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Report to Secretary, Department of Energy; by Monte Canfield, Jr., Director, Energy and Minerals Div.

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Authority: Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409). Department of Energy Organization Act (P.L. 95-91). Small Business Act (15 U.S.C. 631).

Pursuant to the Solar Heating and Cooling Demonstration Act of 1974, the former Energy Research and Development Administration (ERDA) provided the Department of Defense (DOD) with \$3.1 billion in funding authority for two solar demonstration projects on Federal residences.

Findings/Conclusions: The first solar demonstration project, after expenditures of \$719,000 and an 18 month schedule slippage, was never completed because the solar systems to be used in the project were overdesigned. This prevented the project from reaching its cost objectives. Consequently, DOD sought and obtained ERDA's approval to terminate the project and redirect the remaining funds to other DOD solar efforts which were not consistent with the role given DOD under the act. This situation could have been avoided had ERDA and DOD developed a detailed program plan before initiating the project and worked together to implement an effective monitoring system.

Recommendations: The Secretary of Energy should require that detailed plans be developed by DOD and formally approved by the Department of Energy (DOE) for all solar demonstration projects. Such plans should be developed immediately for DOD's second demonstration project and should include project objectives, milestones, decision points, target dates, and design and cost information associated with the solar heating systems to be demonstrated. The Secretary of Energy should work with DOD to establish and implement a formal project monitoring system that would enable DOE management to track progress through periodic and frequent progress reports. To the extent practical, the Secretary should limit the redirection of funds for DOD's first project to those activities that relate to the demonstration of solar heating devices on Federal residential dwellings.

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REPORT BY THE U.S.

General Accounting Office

Solar Demonstrations On Federal Residences—Better Planning And Management Control Needed

Pursuant to the Solar Heating and Cooling Demonstration Act of 1974, the former Energy Research and Development Administration provided the Department of Defense \$3.1 million in funding authority for two solar demonstration projects on Federal residences.

The first solar demonstration project, after expenditures of \$719,000 and a 1-1/2-year schedule slippage, was never completed because the solar systems to be used in the project were overdesigned. This prevented the project from reaching its cost objectives. The project has since been terminated, and a substantial portion of the project funds has been redirected to activities which are not consistent with the role given the Department of Defense under the act.

GAO noted that similar problems could occur in the second project, and makes recommendations to provide better planning and management control over these and future projects.



EMD-78-40
APRIL 14, 1978



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

ENERGY AND MINERALS
DIVISION

B-178205

The Honorable
The Secretary of Energy

Dear Mr. Secretary:

We have been reviewing the solar heating and cooling demonstration program; and although we have not yet completed our work we noted a situation that we believe warrants your immediate attention. As you know, the Department of Energy (DOE) assumed the Energy Research and Development Administration's (ERDA's) overall responsibility for this program on October 1, 1977. These responsibilities include managing and coordinating the various Federal agencies who participate in the program to ensure the successful and timely demonstration of solar heating systems for residential use.

As part of our overall review, we examined activities that the Department of Defense (DOD) has initiated as part of the program. From May 1975 to July 1977 DOD made several unsuccessful attempts to bring into being its first residential solar demonstration project. Consequently, DOD sought and obtained ERDA's approval to terminate the project and redirect the remaining funds to other DOD solar efforts.

Our review showed that DOD's difficulties were related primarily to its overdesign of the solar heating systems to be used in the project. This situation could have been avoided had ERDA and DOD developed a detailed program plan before initiating the project and worked together to implement an effective monitoring system. If such a plan and system would have existed, ERDA could have provided DOD more guidance before the project began or taken timely corrective action to ensure the project's success. In addition, the redirection of funds from this project to DOD nonresidential solar efforts is inconsistent with DOD's role in the program as directed by the authorizing legislation.

Furthermore, problems similar to those which occurred in DOD's first residential project--overdesigned solar heating

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systems, lack of a detailed plan, and an ineffective monitoring system--were noted in DOD's second solar demonstration project, and could effect the success of this project.

Accordingly, we recommend that you:

- Require that detailed plans be developed by DOD and formally approved by DOE for all solar demonstration projects. Such plans should be developed immediately for DOD's second demonstration project and at the outset of all future projects, and should include project objectives, milestones, decision points, target dates, and design and cost information associated with the solar heating systems to be demonstrated.
- Work together with DOD to establish and implement a formal project monitoring system that would enable DOE management to track progress through periodic and frequent progress reports. Such a system would enable DOE to identify problems and take corrective action in a more timely manner.
- To the extent practical, limit the redirection of funds for DOD's first project to those activities that relate to the demonstration of solar heating devices on Federal residential dwellings.

In a separate report to DOD, we are also recommending that the Secretary of Defense (1) issue instructions requiring DOD officials responsible for the solar demonstration projects to fully cooperate with DOE through the development and timely submission of monthly status reports and other documents and information products as required by DOE in conducting the program and (2) monitor and periodically evaluate the DOD solar demonstration projects to insure that they are progressing satisfactorily, giving particular attention to the effectiveness of the actions taken to enhance the cooperation between DOD and DOE.

BACKGROUND

The Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409, Sept. 3, 1974) provides for demonstrating the practical use of solar heating in various U.S. geographic and climatic regions within 3 years from the effective date of the act. Under the act, ERDA was given overall responsibility for managing and coordinating a wide range of activities to ensure the successful and timely demonstration of

solar heating systems for residential use. These responsibilities were transferred to DCE pursuant to the Department of Energy Organization Act (Public Law 95-91, Aug. 4, 1977).

The Solar Heating and Cooling Demonstration Act also specifies that other Federal agencies, including DOD, be involved in the program. DOD's designated role in the program is to demonstrate the use of solar technology on Federal residences. In this connection, section 5(e) of the act states:

"The Secretary of Defense shall arrange for the installation of solar heating systems * * * in a substantial number of residential dwellings which are located on Federal or federally administered property where the performance and operation of such systems can be regularly and effectively observed and monitored by designated Federal personnel." (Underscoring added.)

The Department of Housing and Urban Development (HUD) has similar responsibility for the private residential sector.

To demonstrate residential use of solar heating in the Federal sector, ERDA provided funding authority to DOD for two demonstration projects. Under the first project, DOD was to install solar heating devices on 35 new and 15 existing single family residential units at various military bases across the country. This project was funded in three phases, as follows:

<u>Phase</u>	<u>Date of funding authority transfer from ERDA to DOD</u>	<u>Amount</u>
Conceptual design	5/27/75	\$ 250,000
Procurement of solar equipment	2/09/76	250,000
Additional design work and construction	4/30/76	<u>1,190,600</u>
Total		<u>\$1,690,600</u>

The project was originally scheduled to be operational during the 1975-76 winter season.

The second DOD project is for the demonstration of solar heating systems on 80 residential housing units. This project will employ the use of central collector fields located near the residences as opposed to the installation of solar collectors directly on individual housing units. ERDA transferred funds to DOD in two phases for this project.

<u>Phase</u>	<u>Date of funding authority transfer from ERDA to DOD</u>	<u>Amount</u>
Conceptual design	8/3/76	\$ 96,000
Additional Design and construction	5/2/77	<u>1,300,000</u>
Total		<u>\$1,396,000</u>

All 80 units in this project are scheduled to be in operation in early 1979.

DOD'S FIRST PROJECT NEVER COMPLETED

DOD's efforts on the first residential solar demonstration project began in May 1975. However, after more than 2 years of effort, expenditures of \$719,000, and a 1-1/2-year schedule slippage associated with bringing this project into being, DOD requested ERDA's permission to terminate the project and redirect the remaining unobligated funds--about \$972,000--to other DOD solar efforts. The project was never completed because the bids DOD received for the installation of the solar systems were far above DOD's estimates and considered unacceptable. The high bids DOD obtained primarily resulted from overdesigning the solar systems to be used in the project.

This situation could have been avoided had ERDA and DOD developed a detailed plan at the beginning of the project and worked together to develop an effective monitoring system. Through proper planning DOD, with ERDA guidance, could have designed solar systems to meet its cost estimates. Additionally, if an effective monitoring system existed, timely action could have been taken by ERDA to correct the problems when they became apparent or redirect the project at a much earlier date.

DOD's attempts to complete
the first project

After completing two phases of the first project --engineering and designing the solar systems and purchasing the solar collectors--DOD initiated negotiations with contractors to construct and install the solar heating systems in 35 residential housing units currently being built. DOD estimated that the reasonable upper limit for the cost of constructing and installing these systems would be approximately \$50 per square foot of collector. According to DOD officials, this estimate was based on discussions with industry and ERDA and HUD officials as to what a reasonable cost for solar heating systems should be.

DOD found, however, that the prices quoted by the contractors to install the systems in these residential units far exceeded the DOD estimate. The quoted prices in some instances exceeded \$200 per square foot of collector. As a result, DOD officials decided that the contractors should complete the residences without the solar system, and that all 50 units for the initial demonstration should then become retrofit units.

Accordingly, DOD again attempted to obtain acceptable bids for solar retrofit installations on these 50 residential units. Bids were obtained on a competitive basis and were substantially lower than the previous ones. However, the bids were not low enough in most cases to be considered acceptable by DOD. DOD did make one award for four solar retrofit installations at Sheppard Air Force Base, Texas. The total amount of this award was \$96,000, or about \$120 per square foot of collector.

Finally, DOD attempted to negotiate contracts at three sites with small business firms selected under the provisions of the Small Business Act (15 U.S.C. 631). While the negotiated prices were lower than those obtained by competitive bid, they still ranged from \$87 to over \$100 per square foot of collector installed. After this final unsuccessful attempt to negotiate an acceptable price, DOD officials concluded that they could not obtain a significant reduction in price for the remaining 46 units on a retrofit basis using the present designs. As a result, in a July 18, 1977, letter, DOD requested that the project as originally designed be terminated and that the remaining unobligated funds be redirected to other solar projects with which DOD has had more success.

DOI solar heating systems
overdesigned

To determine why the bids were higher than DOD expected for this project, we conducted a number of discussions with DOD, DOE, and HUD officials; contractors which bid on the DOD systems; and officials of the engineering firm which designed the solar systems. We also examined records made available by them. Our work showed that the solar systems were not designed to reach the DOD cost objective. Instead, DOD required that the systems be designed to provide a majority of the residences' heating needs. This resulted in solar systems which were overdesigned and too costly for the project. DOD was therefore unable to obtain bids which were near the \$50 cost estimate.

To achieve a satisfactory demonstration, DOD believed that the solar systems should provide the majority of the residences' heating requirements and be architecturally attractive. DOD therefore instructed an engineering firm to design solar systems which would

- enhance the architectural design of the residence and
- provide, as a minimum, 60 to 70 percent of the energy needed for water and space heating.

According to an official of the engineering firm, DOD did not require that the solar systems be designed to cost \$50 per square foot of collector. Consequently, no attempt was made to design the systems to meet DOD's cost objectives.

Typically, solar heating systems are designed to provide between 35 to 60 percent of residential heating requirements. In order for the project's solar systems to provide a minimum of 60 to 70 percent of the heating requirements, the engineering firm made substantial architectural changes to the housing designs. The most significant design changes included angling the roof so that the solar systems could collect more energy. Other architectural design modifications were added to make the systems more attractive. In addition, the systems were to be experimental components and a number of additional features, such as heat rejection coils which remove excess heat generated by the system.

Although it is difficult to determine exactly how much of the estimated installation cost was attributable to the required architectural design modifications or other factors, DOD officials and the contractors which bid on the systems believed architectural modifications, in particular those modifications

necessary to collect more energy, were a substantial portion. DOD officials said that 40 to 50 percent of the estimated installation cost was attributable to the architectural modifications. Similarly a contractor stated that the major cost in his bid was the cost of carpentry needed to meet the architectural requirements.

Thus, it appears to us that these architectural modifications were the primary factors which led to DOD's inability to negotiate a price that it believed reasonable for a solar heating system. As a result, the systems as designed were too costly. According to one builder, the DOD systems would have been at least two times more expensive to install than other commercially available solar heating systems and as such were "economically ridiculous."

While we recognize that under certain circumstances the demonstration of solar systems capable of providing a minimum of 60 to 70 percent of a residence's heating requirements might be worthwhile, DOD should have realized that demonstrating such systems would be costly. DOD should have had the solar systems designed around its cost objective instead of requiring that they be designed to provide a majority of the residences' heating needs. Had DOD attempted to demonstrate solar systems designed to collect less energy, it may have been able to obtain lower prices, and through proper planning and control over the project, could have had greater assurance of the successful completion of the project.

Failure to effectively plan
and monitor the project

To accomplish the early and successful demonstration of solar heating systems, an effective management system of planning, oversight, and control is necessary. Such a system would provide management with a mechanism for becoming aware of the progress and problems on projects and for taking timely corrective action when necessary.

At the time the initial phase of the DOD 50 unit demonstration project was funded by ERDA, neither ERDA nor DOD had a detailed plan describing the project, its objectives, decision points, milestones, and total cost. In a letter dated February 9, 1976, over 9 months after the project was initiated, ERDA first asked DOD to develop a detailed plan and made additional funding for the project contingent on ERDA's receipt and approval of such a plan. Although a plan was soon developed, the initial engineering and design phase had already been completed, and purchases of solar equipment had been initiated.

In our view, the plan was completed too late to aid management in directing and controlling the project.

Besides lacking a detailed plan at the start of the project when it would have been of most value, ERDA and DOD failed to set up an effective system to monitor the project's progress. In the initial phase of the project, ERDA relied on periodic communication by telephone to provide sufficient management control. However, in a letter dated November 5, 1975, 6 months after the first phase was funded, the Director of the Solar Division, ERDA, requested that they be kept more fully informed on the project's direction.

"It is our understanding that a consulting A&E [Architectural and Engineering] firm has been engaged to perform site selection and design the solar energy systems. It is our desire to be of assistance to DOD in carrying out this task and to be fully informed on the program * * *.

"Therefore, it is requested that a DOD/ERDA design review meeting be held as soon as possible to discuss the results to date, future plans, and any problems being encountered in the program."

This meeting was held January 8, 1976. After the meeting, correspondence increased between the two agencies. However, this correspondence was sporadic and apparently insufficient to meet ERDA management needs. Consequently, in an April 30, 1976, interagency agreement, which provided funds to DOD for completing the final phase of the project, ERDA required DOD to submit monthly status reports. We found, however, that at no time before the termination of the project did DOD submit such reports. ERDA officials thought DOD to be uncooperative. One official said that his primary mechanism for obtaining information on the project's status was telephone conversations with DOD personnel. DOD officials told us that they do not routinely provide status reports and that they believed the reports were unnecessary.

In our view, had ERDA and DOD developed a detailed plan for the project at its outset, and cooperated in the implementation of an effective system of monitoring the project's progress, the problems encountered by DOD could have been evaluated and corrected, thereby providing greater assurance of the success of this demonstration project.

Redirection of project efforts
should be consistent with
authorizing legislation

As a result of the problems encountered in attempting to carry out the project within established cost ceilings, DOD decided to seek termination of the project. On July 18, 1977, the DOD Director for Energy requested that the project be terminated and the remaining unobligated funds of \$971,779 be redirected. ERDA's approval was granted, and in an August 18, 1977, letter to the Chairman of the Subcommittee on Energy Research, Development, and Demonstration, House Committee on Science and Technology, ERDA's Director of the Solar Division and the DOD Director for Energy jointly advised that the DOD project was being redirected and indicated that this redirection was aimed at those projects which DOD has been successful in deploying. In addition, they stated:

"We feel that the proposed redirection of the DOD effort will result in increased benefits as well as being consistent with the intent of Public Law 93-409."

We examined the redirection efforts and found that most of the funds were being redirected to commercial applications and research and development projects. In our view, these projects are inconsistent with the role of DOD--demonstrating residential solar heating systems on Federal property--as specified in the act.

The following tables shows those projects, accounting for 63 percent of the unobligated funds, which do not involve demonstrating solar heating systems for residential use.

<u>Type of project</u>	<u>Amount</u>
Use of solar collectors for parachute drying	\$ 71,500
Use of solar collectors for heating offices	39,100
Preparation of designs and analysis of solar systems for Army and Air Force Base Exchanges	205,000
Research and development on a modular solar domestic hot water system for DOD barracks	<u>300,000</u>
Total	<u>\$615,600</u>

Of the remaining funds, \$267,961 is planned for use in residential dwellings and \$68,218 is being held in reserve.

Although research and development and demonstrating commercial applications of solar heating are provided for in the Solar Heating and Cooling Demonstration Act, the redirection of the DOD effort is inconsistent with the role DOD was specifically authorized to accomplish in the act--to demonstrate the residential use of solar heating on Federal property. The redirection efforts do not accomplish this goal.

While the redirection projects may be worthwhile, we believe that DOD should continue in its attempts to achieve the demonstration of solar heating systems on Federal residences to achieve the objectives of the act. Accordingly, DOD should be required to use the remaining funds from the first project for that purpose.

SECOND DOD PROJECT--POTENTIAL FOR FAILURE

Before the termination of DOD's first attempt to demonstrate the residential use of solar heating, ERDA provided DOD with \$1.4 million in funding authority for the second residential demonstration project. We examined this project and found that similar problems which caused or led to the termination of the first project--overdesigning the systems, lack of a detailed work plan, and an ineffective monitoring system--may also lead to difficulties in carrying out this second project.

The second demonstration project, which DOD initiated in August 1976, involves 80 residential units at three separate sites. To heat these residences, DOD plans to use central collector fields located some distance away from the housing units. These collector fields are designed to provide 70 to 80 percent of the residences' heating requirements and are to be constructed using much of the solar equipment procured in connection with the first project.

According to solar manufacturers, the use of central collector fields is a concept which is not typical of solar heating systems which are commercially available. As a result, these systems are generally more expensive than existing solar water and space heating systems and may incur technical problems in transporting the collected energy to the residential units. DOD has not established cost objectives for this project. However, if the same cost objective that was applied in the first project--\$50 per square foot of collector--were applied to this project, DOD may have similar problems. An official of an engineering firm involved in this project estimates these systems will cost at least \$57 per square foot. Minor cost overruns could place DOD in the same situation it had with the first project if the original cost objective is used.

We also found that no detailed plan exists for this project. Neither DOD nor DOE had established a formal system to monitor the progress of the project, even though the project was initially funded more than 1 year ago. Without such a plan and systematic monitoring, there is little assurance that problems similar to those which led to termination of the first project will not arise.

CONCLUSIONS

In carrying out its responsibilities under the Solar Heating and Cooling Demonstration Act of 1974, the former ERDA provided DOD with funding authority amounting to \$1.69 million for DOD's first attempt to demonstrate the practical use of solar heating on Federal residences. Under this project, which was initiated in May 1975, DOD was to have installed solar heating devices on 35 new and 15 existing single family residential units.

After more than 2 years of effort, expenditures of \$719,000, and a 1-1/2-year schedule slippage, DOD was unsuccessful in bringing this project into being. Accordingly, in July 1977, DOD requested ERDA's approval to terminate the project and redirect the remaining funds to other DOD solar efforts.

Our review showed that this project failed primarily because of oversized solar systems which precluded DOD from obtaining sufficiently reasonable bids for completing the project. However, in our view, had ERDA and DOD developed a detailed plan for the project at its outset and worked together to implement an effective system to monitor the project's progress, the solar heating systems may not have been oversized. Furthermore, timely action could have been taken to redirect or terminate the project at an earlier date when it became evident that the project was in trouble. Also, much of DOD's redirection efforts are not consistent with the authorizing legislation which requires DOD to demonstrate the residential use of solar heating on Federal or federally administered property. The redirection of these funds should be limited to only those activities relating to the residential use of solar heating devices.

ERDA also provided DOD with funding authority amounting to \$1.4 million for a second residential solar demonstration project. DOD plans to demonstrate solar heating on 80 residential units using central collector fields. Our review showed that problems similar to those which contributed to the first project's failure may occur with this second demonstration project. In this regard, we noted that the systems to be demonstrated in carrying out this second project are expected to be more expensive than typical solar heating systems which are commercially available, and there are similarly no work plans or an effective system to monitor the project.

RECOMMENDATIONS

To avoid a recurrence of the problems encountered in DOD's first attempt to demonstrate solar heating on Federal residences and have DOD's efforts better meet the intent of the Solar Heating and Cooling Demonstration Act of 1974, we recommend that you:

- Require that detailed plans be developed by DOD and formally approved by DOE for all solar demonstration projects. Such plans should be developed immediately for DOD's second demonstration project and at the outset of all future projects. They should include project objectives, milestones, decision points, target dates, and design and cost information associated with the solar heating systems to be demonstrated.
- Work together with DOD to establish and implement a formal project monitoring system that would enable DOE management to track progress through periodic and frequent progress reports. Such a system would

enable DOE to identify problems and take corrective action in a more timely manner.

--To the extent practical, limit the redirection of funds for DOD's first Project to those activities that relate to the demonstration of solar heating devices on Federal residential dwellings.

In a separate report to DOD, we are also recommending that the Secretary of Defense (1) issue instructions requiring DOD officials responsible for the solar demonstration projects to fully cooperate with DOE through the development and timely submission of monthly status reports and other documents and information products as required by DOE in conducting the program and (2) monitor and periodically evaluate the DOD solar demonstration projects to insure that they are progressing satisfactorily, giving particular attention to the effectiveness of the actions taken to enhance the cooperation between DOD and DOE.

As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and the House Committee on Government Operations not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

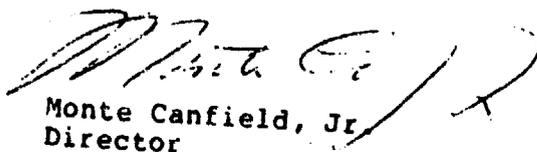
We are sending copies of this report to the four committees mentioned above and to the Chairmen of the energy-related congressional committees. We are also sending copies to the Director, Office of Management and Budget.

A draft of this report was furnished to DOE and DOD officials responsible for carrying out the solar heating and cooling demonstration program. Their comments were considered in finalizing this report.

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We appreciate the courtesy and cooperation extended to our staff during the review.

Sincerely yours,



Monte Canfield, Jr.
Director

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