comparison, or the systems were not working properly.

Reliability and durability problems

Although DOE has no definition of reliability and durability, the architects, builders, and solar industry personnel we contacted during our review stated that solar heating and cooling systems should fail no more often than conventional

systems and should last as long. This view was also expressed by the Congress during its deliberations prior to passage of the Solar Heating and Cooling Demonstration Act of 1974.

It is too early to say how long solar heating and cooling systems will last or what the failure rate and maintenance costs of solar systems in general will be. However, our analysis of project data indicates that DOE and its contractors have had difficulty getting solar systems to operate properly. Although much can be learned from systems that do not work well, too many projects with faulty systems can discourage solar energy's acceptance.

Very few solar systems on the commercial buildings demonstration projects are operating as designed. As of June 1979, only 104 of the 238 projects funded had been constructed and each project's related solar system started up. Of the 104 projects, 55 (or 53 percent) of the systems were either down, partially operational, or were being tested. Only 49 systems were considered by DOE to be fully operational. 1/

Many commercial demonstrations have experienced operating problems, resulting in the solar systems often not operating at all or operating only partially. The Argonne National Laboratory (a Government-owned, contractor-operated, DOE laboratory) is responsible for analyzing solar projects' reliability and durability. The laboratory's reports on 47 projects thus far have pointed out a number of problems plaguing many demonstration solar systems--system freezes, collector connection leaks, and system control failures. Approximately 30 percent of the commercial systems reviewed by Argonne have experienced freezing problems, a major obstacle to successful solar system operations. According to Argonne, to some extent freezing problems have been due to engineers' inattention to details and contractors' lack of knowledge of solar system requirements. The problem with collector connection leaks, which have occurred in over one-third of the commercial projects Argonne reviewed, was primarily due to improper materials and design. With respect to the system control failures, Argonne found a large part of the problems to be due to improper design and poor calibration of the instruments for controlling and regulating the systems' various components.

DOE, recognizing the extent of operating problems, allocated about $2 million in fiscal year 1979 to repair some of the projects with significant problems. Of the 24 projects suggested for repair by the project management offices, only

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1/DOE reports a system to be fully operational if it performs at 50 percent or more of design capacity.

about 11 have been selected to receive repair funds. Included in the criteria for receiving repair funds was the amount of money required, willingness of the owner to cost-share, and the degree of confidence that the project would work after the money was spent. According to DOE officials, any further funding of repairs is uncertain.

We noted that the projects not repaired by DOE may not be repaired at all because some owners are either unable or unwilling to provide the necessary funding. For example, pipe leaks in January 1979 shut down a $325,000 demonstration project on a university field house. According to a university official, it is doubtful that the university will fund the necessary repairs without DOE assistance, so the project's solar system will remain inoperable.

We believe leaving inoperable solar systems, especially on commercial buildings which by their nature normally have high public visibility, can impede stimulation of the solar market. Such an impediment is exactly opposite the goal of the demonstration program under which these projects were funded. We believe the worst possible situation would be leaving a solar system inoperable for an indefinite period, thereby creating a public perception that solar does not work. Such a perception would obviously serve to discourage the widespread use of solar.

Reasons for more projects not demonstrating technical feasibility of solar energy systems

DOE has selected for funding some very complex systems. Some systems used designs and components more appropriate to development than to demonstrations. We believe these complex systems caused many of the problems DOE has encountered in demonstrating feasibility and were selected because DOE had no clear definition of practicality nor a strategy for demonstrating practicality. Another factor contributing to problems is that DOE made selections based on sketchy design data.

DOE selected some very complex systems, even in the first years of the program. For example, one-third of the projects funded in the first cycle of commercial demonstrations involved the least proven type of collector 1/ for the most complex application--cooling. Of the total cost of the projects

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1/The least proven type collector being marketed is the tracking, concentrator collector. It tracks the sun and concentrates the energy.

in the first cycle, about one-half was for cooling systems. Moreover, about one-half of the funds for projects in the first four cycles has been for the least-proven collectors, for cooling systems, or for a combination of both. According to DOE's project managers, the complexity of the collector and application contributed greatly to the nature and severity of problems experienced.

Many of the more complex systems should have been in a development program, not in a demonstration because the technology was not yet proven. The purpose of development programs usually is to bring systems at various levels of design maturity to the point of being marketable for widespread use. When marketable, the system would be a candidate for a demonstration program. Our analysis showed a number of system designs which appeared more suitable for a development program, such as the two large cooling systems selected in the first cycle which have experienced numerous problems. In one case, DOE actually transferred the demonstration project on which it had already spent over $500,000 to a development program, where DOE will be funding the cost of new collectors. Other demonstration projects also employ the more complex and least proven solar technologies, which are characteristics more suitable for a research and development program than demonstration.

We believe DOE selected these complex systems because it did not develop a clear definition of practicality nor a strategy for demonstrating practicality. DOE officials told us that they assumed the Congress intended DOE to fund more sophisticated systems with each cycle in order to learn more about solar-powered systems. Our examination of the act and the legislative history leads us to believe that congressional intention was definitely to demonstrate solar-powered systems' practicality to encourage widespread use. DOE's assumption of funding progressively sophisticated systems is not necessarily compatible with demonstrating practicality. We believe had DOE considered the ultimate objective of the program as specified in the law, it would not have selected such complex systems.

Another factor which contributed to selecting projects which may not demonstrate practicality is the inadequate data available to DOE at the time of selection. Detailed data are needed to ensure the project will work. DOE advised us that it is unreasonable to ask private companies to present very detailed designs for projects which may never be built. In fact, they said the cost involved in preparing detailed designs would make it almost impossible for smaller organizations to submit proposals. However, sketchy design data makes evaluation more difficult. Several of the DOE proposal

evaluators told us that most proposers submit inadequate design data. Yet DOE requires that projects be selected for funding from that data.

DO THE PROJECTS DEMONSTRATE THAT SOLAR HEATING AND COOLING SYSTEMS ARE ECONOMICALLY VIABLE?

Widespread use of solar technology depends on whether the systems are economically viable. Even DOE officials have stated in congressional hearings that the cost competitiveness of solar heating and cooling systems is, in the final analysis, the basic factor which will determine whether a viable solar energy industry will exist without Federal subsidies. Most projects funded in the commercial demonstration program, however, are not economically viable because the selection process did not emphasize cost effectiveness. In addition, a large percentage of the proposals from which DOE had to select were not cost-effective.

Solar heating and cooling systems are capital intensive, requiring a larger initial investment than conventional systems. Once the system is in place, however, alternative fuel costs should be much less. There are many ways of comparing the economics of solar heating and cooling to conventional systems. We evaluated the solar demonstration projects on commercial buildings using two different techniques: (1) a payback analysis, which is a technique often used by industry to calculate the number of years it will take to recover the cost of the system and (2) an analysis of the cost per MBtu of energy delivered by solar versus the alternative energy source, which is a technique used by DOE.

Number of years to payback

Number of years to payback is an analysis frequently used by industry and is calculated by dividing annual savings into the system's cost. Acceptable payback periods varied greatly according to those businesses with which we discussed solar technology. Responses ranged from 1 year to the life of the equipment. However, DOE officials, solar industry representatives, and builders stated that businesses generally require a 3- to 5-year payback period when making decisions on solar energy systems.

During its evaluation of proposals, DOE computed an expected payback period for 129 of the 238 projects, excluding any escalation of fuel prices and assuming that the systems would work as the proposers described. Some proposals did not include enough data to compute payback.

Of the 129 projects for which the payback period was computed, about half were not anticipated to pay for themselves during their expected lives, which is generally considered to be 20 to 30 years. None of the systems was expected to meet the 3- to 5-year payback generally accepted by industry, and only 5 percent of the projects had paybacks in less than 7 years. Some systems, however, such as those for providing hot water, had more favorable payback periods than others. For example, over 90 percent of the hot water systems with data available were expected to pay for themselves in less than 30 years; 16 percent in less than 7 years.

Actual performance data was available for six projects. These projects had been instrumented and both the solar system and instruments had been operating properly for at least one season. We calculated the payback period for each of these projects using the actual annual savings. As part of our calculations, we escalated the savings 10 percent annually for 10 years and 5 percent for each year afterward to allow for increases in fuel prices and made no adjustment in savings for maintenance. Although the calculations show five of the six projects had payback periods of less than 30 years, none show payback periods even close to the 3- to 5-year criteria businesses usually look for.

PAYBACK PERIOD FOR SOLAR DEMONSTRATION PROJECTS ON WHICH ACTUAL DATA WAS AVAILABLE

Type of Project				
Building	System	Actual cost	Annual savings (note a)	No. of years to payback
Warehouse	space heating (passive) [b]	$36,598	$682	20
Office building	space heating and hot water	17,366	174	28
School gymnasium	space heating and hot water	94,541	1197	25
Laundry	hot water	233,365	3180	24
Restaurant	hot water	297,782	4235	23
Office building	space heating and cooling and hot water	494,219	2656	38

[a] Annual savings are increased each year to allow for fuel price escalation of 10 percent each year for the first 10 years and 5 percent each year thereafter. No maintenance costs are estimated.

[b] Passive systems rely primarily on architectural design to heat and cool buildings.

Comparison of cost per MBtu of energy delivered by solar versus alternative energy sources

Another way to determine whether solar is economically viable is to compare the cost per MBtu for solar to other energy alternatives. DOE uses this analysis in presenting data about its projects, and some analysts have concluded that this comparison is the best criterion for deciding when to invest in solar technology because, in their opinion, the optimal time to invest in a solar heating and cooling system is when the unit price of solar energy is equal to or less than that of conventional fuel.

A contractor for DOE developed a formula for comparing the cost per MBtu of solar to other energy sources. The formula calculates the first-year solar energy cost by computing an annual cost for the capital investment and adding insurance, maintenance, interest, and depreciation as a fraction of the required capital investment. Taxes are considered in the formula when the tax rate of the company is known or can be assumed. This total annual cost (before and after tax) is then divided by the amount of usable energy produced by the system during the year to compute the cost per MBtu. The cost per MBtu of solar can then be compared to the cost per MBtu of alternatives.

To determine how solar energy costs for the demonstration projects compare with the cost of alternative fuels, we used the before tax formula discussed above and computed the expected cost per MBtu for each project funded, based on the MBtu amounts that designers expected their solar systems to contribute. The costs of alternative energy sources vary geographically, but the Department of Labor reports a range of $4.92 to $5.12 for fuel oil, $11.70 to $18.69 for electricity, and $2.80 to $4.80 for natural gas. Of the 238 projects, only six had expected costs per MBtu under $10, and only 26 projects had expected costs per MBtu ranging from $11 to $20. Of the 189 projects with expected costs per MBtu greater than $20, 96 projects' costs are expected to exceed $50 per MBtu. The proposal data for 17 projects was not adequate for computing the expected costs per MBtu. Comparing even the highest costs of alternative fuels to solar energy makes solar unattractive in most cases.

Actual MBtus delivered and actual cost of the alternative fuel were available for six demonstration projects. As shown in the following table, in every case solar energy is much more expensive than the alternative fuel--at least seven times more expensive.

COMPARISON OF COST PER MBTU OF SOLAR TO ALTERNATIVE FUELS FOR PROJECTS WITH ACTUAL DATA AVAILABLE

Type of project		Type alternative fuel (note a)	Cost per MBTU of alternative (before tax)	Cost per MBTU solar (before tax)
Building	System			
Warehouse	Space heating (passive)	Oil	$5.50	$39.00
Office building	Space heating and hot water	Natural gas	4.70	62.00
Gymnasium	Space heating and hot water	Propane	8.80	91.00
Laundry	Hot water	Natural gas	4.00	39.00
Restaurant	Hot water	Natural gas	5.00	46.00
Office building	Space heating and cooling and hot water	Electricity	11.70	287.00

a/ The type alternative fuel is the fuel which would have been used in place of solar.

Why projects are not economically viable

Since economic viability plays such a large part in determining whether demonstration projects will stimulate private investment, it should have been emphasized heavily in the selection process. While DOE gave economic viability some consideration, it did not emphasize this attribute when scoring proposals in the selection process. Also, some rejected proposals were more cost effective than those selected. However, the majority of proposals submitted by industry were for projects which were not economically viable.

DOE did solicit cost-effective proposals in two of its requests for solar heating and cooling demonstration projects. However, our analysis of DOE's rating system for proposals showed that economic viability was not considered in scoring the proposals, although officials said it was considered qualitatively in its process of choosing projects. We believe DOE should have placed greater emphasis on this

criteria and given greater weight to it during its selection process. DOE's failure to emphasize economic viability may have caused it to reject proposals for cost-effective projects. We noted for example that in the fourth cycle of procurements, 46 rejected projects had paybacks of less than 20 years, and 4 of those had paybacks of less than 10 years, one of which had an expected payback of 4 years.

Industry responses to DOE's four procurement cycles yielded project proposals with paybacks of from 1 year to over 999 years. The majority of these were not economically viable. For example, 52 percent of the proposals submitted for the fourth cycle of demonstrations had estimated payback periods exceeding 50 years. Thus, the results of the program and data in proposals indicate strongly that solar heating and cooling for commercial buildings is not economically viable in terms of meeting industry's preferred 3- to 5-year payback period or of competing with the cost of alternative fuels.

DOE officials told us that they believe the projects they have funded are representative of the systems available to the public in terms of cost and performance. Therefore, it appears to us that for most systems and applications, solar heating and cooling for commercial buildings is not economically viable: Our analyses of DOE projects shows that only hot water and a few heating systems are. However, we believe had DOE emphasized cost effectiveness, industry might have been induced to come up with cost-effective systems.

CONCLUSIONS

While the solar projects on commercial buildings have provided invaluable hands-on experience for builders, installers, and others integrally involved with the program, most of the projects funded have not demonstrated that solar heating and cooling of buildings is practical--many of the projects are not operating properly, and most projects are not cost effective.

Very few commercial demonstration projects are operating as designed. As of June 1979, only 104 of the 238 projects funded had been constructed and their systems started up. The solar systems on 55 of those projects, or over 53 percent, were either down, partially operational, or being tested. For many systems neither DOE nor the project owner knew how much energy the solar system was contributing. Of those with data available, many were not providing the expected energy. Only 10 instrumented projects have been working properly long enough to publish complete seasonal data. Of these 10 projects, 9 had data available on expected

energy. Only one of the nine solar systems was providing close to the expected energy.

Most projects funded in the commercial buildings demonstration program are not economically viable. We analyzed the projects using (1) a payback analysis, which is a technique often used by industry, and (2) an analysis of the cost per MBtu of energy delivered by solar versus the alternative energy source, which is used by DOE. Of the six projects for which actual cost data was available, none of the systems was cost effective using either analysis. Using the proposal data for the projects funded and applying the same analyses, most projects do not pay for themselves within the 3- to 5-year payback period usually expected by industry, and most have a cost per MBtu several times greater than the most expensive alternative fuel.

We identified several factors that hampered the projects' demonstrating practicality, such as (1) DOE's lack of a clear definition of practicality, which caused DOE to select very complex systems, (2) DOE's selection of projects based on sketchy design data, (3) DOE's lack of emphasis on economic viability when soliciting and evaluating proposals, and (4) the poor cost effectiveness of most proposals submitted by industry.

We believe had DOE better defined practicality and placed greater emphasis on those characteristics when soliciting and evaluating proposals, it would have increased its chances of demonstrating solar's practicality for commercial buildings. We recognize that requiring detailed design data to allow evaluation of the characteristics critical to practicality could place an additional burden on the proposer and discourage responses. We believe, however, there are ways to minimize this burden and maximize information available to DOE. One way is to fund the proposals in stages, whereby proposals are first screened, some are funded for detailed design work, and only those which can demonstrate practicality based on a review of the detailed design data are funded for construction. This would eliminate the problems inherent in the current practice of committing total project funds based on limited or sketchy designs.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Because most solar demonstration projects on commercial buildings are not demonstrating that solar heating and cooling is practical and because a large number of projects with operational problems can serve as disincentives to widespread use of solar energy, we recommend that the Secretary:

--Evaluate all solar demonstration projects on commercial buildings to identify the magnitude of each project's problems, what it would take to correct the problems, and the likelihood that the project will show solar to be practical. Projects should then be categorized into those projects requiring no assistance, those which should be repaired or modified, those which are not ready for demonstration and need further research and development, and those which should be dismantled. Action should then be taken to correct the problems identified.

--Increase the likelihood of funding projects which demonstrate solar to be practical and thereby encourage more use of solar heating and cooling by such actions as:

1. Defining precisely what characteristics the projects should have to ensure they show solar energy systems to be practical. Such characteristics should include specific criteria for demonstrating technical feasibility in terms of amount of expected energy, and system reliability and durability, as well as economic viability. Such characteristics should be emphasized when requesting proposals and in evaluating such proposals prior to project selection.

2. Considering funding projects in two phases. In the first phase, DOE should fund the detailed design work for those proposals that look most promising. Detailed designs should be critically reviewed, and funding for construction (second phase) should be based on whether the detailed design indicates the system will demonstrate that the solar energy system proposed is practical.

AGENCY COMMENTS AND OUR EVALUATION

In its formal comments on our draft report (see app. II), DOE agreed with all our recommendations with one qualification. In DOE's opinion, our criticism of the economic viability of the demonstration projects failed to take into account the intent of the Congress when it passed the Solar Heating and Cooling Demonstration Act of 1974. To substantiate its opinion that the Congress did not intend demonstrations to be aimed at those systems that were economically viable as defined by industry, DOE pointed to (1) passages in the act which referred to the necessity for research, development, and

testing on some solar energy systems and (2) the Military Construction Authorization Act of 1979.

We disagree with DOE's position. As discussed on pages 7 and 8 of our report, we reviewed the legislative history to clarify congressional intent. That review showed that the Congress clearly intended economic viability to be emphasized in demonstration projects in order to encourage widespread use of solar energy systems. In our opinion, the reason the act mentions some aspects of solar energy systems still requiring research and development is to give logic for the other programs called for in the law (such as the development in support of the demonstrations program), not to imply that uneconomical systems should be demonstrated.

While there may be some validity to DOE's concern that emphasing cost effectiveness would eliminate most systems from the program, we believe DOE could have taken steps to prevent this. For example, as stated on pages 14 and 15, had DOE emphasized cost effectiveness during its solicitation and review of proposals, more cost-effective systems may have been proposed and funded.

The Military Construction Authorization Act cited by DOE requires DOD to use solar energy systems in all military housing and some construction projects if the systems pay for themselves over the related facilities' expected lives. The life cycle cost criterion suggested, therefore, applies to Federal facilities. It is widely recognized, however, that most of private industry requires shorter paybacks on capital intensive projects than the Federal Government. We believe the criteria for cost effectiveness should be the criteria stated by the potential users of the systems, not the asserted criteria contained in another piece of legislation that was aimed at a different target group.

Also in its comments, DOE suggested three recommendations to deal with the premature nature of the demonstrations: (1) placing greater emphasis on research and development, (2) field testing on systems and components which successfully pass the research and development stage, and (3) limiting systems in the demonstration program to those nearly competitive with conventional systems in terms of performance, reliability, and economics. We believe the thrust of DOE's recommendations for more research, development, and field testing of systems in the demonstration program are adequately covered by our recommendations contained in this chapter. In that chapter, for example, we are recommending that DOE evaluate each project and move into a research and development mode those projects which are not yet ready for demonstration.

We believe, however, that the projects requiring more research, development, and testing should not have been selected for the demonstration program in the first place; they were more appropriate for DOE's research and development, or development in support of demonstrations, program.

We disagree with DOE's suggested recommendation that systems selected for the demonstration program should be limited to those nearly competitive with conventional systems. Supporting some nearly competitive systems may have merit, particularly where careful evaluations show that they have excellent prospects for becoming competitive in the short term. However, the thrust of DOE's suggestion would exclude those systems that are clearly competitive with conventional systems. We believe the primary focus of the program should be on selecting systems that demonstrate solar energy's competitiveness in terms of performance, reliability, and economics in order to encourage the widespread use of solar. Demonstrations showing anything short of competitiveness will most likely cause potential users to delay their investments in solar heating and cooling.

CHAPTER 3

HOW SUCCESSFUL HAS DATA DISSEMINATION BEEN?

The Solar Heating and Cooling Demonstration Act of 1974 requires DOE

> "* * * to assure that full and complete information with respect to the demonstrations * * * is made available to Federal, State, and local authorities, building related industries, scientific and technical communities, and the public at large."

To carry out this objective, DOE has established a data dissemination program which is to provide individuals and organizations with reliable, objective information on which to base decisions concerning the purchase and use of solar heating and cooling equipment. DOE's practice is to publish both favorable and unfavorable data on projects because it provides the full information necessary to help people make knowledgeable decisions on solar energy use.

The data dissemination program for commercial demonstrations, through fiscal year 1979, has cost more than $13 million. The benefits from this program thus far have been limited. Site data collection and analysis have been relatively slow, with only a few sites actually providing reportable data. Some sites will probably have no data collected. Additionally, it is doubtful that the information collected is reaching much of the target population.

DESCRIPTION OF DATA COLLECTION

Project information is gathered through two means: (1) instruments which automatically collect environmental and system operational data and (2) manual reports on system description, construction costs, and maintenance data. Both types of data are necessary for fully understanding the cost and performance aspects of a solar system. DOE plans to instrument less than half of the commercial demonstration projects and had initially planned to collect manual data from all projects.

At instrumented sites, data are collected automatically every 5 minutes on cassettes and transmitted once a day to a computer system. Measurements taken by instruments include total sunshine and temperatures for the outside air, the building, the storage units, and the collectors. For each

instrumented site, monthly and seasonal performance reports are prepared describing how well the components are working and how much energy is being delivered.

Manual data are collected at various points throughout a project's construction and operation, as described in appendix 1. Most of the data are collected either by the Planning Research Corporation (PRC), a DOE contractor, or the site owners, and are analyzed by PRC. The rest of the data are collected and analyzed by the Argonne National Laboratory. The two primary reports developed from this manually collected data are the Solar Project Description Report and the Solar Project Cost Report.

The cost of the commercial demonstration data program has been relatively high, exceeding $13 million--or one-fourth the cost to DOE for the projects themselves. The most expensive component of the data program is collecting instrumented data. Site instrumentation cost, according to a DOE official usually runs about $39,000 to $53,000 per site, but has gone as high as $90,000. Data collection and dissemination costs through fiscal year 1979 for commercial demonstrations are shown below:

	Cost (thousands)
Instrumented data	$10,060
Manual data	1,919
Data dissemination	1,484
Total	$13,463

FEW PROJECTS ARE PROVIDING REPORTABLE DATA

Our review indicated that many demonstration projects may never have data published about them. Because of cost and other difficulties in getting reliable data, less than half the projects are planned to be instrumented, and based on DOE plans and priorities, many may never have manual data collected.

One of the most important data elements needed to determine whether a solar-powered system is "practical" is a measure of the energy contributed by that system. DOE will probably not know the actual energy contribution of more than half its commercial demonstration projects. Instruments are necessary to make such a determination, but because instrumented

data are so expensive to obtain, DOE plans to instrument no more than 100 of its 238 projects.

DOE has collected and published instrumented data on only about 11 percent of all commercial demonstrations since the first commercial demonstration project was funded over 4 years ago. A total of 67 sites have been selected so far for instrumentation. Of these, 41 actually have instruments installed. However, data resulting in monthly performance reports has been collected from only 27 of these sites. As of March 1979, 201 monthly performance reports had been published, 55 percent of which covered only 7 sites. In fact, only 15 demonstration sites have had at least 6 performance reports published.

Not only have the majority of the monthly performance reports come from relatively few projects, but published performance data from many projects have been sporadic. For example, during the 3-month period from January to March 1979, monthly performance reports were published for only 14 of the 41 instrumented projects in each of the 3 months. The number of projects for which reports are being consistently published is small because it has been difficult to keep the solar-powered systems working well long enough to collect reliable data. In fact, DOE is planning to cancel instrumentation on 16 commercial projects, 10 of which have already been instrumented, because of solar system and/or instrument problems and increasing program costs.

DOE has had poor progress in collecting and publishing reports from manual data. As of May 1979, manual data had been collected for almost 30 projects but reports had been published for only 8 projects. The criteria for publishing reports from data collected manually is that the project have three or more consecutive monthly performance reports published from instrumented data. DOE told us that progress was slow because it funded the data collection program at a lower level than anticipated, and within the data collection program, DOE gave priority to instrumented data. DOE officials agreed that if the present level of emphasis is continued, it is possible that there will be many commercial demonstration projects which will have no reports published on them.

Limited data has been published on the reliability of solar-powered heating and cooling systems. As of May 1979, Argonne National Laboratory had published only two such reports and was preparing four others. Having received maintenance data from only three sites, the two published reports were based on alternative information sources, such as DOE project managers, conference proceedings, and contractor

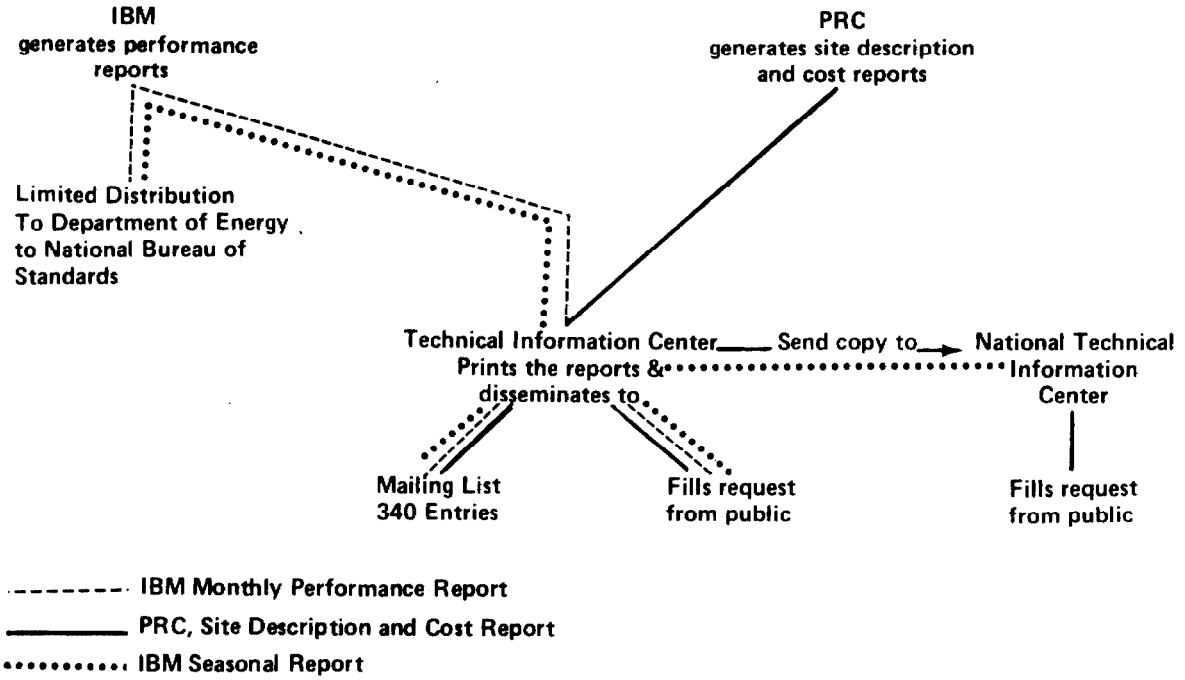
reports. Also, Argonne personnel visited numerous sites to evaluate solar energy systems' reliability.

DOE'S TARGET AUDIENCE MAY NOT BE GETTING THE DATA

As mentioned previously, the Solar Heating and Cooling Demonstration Act of 1974 specifies that demonstration data be made available to key groups influencing the solar industry. DOE has identified a target audience for the information it is generating. It is doubtful, however, that certain groups such as architects, engineers, building owners, and plumbers are receiving data or are aware that the data about commercial projects are available.

Although DOE disseminates commercial demonstration data through distribution centers, conferences, workshops, trade associations, and journals, its Technical Information Center (TIC), which is a Government-owned facility located in Oak Ridge, Tennessee, is DOE's primary medium for disseminating data about commercial demonstration projects. TIC is aided by the National Technical Information Service (NTIS), which is part of the Department of Commerce in Springfield, Virginia. The following figure illustrates the dissemination of commercial demonstration project reports.

CHANNELS FOR DISSEMINATING COMMERCIAL DEMONSTRATION DATA



TIC is responsible for bulk distribution of data about commercial projects and receives all relevant reports. According to TIC officials, it usually prints 400 to 500 copies of each report about a commercial demonstration project and uses a mailing list to distribute about 340 copies. The remainder are distributed on request. TIC fills all requests for monthly performance reports of individual commercial demonstration projects. Requests for other information, such as descriptions of commercial projects, and seasonal performance reports, are forwarded to NTIS after TIC distributes the amount initially printed.

Our analysis shows that many identified user groups are not receiving data about the commercial projects and may not be aware of the available data. TIC's mailing list is composed primarily of Government agencies and Government contractors; over 50 percent of the mailing is to Government agencies. In fact, many of the target groups cannot get on the mailing list since TIC requires all mail recipients to be either a Government agency or Government contractor. The exceptions are those entities DOE adds to the list because DOE believes it would be in the Government's best interest

to include them. The reason for this limitation is the lack of resources at TIC to handle numerous mailouts. Although there are probably thousands of companies that have an interest in solar energy and what is being learned from the demonstration projects, TIC has distributed less than 160 performance reports to private companies.

According to the NTIS officials, they do not advertise information on the commercial solar projects until after they receive the report from the TIC. As of July 1979, the NTIS stated that it had distributed only one copy each of four reports on the commercial solar demonstration projects.

Conferences and workshops sponsored by DOE have reached a number of user groups in DOE's target audience. However, these conferences and workshops are limited in number and can inform only a small percentage of each group. A DOE official said that, even though trade associations and journals are excellent mechanisms for promoting data use, they have not been actively pursued by DOE; however, DOE plans greater use of these mechanisms.

CONCLUSIONS

Disseminating data from commercial demonstration projects thus far has had limited benefits. Few sites have consistently produced reportable instrumented data and even fewer have had sufficient manual data collected to produce reports. It is likely that many commercial demonstration projects will never have data published about them. In this connection, we noted that DOE plans to have less than half of the projects instrumented and many projects may never have manual data collected. Also, the data being collected and published are not reaching a majority of intended industry user groups. TIC, DOE's primary means of disseminating data, distributes primarily to Government related entities, with only limited distribution, upon request, to others.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Although making more projects operational should improve the flow of data from demonstration projects, we believe further improvements are needed. To further improve the data dissemination program, we recommend the Secretary of Energy to:

--Devise a means to determine the amount of energy being provided by each demonstration project. Such information is critical to evaluating the system's practicality and will also add meaning to the manually collected data.

--Direct TIC to expand its criteria for adding groups to its mailing list to ensure that more industry user groups are reached.

--Place greater emphasis on making user groups aware of the availability of data produced from demonstration projects.

CHAPTER 4

HAS THE SOLAR DEMONSTRATION PROGRAM AIDED IN DEVELOPING A VIABLE SOLAR INDUSTRY?

One of the underlying objectives of the Solar Heating and Cooling Demonstration Act of 1974 is to encourage private industry to produce solar equipment. However, the Congress recognized that industry would not produce the equipment unless it were convinced that an adequate market existed. A successful, highly visible demonstration program was supposed to help create a viable solar industry by stimulating demand for solar systems. A general criterion for judging the success of demonstration programs is whether the demonstrations resulted in use of the innovation at other sites.

DOE has changed its definition of a viable solar industry several times but has never translated its definition into specific measurable criteria. Additionally, DOE has not established any mechanism for measuring the commercial building program's impact on the solar industry. While the industry has grown considerably and DOE has implied that its program is generating private buying, our analysis indicates DOE does not know what effect its program is having.

WHAT IS A VIABLE SOLAR INDUSTRY?

A clear definition of a viable solar industry encompassing specific measurable criteria would help DOE assess progress of the industry and develop strategies for stimulating the industry. DOE has changed its definition of a viable solar industry several times, but at no time has it translated the definition into specific measurable criteria and related it to what is expected from the commercial buildings demonstration program.

DOE's definition of viable solar industry has ranged from describing characteristics of the industry to specifying desired energy contributions of the industry. To illustrate, the program document for solar heating and cooling of buildings, "National Program for Heating and Cooling of Buildings" (November 1976), defined a viable solar energy industry as

> "* * * one which has cost-effective solar heating and cooling systems for an increasing range of building designs, has a solar energy system"

"production growth rate commensurate with energy savings objectives, is financed by private capital, and has definitive solar system standards in effect."

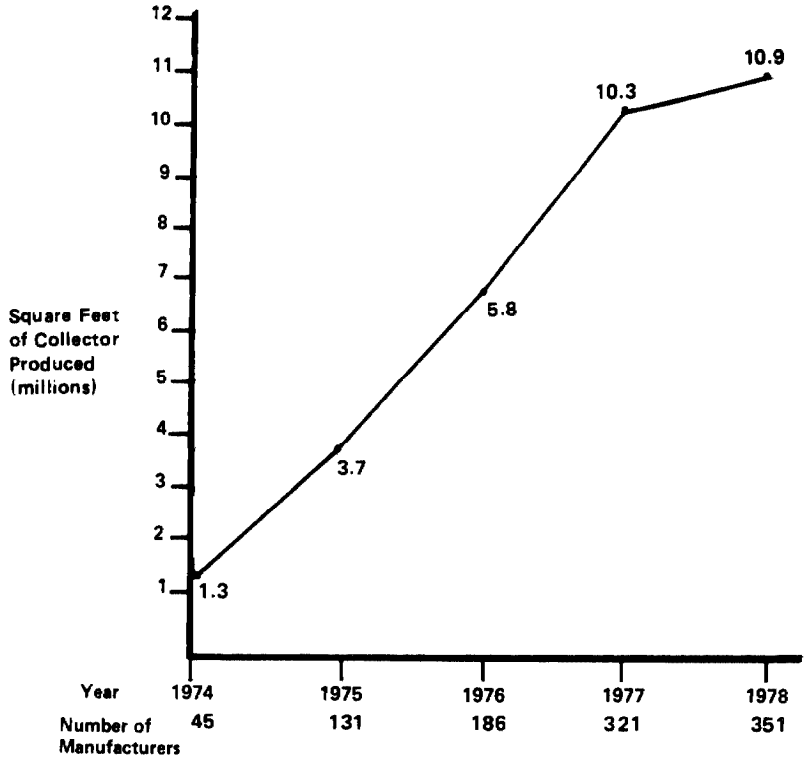
In its latest program document, "National Program for Solar Heating and Cooling of Buildings" (July 1978), DOE stated that industrial viability for the solar business means the solar industry could supply a reasonable percentage of the Nation's energy demand--10 percent by the year 2000. In neither case did DOE develop measurable criteria or the mechanisms necessary to assess program achievements so that plans could be altered as necessary. Although the latest definition contains a specific measurable criterion, it is long-range and DOE has not established any interim measure of industry development or of what specifically is expected from the demonstration program.

WHAT HAS HAPPENED TO THE SOLAR INDUSTRY SINCE 1974?

The production of solar collectors has grown dramatically, and the average number of square feet of collector produced per manufacturer has been steadily rising. However, only a small percentage of new commercial buildings are installing solar systems.

Production of solar collectors has increased more than eightfold since 1974. The following figure charts the square feet of collector manufactured during the period from 1974 through 1978.

ANNUAL SOLAR COLLECTOR PRODUCTION



Source: "Solar Collector Manufacturing Activity," U.S. Department of Energy, Energy Information Administration (DOE/EIA-0174) September 1979.

According to DOE, the annual average production by each manufacturer has increased from 28,000 square feet in 1974 to about 31,000 in 1978. A large percentage of the production was for low-temperature collectors, which are used primarily for heating swimming pools.

Although production of solar collectors has increased dramatically, there are indications the use of solar on commercial buildings is minimal. The Bureau of the Census is sampling annually for DOE the new commercial buildings to determine the number which have solar equipment installed. The Bureau projected from its sample in 1978 that of the 133,174 non-residential buildings constructed, only 215--or about 0.16 percent --had solar equipment. The year 1978 is the only year for which a full year of data was available.

WHAT EFFECT HAS THE COMMERCIAL BUILDINGS SOLAR DEMONSTRATION PROGRAM HAD ON THE INDUSTRY?

DOE has not developed a mechanism for measuring its program's impact on the industry. DOE has implied in hearings

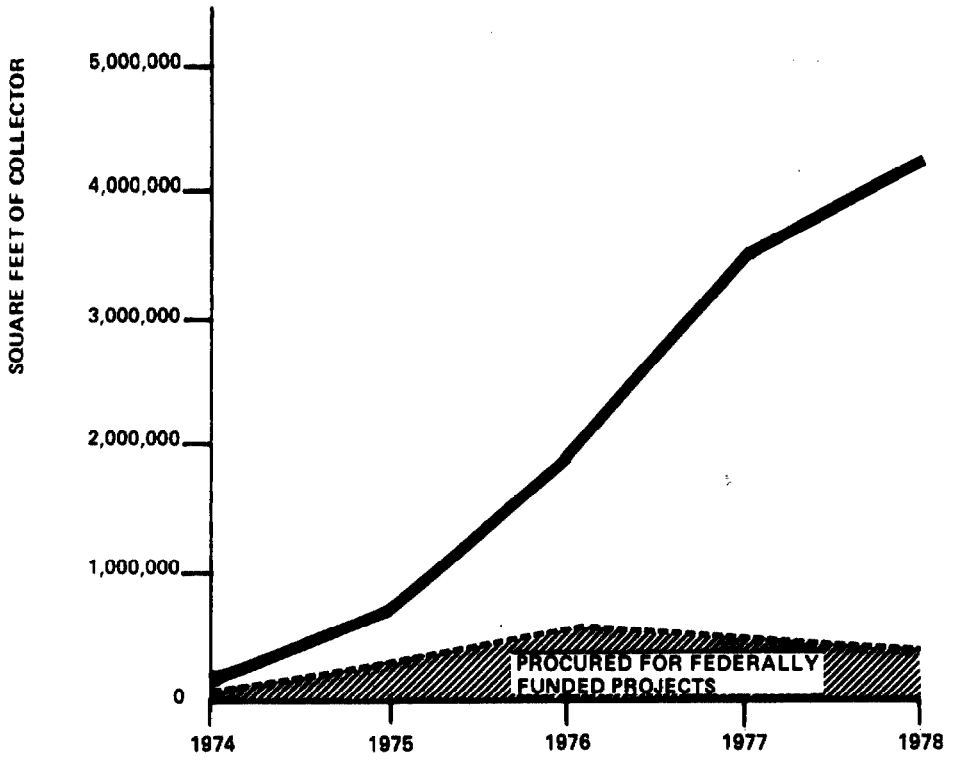
and program documents that, for every $1 it spends on the solar heating and cooling demonstrations, it is generating $10 in private spending. Our analysis indicates this is misleading. Benefits have accrued from the program--experience gained by participants in the program and partial subsidization of the purchase of a large volume of solar collectors--but DOE does not know whether the program has induced any additional buying.

A study done by PRC for DOE in 1976 recommended that DOE's management plan for the commercial buildings demonstration program include a technique for determining the amount of market penetration directly ascribable to the program. PRC also recommended a rigorously designed statistical survey to estimate the effectiveness of the program in influencing purchasing decisions. DOE did not act on PRC's recommendations.

DOE has stated that a solar energy industry would eventually develop without a Federal program because solar heating and cooling is technically feasible and because alternative fuel prices are expected to continue to rise faster than inflation. Its program, therefore, is designed to accelerate development of a solar industry. In the 1979 appropriation hearings and in DOE's latest program document, "National Program for Solar Heating and Cooling of Buildings" (July 1978), DOE states that

> "* * * program results can be measured [by] the further application of the technology in privately financed construction. Based on this measurement, the program has been successful. Studies indicate that for each Federally-financed project, there may be as many as 10 privately financed projects."

The implication made here, and by DOE during hearings, is that the Federal spending has induced the private spending. However, we found no study to support DOE's position. In fact, DOE has no mechanism for determining its program's impact. In discussing this with DOE, we found that DOE's statements were based solely on a comparison of the amount of collectors bought by DOE's residential and commercial demonstration programs to the total amount of collectors sold. The following figure is a reproduction of the graph used by DOE to support this point.



Source: DOE's graph comparing private and Federal purchases of collectors

Although the area under the broken line in the graph is labelled as "federally funded projects," it is actually just the "square feet of collectors" purchased by the residential and commercial buildings demonstration program. Much of what purports to be private spending is actually Federal money--but in other programs. For example, the Department of Labor, the Tennessee Valley Authority, and numerous other agencies have programs under which solar collectors are purchased; even DOE has other programs. Yet, even if there were no errors in the graph, no causal relationship has been established between DOE's spending and private spending; private spending may have taken place in spite of DOE demonstrations, not because of them. In fact, we believe it is doubtful that the projects funded have stimulated much additional buying because, as shown in chapter 2, most of the projects do not show solar-powered systems for commercial buildings to be practical.

CONCLUSIONS

DOE has not established specific measurable goals for the program, which we believe would help DOE assess progress of the industry and develop strategies for stimulating the industry. DOE has not established any mechanism for measuring its program's impact on the solar industry. While the industry

has grown considerably and DOE has implied its program is generating private buying, our analysis indicates DOE does not know what effect its program is having. We believe it is doubtful that the projects funded have stimulated much additional buying because, as shown in chapter 2, most of the projects do not show solar-powered systems to be practical.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Because DOE does not know whether its program is aiding in developing a viable solar industry, we recommend that the Secretary of Energy develop appropriate measurements to gauge the impact of its solar demonstrations on commercial buildings. The measurements should be developed from a clear definition of program goals. If DOE finds that the demonstrations are not having the intended effect, the Secretary of Energy should develop alternative strategies or options, including legislative proposals, for encouraging the widespread use of solar on commercial buildings. The Secretary should present the options with probable costs and impacts to the Congress for its consideration in funding further solar programs.

MATTERS FOR CONSIDERATION BY THE CONGRESS

DOE does not know to what extent its program results in developing a viable solar industry. In addition, as discussed in chapter 2, many of the projects funded in the program have failed to demonstrate practicality of solar heating and cooling on commercial buildings and, as such, it is very doubtful that the program will lead to widespread use of solar.

We are making recommendations to the Secretary of Energy which should improve DOE's solar demonstrations on commercial buildings. However, even with improvements, many solar projects funded under the program may not demonstrate practicality and, consequently, may not promote widespread use of solar heating and cooling systems on commercial buildings. Therefore, we are recommending that the Secretary of Energy periodically measure the impact of the solar demonstration projects. If DOE finds the demonstrations are not having their intended effect, we are recommending the Secretary of Energy develop and report to the Congress alternative strategies for encouraging widespread use of solar and developing a viable solar industry. Such strategies could include new legislative proposals. In that event, the Congress will have to carefully weigh the costs and associated impacts of each proposal in order to decide which are best for promoting widespread use of solar heating and cooling of commercial buildings.

APPENDIX I

DESCRIPTION OF DATA COLLECTED MANUALLY

Type Data	Description
Building and Solar System Design	Provides description of the project site, building, solar system and various subsystems such as the collector and storage. This data is collected once, generally after the project is operational.
Solar System Construction	Includes any legal, financial, or construction installation problem experienced and a relatively detailed breakdown of the solar system cost. This information is obtained once, generally after the project is operational.
Owner/User Attitudinal Data	Gives owner/user's attitudes toward things such as managing and operating a solar system and the economic benefits of a solar system. This information is obtained from a telephone interview after the project is operational.
Purchased Energy Costs and Solar System Maintenance	Provides cost data on energy required to run and back up the solar system. It also includes information on system or component failure and each maintenance action required over a 6-month period. This data is collected monthly after each project becomes operational.

APPENDIX II

Department of Energy
Washington, D.C. 20585

FEB 1 19[illegible]

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 Demonstrations of Solar Heating and Cooling on Commercial Buildings Have Not Been Very Effective." Our views with respect to the text of the report and recommendations contained therein are discussed below.

The GAO criticism of the economic viability of the demonstration projects fails to take into account the intentions of Congress when it passed P.L. 93-409 and we quote from the act:

Sec. 2 (a) The Congress hereby finds that--

. . .

(3) the technologies for solar heating are close to the point of commercial application in the United States;

(4) The technologies for combined solar heating and cooling still require research, development, testing and demonstration but no insoluble technical problem is now forseen in achieving commercial use of such technologies;

. . .

(10) evaluation of the performance and reliability of solar heating and combined heating and cooling technologies can be expedited by testing under carefully controlled conditions; and

(11) commercial application of solar heating and combined solar heating and cooling technologies can be expedited by early commercial demonstration under practical conditions.

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Sec. 12 (b) In addition, the Secretary shall-

. . .

(3) Study the necessity of a program of incentives to accelerate the commercial application of solar heating and cooling technology.

Sec. 15 (b) Consideration shall be given to projected costs of commercial production and maintenance of the solar heating systems and combined solar heating and cooling systems utilized in the demonstration programs.

The implication of the above is that, while Congress realized that solar heating was not quite ready economically and solar cooling was still in the R&D stage, they believe that the injection of money into an early "demonstration" program was a worthwhile expenditure in spite of the implicit premium. Evidently the Congress did not intend that only projects that were economically viable as defined by industry be demonstrated as this would have eliminated almost all available systems. In effect, Congress was trying to accelerate the market penetration of solar energy. The Military Construction Authorization Act of 1979 (P.L. 95-356) tends to substantiate this interpretation. Section 804 of that Act requires the Department of Defense (DOD) to use solar energy systems (if such systems are demonstrated to be cost effective) in all new military housing and 25 percent of all other military construction. A review of the legislative history for section 804 makes it clear that Congress is willing to pay a premium for solar energy systems with higher initial costs to achieve potential national benefits. The legislative history does not show whether Congress intended DOE to achieve this goal through the use of any specific financial calculation. However, section 804(c) provides that a solar energy system "shall be considered to be (cost) effective if the original investment cost differential can be recovered over the expected life of the facility." Consequently, it would be reasonable to conclude that the GAO position is not entirely compatible with the legislative intent.

Many of the operational problems which have plagued the projects are of the type which would have been eliminated through an adequate field testing program. Congress, however, chose to bypass the field testing stage. Solar cooling, one of the more complex technologies (as was recognized by Congress), was mandated by Congress to be demonstrated within five years of the passage of the Act. With the exception of the economic viability criterion, we agree with GAO's recommendations to the Secretary of Energy. Since the program failure was due primarily to the premature nature of the demonstrations, the recommendations should include the following:

(1) Greater emphasis should be placed on R&D.

APPENDIX II

(2) Field testing on systems and components in the program which successfully pass the R&D stage.

(3) The demonstration program should be limited to systems which are nearly competitive with alternative (conventional) systems in terms of performance, reliability and economics.

We appreciate your consideration of the comments in the preparation of the final report and will be pleased to provide any additional information you may desire.

for Jack E. Hobbs

(307180)

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