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The National Commercial Solar Heating and Cooling Demonstration: Purposes, Program Activities, and Implications for Future Programs

Robert Koontz
Michael Genest
Becky Bryant

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Solar Energy Research Institute
A Division of Midwest Research Institute

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Golden, Colorado 80401

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MICHAEL GENEST
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PREFACE

The Solar Heating and Cooling (SHAC) Commercial Demonstration Program was an important part of the total activities mandated by the Solar Heating and Cooling Act of 1974 (PL 93-709). The U.S. Energy Resources Development Agency (ERDA) initially administered the program; later, it was placed under the U.S. Department of Energy (DOE). This program provides much information about active solar heating and cooling, but, more importantly, it offers suggestions and implications for the commercialization of other solar technologies.

This report was prepared by staff of the Solar Energy Research Institute (SERI) with the assistance of selected solar heating and cooling systems designers, contractors, and manufacturers as part of SERI Task No. 6131.13.

Robert P. Koontz
Senior Evaluator
Buildings, Applications, and
Policy Branch

Approved for:

SOLAR ENERGY RESEARCH INSTITUTE

Dennis Costello, Manager
Buildings Division

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SUMMARY

OBJECTIVE

Market stimulation of a new technology by either industry or government is a very difficult and often lengthy process. Yet, if we are to replace exhaustible energy sources with alternative ones, we must demonstrate in commercial and domestic environments that these alternatives work and that they are economical. The objective of this study is to provide the U.S. Department of Energy (DOE) with information gained from and the implications of the first government-sponsored demonstration of solar energy—the Commercial Solar Heating and Cooling Demonstration Program.

We contend that this program exemplified many of the factors that policy makers must deal with to demonstrate solar technologies now ready for the market. The Commercial Heating and Cooling Demonstration Program presented a new, decentralized source of energy. This program and the infrastructure needed to support it are similar to those appropriate to small wind machines, photovoltaic residential systems, and some biomass technologies. For this reason, the Commercial Demonstration Program should be studied to gain information on how to increase the success of demonstrating these types of technologies.

To place the Commercial Program in perspective, we examined its legislative and bureaucratic origins, determined what type of demonstration it was to be, developed criteria for reviewing the program's outcomes, and studied these outcomes by applying the criteria. To develop the criteria, we relied heavily on builders, contractors, installers, and manufacturers of solar collectors for information on the critical factors necessary for market success.

We found that Congress intended that the U.S. Energy Research and Development Administration (ERDA) and, later, DOE should assume that the technology was commercially ready so that DOE should move quickly to demonstrate its utility. Examining the literature, we determined this type of initiative to be a policy-implementing demonstration. That is, its purpose would be to actually show purchasers and those in the industry that the technology is workable and economical. Solar industry officials emphasized that, for this type of demonstration to work, the technology must be well in hand and cost and performance characteristics of the technology must be predictable.

DISCUSSION

Our research revealed that DOE vigorously carried out the intent of Congress. Solar heating and cooling systems were installed in over 240 commercial projects in a variety of applications. We also found that DOE initiated concurrent data-gathering and research efforts to gain the information necessary for successful technology development and later commercialization; i.e., reliability, performance, and cost data. These data were used in our analysis. We also found that Congress probably underestimated the readiness of the technology at the time of the demonstration. For example, available technology, cost, and performance data could not ensure marketing success through system demonstrations. There were, however, beneficial results of the program, mentioned in this report as meriting further study. For example, solar collector manufacturers boosted their production, capital was raised for an infant industry, and many system installers received training in what were to them new technology skills.

CONCLUSION AND RECOMMENDATIONS

Demonstrations in themselves are risky, but inaction may involve greater risks. Without demonstrations, technologies and their practical uses remain uncertain or unknown. On the other hand, demonstrations presented too early in a technology's development can discourage rather than encourage public acceptance. We therefore support DOE's present phased approach: research; small field tests; and, finally, market or policy-implementing demonstrations. In addition, Congress can be made more aware of the necessity for and the possible risks of demonstrations. Any risks can be reduced, however, by phasing and by carefully targeting demonstrations to the intended technology users.

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SECTION 1.0

INTRODUCTION

This study presents the results of our work on findings and implications of DOE's early solar commercialization program efforts. It reviews the Commercial Solar Heating and Cooling Demonstration Program in terms of its stated goals and objectives. From this review and that of other demonstration literature, the study shows how future solar demonstrations can reflect and relate to DOE's current approach to the commercialization process, and suggests ways that solar demonstrations might be more effectively used.

1.1 THE PURPOSE OF PROGRAM REVIEWS

Program reviews often become difficult analytical tasks. First, programs seldom have a single set of goals. Political implications and pressures, as well as existing government regulations, can prevent a program manager from acting to ensure a program's success. Additionally, measurement problems can be encountered in developing adequate assessment criteria, in securing the data necessary to apply these criteria, and in discovering and evaluating unintended consequences of program activities. Such unexpected results are sometimes more important, or have a greater impact, than expected results. Despite these difficulties, however, program assessment is vitally necessary to show us how far we have come, how far we still need to go, and which way to proceed when similar situations confront us. Our purpose here is not to perform an audit, fix blame, or settle accountability questions. Rather, we studied the results of the Commercial Solar Heating and Cooling Program largely to extract from them ideas on how best to plan future demonstrations.

1.2 SCOPE AND ORGANIZATION OF THE REPORT

Program origins, the type of demonstration used, and assessment criteria were analyzed. Possible modifications of the program were considered, so that it might be more effective and coincide more with current development and commercialization processes. Three major conclusions were formulated.

Section 2.0 discusses enabling legislation and the legislative history of the program. It also cites the major DOE policies formulated to carry out the intent of the Congressional legislation. To place this particular program in perspective, other demonstration literature were reviewed, and the program was compared with other types of federal demonstrations. Section 3.0 discusses how the evaluation criteria were developed, their relation to the program's stated purposes, and their relevance to the type of demonstration Congress envisioned. Section 4.0 applies these criteria to the data base and discusses the study results. Section 5.0 presents the implications of the results vis-à-vis future demonstration programs.

Throughout the report, we point out what could have been limitations in the program's method, and any other approaches that might be tried in a broader evaluation. It must be emphasized that this study is not an assessment of the present state of the art of solar collector technology and its marketing successes or failures. The technology has been developed and used more extensively since the installations discussed in this report were completed.

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SECTION 2.0

PROGRAM PURPOSES AND GOALS

The Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) created a Solar Heating And Cooling (SHAC) Demonstration Program for the purpose of demonstrating practical uses of solar heating (within three years) and of combined solar heating and cooling (within five years). An important component was the Commercial Demonstration Program, initially administered by ERDA and now by DOE.

2.1 LEGISLATIVE GOALS OF THE SHAC COMMERCIAL DEMONSTRATION PROGRAM

Demonstrations can be either policy-formulating or policy-implementing [1]. Policy-formulating demonstrations are designed primarily to help policy makers decide whether, when, or in what form to adopt a particular course of action or developmental thrust. The primary goal of these demonstrations is to provide information about an innovation. In contrast, policy-implementing demonstrations are designed to promote the use of an already developed innovation.

Clearly, a policy-implementing demonstration that produces negative information about an innovation will not succeed. Policy-implementing demonstrations should, then, be undertaken only when the innovation being demonstrated is feasible, locally reproducible, reasonably cost-effective, and otherwise desirable [2].

PL 93-409 calls for a policy-implementing demonstration program: the Act requires "the early demonstration of the feasibility of using solar energy for the heating and cooling of buildings" and anticipates the future "widespread use of solar energy" and the "mass production . . . of solar . . . equipment" [3].

The intent of the Act can be discerned from its legislative history. One congressman stated that it "provides the nudge and incentive necessary to make industry and the marketplace aware of the advantages of solar heating and cooling systems . . . . It seems a small investment to make in an energy system which will put us well on our way to energy independence" [4]. A member of the House Committee on Science and Astronautics was more specific, stating that the demonstration program would help "to make solar warming and air conditioning of homes and offices commercially available in five years" [5].

Throughout the debate and the various committee hearings on the Act, few important technical questions regarding the feasibility of widespread applications of SHAC remained unanswered. The Chairman of the Subcommittee on Energy of the House Committee on Science and Astronautics stated that "this bill does not establish a national solar energy R&D program. It is a demonstration of solar heating and cooling technology, designed to prove that solar energy can be used for this purpose in the immediate future" [6].

At the time PL 93-409 was passed, solar energy development was a relatively new and little understood policy issue. In 1972, for instance, no solar legislation was passed by Congress. However, the 93rd Congress experienced an explosion of interest, set off by the OPEC oil embargo, in solar energy. More than 25 solar bills were introduced and four were passed, including PL 93-409—the first major bill on solar energy. Since 1974 there has been a steady growth in the number of solar-related bills introduced in Congress. Of those passed, two had a significant effect on the goals and objectives of the SHAC demonstration program [7].

The Solar Energy Research, Development, and Demonstration Act (PL 93-473) of 1974, and the Energy Reorganization Act of 1974 (PL 93-438), both of which were passed shortly after PL 93-409, incorporated the SHAC Demonstration Program into a more comprehensive national solar development policy. PL 93-473 states that "it is the policy of the Federal Government to —

"1. pursue a vigorous and viable program of research and resource assessment of solar energy as a major source of energy for our national needs; and

"2. provide for the development and demonstration of practicable means to employ solar energy on a commercial scale."

Linking research and development to the demonstration of solar energy for heating and cooling is a realistic approach to the problems of solar energy commercialization.

2.2 DOE GOALS FOR THE SHAC COMMERCIAL DEMONSTRATION PROGRAM

Because the SHAC Demonstration Program has its roots in three separate laws, it would be very difficult to describe the program's goals and objectives by reviewing and combining the legislative histories of each of the laws or even by examining the texts of the laws. Fortunately, ERDA, the agency that initially administered the commercial component of the demonstration, produced a concise statement of program goals for its Second Annual Program Status Report. According to that report, "The National Program for Solar Heating and Cooling of Buildings aims to stimulate the development of an industrial, commercial, and professional capability for the production and distribution of solar water heating, space heating and cooling systems."

Several activities were designed to achieve this goal. Among these were initiating research and technology developments aimed at reducing costs, improving collection and dissemination of information on system performance, developing analytical methods for economic and technical assessments of solar energy systems, and other activities that can be characterized as demonstration support. The specific goals of the commercial demonstration program were to:

"(1) demonstrate the use of solar heating technology in new and existing . . . commercial buildings by 1977; and

"(2) demonstrate the feasibility of solar heating and cooling in new and existing . . . commercial buildings by the end of 1979, with special emphasis on the development of low cost systems for retrofit installations" [8].

Thus, the goals described by ERDA differ in two ways from the goals of PL 93-409. First, the more realistic and broader program established by PL 93-473 allowed ERDA to create a demonstration support program not included in the original Act. Second, the program as administered by ERDA focused on the sectors involved in production and installation.

When DOE assumed responsibility for the Commercial Demonstration Program, it also chose to focus on the solar industry. In a 1978 speech entitled "Solar Demonstration Program Overview," the DOE official in charge of the program said, "The primary goal of the program is to work with the solar equipment industry in the development and early introduction of economically competitive and environmentally acceptable solar energy systems. . . . The thrust of the program is to demonstrate the economic viability within a five-year program" [9]. This official went on to state, "The Demonstration Program will reduce uncertainties in solar system performance and cost by producing a reliable basis for the design and installation process" [10].

Thus, the commercial demonstration program is viewed as a policy-implementing demonstration operating within a broader context—the National Program for Solar Heating and Cooling of Buildings. The NPSHACOB has many elements designed to formulate SHAC policy. In particular, the research and development component is responsible for developing and testing SHAC systems.

In theory, this process should have lead to the identification of systems ready for demonstration. In practice, the research and development component of the NPSHACOB had little opportunity to identify those systems before the demonstration contracts were let. Demonstration program managers did not have the benefit of early research and development. Instead, ERDA, and later, DOE, relied on program opportunity notices (PONS) as a way of identifying SHAC systems and components that were ready for demonstration. The PONS comprised a series of public notices soliciting proposals from architects, engineers, and builders. The notices specified that only those proposals utilizing proven, well understood SHAC systems and components would be considered. The officials responsible for administering the program had little leeway to institute a phased program, because the one Congress mandated appeared to call for a large-scale, nonphased demonstration [4].

SECTION 3.0

METHODS

Based on legislative and DOE goals for the Commercial Demonstration Program, the policy-implementing success of the program was measured against certain criteria.

3.1 CRITERIA FOR DETERMINING THE POLICY-IMPLEMENTING SUCCESS OF THE COMMERCIAL DEMONSTRATION PROGRAM

The first and perhaps most obvious criterion for evaluating the success of the Commercial Demonstration Program is the degree to which the program actually promoted the use of SHAC in commercial applications. Such a direct test is, unfortunately, difficult to make.

To be sure, commercial SHAC installations have dramatically increased in the United States since the demonstration began [11]. To determine exactly what portion of this increase, if any, is directly or indirectly attributable to the demonstration would be a very difficult task. Indeed, several recent developments could account for much of the increase: the dramatic rise in energy prices, growing popular interest in solar energy, and the results of the nondemonstration elements of the national plan for solar heating and cooling of buildings. Unraveling all these factors would require a far more extensive study than the present one.

Nevertheless, the nature of policy-implementing demonstrations suggests several reasonable criteria for judging such demonstrations. Since policy-implementing demonstrations are designed to provide potential users of an innovation with information that promotes the use of the innovation, the demonstrations should answer key questions of both builders and end users. That is, do the projects demonstrate that the technology is well in hand and that performance and cost are predictable? More specifically, commercial demonstrations were evaluated using the criteria and indicators in Table 3-1.

Table 3-1. COMMERCIAL DEMONSTRATION PROGRAM SUCCESS CRITERIA AND INDICATORS

Specific Criteria	Indicators
1. Technology Well in Hand	Installation problems are minor
	Maintenance can be classified as routine.
2. Cost	Final cost did not vary widely from estimates; i.e., equal to or less than 10% overruns.
3. Performance	System performed close to predicted values.

These criteria were developed through interviews with installers, contractors, manufacturers, and architects familiar with solar heating and cooling projects. The conclusion was that marketing goals and strategies and willingness to assume certain risks were based on receiving reliable systems with predictable performance and cost (see Appendix). Demonstrations apparently are successful when they supply such information to prospective building contractors and end users. According to one heating and air conditioning installer, building construction is difficult enough without having to contend with uncertainty about system costs, reliability, and performance. Also, before a solar building can be sold, builders must be able to tell prospective buyers how much it will cost and what its performance characteristics are.

3.2 DATA BASE FOR THE ANALYSES

A great deal of data has been generated from both the residential and commercial demonstration programs. The data include performance of individual units, collector performance, system characteristics and cost information, infrastructure opinions and reactions, and environmental and socioeconomic data [12]. Most of these data were reviewed and some of the officials responsible for collection and dissemination were interviewed.

Two contractor reviews, however, gave information on cost, performance, installation experience, and reliability characteristics that was most suitable here. The most recent one was chosen for this assessment. Its purpose is summarized:

> The Second Solar Heating and Cooling Demonstration Program Contractors Review is the second annual meeting of project representatives from the Commercial Demonstration Program with Government officials and Government-contractor representatives in order to exchange information on systems currently in operation, under construction and still on the drawing board. The representatives from earlier projects can pass on the benefits from their experiences to representatives from the latest projects who can avoid committing some of the same mistakes and repeat some of the proper decisions.[13]

3.3 APPLICATION OF THE CRITERIA TO THE DATA BASE

The contractor review described above contains 114 papers on projects in varying degrees of completion. After reviewing all of the papers, 37 were judged to be complete enough to be relevant here. These 37 concerned projects that had operated long enough to allow the contractors to accumulate some data. At the time of this study, DOE had awarded funds for 240 commercial projects, with plans for additional awards to build 500 projects. A more extensive study would review these additional demonstrations when they are completed.

Such an extensive evaluation might not be necessary or even possible unless DOE decides to hold contractor reviews after every cycle, which would be expensive. Later, DOE or a researcher may wish to use this methodology to do a more complete evaluation, if more data become available.

Where the data permitted, each project was judged as to whether the technology was well in hand, and whether cost and performance were predictable (see Table 3-1). For a system to be judged positive on a criterion, e.g., technology well in hand, it had to rate positive on both of the associated indicators: installation and maintenance. In those cases where there were insufficient data to apply the indicators, the space was left blank. In doubtful cases, a positive score was given to the indicator, a standard assessment technique that mitigates against any evaluator tendencies to assume negative results.

Two examples serve to explain how the criteria were applied to the 37 cases analyzed. DOE awarded the Bartlesville, Oklahoma, Energy Technology Center a commercial demonstration grant in 1977 for a hot water unit with a 1,700-gal. capacity. Energy is supplied to the system with 600 ft^2 of collector area. This system rated positively on all of the criteria. The technology appeared to be well in hand, the cost estimate was met, and the owners were satisfied with performance. The contractor's report stated that "the only operational problem encountered was a bearing failure on the solar circulation pump." It added that this failure involved only two hours of down time. The cost of the project was $58,389.24. Nothing in the report indicates that this cost exceeded the budget. Regarding performance, the report states that the system is performing at or above the expected level. The paper concludes: "We are very pleased with the operating/maintenance-free reliability of the system" [14].

In contrast, complex problems were encountered in the solar heating and cooling project at the Florida Welcome Station at the Florida-Georgia border on Interstate I-95. According to the contractor report, "This project seems to have experienced an unusually large amount of problems." For example, 12 of the 272 collectors were damaged in shipment, collector sheet metal housings were bent, there was gross leakage in the system, rust, and inoperative control motors, among other problems. Regarding costs, the report cites an original estimate of $246,000 and a $42,600 overrun. No performance data were furnished so the system was not rated on this criterion [15].

The criteria were applied to the other 35 projects in the same way as to these examples. Results of the analysis appear in the next section.

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SECTION 4.0

ANALYSIS OF THE DATA

The projects analyzed and included in the Commercial Demonstration Program constitute a wide range of system types. They include a relatively simple hot water system for some motels in Virginia; a solar-heated heat pump system in West Bend, Wisconsin; and a large, complex solar heating, hot water, and cooling system at Walt Disney World, Florida. These installations included both publicly and privately financed buildings. Both these types, of course, used DOE grants for their solar systems but the work was planned and performed by private heating and air conditioning contractors.

The results of the study are summarized in Table 4-1. The discussion of these results is arranged by technology-well-in-hand, cost, and performance criteria.

4.1 FIRST CRITERION: TECHNOLOGY WELL IN HAND

On this criterion, 9 systems were rated positively, 25 negatively, but for 3 there were insufficient data on which to base a judgment. For a system to get a positive rating, the report had to contain favorable remarks about installation and maintenance or mention only a few problems with the system.

Frequently mentioned problem areas which were classified as negative indicators of the technology-well-in-hand criterion were major installation problems, difficulty with controls, leakage, freeze-ups, and major design changes while the system was under construction. Some of the systems had all of those problems while others had only one; but that one problem was enough to either stop the operation of the system for a significant time or cause a major building delay. Positive indicators were easiest to classify. For example, one report stated that "this system has performed flawlessly for one year" [16]. Although this alone would qualify the system for a positive rating, the report went on to mention that problems with the system had been minor.

4.2 SECOND CRITERION: COST CERTAINTY

From a policy-implementing standpoint, there are at least three important cost considerations. These are the costs of the systems compared with costs of alternative fuels, life cycle costs, and whether the systems can be built within estimated costs.

Because of limited operating experience with these systems in the contractor study, cost estimates became the primary consideration. It would be a rare contractor or owner who would feel comfortable building or buying systems for which costs cannot be estimated accurately.

Estimated costs are also important from a policy-formulating perspective. Even though a solar system may cost more than a conventional system, these costs can be reduced by subsidies of one form or another. This is, of course, a national policy decision, but one that cannot be made until the final costs of delivered systems can be accurately estimated. Therefore, the systems in the contractor review were assessed as to how well estimated costs squared with final costs. The analysis determined that 12 systems met

Table 4-1. ANALYSIS RESULTS

No.	Type[a]	Technology Well In Hand	Cost Certainty	Performance
1	HHW	[b]	No	
2	HHWC	Yes		No
3	H	Yes	Yes	Yes
4	HHWC	No		
5	HC	No	Yes	
6	HC	No	No	
7	H	No		
8	HHWC	No	Yes	
9	HW	No	No	Yes
10	HHW	No	Yes	
11	HHWC	Yes	No	
12	H	No		
13	HHWC	No	No	
14	HHWC	No		No
15	HC	Yes	No	
16	H	No	No	No
17	H	Yes	Yes	
18	HHWC	No		No
19	HHW	No	Yes	
20	HHW	No	No	No
21	H	No		Yes
22	HW	No		No
23	HHW	No	Yes	
24	HHW	No		
25	HHW	No	Yes	
26	HHWC		Yes	
27	HHWC	Yes	Yes	No
28	HHWC	No	Yes	
29	HHW	No	No	Yes
30	H	No		
31	H	No	No	Yes
32	HHWC	Yes	Yes	Yes
33	H		No	
34	HHW	No	No	
35	HW	Yes		Yes
36	HHW	Yes		Yes
37	HHWC	No		

Total (37)	Technology Well In Hand			Cost Certainty			Performance		
	Yes	No	Blanks	Yes	No	Blanks	Yes	No	Blanks
	9	25	3	12	12	13	8	7	22

[a]Key:
- (H) Heating only.
- (HC) Heating and cooling.
- (HW) Hot water only.
- (HHW) Heating and hot water.
- (HHWC) Heating, hot water, and cooling.

[b]Blanks indicate insufficient data upon which to base judgments.

estimated costs, 12 did not, and 13 could not be classified because the data were insufficient to make a determination.

According to one report about a system that met estimated costs, the total cost was \$150,000 for a heating and cooling system with 2,080 ft^2 of collector area. It reported a cost overrun of \$3,000, but stated that "installation costs were slightly less than planned helping to offset the overrun" [17]. Another contractor for a solar heating and hot water system reported, "Cost overall has been predicted very well except for those areas of controls and instrumentation where we were unsure of the actual work required in the beginning phases. Even so, cost overruns were in the area of \$2,000.00 to \$3,000.00 out of the approximate \$300,000.00 cost of the system" [18]. As was the case with the technology-well-in-hand criterion, neutral comments on costs were judged as positive.

Some of the negative comments on costs dealt with difficulties in making estimates and unexpected construction or design problems that increase costs unexpectedly. The following example illustrates some of those problems:

> The original construction cost for the system was \$246,000. This did not include engineering design fees of \$19,000. Due to SDAS and instrumentation wiring changes, collector systems changes and problems, extra labor charges for repairing leaks and re-testing the system, additional contractor supervision and overhead charges and the addition of miscellaneous other changes we have added \$37,600 to the contract cost with approximately \$5,000 more expected. At this writing, the system is not complete and is not operational.[19]

The example indicates at least a 14% overrun; 10% was the maximum overrun allowed to rate the system's costs predictable. This system report contained most of the factors cited in other reports as reasons for overruns.

The interviews suggested that cost estimating for these systems was difficult, but not impossible. Although solar systems are more complex than standard heating and air conditioning systems, there are no technical reasons for cost estimates to be in-accurate. The data indicate, however, that cost was a problem for 12 of the 37 systems studied. Certainly, cost estimating is a key variable and one that needs industry attention if solar systems are to achieve widespread use.

4.3 THIRD CRITERION: PERFORMANCE

Cost-benefit equations, comparative fuel costs, and life-cycle costing all require performance information. Buyers and contractors generally base their decisions on what they are getting for how much. The interview results were mixed on the degree of difficulty involved in calculating performance of solar systems. Those interviewed agreed that this information is critical to both contractor and buyer decisions.

The analysis showed that 8 systems met their performance predictions, 7 did not, and the data were insufficient on 22 to rate them on the criterion. This latter figure resulted from several factors. The primary one was that many of the systems did not contain instruments designed to measure the contribution of the solar system. Other contractor reports did not mention performance; a few systems had not been operating long enough to permit calculation of their performance.

The more detailed and precise contractor reports were the easiest to rate on the performance criterion. If this criterion were to be used on all systems, the format followed in the report of the Scattergood School Solar Heating System could serve as a model performance reporting system. This report concludes that "about 87% of the energy requirements for the building were provided by the solar heating system." The design calculations estimated 75%. In addition to these conclusions, monthly solar system performance and system efficiencies are given. Cost figures are provided that include comparative fossil fuel savings. DOE might want to try using a standard format for monitoring systems on technology readiness, cost, and performance along the lines suggested in this example [20].

It was possible to infer a high performance on some systems even though extensive data were not provided. For example, one report stated that:

> During the building's first year of operation, the instrumentation system was not yet installed. However, the general performance of the solar system was determined by physically shutting off the gas supply. Results of this period (September 1975 to January 16, 1976) indicated that the solar system provided 100 percent of the building's heat load.[21]

This system was rated as matching or exceeding design specifications.

4.4 SUMMARY

The description of the 114 systems in the review reveal a variety of kinds of systems, experiences, and attitudes toward the systems. Many have been closely monitored and there is a wealth of data for further analysis. Despite some problems with the systems, the reports indicate a positive attitude toward solar energy. Report authors generally considered their systems to be experimental. One author, for example, after discussing the problems of his system, wrote, "We feel fortunate to be able to participate in this ERDA program. Our system, although small, affords the public an opportunity to see a functional system in a scope they can relate to domestic applications" [22].

An important reason for this attitude doubtless was the federal government's willingness to underwrite the major cost of the systems. If these systems supplied a positive flow of energy to the buildings, owners saw them as beneficial—even though there might be technical, performance, and cost problems.

To achieve policy-implementation success, i.e., market penetration, solar demonstrations must show that the technology is well in hand and that performance and cost are predictable. Only then can builders and consumers rationally incorporate solar systems into their building and renovation plans.

From a policy-implementing or market-penetration viewpoint, there was not much evidence to suggest that the Commercial Demonstration Program was a success. That is, the technology, cost, and performance uncertainties were too large to stimulate retail marketing.

Again, program managers probably realized the difficulty of accomplishing this goal early in the program. They instituted research, development, and information-gathering efforts so that technology could be improved and cost and performance uncertainties could be discovered and minimized.

Policy implementing is not the full story of the Commercial Demonstration Program, however. The final section of this paper discusses the program against the background of other federal demonstration programs, presents other measures for judging the worth of the program, and makes some suggestions as to how demonstrations should be employed to expedite the commercialization of solar energy systems in the future.

SECTION 5.0

THE ASSESSMENT OF SOLAR SYSTEM DEMONSTRATIONS AND THEIR RELATION TO THE COMMERCIALIZATION PROCESS

Assessing the policy-implementing success of the demonstration program is more complex than is perhaps apparent here. Not only are technology, performance, and cost factors for owners and builders considerable, but the demonstration could have affected other groups crucial to the commercialization process as well. For example, a more extensive policy-implementation evaluation should consider impacts on manufacturers, installers, attitudes of lenders, etc.

5.1 ADDITIONAL CRITERIA FOR ASSESSING THE POLICY-IMPLEMENTING SUCCESS OF DEMONSTRATIONS

A somewhat narrow set of criteria was chosen to assess the program. While these are necessary to achieve the commercial or policy-implementing success of the program, there are other important criteria to consider. For example, the demonstration program could have changed the capital use and acquisition position of manufacturers, the training levels of installers and other technicians, the attitudes of local lenders and officials, and other preconditions necessary for a vigorous solar system industry [23].

For example, interviews revealed that the capital position of manufacturers was improved as a result of the demonstration program (see the Appendix). The reasoning was that manufacturers could point to the use of their collectors in government demonstrations to raise capital from lenders and prospective investors. At the same time, the building industry increased its knowledge and familiarity with solar heating and cooling systems. Another interview indicated that different training and compensation systems were needed for installation of solar systems than for conventional systems. Workers installing a conventional system had a larger margin of error in which to work; e.g., a leak in a conventional system would result in a smaller decrease in efficiency than it would for a solar system. Therefore, solar system installers must be compensated less for speed of installations and more for quality. How much the solar demonstration program changed management practices and solar installers' behavior is an important assessment factor.

In the Residential Demonstration Program, officials collected a large amount of data on attitudes and changes in attitudes of local lenders, code officials, and others. These data, available through the U.S. Department of Housing and Urban Development (HUD), could be used to examine this factor, eliminating any necessity to collect similar data for the Commercial Program.

Within the federal government, and among states and professional associations, solar system standards and testing questions are being raised and data are being accumulated to answer pertinent questions. Much of this data-gathering and concern result from the demonstration programs. The extent of the success these programs had in resolving issues surrounding standards and testing would be an important element to consider in studying either or both of the demonstration programs.

It is perhaps appropriate here to question why we do post-mortem policy assessments at all. There are many reasons, but among the most important are to establish how far we have come, how far we need to go, and to help decision makers consider how or even if we should proceed. It is not appropriate here to do an audit, fix blame or responsibility, or settle other accountability questions. In regard to the demonstration programs, Congress mandated that the government would proceed and policy makers were to implement the mandate. Much new information and knowledge resulted; this information should be critically, constructively, and extensively examined.

5.2 DEMONSTRATIONS AND THE COMMERCIALIZATION PROCESS

In Section 2.0, we divided demonstrations into policy-formulating and policy-implementing categories. The primary goal of a policy-implementing demonstration was to establish a goal for the government, for example, that would bring about the widespread use of solar systems. On the other hand, we stated that the purpose of a policy-formulating demonstration is to help decision makers establish policies, make choices, and construct plans. Policy-formulating demonstrations emphasize the information-gathering and dissemination characteristics of the projects. A review of the demonstration literature and the commercialization process and a study of the Commercial Demonstration Program indicate that demonstrations should be used primarily for policy-formulating purposes rather than policy-implementing ones.

Demonstrations have more strengths and fewer weaknesses as policy-formulation tools than as policy-implementing ones. First, demonstrations are a way that information can be gathered in a quasi-experimental mode. They can reveal the problems of operating a nascent technology in near real-world conditions. For a small investment in hardware, with a minimum of government guidance, demonstrations can yield information about the returns, reactions, and proclivities of the principals who will be involved in the ultimate dissemination of the new technology. This information can be developed under various conditions of performance, geographical location, types of design, local regulations, and a host of other real-world conditions. Then, once uncertainty is reduced about the technology, cost, performance, social and institutional factors, decisions can be made about whether the nation wants to pay the costs of bringing this technology into widespread use.

On the other hand, it could be risky to burden demonstrations with the mission of convincing skeptics that uncertainties are few and therefore they should adopt the technology. Unexpected barriers also could stand in the way of consumers immediately buying the products. More difficulty arises if the demonstration is trying to reduce technology, cost, and performance uncertainties at the same time it is attempting to influence market decisions of builders and buyers. Major uncertainty levels may not be reduced, because reduction of uncertainty is not the primary goal of a policy-implementing demonstration.

Once uncertainty levels are reduced to a minimum and decision makers begin to promote the technology, however, there are better and more powerful inducements for buyers, builders, lenders, and other infrastructure members. In a paper on "The Role of the Government in the Development of Solar Energy," Yokell concludes that "subsidies operating on the demand side rather than the supply side of the market are preferable because their benefits are spread more broadly." He cites tax deductions, tax credits, tax rebates, and below-market rate loans for solar system end users [24]. In addition, there are institutional and legal barriers to innovation as well as economic ones; however, demonstrations can identify the amount of economic aid needed and what the institutional barriers are. Policy makers then must decide whether to remove barriers and to subsidize the technology to hasten early adoption. Success in achieving early adoption goals depends on the policies adopted and these in turn depend on the reduction of uncertainties.

5.3 INDICATIONS FOR PHASING FUTURE DEMONSTRATION PROGRAMS

Table 5-1 lists a series of phases for various solar technologies [25]. Even with hindsight, it is difficult to decide where to place the Commercial Demonstration Program. Based on our analysis, the program appears to have elements of prototype system development and testing, field testing, and test marketing. It appears that the Commercial Program could have been more effective if it had been broken down into these clearly defined three phases. The test marketing phase should have been directed at obtaining as much information as possible on the relevant variables. Test marketing, however, should not begin until the technology is well in hand and cost and performance uncertainties are low. Unfortunately, the program managers have not had the luxury of this gradual phasing, because Congress has mandated that a vigorous policy-implementation demonstration program be initiated quickly.

5.4 CONCLUSION

To use or not use demonstrations involves a certain element of risk. No technology is assured of success. The Charpie Task Force, in a report to DOE on demonstrations, points out that:

> In industrial practice, only about one in twenty projects entering research, or one in five projects entering development, is carried forward to ultimate commercialization. [26]

If demonstrations are used, or particularly, used too early, consumer confidence may be lowered. The information-gathering function can be impaired. On the other hand, no demonstrations at all is risky because policy may then be formulated based on insufficient information.

For these reasons, we recommend a conservative approach. Demonstrations should be graduated into the steps now being considered by DOE; i.e., prototype testing, field testing, and test marketing. The goals of each step should be limited to the information needs of policy makers. The purpose of the demonstrations and their evaluation should be on information-gathering and dissemination and not as market penetration or financial incentive devices.

Market penetration and building or providing incentives are separate activities that address different problems in the commercialization process. One more suggestion is in order. If demonstrations are pointed toward information-gathering goals, then nonscientist policy-makers' needs should be considered carefully. For example, performance and cost information mean different things to the consumer, builder, and installer than to the scientist. These parameters are based on scientific information but this information needs to be translated into practical, economic terms so that decision makers can make informed judgments. Technology proponents must answer questions about how much a system costs and what it will do for the purchaser.

Table 5-1. STEPS IN THE PRODUCT DEVELOPMENT PROCESS

	Step	Description
1.	Basic Materials Research	Self-explanatory
2.	Market Research and Product Justification	The establishment of specific performance and cost goals
3.	Component Development and Testing	Self-explanatory
4.	Prototype System Development and Testing	Combination of separate components for system testing
5.	Field Testing	Testing the system in a nonlaboratory setting
6.	Test Marketing	Placing a large number of systems in the field to better understand the reactions and attitudes of potential buyers
7.	Production	Commercial production begins
8.	Sales and Marketing	Promotion and sale of the product

SECTION 6.0

REFERENCES

1. Glennan et al. The Role of Demonstrations in Federal R&D Policy. The Rand Corporation, May 1978, R-2288-OTA.

2. Baer, Walter S.; et al. "Government-sponsored Demonstrations of New Technologies." Science; 27 May 1977; pp. 950-956.

3. U.S.C.A. 42 5551.

4. Solar Heating and Cooling Act of 1974, Background and Legislative History. H.R. 11864. Committee on Science and Astronautics, U.S. House of Representatives, 93rd Congress, Second Sess. Committee Print, U.S. Government Printing Office; 28-9430.

5. Ibid.

6. Ibid.

7. Solar Energy Through the 91st Congress. Prepared for the Committee on Science and Technology, U.S. House of Representatives, 94th Congress, by the Science Policy Research Division, Congressional Research Service, Library of Congress. Washington D.C.: U.S. Government Printing Office; 1977.

8. Annual Program Status Report. ERDA 76-6, cite to ERDA 23A.

9. Corcoran, William. "Solar Demonstration Program Overview." Given at the Second Annual Solar Heating and Cooling Commercial Demonstration Program Constractors Review, 1978.

10. Ibid.

11. DOE, Energy Information Administration, Solar Collector Manufacturing Activity. July 1977 through June 1978; February 1979. Washington D.C.: U.S. Government Printing Office; #061-000-00238-3.

12. DOE, Assistant Secretary for Conservation and Solar Applications, Proceedings of the Department of Energy's Solar Update. Washington, D.C.: U.S. Department of Energy, Contract No. EC-78-C-01-4131, pp. 163-168.

13. DOE, Assistant Secretary for Conservation and Solar Applications, the Preprinted Papers of the Second Solar Heating and Cooling Commercial Demonstration Contractors Review. Washington, D.C.: U.S. Department of Energy, Contract No. EC-78-C-01-4131, p. 2.

14. Ibid., pp. 179-184.

15. Ibid., pp. 323-330.

16. Ibid, p. 623.

17. Ibid, p. 680.

18. Ibid., p. 578.

19. Ibid., p. 329.

20. Ibid., pp. 381-388.

21. Ibid., p. 545.

22. Ibid., p. 253.

23. Bryant, Becky; Koontz, Robert. Research Proposal; Evaluation of the Solar Heating and Cooling Demonstration Program's Impact on Manufacturers. Golden, CO: Solar Energy Research Institute; May 1979.

24. Yokell, Michael. The Role of the Government in the Development of Solar Energy. Golden, CO: Solar Energy Research Institute; December 1978, p. 15.

25. DOE. Draft Conservation and Solar Applications Photovoltaics Multiyear Program Plan. Washington, D.C.: DOE Office of Conservation and Solar Applications; July 20, 1979.

26. DOE, Assistant Secretary for Resource Applications. The Demonstration Project as a Procedure for Accelerating the Application of New Technology (Charpie Task Force Report). Washington, D.C.: U.S. Department of Energy, DOE/RA-0003/1, February 1978, p.3.

APPENDIX

INDUSTRY PERSPECTIVES ON ASSESSMENT CRITERIA

SERI visited nine companies and one government official active in or familiar with the solar heating and cooling industry. Six of the companies are collector manufacturers and one is a collector distributor and installer. SERI also visited an architectural firm that specializes in buildings employing solar systems and a government official who participated in the demonstration program. While these interviews were not conclusive by themselves, they provided indications of what the initial assessment variables were from an industry perspective. These indications, combined with the purposes and objectives of the legislation, were used to write the assessment criteria and suggestions for a broader assessment of the program.

The interviews were informal and topics covered included critical variables needed for the success of the solar heating and cooling industry, and direct and indirect impacts of the demonstration program. Also discussed were reasons why the identified factors were critical to the success of the industry. Table A-1 lists the interviewees by position and type of institution. All, except the government official, were from the Denver area.

A-1. CRITICAL FACTORS NEEDED FOR THE SUCCESS OF THE SOLAR HEATING AND COOLING INDUSTRY

Solar collectors are evidently now being sold in the Denver area. They are used, however, generally for large custom-built homes, where cost is not the overriding consideration. According to interviewees, collectors are not being used in specification or mass-built housing or commercial buildings. In addition to the rising cost of competitive fuels and building subsidies, the following factors were identified as being crucial to a large solar heating and cooling industry:

Good System Design. Presently, most architects and conventional heating and cooling engineers and designers are not familiar with solar systems. Poor system design can contribute to unreliability, poor performance, and high systems cost, so designs must be proven and made available to engineers and manufacturers.

System Reliability. At the time of this survey, builders enjoyed a seller's market. Because they could sell almost anything they built, they were reluctant to include a heating and cooling system that could cause maintenance problems, at the very least.

Consumer Demand. Builders are not willing to try to sell something that consumers are not demanding. Consumer education and familiarity with technologies are needed to sell solar systems.

Uniform Collector Standards for the United States. Collector manufacturers point out that no uniform collector performance standards now exist. They believe such standards are needed so collector manufacturers can standardize and ship freely across state lines.

Capital Needs for Manufacturers. Collector manufacturers are caught in a classic bind. Before prices can drop, volume production is needed; but to achieve volume, reduced prices are needed. To achieve their initial price reductions, solar manufacturers need increased capital, large government buyers, or both.

Table A-1. LIST OF INTERVIEWEES

Position	Type of Enterprise
President	Solar Collector Manufacturing Company
Sales Manager	Solar Collector Manufacturing Company
President	Solar Collector Installation and Distribution Company
President	Solar Collector Manufacturing and Installation Company
President	Architectural Firm Specializing in Solar Design
President	Solar Collector Manufacturer
Vice President	Solar Collector Manufacturing and Installation Company
President	Solar Collector Manufacturing Company
President	Solar Collector Manufacturer
Federal Program Administrator	Solar Collector Manufacturer
Administrator	Solar Heating and Cooling Demonstration Program

Trained Installers. In the past, many contractors have encouraged installers to install conventional systems quickly and cheaply. Because solar energy is a relatively low energy source, care in workmanship and extremely high installation standards are important. This value, as well as the technical aspects of solar installation, needs to be part of the industry's practice.

Sympathetic Lenders. So far, lending institutions have been willing to finance the added cost of solar systems. However, as money becomes tighter and homes more expensive, lenders could take the short view and not continue to provide the money necessary for solar systems.

A-2. POSSIBLE IMPACTS OF THE DEMONSTRATION PROGRAM

One of the larger Denver manufacturers told us that over half of his business had resulted directly from the demonstration program. That is, over one-half of his sales were of demonstration units. While he knew that his share could not be maintained because the demonstration program would end, the business had been extremely helpful to his company. Other possible impacts include:

Improvement of the Capital Position of the Collector Manufacturers. One collector manufacturer told us that he had used his company's participation in the demonstration program to impress prospective lenders and stockholders. Other manufacturers agreed to a lesser extent that this may have been an indirect impact of the program.

Training of a Large Number of Personnel in Solar Systems Technology. Through publicity from the demonstration program and by direct hands-on experience, contractors and installers gained needed knowledge from the demonstration program.

Contributions to Knowledge Base for Solar System Technology. Two collector manufacturers stated that their collector designs were improved as a result of the demonstration program. Problems were brought to their attention and remedied as a result of this program.

A-3. CONCLUSION

The interviewees were not a representative sample of manufacturers, installers, and system designers. They were, however, experts in their fields who work with solar heating and cooling systems on a regular basis. They were recommended by SERI officials as individuals who could give good technical answers to technically based questions. After the interviews, the study staff were satisfied that these interviewees had provided important variables from which to select criteria for assessing the Commercial Demonstration Program.

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R. Koontz; M. Genest; B. Bryant

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The Solar Heating and Cooling Demonstration Act of 1974 created a set of activities to demonstrate the potential use of solar heating within a three-year period and of combined solar heating and cooling within a five-year period. This study assesses the Commercial Demonstration Program portion of the activity in terms of its stated goals and objectives. Our primary data base was DOE contractor reports on commercial demonstration projects. We concluded that the program did not provide data to support a positive decision for the immediate construction or purchase of commercial solar systems. However, the program may have contributed to other goals in the subsequent legislation; i.e., research and development information, stimulation of the solar industry, and more informed policy decisions.

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