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REPORT BY THE U.S.

General Accounting Office

DOD Should Give More Consideration To Passive Solar Systems For New Military Family Housing

GAO found that the Department of Defense (DOD) was making limited use of active and passive solar systems in its military family housing units. After DOD evaluated the potential for using various configurations of active systems, it generally found such systems uneconomical. However, it did not give equal or adequate consideration to passive solar systems. It had not established a policy nor provided guidance to the military services concerning passive solar. As a result, detailed evaluations for passive systems were not routinely made.

Although Department of Energy studies and demonstrations indicate that many passive solar features are economical for the private sector, DOD remains unconvinced that those features would be economical for military family housing units.

This report contains recommendations which should help ensure that passive solar systems are adequately considered and included on new military family housing units where economical.



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

ENERGY AND MINERALS
DIVISION

B-205311

The Honorable Caspar W. Weinberger
The Secretary of Defense

The Honorable James B. Edwards
The Secretary of Energy

The Department of Defense (DOD) has an active military family housing construction program, which during fiscal years 1981 and 1982 called for constructing more than 4,500 new housing units. Since 1979, DOD has been required to consider using solar energy systems in all new units constructed under its program. Both active and passive solar energy systems are considered particularly well-suited for providing heat and hot water for residential-type structures and, according to the Department of Energy (DOE), the private sector's use of these systems has been increasing rapidly in recent years. The General Accounting Office conducted a review to determine the extent to which DOD was considering the use of such systems for new military family housing.

For fiscal years 1981 and 1982, we found that DOD had planned to use very few active and passive solar energy systems in its military family housing. The reasons for not using more of these systems varied. With respect to active systems, DOD established a policy, issued guidance, and the military services were routinely making detailed evaluations of the potential for using various configurations of active solar systems. DOD generally found such systems uneconomical. Based on our work, DOD's evaluations appeared reasonable. With respect to passive systems, DOD had not established a policy nor provided detailed guidance to the military services. Consequently, passive solar systems were not evaluated to the same extent as active systems, and the consideration each service gave to including passive solar systems in newly constructed military housing units differed.

DOE has funded numerous studies and demonstrations showing that passive solar features are currently economical for residential structures in various regions of the country. However, since the economics of some of these features had not been fully demonstrated using DOD's life-cycle cost analysis criteria, DOD remained unconvinced that they would be economical for military family housing projects.

We believe the military services should give greater consideration to using passive solar systems in new military family housing units and install such systems where economical. To do this, however, the military services need guidance to help determine which passive solar features are likely to be economical for military family housing. We believe DOE can play a useful role in helping the military services arrive at these determinations by providing DOD information obtained from the various DOE passive solar projects.

This report contains recommendations to the Secretary of Defense and the Secretary of Energy. Our recommendations are aimed at helping to ensure that passive solar energy systems are adequately considered and included on new military family housing units where economical.

The following sections discuss our objectives, scope, and methodology; contain a brief background; and present the results of our review along with our conclusions and recommendations.

OBJECTIVES, SCOPE, AND METHODOLOGY

We performed detailed work at DOD and the headquarters offices of the Departments of the Army, Navy, and Air Force. We reviewed family housing construction plans for fiscal years 1981 and 1982 to determine how much construction was planned by each military service and the extent that the use of solar systems was included in the plans. We examined the analyses each of the military services prepared in considering whether to include solar, concentrating on the type of solar systems considered and the criteria used. We reviewed pertinent legislation and related legislative histories, regulations, guidance, and other documents dealing with military construction and solar energy, and discussed the use of solar systems with engineers at various levels within DOD. In addition, we discussed the potential use of solar in Federal buildings with DOE program officials and with officials from the Los Alamos Scientific Laboratory in Los Alamos, New Mexico, and the Solar Energy Research Institute in Golden, Colorado.

We limited our review to new military family housing construction because DOE officials told us that active and passive solar systems for smaller structures are generally the most economical. Also, we were told that the use of these systems for providing heat and hot water--particularly in smaller structures such as residences--has been increasing rapidly in recent years.

Our review was performed in accordance with GAO's current "Standards for Audit of Governmental Organizations, Programs, Activities, and Functions."

BACKGROUND

Both active and passive solar energy systems are currently used in many regions of the country to provide heat and hot water for various types of buildings. Active solar systems employ predominately modular or site built collection systems which convert insolation (radiation from the sun) into thermal energy by absorbing the radiation. Mechanical subsystems transfer the heat into the building using air or liquids, where it goes directly to heat space, heat service water, or is stored for later use.

Passive solar systems employ architectural building designs that call for using elements of the building to collect, store, and distribute energy. Passive systems are intended to maximize the benefits of natural energy flows and minimize dependence on conventional energy resources and mechanical equipment. There are many techniques and features that can be employed in passive solar designs ranging from those that are rather simple, such as using roof overhangs and orienting the building to maximize southern exposure, to those that are comparatively sophisticated, such as using Trombe walls and sunspaces. 1/

According to DOE, both active and passive solar systems are particularly well suited for smaller structures such as residences, and their use has been increasing each year with the greatest use in the private residential sector.

DOD currently has approximately 415,000 residential units in its military family housing inventory geographically dispersed across the country and around the world. The inventory contains a wide assortment of structures and includes both single family, unattached units, as well as various types of housing clusters containing several units. In addition, DOD has an ongoing construction program under which it planned more than 4,500 new military family housing units during fiscal years 1981 and 1982. Most of these units are currently under construction or in the design phase.

Since 1979, DOD has been required to consider using solar in its military construction program. Section 804 of the Military Construction Authorization Act, 1979 (P.L. 95-356, Sept. 8, 1978)

1/A Trombe wall is a south-facing masonry wall that is insulated from the exterior by glass with an air space between the wall and glass. The wall collects and stores solar heat which is released into the building by radiation and convection. A sunspace, or greenhouse is an attached (predominately glass) south-facing room which works in a similar manner, moving air warmed by direct gain into other areas of a building.

required that solar energy systems be considered for use on newly constructed military family housing. In the following year, the Military Construction Authorization Act, 1980 (P.L. 96-125, Nov. 26, 1979) expanded this requirement to include all military construction by adding Section 2688 to Title 10 of the United States Code. This section requires that (1) the design of all new military facilities, including family housing, should take into account solar energy systems when it may save energy derived from fossil fuels and (2) construction contracts to build these facilities must require that solar systems be installed where cost effective. In addition, Section 2688(b) contained a definition of the term "cost effective," which was amended by subsequent authorization acts for fiscal years 1981 and 1982 (P.L. 96-418 and P.L. 97-99, respectively) to require DOD to use life-cycle costing in making its cost-effectiveness evaluations. 1/

In light of these legislative requirements, before DOD can use active or passive solar systems, each system must be economical using life-cycle cost analysis criteria. Life-cycle cost analysis provides an evaluation of the net effect, over time, of reducing fuel costs by purchasing, installing, maintaining, operating, repairing, and replacing building systems. Although varying from time-to-time, the criteria governing military construction projects planned for fiscal years 1981 and 1982 are consistent with criteria contained in guidelines published by DOE to assist other Federal agencies in making life-cycle cost analyses of their building projects.

There are four key factors considered in life-cycle cost analyses--initial costs, maintenance and operating costs, fuel escalation rates, and a discount rate. Estimates of initial solar system costs, which include installation, are developed from manufacturer's and/or builder's price lists. There are no historical data on the annual costs of operating and maintaining solar systems, and DOD and DOE guidelines established a range of 1 to 4 percent of the system's initial costs as a reasonable estimate. Fuel escalation rates are used to estimate future energy savings expected. These rates vary according to the type of fuel displaced and the geographic region in which the system is to be located. The discount rate (currently 7 percent) is used to calculate the present value of a system's expected yearly costs and energy savings.

1/The related appropriations acts for those years (P.L. 96-436 and P.L. 97-106) contained similar language restricting the use of appropriated funds.

DOD'S LIMITED USE OF ACTIVE
AND PASSIVE SOLAR IN MILITARY
FAMILY HOUSING

Although DOD planned more than 4,500 military family housing units in fiscal years 1981 and 1982, solar was planned for only two projects containing 397 housing units. One of the projects, however, was subsequently redesigned and the planned solar system was no longer considered practical for the project's 165 units. The reasons for not using more systems varied. With respect to active systems, DOD's life-cycle cost analyses have shown that such systems are generally uneconomical. Passive systems, on the other hand, were not adequately considered by DOD, and the military services generally did not perform life-cycle cost analyses to evaluate passive solar's possible use on these projects. Without such analyses, the economic viability of passive solar systems for military family housing has not been clearly demonstrated, although DOE studies and demonstrations have shown passive solar to be economical in various regions of the country.

Active systems are
generally uneconomical

DOD had not included active solar systems on planned military family housing projects because the evaluations made by the military services have shown that such systems are generally not economical. Based on our review, these evaluations appeared to provide reasonable estimates of the economic viability of each system considered and were prepared in accordance with appropriate guidelines and criteria.

After analyzing various active solar configurations for each fiscal year 1981 and 1982 housing project, active solar systems proved economical for only one project. For fiscal year 1981, DOD planned to build 2,651 military family housing units. The military services considered the use of active solar systems for all projects and performed life-cycle cost analyses, but in every case, each system's estimated costs exceeded the estimated savings over the system's life. Results were much the same for the 1,917 family housing units DOD planned to build in fiscal year 1982. Again, life-cycle cost analyses were made and active solar systems were found uneconomical, except for one Navy project involving 165 housing units at Kings Bay, Georgia. Navy officials, however, advised us that its subsequent redesign of the project's heating and cooling requirements had rendered use of the planned active solar heating and hot water system no longer practical.

Our review showed that the services generally complied with DOD life-cycle costing guidelines when evaluating active solar's economic viability for military family housing construction projects. In accordance with DOD policy and guidance for active solar

systems, the services considered and performed life-cycle cost analyses for various types of systems, including solar heating, solar hot water, and a combination solar heating and hot water system for each planned construction project in fiscal years 1981 and 1982. According to DOD officials, such analyses will continue to show that active systems are generally uneconomical until the cost of the systems decrease or the cost of conventional fuel rises dramatically.

DOD has not adequately considered
passive solar systems

In contrast to the emphasis DOD placed on active solar systems for military family housing, passive solar was given relatively little consideration. DOD had not established a policy nor issued detailed guidance addressing the use of passive solar. Although passive solar's economic viability had not been clearly demonstrated for military family housing using DOD's life-cycle cost analysis criteria, DOE had conducted numerous studies and demonstrations showing that many passive features are currently economical in various regions of the country.

The legislative history of the 1979 Military Construction Authorization Act which first established a requirement to consider solar systems for family housing shows that the Congress clearly contemplated that DOD consider and evaluate both active and passive solar systems. In this connection, the Senate Armed Services Committee Report No. 95-847 states:

"Solar energy systems include much more than solar collectors, piping, storage, and heat exchangers; the committee expects that every facility that the Defense Department builds in the future would take advantage of passive solar design techniques (building orientation, amount and location of windows, et cetera)
* * *." (Emphasis added.)

The Military Construction Authorization Act, 1980, which expanded the requirement to include all military construction programs, had no impact on the technologies that were to be considered (Conference Committee Report, H. Rep. 96-595). We found nothing in the legislative history of this act to indicate that only active systems should be considered. Also the legislative histories of subsequent acts concerning military construction activities, including the related authorization acts for fiscal years 1981 and 1982, provide no further clarification concerning the types of solar systems DOD is to consider and evaluate.

In the absence of a DOD policy requiring the services to consider the use of passive solar systems when planning military family housing projects, the services rarely considered such

systems. Instead they relied primarily on contractors to consider and incorporate passive solar in these projects, at the contractors' discretion. ^{1/} For the military family housing units planned in fiscal years 1981 and 1982, we identified only one instance where passive solar designs were considered by the services during the planning process and included in the general specifications provided to contractors to include in their proposals. In that instance, the Department of the Army, assisted by DOE's Passive Solar Division, considered a wide range of passive solar features for a family housing project at Ft. Drum, New York. As a result of its evaluation, the Army plans to include some of these features in 232 housing units planned for construction during fiscal year 1982.

On the other hand, neither the Navy nor the Air Force had made similar evaluations. In fact, the Air Force had established a policy which specifically precluded its personnel from considering most of the more sophisticated passive solar features. One major command within the Air Force had planned to include such features in a major housing renovation project. However, Air Force officials at the headquarters level issued instructions stating that such features had not been proven cost effective and should not be considered for either new construction or renovation projects until the Air Force determined whether they are economical. The Air Force plans to begin testing these features in fiscal year 1983, when one passive solar project is planned, and in fiscal year 1984, when two more are planned.

We discussed the Air Force's policy with the head of DOE's Passive Solar Division. He objected strongly to the policy, stating that DOE's passive solar demonstrations have shown that buildings incorporating some of the more sophisticated passive solar design features can save 30 to 80 percent of conventional energy usage, with little or no increase (0 to 10 percent) in construction costs. Subsequently, in an October 6, 1981, letter to the Department of the Air Force, the head of DOE's Passive Solar Division stated that a reasonably adequate data base exists for these features to have confidence in their performance and that the necessary tools are available to integrate them into new buildings.

We examined the basis for DOE's contention that these passive solar features are economical. Studies and demonstrations

^{1/}DCD and the military services' construction manuals provide general instructions to contractors in designing military family housing units. These instructions encourage contractors to consider some simple passive designs, such as roof overhangs, but none of the more sophisticated passive features.

by DCE and its contractors, covering a wide range of passive solar features for both residential and commercial buildings, have shown that various types of these features are economical in many regions of the country. Unfortunately, neither DOE nor any of its contractors used the life-cycle costing criteria DOD follows in evaluating solar systems for military family housing. Instead, they chose economic criteria which they believed to be more applicable to the private sector. The studies generally used lower discount rates and higher fuel escalation rates, which made solar seem more economically attractive than would otherwise have been the case using DOD's criteria. The results do, however, provide indications of passive solar's economic potential. For example:

--The Los Alamos Scientific Laboratory in Los Alamos, New Mexico, has been active in conducting economic studies for DOE of passive solar applications on residential type structures. The studies have concluded that such applications can be cost effective depending upon the location and the conventional fuel displaced. Specifically, the studies indicate that Trombe walls and other direct gain applications currently compete favorably against electric resistance heat in many States, but generally cannot compete against natural gas.

--The Solar Energy Research Institute in Golden, Colorado, has conducted economic analyses of single family passive solar residences. Such analyses are being completed for 12 passive solar homes in the Denver metropolitan area. In each case, an attempt was made to analyze incremental costs of the passive solar features compared to a base design conventional house and to calculate economic pay-back periods for the passive solar house. The passive solar features analyzed included sunspaces, Trombe walls, and other direct gain applications. Study results to date on six houses show that for each house the passive solar features analyzed are cost effective, compared to gas or electric heating, both with and without Federal and State tax credits.

CONCLUSIONS

DOE has been mandated to consider using solar energy systems in its new military family housing units since 1979, and to install such systems in these units where economical. Although the private sector's use of active and passive solar systems may be rapidly increasing particularly for residential-type structures, we found that for fiscal years 1981 and 1982, DOD had made very limited use of such systems in its military family housing. The reasons for such limited use varied.

With respect to active systems, DOD had established a policy, issued guidance, and each service was routinely considering and making detailed evaluations of the potential for using various configurations of active solar systems. The evaluations, however, generally showed such systems to be uneconomical. In our view, these evaluations appeared to provide reasonable estimates of the economic viability of each system and were prepared in accordance with appropriate guidelines and criteria.

With respect to passive systems, DOD had not adequately considered using passive solar in its new military family housing units. DOD had not established a policy requiring the military services to consider passive solar in planning new military family housing units. In the absence of such a requirement, the amount of consideration the services gave to passive systems differed and detailed evaluations were not routinely being made. We identified one instance where passive solar was evaluated and resulted in the Army's deciding to include passive solar features on 232 planned housing units.

DOE studies and demonstrations have shown that a wide range of passive solar features are currently economical in many regions of the country. DOD was not convinced that some features would be economical for military family housing, because neither DOE nor any of its contractors used the life-cycle costing criteria that DOD must use in evaluating solar systems for military family housing. Although the economic viability of passive systems has not been clearly demonstrated, the DOE studies do provide indications of passive solar's economic potential for military family housing.

RECOMMENDATIONS

We recommend that the Secretary of Defense establish a policy requiring the military services to consider, evaluate, and install passive solar systems when economical. We also recommend that DOD develop, with assistance from DOE, guidance for the services to implement that policy. The guidance should identify which passive solar features should be considered, and under what circumstances or conditions--such as location and type of conventional fuel displaced--these features are likely to be economical.

We recommend that the Secretary of Energy analyze information from DOE's ongoing and completed passive solar projects to determine the economics of passive solar features using the life-cycle costing criteria DOD must use in its military family housing program. We further recommend that the Secretary of Energy provide the results of these analyses to DOD to assist in developing appropriate guidance for using passive solar energy in military family housing. The results should be in sufficient detail to

determine the conditions and extent to which the different passive solar features are likely to be economical.

VIEWS OF DOD AND DOE
PROGRAM OFFICIALS

We discussed the matters contained in this report with DOD and DOE program officials and their comments have been incorporated where appropriate. DOE officials agreed with our findings, conclusions, and recommendations. DOD officials generally agreed with our findings, but believed that efforts currently underway will resolve the problems identified in this report. Overall, DOD believed that in light of rather limited documentation concerning the economics of certain passive solar features, it should proceed cautiously in the application of these features. DOD officials also provided us a copy of draft changes to its construction manual addressing the use of both active and passive solar systems in military construction programs. The draft is currently being circulated among the services for comment before the changes are finalized.

Although the proposed changes require that the services routinely consider and evaluate some simple passive solar features for new buildings, we believe these changes will not fully resolve the problems identified in this report. For example, each service would still have complete discretion in deciding whether to consider any of the more sophisticated passive features thereby allowing them to continue the inconsistent treatment accorded to these features. We continue to believe that DOD needs to establish a policy and provide guidance which will ensure that the services consistently consider and evaluate all passive solar features which are likely to be economical.

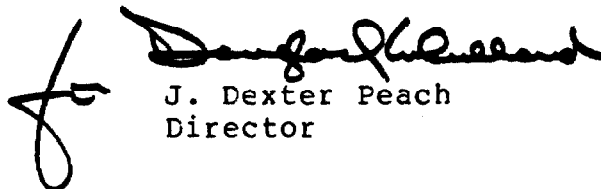
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As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and the House Committee 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 congressional committees concerned with military construction and energy-related matters. We are also sending copies to the Secretaries of the Army, Navy, and Air Force, and to the Director, Office of Management

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and Budget. We appreciate the courtesy and cooperation extended to our staff during the review and would appreciate being informed of the actions you take on our recommendations.

A handwritten signature in black ink, appearing to read "J. Dexter Peach". The signature is written in a cursive style with a large, looping initial "J".

J. Dexter Peach
Director

(307204)

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