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January 1992

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

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PNL-7956

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# DEMONSTRATION OF THE DOE INTERIM ENERGY CONSERVATION STANDARDS FOR NEW FEDERAL RESIDENTIAL BUILDINGS

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## SUMMARY

In accordance with federal legislation, the U.S. Department of Energy (DOE) has sponsored a study to demonstrate use of its Interim Energy Conservation Standards for New Federal Residential Buildings. The demonstration study was conducted by DOE and the Pacific Northwest Laboratory (PNL). The demonstration is the second step in a three-step process: 1) development of interim standards, 2) demonstration of the interim standards, and 3) development of final standards. The standards are mandatory for federal agency housing procurements. Nevertheless, PNL found at the start of the demonstration that agency use of the interim standards had been minimal.

The purpose of the standards is to improve the energy efficiency of federal housing and increase the use of nondepletable energy sources. In accordance with the legislation, the standards were to be performance-based rather than prescribing specific energy conservation measures. To fulfill this aspect of the legislation, the standards use a computer software program called COSTSAFR which generates a point system that individualizes the standards to specific projects based on climate, housing type, and fuel costs. The standards generate minimum energy-efficiency requirements by applying the life-cycle cost methodology developed for federal projects.

For the demonstration, PNL and DOE chose five federal agency housing projects which had been built in diverse geographic and climate regions. Participating agencies were the Air Force, the Army (which provided two case studies), the Navy, and the Department of Health and Human Services.

PNL worked with agency housing procurement officials and designers/architects to hypothetically apply the interim standards to the procurement and design of each housing project. The demonstration started at the point in the project where agencies would establish their energy-efficiency requirements for the project and followed the procurement process through the designers' use of the point system to develop a design which would comply with the standards. PNL conducted extensive interviews with the federal agencies and design contractors to determine what impacts the standards would have on the existing agency procurement process as well as on designers.

Overall, PNL found that the interim standards met the basic intent of the law. Specific actions were identified, however, that DOE could take to improve the standards and encourage the agencies to implement them.

Agency personnel found the minimum efficiency levels established by the standards to be lower than expected, and lower than their existing requirements. Generally, this was because the standards factor in fuel costs, as well as energy savings due to various conservation measures such as insulation, when they determine the minimum efficiency levels required. The demonstration showed that federal agencies often pay low prices for heating fuel and electricity; these lower costs "tipped the scales," allowing designers to meet the efficiency target with designs that were relatively inefficient. It appeared, however, that the low prices paid by agencies directly to suppliers did not capture the agencies' full costs of providing energy, such as the costs of distribution and storage.

Agency personnel expressed some concern about the standards' ability to incorporate new energy-efficient technologies and renewable resource technologies like solar heating systems. An alternative compliance procedure was developed to incorporate new technologies; however, demonstration participants said the procedure was not well documented and was difficult and time consuming to use.

Despite these concerns, most agency personnel thought that the standards would fit into current procurement procedures with no big changes or cost increases. Many said use of the standards would decrease the time and effort they now spend to establish energy-efficiency requirements and to confirm that proposed designs comply. Personnel praised the software and documentation for being easy to use and providing energy efficiency requirements in energy dollars. Personnel were concerned about how the standards could be modified to analyze unusual design features. A centralized information source for agencies using the standards was suggested.

Housing designers agreed that the DOE standards were easy to use to determine that their designs meet energy efficiency goals. They noted that the information provided by the standards could be useful in their design process. Most designers agreed with agency personnel that the alternative

compliance procedure was too time consuming. They suggested that assistance be available so that the proposal and procurement process would not be interrupted.

Additional conclusions were that training and assistance is needed by field office personnel because much of the federal agency procurement activity occurs at the field offices. Agency training needs fall into three categories: 1) specific improvements in the documentation, 2) materials and courses to educate users, and 3) mechanisms for providing information to users. Designers will need additional help, particularly in understanding how to design housing with improved energy-efficiency. A procedure to update the standards will be needed. DOE has met its legal requirement for obtaining public input but successful implementation of the standards will depend on mechanisms for continued public, industry, and agency feedback.

Based on the demonstration, PNL recommends establishing task forces that will actively involve agency personnel and others in future revisions and development of the final standards. PNL also recommends that agencies use fuel and energy prices in the standards that reflect total costs better than the direct fuel prices that the agencies pay their suppliers. A number of ways are recommended to improve communications and the tools for implementing the standards. Several recommendations are made for increasing the number of renewable resource options that are included in the standards. Finally, PNL recommends on-going monitoring activities to continue to identify ways in which the standards can be improved.

## ACKNOWLEDGMENTS

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## ACRONYMS

| | | |
|---|---|---|
| A&E | - | architect and engineer |
| ACP | - | alternative compliance procedure |
| AFB | - | Air Force Base |
| AFUE | - | annual fuel utilization efficiency |
| ASHRAE | - | American Society of Heating, Refrigerating, and Air-Conditioning Engineers |
| ATC | - | Air Training Command |
| BAQ | - | basic allowance for quarters |
| BFR | - | base facilities requirements |
| CAPS | - | Computerized Automated Point System |
| CFR | - | Code of Federal Regulations |
| COSTSAFR | - | Conservation Optimization Standard for Savings in Federal Residences |
| DHHS | - | Department of Health and Human Services |
| DHW | - | domestic hot water |
| DOD | - | U.S. Department of Defense |
| DOE | - | U.S. Department of Energy |
| DOS | - | Disc Operating System |
| E | - | emissivity |
| ECM | - | energy conservation measure |
| EER | - | energy efficiency rating |
| FEMP | - | Federal Energy Management Program |
| FR | - | Federal Register |
| FY | - | fiscal year |
| G&A | - | general and administrative |
| HSPF | - | heating season performance factor |
| HUD | - | U.S. Department of Housing and Urban Development |
| HVAC | - | heating, ventilation, and air conditioning |
| IHS | - | Indian Health Service |
| LCC | - | life-cycle cost |
| LPG | - | liquid propane gas |
| MILCON | - | Military Construction Program |
| OES | - | Office of Engineering Service, Public Health Service |
| PC | - | personal computer |
| PHS | - | Public Health Service |
| PNL | - | Pacific Northwest Laboratory |
| POSTSAFR | - | Postprocessor for COSTSAFR |
| PV | - | photovoltaic |
| R | - | thermal resistance (R-value), $h \cdot °F \cdot ft^2/Btu$ |
| REEEM | - | Residential Energy and Economic Evaluation Manual |
| RFP | - | request for proposal |
| SAC | - | Strategic Air Command |
| SEER | - | seasonal energy efficiency rating |
| SEI | - | site engineering investigation |
| U | - | heat loss coefficient (U-value), $Btu/°F \cdot h \cdot ft^2$ |
| USC | - | U.S. Code |
| VHA | - | variable housing allowance |

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## FIGURES



## TABLES

# 1.0 INTRODUCTION

This report describes a project conducted to demonstrate the U.S. Department of Energy's (DOE) Interim Energy Conservation Standards for New Federal Residential Buildings. The demonstration project was conducted for DOE by the Pacific Northwest Laboratory (PNL).[a] A condensed version of this report is also available.[b]

DOE developed the Interim Energy Conservation Standards in response to a series of laws, which are discussed in Chapter 3. According to these laws, the standards are to improve the energy efficiency and increase the use of nondepletable, or renewable, energy sources in residential buildings. The laws require the standards to establish performance-based criteria for houses, rather than prescribe specific energy conservation measures. Although the original intent of the law was for the standards to apply to all new residential buildings, the law was amended in 1981 to make the standards mandatory only for residential buildings constructed or used by federal agencies (if these buildings are not legally subject to state or local building codes or similar requirements).[c]

In accordance with the legislation, DOE developed the interim standards.[d] Computer software was designed to implement the standards. This software is for use by federal agencies at the beginning of their procurement process. An advisory group comprised of representatives of the military services reviewed the software during development of the standards and provided comments and suggestions on software design.[e] The energy-

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(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy.

(b) Lee, A. D., M. C. Baechler, F. V. Di Massa, R. G. Lucas, and D. L. Shankle. 1991. Demonstration of the DOE Interim Energy Conservation Standards for New Federal Residential Buildings: Executive Summary. PNL-7955, Pacific Northwest Laboratory, Richland, Washington.

(c) In a separate but related activity, DOE is also developing voluntary energy conservation standards for private-sector housing.

(d) DOE was assisted in the development of these standards by PNL.

(e) It was determined early in the development phase that over 90% of housing to which the standards would apply is built by or for the military.

efficiency performance-based requirements of the standards are specific to each housing project, taking into account local climate and fuel costs.

On August 25, 1988, DOE published the interim standards, and they became effective for federal agencies on February 21, 1989 (53 Federal Register (FR) 32536-46).[a] On the same day, DOE published for comment a proposed modification that added credit for three different thermal mass wall configurations, added new data and options for energy-efficient windows, and established an alternate compliance procedure (53 FR 32547-55). On January 31, 1991, the modified interim standards were published and became effective on July 31, 1991 (56 FR 3765-3773). Although federal agencies provided some comments on the standards, there was little evidence that agencies began implementing the interim standards when they became effective.

Federal legislation also required DOE to conduct a demonstration project for at least 12 months in at least two geographical areas and to prepare a report to Congress containing an analysis of the findings and conclusions. This document comprises that report. The information reported here from the demonstration will be used as the basis for developing final standards.

The demonstration consisted of hypothetical applications of the interim standards to five federal agency housing projects. The projects were actual buildings, already designed or constructed in five diverse geographic and climatic zones. Federal agencies were requested to use the standards retroactively to generate energy-efficiency requirements for the projects, which had been designed based on existing agency requirements. PNL then subcontracted with design firms to determine what changes they would have made to the original design to meet the requirements of the DOE standards. The demonstration was a "paper" study; no actual design or construction work was undertaken.

Extensive interviews were conducted to document current agency and designer practices. Data collection forms were developed and used to document the likely effects of the standards. Current agency and designer practices established a baseline from which the incremental impacts of the DOE standards

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(a) The actual language of the standards can also be found in 10 Code of Federal Regulations (CFR) Part 435.

were measured. Impacts that were analyzed included both qualitative and quantitative effects, specifically effects on agency and designer processes, housing costs, and energy consumption.

Chapter 2 of this report describes the standards and the process for implementing them. Chapter 3 discusses the design of the demonstration. Four federal agencies participated in the demonstration: the Air Force, the Army (which provided two case studies), the Navy, and the Department of Health and Human Services. The housing procurement process for each of these agencies is described in Chapters 4 through 7. These chapters also describe the housing projects included in the demonstration, and assess the impacts of the DDE standards. Chapter 8 presents the overall findings from the demonstration projects. Chapter 9 presents the recommendations based on this demonstration. Chapter 10 lists the references. Appendixes A, B, and C provide examples of the data collection instruments used to obtain information from the agencies and design contractors. Appendix D discusses the feedback received from the agencies and how that feedback was incorporated into this report.

## 2.0 DESCRIPTION OF STANDARDS

Congress required DOE to develop energy efficiency standards for housing that were performance-based (see Chapter 3). These are standards that require houses to perform to certain levels of energy efficiency, rather than requiring that specific measures or devices be installed. To be consistent with the performance-based requirement and to produce the maximum practicable improvements in energy efficiency, as required by the legislation (see Chapter 3), DOE developed energy conservation standards that set requirements which are based on project-specific conditions rather than being pre-defined. The conditions that had to be factored into developing conservation requirements included the local climate, types of houses, applicable fuel prices, and local construction costs.

Early in the development process it became clear that, to calculate housing performance using site-specific criteria, a software tool would be needed. Initial development of the software started in 1984. The software is called the Conservation Optimization Standard for Savings in Federal Residences (COSTSAFR). COSTSAFR is designed to be implemented by federal officials responsible for federal housing procurement. This chapter describes COSTSAFR, the compliance forms it generates, the alternative compliance procedure (ACP), and the role of the standards in new housing procurement.

### 2.1 DESCRIPTION OF SOFTWARE AND ITS USE

The COSTSAFR software operates on IBM personal computers or other IBM-compatible personal computers. COSTSAFR is designed to be used by federal housing procurement officials. Its primary purpose is to produce point system compliance forms. (This point system is further discussed in Section 2.I.2 below.) Each form provides a list of the most cost-effective energy conservation choices for a number of building components in one type of residential building. The form also gives the user a point total representing a minimum reduction in energy costs that must be achieved. This reduction is the target that any building design must meet to comply with the standards. COSTSAFR is intended to be simple to operate, requiring the user to enter only

basic information relating to a federal housing construction project. A user's manual provides the information needed to operate COSTSAFR (DOE 1988a).

The COSTSAFR program does a project-specific life-cycle cost (LCC) analysis using a 25-year period of analysis and a federal discount rate established by the Federal Energy Management Program (FEMP). Fuel price escalation rates for future years are established and updated yearly by FEMP. The LCC analysis accounts for tradeoffs between the non-energy costs (purchase, maintenance, replacement costs, and salvage values) of energy conservation measures (ECMs), and the results of life-cycle energy cost savings over the life of a house. For a given run, the LCC analysis produces an "optimum design," which is the set of ECMs with the lowest LCC, based on the ECMs included in COSTSAFR. As noted earlier, the total energy cost savings for the optimum design establish a point total that represents the target energy cost reduction one must meet to comply with the standards. Technical support documents provide detailed information about the economic and technical underpinnings of the standards and the software (DOE 1988b, DOE 1988c).

To obtain project-specific conditions, the user enters data that include the year of occupancy, project location, allowable foundation and housing types, allowable space heating fuel and equipment types, whether air-conditioning is included, allowable domestic hot water (DHW) equipment types, and fuel costs. COSTSAFR analyzes seven different prototypical houses: single- and double-section manufactured houses; ranch, two-story, and split-level detached houses; and town house and apartment low-rise attached housing.[(a)]

The ECMs incorporated in COSTSAFR include envelope component (ceiling, wall, and floor) insulation levels; window types; heating and cooling equipment types and efficiencies; and refrigerator/freezer and water heater types and efficiencies. In performing the LCC analysis, COSTSAFR accesses two databases containing ECM data.

---

(a) COSTSAFR analyzes both mid- and end-units in town houses and low-rise attached housing, and generates separate compliance forms for the mid- and end-units, if desired. Consequently, there are nine different unit types that can be analyzed.

One database contains all ECM cost data, including initial cost, maintenance cost, replacement costs, and salvage values. COSTSAFR allows the user two options for making modifications to the existing cost database. The user can either make overall adjustments to the ECM cost database to account for inflation and local construction costs, or change individual ECM costs.

The second database contains the energy consumption data for each ECM. The energy database was created with the DOE-2.1 (DOE 1988c) building simulation model. COSTSAFR has separate energy data for each of the seven house prototypes (or nine unit types). Furthermore, each of 45 predefined climate zones within the United States has a full set of separate ECM energy data. The two ECM databases, coupled with fuel cost escalation rates and the user-entered information, provide COSTSAFR with all the input data needed to perform the LCC analysis and generate the point system for a specific project.

Figure 2.1 shows a diagram of the COSTSAFR structure including the three data sources, the analysis performed, and the output (point system) produced. COSTSAFR analyzes four types of energy end-uses: space heating, space cooling, water heating, and refrigerator/freezers. For space heating and cooling, COSTSAFR calculates the energy required to heat and cool (condition) indoor spaces based on envelope insulation levels and window types, and adjusts these to account for heating and cooling equipment efficiencies. Five heating fuel/equipment types are included in COSTSAFR: natural gas, oil, liquid petroleum gas (LPG, or propane), electric furnaces, and electric heat pumps. The water heating and refrigerator/freezer end-uses are independent from the space heating and cooling. Water heater types included are natural gas and electricity; LPG can be substituted for natural gas. The COSTSAFR user can exclude refrigerator/freezers if desired.

### 2.1.1 History of COSTSAFR

Three versions of the COSTSAFR software have been issued to the public to date. The initial version (Version 1) was issued in the Federal Register for public comment on August 20, 1986 (51 FR 29754). About 200 public comments were received. The public comments varied widely in topics and scope.

The COSTSAFR program was modified in 1987 in response to the public comments and also to make general improvements and updates. On August 25,

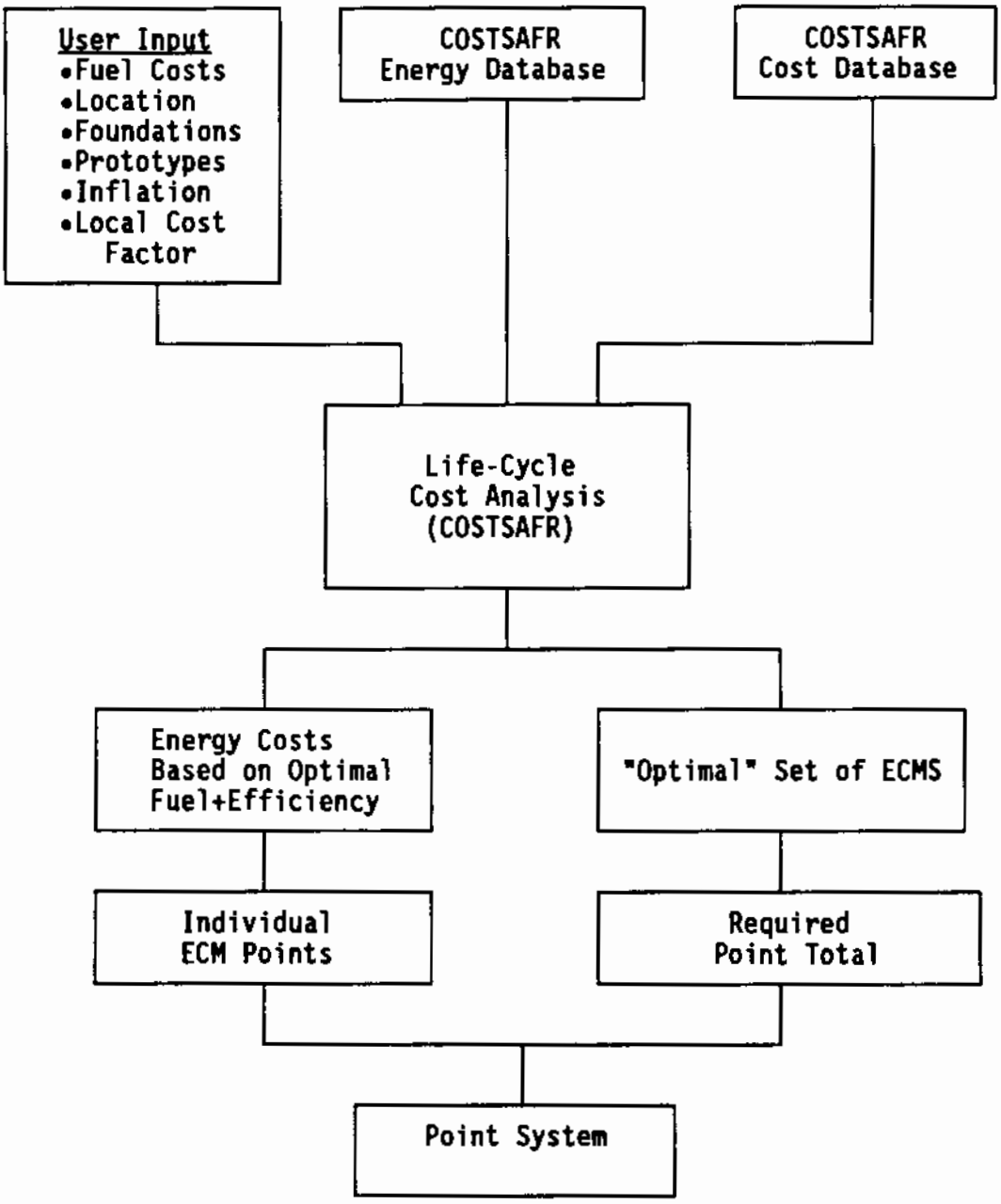


FIGURE 2.1. COSTSAFR Flow Chart

1988, a new version of the software (Version 2) was issued (53 FR 32536). Another version (Version 3) was issued on the same date for public comment (53 FR 32547). These new versions were very similar in appearance and operation to the original version. Version 2 is the Final Interim Rule, which became effective on February 21, 1989. Version 3 is similar to Version 2 but has

new, improved window energy data and has the additional ECM category of walls with thermal mass (i.e., heavyweight materials to take advantage of solar energy). Version 3 was further improved to become Version 3.1, which was issued on January 31, 1991 (56 FR 3765-73).

### 2.1.2 The Point System

The energy-efficiency requirements of the standards are presented in point system compliance forms produced by COSTSAFR. The paper version of these compliance forms is about seven pages long. Each form is customized so that the energy-efficiency requirements stated on the form are based on the location, fuel costs, and building type of the particular project. The point system compliance forms are used by designers (usually prospective housing contractors) to develop a design that complies with the DOE standards.

COSTSAFR calculates points for all ECMs included in the database. COSTSAFR determines points for a specific ECM by comparing its life-cycle energy cost savings with those of the least energy-efficient ECM in the COSTSAFR database for that component. For example, the least efficient ECM for ceilings is R-11 insulation so the points for R-19 ceiling insulation are related to the life-cycle energy cost savings that R-19 provides when compared with R-11. One point equals $100 saved in energy cost over the life of the building. The set of ECMs that produces the lowest life-cycle cost (including first cost, energy cost, and all other costs) constitute the optimum design choices. The point total for the optimum design establishes the target that buildings must meet.

The designer uses the point system to evaluate selected ECMs for each component in a house design. The point system tells the designer how many points each selected ECM is worth. The points from the complete set of ECMs selected by the user produce a point total. To show compliance with the standard, the user's point total must meet or exceed the target determined by COSTSAFR.

The designer must make an ECM selection for each of the following components: ceiling, wall, and floor insulation; infiltration controls; window types and areas; space heating and cooling equipment and efficiencies; water heater type and efficiency; and refrigerator/freezer efficiency (if

desired by the federal agency). The designer also may select window coatings or treatments (e.g., low-emissivity [E] glazing), sun spaces, movable window insulation, and roof color to improve energy efficiency.

Figure 2.2 shows sample sections of the point system. The ceiling and wood frame wall sections of the point system are shown for a split-level house in Denver, Colorado. The numbers in the heating and cooling columns are the COSTSAFR-generated, project-specific points. The optimized selections are shown beneath each list of options.

The requirement of meeting a minimum point total ensures that a cost-effective level of energy conservation is met or exceeded. The points assigned to individual options in the point system represent energy cost savings and do not include non-energy costs. Although COSTSAFR includes all costs in determining the optimal ECMs that establish the required point total,

POINT SYSTEM FOR: pg. 1
Split Level Houses
federal HOUSING PROCUREMENT
Denver, CO
RFP# _____

Design #: _____
Unit type: _____
Proposer: _____

A: CEILING INSULATION POINTS

| | Heating | Cooling |
|---|---|---|
| R-11 | 0.0 | 0.0 |
| R-19 | 3.3 | 0.0 |
| R-30 | 5.9 | 0.0 |
| R-38 | 6.9 | 1.1 |
| R-49 | 7.7 | 1.3 |
| R-60 | 8.2 | 1.4 |

The Optimized Selection: R-19

Points for A: _____ (H) _____ (C)

B: WALL INSULATION POINTS (Select either Wood Frame or Thermal Mass Walls)

Wood Frame Walls

| | H | C |
|---|---|---|
| R-11 | 0.0 | 0.0 |
| R-13 | 1.3 | 0.0 |
| R-19 | 5.2 | 0.0 |
| R-24 | 7.3 | 0.0 |
| R-26 | 8.0 | 0.0 |

The Optimized Selection: R-19

Points for B: _____ (H) _____ (C)

FIGURE 2.2. Sample Sections of a Point System Compliance Form

the point system compares alternative ECMs only for their effect on energy costs. One reason the point system considers energy costs only is that the DOE standards are intended primarily to be energy conservation standards. A second reason is that designers will be motivated to minimize construction costs when they make their design choices because they want to have a competitively low bid. Therefore, the point system allows the designers flexibility in minimizing their construction costs, while at the same time ensuring the cost-effective level of energy conservation is met or exceeded.

The point system can be completed on paper or by using a computer program called CAPS (Computerized Automated Point System). Either format can be used to specify a set of ECMs that complies with the standards for any given project.

The CAPS software is an easy-to-use program that allows the user to input design selections into a personal computer. Even for users with limited computer experience, the CAPS program offers some significant advantages over the paper format. The CAPS program automatically does all the calculations necessary to determine the point total obtained for the user-selected ECMs, eliminating the possibility of math errors. Furthermore, CAPS instantly calculates the point total when the user selects an ECM and notifies the user whether the design complies with the standards. This software provides the user with immediate feedback on the impact of any ECM selection and allows designers to quickly test a variety of approaches for meeting the standards.

At the time the demonstration project was conducted, use of a program called POSTSAFR was necessary to prepare COSTSAFR point system files for CAPS. The sole role of POSTSAFR was to process the point system file into a format that CAPS required. POSTSAFR would normally be operated by the federal officials who were charged with the assignment of using COSTSAFR. As will be seen in the following chapters, a number of negative comments were received from federal officials about the extra inconvenience that use of the POSTSAFR program necessitated. The updated versions of COSTSAFR and CAPS software issued in 1991 had enhancements that completely eliminated the need for POSTSAFR.

## 2.2 ALTERNATIVE COMPLIANCE PROCEDURE

The typical method for complying with the interim standards is for the federal agency to use COSTSAFR to generate the compliance forms that the designer then uses to demonstrate compliance. The COSTSAFR program covers a wide range of ECMs; however, it does not have the ability to analyze all building designs and unusual or innovative ECMs. Therefore, an alternate means of compliance for such designs, the alternative compliance procedure (ACP), is provided. The ACP permits analysis of designs, materials, and construction techniques not covered by COSTSAFR, and remains consistent with the basic framework and economic assumptions of COSTSAFR. The ACP should be used if the designer for a new federal housing project proposes energy conservation design features not included in COSTSAFR.

To be consistent with the energy database used by COSTSAFR, the ACP requires use of the DOE-2.1 simulation model (DOE 1988c) to calculate the yearly space conditioning energy loads (energy consumption for heating and cooling) for the proposed house. The yearly loads are adjusted by equipment efficiency and fuel escalation rates to obtain the 25-year LCC for energy. To comply with the interim standards, the life-cycle energy costs calculated based on DOE-2.1 runs of the proposed design must be equal to or less than the energy costs for the optimum design calculated by COSTSAFR for the COSTSAFR prototype most similar to the proposed design.

After the agency runs COSTSAFR, the energy LCC must be determined for the optimal design. This value can be calculated by completing the estimated unit energy cost equations at the bottom of the final page of the paper compliance forms. This value is also given in the output from the CAPS program.

The DOE-2.1C (or later version) simulation model must be run for the proposed design with assumptions equivalent to the assumptions used to create the COSTSAFR energy database wherever possible. DOE-2.1 must be used to ensure consistency in calculation procedures. Section 435.305 in the Code of Federal Regulations provides specific requirements applying to the DOE-2.1 simulations.

The DOE-2.1 space heating and cooling energy consumption must be converted into energy LCC. Water heating and refrigerator/freezer energy LCCs

can be calculated from their assigned points in the COSTSAFR compliance forms. The combined space heating, space cooling, water heating, and (if included) refrigerator/freezer energy LCC make up the total energy LCC for the design. The total energy LCC for the proposed design has to be equal to or lower than the energy LCC from the point system.

## 2.3 ANTICIPATED ROLE OF STANDARDS IN FEDERAL AGENCY PROCUREMENTS

Federal agencies use several processes to procure new housing. Typically, a private contractor is hired to design the housing units. Many agencies use a "turnkey" process in which they conduct a competitive Request for Proposal (RFP) process, and the winning contractor both designs and builds the units. Some agencies separate the design and building phases by first awarding a contract for the design only, and then hiring a construction contractor to build the units. For most procurement processes, the use of the standards will be a three-part process: 1) generation of the point system by the federal agency using COSTSAFR and integration of the point system compliance form with the RFP package, 2) completion of the point system by the designer, and 3) agency evaluation of the proposed designs and verification that the designs comply with the standards. Use of the COSTSAFR software and use of the point system are separate processes: the designer using the point system never needs to use COSTSAFR. The point system was designed to be simple enough to use that it does not cause the designer any significant difficulties or delays.

The federal agency will use the COSTSAFR software to generate project-specific point system compliance forms. It is anticipated that, in those field offices active in procuring new housing, one or two staff members will become experienced with COSTSAFR and the standards. The point system and the associated instructions will be included with the RFP package sent to interested parties. The design architects and engineers (A&Es) show compliance with the standards by completing the point system form and specifying a set of ECMs that meets the required point total.

Evaluation of the completed point system will be part of the agency's overall technical evaluation of proposals. In this evaluation, the agency will be responsible for verifying that the design complies with the DOE

standards. Verification of compliance is done by confirming that the required point total is met or exceeded and reviewing the ECMs selected by the bidder.

The completed point system is a simple but powerful tool for agencies to use in evaluating proposals. Beyond the standards' requirement for a certain level of energy conservation, it is the agencies' prerogative to give extra credit for conservation features as they see fit. The point system gives the agencies a simple method of awarding extra credit because points represent energy savings in hundreds of dollars. Extra credit can be given based on how much the required point total is exceeded. The point system also provides the technical staff with the energy cost savings associated with individual ECMs.

# 3.0 DESIGN OF DEMONSTRATION PROJECT

Federal legislation established the general requirements for DOE's project to demonstrate the Interim Energy Conservation Standards for New Federal Residential Buildings. This chapter discusses the legislative requirements, how they were interpreted, and the design of the demonstration.

## 3.1 LEGISLATIVE REQUIREMENTS AND GENERAL APPROACH USED IN DEMONSTRATION

Public Law 94-385, the Energy Conservation Standards for New Buildings Act of 1976 (42 U.S. Code (USC) 6831-6840, as amended), established the initial requirements for the development and implementation of performance standards for new residential buildings. The standards were to be "designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of nondepletable sources of energy. . . ." (42 USC 6831). The original act did not distinguish between standards for federal and private-sector buildings, and did not require a demonstration project.(a)

A 1980 amendment to the act, Public Law 96-399 (42 USC 6833), required DOE to conduct a three-step process that included promulgating interim standards, conducting a demonstration project, and developing and promulgating final standards. Specifically, DOE was required to

> develop and publish in the Federal Register . . . standards for new residential buildings . . . and, for at least the 12-month period [after promulgation] . . . conduct a demonstration project utilizing such standards in at least two geographical areas in different climatic regions of the country . . . [N]ot later than 180 days after completing such demonstration project, such Secretary of Energy shall transmit to both Houses of the Congress a report containing an analysis of the findings and conclusions made as a result of carrying out such a project including at least (A) an analysis of the impacts of such standards on builders (especially on small builders) and on the cost of constructing such buildings and the impact of such cost on the ability of low- and moderate-income persons to purchase or rent such buildings, and (B) an analysis of the estimated total energy savings (including the types of energy) to be realized from utilizing such standards in residential

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(a) Federal buildings were defined as "any building to be constructed by, or for the use of, any Federal agency which is not legally subject to State or local building codes or similar requirements" (Energy Conservation Standards for New Buildings Act of 1976, Sec. 303).

buildings. Final . . . performance standards for such buildings shall be promulgated . . .(42 USC 6833(a)(2)).

It is important to note that the original legislation and the amendments through 1980 were designed primarily to be applied to private-sector buildings receiving federal financial assistance. Thus, the requirements regarding the three-stage process and a demonstration project were driven largely by the characteristics of the private-sector housing market rather than the characteristics of federal housing.

In 1981, Public Law 97-35 modified the requirements to make the standards voluntary for the private sector. They continued, however, to be mandatory for the federal sector. In response to this amendment, DOE separated its residential interim standards development and demonstration efforts into one standard for voluntary private-sector standards and another for mandatory federal residential standards. The demonstration of the mandatory federal interim standards is the subject of this report.

### 3.1.1 Climate Regions

The legislation required that the demonstration be conducted in at least two geographical areas in different climatic regions of the country. This requirement ensured that the results represented the range of impacts produced by the standards as a consequence of differences in climate and geographically dependent variables.

Because climate and utility prices are the main driving forces in the requirements established by the DOE interim standards, DOE decided to select housing projects in five different climate regions rather than the minimum of two regions required by the legislation. Expansion to five regions increased the diversity represented by the demonstration results.[a] The five regions were based on the climate characteristics shown in Table 3.1.

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(a) Two of the five case studies were located in regions with climates that bordered on two different climate categories, cold and very cold.

TABLE 3.1. Climate Regions

| Climate Region | Description[a] |
|---|---|
| Hot | Greater than 2000 cooling degree-days[b] |
| Hot and humid | Greater than 2000 cooling degree-days and relative humidity greater than 75% |
| Mild | 2000 to 5000 heating degree-days |
| Cold | 5000 to 7500 heating degree-days |
| Very cold | Greater than 7500 heating degree-days |

(a) Units are heating or cooling degree-days per year based on an ambient temperature of 65 degrees F.
(b) The number of degree-days for one day is the difference between the base temperature and the mean daily ambient temperature. Degree-days per year equals the sum of the daily degree-days for all of the days of the year.

### 3.1.2 Schedule and Timing

The legislation required the demonstration to be conducted for at least 12 months after promulgation of the interim standards. The interim standards became effective on February 21, 1989, and the demonstration commenced on this date.[a] The report to Congress had to be delivered within 180 days after the demonstration was completed. The demonstration was completed on September 2, 1991, and the report to Congress will be delivered within 180 days of that date.

(a) A modification to the interim standards was issued on January 31, 1991, and became effective on July 30, 1991 (56 FR 3765-3773). The modification consisted of additions to the design options covered by the standards and an ACP, which could be used in place of the point system compliance form generated by the COSTSAFR computer program. These modified interim standards were used in the demonstration because 1) they added flexibility to the original interim standards and 2) they made the results of the demonstration relevant to the very latest version of the interim standards.

### 3.1.3 Type of Demonstration

The legislation imposed no specific requirements on how the demonstration was to be conducted. One option was to identify housing units that were not yet constructed, and design and build these to the DOE standards. The energy consumption of these units and a set of "control" homes built to prevailing standards could then be monitored and analyzed to determine energy impacts of applying the DOE standards. This approach posed major problems, however.

The major difficulty was time. The acquisition and construction process easily could have taken 2 years or more. It would have required at least a year to acquire the necessary energy consumption data. Consequently, the demonstration could have taken 4 years or more to complete, which would have delayed development of the final standards.

In addition to the time required, it would have been difficult and costly to include enough homes in the demonstration to provide a reasonable sample size. Further, it would have required a major effort to identify suitable control homes for establishing a baseline with which to compare the results for homes built to the DOE standards. Also, it would have been difficult to minimize the influence of factors other than energy conservation measures, such as consumer habits, on energy consumption.

The approach selected instead was to conduct a "paper" study. This involved four steps. First, we selected housing projects that were already designed. Second, the federal agency applied the DOE standards to the project retrospectively. Third, a designer indicated how the project might have been changed to meet the requirements of the DOE standards. Fourth, interview data and simulation analysis results were used to assess the impacts of the standards on the agencies, the designers and builders, and the energy consumption of the housing units studied.

### 3.1.4 Focus of Demonstration and Analysis

The legislation specifies that the demonstration produce findings and conclusions including at least 1) the impacts of the standards on builders (especially on small builders), construction costs, and the ability of low- and moderate-income persons to purchase or rent such buildings and 2) an analysis of the estimated total energy savings (including the types of energy)

resulting from the standards. The demonstration and analysis addressed these issues, but also emphasized other issues that reflected the unique characteristics of federal housing procurement.

In particular, DOE was concerned about how the standards would affect the procurement processes employed by federal agencies and the design processes used by housing project designers. This concern arose because the interim standards do not simply prescribe energy-efficiency requirements; instead, they provide an entire methodology for establishing the requirements, conveying the requirements to designers, and evaluating whether proposed designs comply with the requirements. This methodology must be integrated into the agencies' acquisition processes and the designers' processes. To evaluate the process impacts of the standards, one major focus of data collection was on how the interim standards affected the current procurement processes used by federal agencies. Another focus was on how the standards affected the work done by project designers. The underlying reason for focusing on such process impacts was DOE's conviction that the standards would be effective only if agencies were able to implement them without having to change their procurement processes significantly.

The demonstration also addressed more quantitative impacts of the standards. Energy impacts were estimated using the energy database developed for the standards. Construction cost impacts were estimated based on data provided by designers during the demonstration. The effects of the standards on agency costs, labor, and time were estimated from data provided by the agencies during the demonstration.

Assessing how the standards would affect the ability of low- and moderate-income persons to rent or purchase buildings constructed to them was not considered to be very important in this demonstration. This requirement of the legislation appeared more relevant to standards developed for the private sector than standards for the federal sector. For military family housing, the monthly housing costs, including utility bills, are usually paid by the military agency. On the other hand, non-DOD agency personnel may have to pay monthly costs in federal housing. Because military family housing is the dominant form of federal housing covered by the standards, this issue was

not analyzed in great detail. Nevertheless, information is provided where the issue is relevant.

The overall purpose of data collection and analysis during the demonstration was to provide a sound basis for recommendations that could guide development of the final standards. Consequently, data collection included asking demonstration participants for their opinions about how the standards could be improved. The analysis of all the information was then conducted with an emphasis on identifying how the processes, tools, and implementation of the standards could be improved.

## 3.2 AGENCY HEADQUARTERS: ROLE AND DATA COLLECTION

At the beginning of the demonstration, meetings were held with personnel from each agency's headquarters office. To better understand the procurement process from the headquarters' point of view, personnel at each headquarters office were requested to answer several questions about the agency's current housing procurement process. A copy of the questionnaire used can be found in Appendix A. Information was collected from all of the agencies about who is responsible for administering existing energy-efficiency requirements, the roles played by headquarters and the field offices, how the housing procurement process is implemented, and how the energy-related considerations fit into the process. In addition, information was collected from the agencies on how LCCs are taken into account in their procedures, what they perceived to be the strong points of their conservation procedure, what improvements could be made, and alternate methods available to designers to demonstrate compliance.

A consistent message from the headquarters interviews was that agency field or regional offices played the major role in implementing the housing procurement process. Consequently, each agency's headquarters personnel were asked which field offices conducted housing procurements. The agencies were also asked to recommend field or regional offices to participate in the demonstration based on their volume of procurements, probable willingness to cooperate, and recent activity. In some cases, more than one field office was suggested.

## 3.3 SELECTION OF AGENCIES AND PROJECTS

The initial step in selecting agencies and projects to include in the demonstration was to determine which federal agencies acquire new housing. Agency Energy Coordinators for members of the Federal Interagency Energy Policy Committee (the "656" Committee) were surveyed to determine this. Agencies represented on the committee consume over 99% of all energy used by the federal sector. This survey revealed that most agencies do not provide housing for their personnel and, therefore, are not affected by the standards. The agencies that construct housing for their personnel are the Department of Defense, Department of Health and Human Services (DHHS), Department of the Interior, Department of Transportation, and Department of Agriculture.

### 3.3.1 Criteria

The principal criterion in the process to select agencies for participation in the demonstration was that the agency conducted a relatively large amount of federal housing procurements. Such agencies were likely to be impacted most by the standards. PNL decided to conduct demonstrations of the standards with each of the three military branches (Navy, Army, and Air Force) and one non-DOD agency, Health and Human Services. These four organizations were selected because they had high levels of new housing construction activity and they had recently conducted housing projects.

Climate was another criterion used to select housing projects for the demonstration. Specific projects were selected to provide the desired climate diversity.

### 3.3.2 Selected Agencies and Projects

Housing procurement is normally managed by staff at field offices of the various agencies. These personnel would be directly involved in implementing the DOE standards. The field offices administer either a region of the country or a particular sector of operations (such as the Air Force Strategic Air Command, or SAC). Through meetings with headquarters of the military services and DHHS, the field offices most active in new housing procurement were identified (see Section 3.4 for a description of the meetings that were held). Meetings were then held at these field offices, and suitable projects for demonstration were selected. These field offices and housing projects are

outlined below. Table 3.2 lists the projects included in the demonstration and their respective locations, sponsoring agencies, and climate regions.

3.3.2.1 Air Force

The SAC operates from Offutt Air Force Base in Omaha, Nebraska. A housing project at Ellsworth Air Force Base in South Dakota was selected for the demonstration. This project consisted of 200 detached units that were constructed in 1989-1990. This project was of particular interest because the contractor was a small, local corporation. This project represented the "very cold" or "cold" climate region specified in Table 3.1.

3.3.2.2 Army Corps of Engineers

Procurement of family housing for the Army is conducted by district offices of the Corps of Engineers. Interviews were conducted with the Fort Worth and Sacramento offices. Recent family housing projects procured through each of these offices were selected for the demonstration. The project managed by the Sacramento office was a 270-unit project constructed from 1988 to 1991 at Fort Irwin near Barstow, California. The Fort Irwin climate region fell into the "hot" category. This project was singled out for specific investigation of the thermal mass (heavyweight) walls ECM in addition to the normal redesign.

The project handled by the Fort Worth office involved 350 family housing units at Fort Polk, near Alexandria, Louisiana. This project fell into the "hot and humid" climate category.

TABLE 3.2. Demonstration Projects

| Project | Agency | State Location | Climate Region |
|---|---|---|---|
| Ellsworth | Air Force | South Dakota | Cold/Very cold |
| Fort Polk | Army | Louisiana | Hot and humid |
| Fort Irwin | Army | California | Hot |
| Alameda | Navy | California | Mild |
| Rosebud | Health & Human Services | South Dakota | Cold/Very cold |

#### 3.3.2.3 Navy

The Navy is one of the most active agencies procuring federal housing. The Naval Facilities Engineering Command is responsible for housing procurement within the Navy. Interviews were held with command staff from headquarters and two division offices, Western Division (WESTDIV), located in San Bruno, California, and Northern Division (NORTHDIV), located in Philadelphia, Pennsylvania. A housing project at the Alameda Naval Air Station in Alameda, California, was chosen for the demonstration. This project of 300 townhouses was selected to represent a mild climate. Plans for the project were approved in 1990 and construction is underway. This project is managed by the Western Division office.

#### 3.3.2.4 Health and Human Services

The DHHS requires housing for staff who work at Indian Health Service (IHS) facilities in remote locations. Procurement of new housing for DHHS is managed by three regional Offices of Engineering Services (OES). PNL met with staff from the Northern Plains OES in Seattle and selected a project in Rosebud, South Dakota, for redesign. Between 1989 and 1991, 76 units were scheduled to be built. The climate was similar to that for the Air Force demonstration project at Ellsworth Air Force Base, South Dakota, falling between the "cold" and "very cold" categories. However, the utility rates, which greatly affect the standards' requirements, were quite different from the Ellsworth rates, thus providing diversity in the effects of the standards.

## 3.4 ROLE OF THE AGENCY FIELD OR REGIONAL OFFICE

Because most of the actual procurement work is done by the agency field offices, it was decided to work directly with them to better understand how they approached the procurement process and how the energy-efficiency requirements fit into the process. Typically, the agency headquarters office made the first contact with the field or regional office to discuss the demonstration. Following this, the demonstration project team called the field office to discuss the demonstration in more detail. The phone call was then followed up with a letter explaining the demonstration, what type of information was needed, and the agency's role in the demonstration.

The next step involved project team representatives making a 1-day visit to each participating agency field office to 1) explain the purpose of the standards and DOE's objectives in undertaking the demonstration, 2) learn about the agency's housing procurement process and how energy conservation was currently handled, 3) demonstrate the standards' software to the office staff and discuss possible problems they might encounter in using it, 4) describe the automated version of the point system (CAPS), and 5) initiate a process for the office to test the standards and facilitate working with their design and construction contractors to monitor the standards' impacts on them.

### 3.4.1 Procurement Process

During the visits with each agency field office, PNL collected additional information about the agency's housing organization, how energy-efficiency requirements were handled, and how the requirements fit into the procurement process. This information would be used later to develop recommendations to DOE on how to make the DOE final standards more suitable to the agencies' needs.

Additional information gathered to better understand the overall procurement process used by each agency field office included the following: 1) information about the personnel in the office involved in housing procurement, including the number, skill levels or grades, and the split between military and civilian employees; 2) a description of the steps in the housing procurement process, when the evaluation and selection occurs, and the typical amount of calendar time involved; and 3) an estimate of the resources, such as labor types, labor hours, and dollars, required to process a typical housing procurement. This information was obtained to establish a baseline against which the effects of the DOE standards could be measured.

### 3.4.2 Application of the Standards to a Demonstration Housing Project

The second phase of the demonstration involved having the agency field office retrospectively apply the DOE standards to a selected housing project. The goal was for the agency field office to use the standards as it would have during an actual procurement.

A recent housing project, either under construction or completed, was selected for a test of the standards. The procurement organization within the

agency field office ran COSTSAFR for the selected housing project to create the compliance worksheets for the project. The POSTSAFR program was then used to create the input file needed for CAPS.

### 3.4.3 Data and Information Collection

After the agency personnel had used COSTSAFR and POSTSAFR, they completed a questionnaire to document their experiences with the software and the process. A copy of the questionnaire can be found in Appendix B. Special attention was given to learning about any concerns or comments the agency personnel had about how the standards would fit in with their overall procurement process.

The questionnaire included questions about characteristics of the selected housing project, learning how to use the standards, using the standards, and contractor compliance with the standards. It requested both quantitative data, such as labor hours required, and qualitative data, such as descriptions of problems encountered with the software.

## 3.5 THE ROLE OF THE DESIGNER AND/OR BUILDER

Data were collected from designers and builders to determine how the DOE interim standards would affect them. Housing project designers and builders are responsible for producing designs and constructing houses that comply with the standards. The intent of collecting data from designers and builders was to determine what design changes they would make to meet the standards and how the standards would affect both their design activities and the characteristics of the housing units they designed.

### 3.5.1 Conduct Hypothetical Redesign to Meet standards

Small contracts were set up with design contractors to collect information for the demonstration. An attempt was made to work with the original designers of the housing projects because they would be able to provide the best information on the effects of the standards. Unfortunately, it was possible to recruit the original designers for only two of the projects studied, but other approaches were used in these cases to obtain high quality information and data. These approaches are described in the case studies presented in Chapters 4 through 7.

The designers performed a test implementation of the standards using the point systems to "redesign" the recently built projects such that the new designs complied with the DOE standards. Data were collected on the new conservation levels proposed and the associated costs of these conservation levels. The designers were asked to conduct the redesign in the most realistic manner possible, i.e., as if they were actually creating a real proposal for the project.

A questionnaire was completed by the contractors participating in the demonstration. The questionnaire was designed to study the effects of the DOE standards on the process of generating a proposal. This questionnaire is included in Appendix C. Effects were studied for each of the process steps including creating a complying design, showing compliance using the point system, and integrating the requirements of the DOE standards with other non-energy design issues.

### 3.5.2 Provide Data and Information on Results of Redesign

A primary objective of the demonstration was to determine the construction cost impacts of the standards. Cost information was collected directly from the designers in the demonstration. These data were collected on a "Redesign Worksheet" that asked the design contractors to isolate and document costs of ECMs affected by the standards. The worksheet is included in Appendix C. The data focused on the incremental costs of ECMs selected for the redesign as compared with the costs of energy-efficiency measures actually installed during construction. Thus, cost information was provided for only the building components and equipment that were changed from the original design.

The costs provided were per housing unit. All costs collected were in terms of the price charged to the federal government; i.e., costs include material, labor, overhead markups, and profit. Incremental design and other one-time costs were also requested from the contractor. All costs were based on prices and costs in effect when the bid was submitted for the actual project.

Designers were also asked to provide qualitative information on the effects of the standards. They were asked for their opinions about the paper

point system, the CAPS program, and the documentation. They were also asked for any recommendations or suggestions on how to improve the materials or the process.

## 3.6 ANALYSIS APPROACH

An integral part of the demonstration is the analysis of how well the standards were able to achieve their goals and objectives. The methodology for the analysis was developed by project team members at PNL and DOE.

### 3.6.1 General Approach

The study team decided to approach the demonstration and its analysis as a "goal-oriented" evaluation (Stecher and Davis 1987). In such evaluations, program performance is measured in terms of a set of goals and objectives defined for the program. This approach requires reaching agreement on program goals and then establishing objectives against which the success of the program can be measured.

### 3.6.2 Goals of the Interim Residential Standards

Three goals were established for the federal residential standards program. These were to

- achieve maximum practicable energy-efficiency improvements
- increase the use of renewable resources
- facilitate successful implementation of the standards by federal agencies, designers/builders, and DOE.

The first two goals were mandated by federal law, as discussed earlier. The third goal was essential to ensure that the standards accomplished what they were designed to do.

### 3.6.3 Objectives of the Standards

Establishing the standards' objectives was essential to help with the evaluation and assessment phase of the standards demonstration. The objectives helped to shape data collection and analysis, and they provided a means by which to measure the performance of the interim standards. A comprehensive list of 19 objectives necessary to meet the goals was developed.

The objectives were then rank-ordered by importance. Many of the objectives were considered to be of about equal importance. The 12 most important objectives were to

- generate maximum practicable energy-efficiency requirements (1)
- encourage use of renewable energy resources (1)
- accommodate existing renewable resource technologies (2)
- build consensus among user agencies (2)
- minimize disruption to agency processes and simplify use of the standards (2)
- provide training/support to agencies (2)
- minimize disruption, cost impacts, and complications to design/construction processes (2)
- provide training/support to designer/builders (2)
- facilitate periodic review/updates by DOE (3)
- achieve compliance in houses built under requirements of the standards (4)
- permit incorporation of new energy-efficiency technologies (4)
- facilitate distribution of appropriate standards materials to appropriate people at agencies (4).

The numbers following the objectives listed above indicate their importance in the ranking. This ranking was used to focus the analysis of the data and information from the demonstration.[a]

The first three objectives originated in the Congressional purpose for the standards. The five remaining second-level objectives were associated with implementation of the standards by federal agencies and housing

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(a) The other seven objectives, which were considered less important, were as follows: incorporate mechanisms to provide designer/builder feedback, accommodate new renewable resource technologies, elicit public comment and involvement, facilitate distribution of appropriate standards materials to designer and builder personnel, provide tracking and monitoring of the standards for DOE, incorporate mechanisms to provide agency feedback, and minimize negative economic impacts on housing occupants.

designers. If DOE could use the standards to "build user agency consensus" on the importance of energy efficiency and the approach used to incorporate it in federal housing, then energy efficiency would be more viable over the long-term and costs of implementing it would decline. A key element of implementation would be providing adequate training to both agencies and designers/builders.

The project team believed that agencies and designers/builders would be more receptive to the standards if the standards could be updated as conditions and information changed. Thus, it was essential to ascertain how feasible it was to update the standards. The effectiveness of the standards would depend not only on the efficiency levels established but also on verification that designers and builders were complying with them. Therefore, assessment of compliance with the standards became a key objective. The effectiveness of the standards also would depend on how adequately the necessary materials were distributed to both agency personnel and designers/builders.

### 3.6.4 Measuring Achievement of the Objectives

The methodologies selected to measure achievement of the 12 objectives are listed in Table 3.3. Many of the measurements were based on qualitative information collected through the interviews with agency or designer personnel.

Some of the objectives were unlikely to be achieved by the standards because of decisions made during the development phase. For example, DOE had decided that renewable energy technologies and new energy-efficiency technologies should be included in the standards only if valid testing procedures existed. This requirement was intended to prevent risky or unproven technologies from receiving undue credit in the standards. Consequently, it was known at the outset that objectives 2 ("Encourage use of renewable energy resources") and 11 ("Permit incorporation of new energy-efficiency technologies") would not be fully met. Nevertheless, measuring how well these objectives were achieved by the interim standards would help DOE and PNL determine their importance during development of the final standards.

Several of the objectives were related to the process of implementing the standards, rather than the requirements of the standards themselves. For example, objective 12, "Provide materials to appropriate agency personnel," is a procedural objective that may require actions by DOE and the headquarters and field office staff of implementing agencies. Measuring how well such objectives were achieved provided insights into where problems might arise and ways to alleviate them.

### 3.6.5 Integration of the Results

Each of the projects in the demonstration was treated as a case study and evaluated as to how well the standards performed according to each of the goals and the objectives listed in Table 3.3. To determine how well the interim standards achieved their goals, the results from the case studies were reviewed for common themes and trends. The summary of these findings is presented in Chapter 8 of this report.

### 3.6.6 Development of Recommendations

Based on the overall findings, a set of recommendations was developed on what should be done to improve the effectiveness of the standards. The analysis of the findings from the agencies and designers provided the impetus for many of the recommendations that are offered in Chapter 9 of this report. These recommendations are presented in this report as the basis for DOE's development of the final standards.

TABLE 3.3. Measurement of Objectives

| Objectives | Methodologies to Measure Achievement |
|---|---|
| 1. Generate maximum practicable energy-efficiency requirements | Define "maximum practicable;" compare requirements of standards with agency current practice and other codes; examine technical feasibility of high-efficiency requirements. |
| 2. Encourage use of renewable energy resources | Determine whether agencies and designers believe standards encourage use of renewables. |
| 3. Accommodate existing renewable resource technologies | Determine whether agencies and designers feel standards accommodate existing renewables and demonstration redesigns include renewables. |
| 4. Build consensus among user agencies | Assess whether agencies agree on the value of the standards and the benefits of a uniform approach across agencies. |
| 5. Minimize disruption to agency processes and simplify use of the standards | Determine whether standards are easy for agencies to implement, cause minimum disruptions or complications, or simplify current agency processes. |
| 6. Provide training/support to agencies | Assess whether DOE and PNL assistance has made it easy for agencies to use standards and minimizes problems. |
| 7. Minimize disruption, cost impacts, and complications to design/construction processes | Determine whether the standards impose few problems and minimum costs on designers and builders. |
| 8. Provide training support to designer/builders | Assess whether DOE and PNL assistance has made it easy for designers to use standards and minimized problems. |
| 9. Facilitate periodic review/updates by DOE | Determine whether standards' software and process allow easy updates. Determine whether DOE has an effective review/update process in place. |
| 10. Achieve compliance in houses built under the standards | Verify that housing built under the standards has the required measures installed and performs as predicted. |

TABLE 3.3. (contd)

| | |
|---|---|
| 11. Permit incorporation of new energy-efficiency technologies | Determine whether the standards have the flexibility to include new technologies. |
| 12. Provide materials to appropriate agency personnel | Assess whether agency procurement officials have received all the materials needed to implement the standards effectively. |

# 4.0 AIR FORCE CASE STUDY

The first project completed in this demonstration was conducted by the Air Force through the Strategic Air Command (SAC). Like the other military services, the Air Force follows a housing procurement approach that is defined primarily by the overall Department of Defense (DOD) approach. This chapter presents information about the general DOD procurement process; the Air Force housing procurement process, based on information from Air Force headquarters and two commands; and details of the SAC demonstration project. The DOD procurement process is the basis for the procurement process followed by the Army and Navy, as well as the Air Force. The basic DOD process is discussed in this chapter only and the reader should refer to this discussion when reading Chapters 5 and 6.

## 4.1 U.S. DEPARTMENT OF DEFENSE PROCUREMENT PROCESS

The DOD's general procurement process has evolved over time. The traditional military family housing procurement approach was to award two separate contracts. The first was awarded to an architectural and engineering firm to design the housing units and to prepare construction documents. The second contract was awarded to a general contractor to construct the housing units according to the construction documents. A DOD construction manager was responsible for overseeing construction of the housing units.

In the mid-1980s, a two-step "turnkey" procurement process became the favored approach for procuring military family housing. Turnkey means the contractor provides both design and construction services in a two-phase process. The first phase involves design and construction document preparation. The second phase involves construction.

Although the military agencies have different procurement alternatives (e.g., buying or leasing), they often employ the turnkey approach. The basic steps in a turnkey procurement, as implemented when this demonstration project began, are listed below:

1. Notification of the request for proposal (RFP) is advertised, usually in the Commerce Business Daily. The RFP is almost always issued at the command (Air Force), district (Army), or regional (Navy) level. The

entity issuing the RFP is also responsible for delineating energy conservation features or design goals.

2. The RFPs are sent to those requesting them. The RFP describes the project, outlines its scope, and gives details on the architectural program. Performance specifications are included as a way to describe the functional requirements of the units. This is where the government lists its requirements for energy performance, utilities, amenities, and other functions and features. The RFP also specifies the criteria by which proposals will be evaluated.

3. Approximately 3 to 4 weeks after the RFPs are made available, a pre-proposal conference may be held to explain details, answer questions, and clarify sections of the RFP.

4. A single point of contact is provided. This person is available to anyone requesting additional information or clarifications. Any information concerning changes in the project is provided to every company or individual who requested the RFP.

5. Contractors prepare their proposals. Although the format and size vary between services and from project to project, the proposals include preliminary plans, specifications, and financial data.

   Generally, the proposals are provided in three separate sections. The first section is a technical presentation. It is normally somewhere between a conceptual design and a 35% design. It will typically show unit elevations and floor plans, section details, and materials specifications. Heating and cooling loads, fuel consumption estimates, and other energy performance information are included. Site utility plans are also part of the proposal package. The second section is a lump-sum cost proposal. The final section describes the experience, capabilities, and financial status of the contractor. This "resume" provides the government with assurance that the contractor is in fact capable of performing the proposed work.

   Proposals are sent to the DOD entity that issued the RFP. A deadline, established in the RFP, must be met.

6. Proposals are first subjected to a screening process. The technical section of the proposal is sent to an evaluation board, which will review the proposal in a "blind" process. The technical evaluation board considers two basic elements of the proposal. First, it confirms that the proposal meets the minimum technical specifications of the RFP. Then it assigns a "quality rating" to the proposal. This rating is itself made up of two elements. The first is a comparison of the proposal and the RFP specifications. The second is a comparison of each proposal to the others submitted for the project. The board then assigns a number of "technical points" to the proposal.

7. After the proposal has received its quality rating with technical points, the technical and cost information is sent to a selection board. The

selection board makeup varies with the different military branches, but it is usually at the command, district, or regional level. Proposals for highly visible or extremely large projects may be evaluated by headquarters-level officials.

The selection board considers the proposal on the basis of technical quality, as established by the quality rating, and cost. The ratio of technical points to costs establishes the relative quality of the proposals for comparison by the selection board. Normally, the proposal with the highest ratio is chosen. This method makes it possible for a proposal with a high number of technical points or a low cost to win the award. Realistically, however, a winning proposal will have a reasonably high number of technical points and a reasonable cost. When one of the proposals is accepted, a public announcement is made regarding the award of the contract.

8. Following award, a full set of construction documents is prepared by the successful contractor. These include complete plans and specifications. Final construction documents must be in substantial agreement with the preliminary designs submitted in the proposal. There are also several DOD standards which must always be met. These are the standards set by Congress regarding the size and features of housing provided for the various grade levels of military personnel. The standards include the number and size of rooms, unit density on the site, and community amenities.

9. Following contract award, a debriefing session is normally held for unsuccessful proposers. This provides the other contractors with an opportunity to learn why their proposals were not accepted.

10. The contracting officer, who has participated throughout the proposal process, oversees the project. The construction period was previously defined in the RFP. A starting date is agreed upon by the contractor and the contracting officer.

11. Construction begins. Units are typically turned over to the base in blocks so completed units can be occupied before the entire project is completed.

At this time, the primary authority to acquire new or replacement military family housing is through the Military Construction Program (also known as MILCON). Title 10 USC Section 2821 requires that any construction or acquisition of housing be specifically authorized by law. The authorization for the military family housing procurement of all three Services for an entire fiscal year is provided by the "Military Construction Act," which is part of the federal budget bill. Each project to be funded is listed, and its scope and dollar amount are described. The initial requirements for new housing projects are based on a housing survey that is confirmed with an

independent housing market analysis. Projects to replace existing housing are justified by an engineering or economic analysis.

Specific projects are proposed by each command. They are evaluated at the Service level. If a project is considered valid, it is included in the annual Program Objective Memorandum. The memorandum sets the Service's objectives for the year, and is used to develop the budget.

MILCON projects compete for funding with other Service programs. If funded, the competitive turnkey process previously described is used to select a contractor and housing design.

Public Law 98-II5 contains two sections that authorize the DOD to test other procurement processes, a build-to-lease and a rental guarantee program. These sections are known as 801 and 802, respectively. Section 2667 of Public Law 97-214 authorizes the DOD to out-lease non-excess government property to private entrepreneurs and has been used to support housing requirements. Funding for Section 801 programs is included in the Military Construction Act each year. Section 802 and 2667 lease payments are made by the occupants with their basic allowance for quarters (BAQ) and variable housing allowance (VHA), if a VHA is available. The BAQ is a national standard allowance, which is the same across the country. The VHA, when available, is a local adjustment to the BAQ.

The primary objective of Section 801 is to stimulate the production of housing units by the private sector, while reducing the contractor's risk. The Section 801 program can only be used if a verifiable housing deficit exists in the area. A deficit is defined as a condition resulting from high rental costs for private sector housing as well as scarce housing. Section 801 authorized a test of a build-to-lease program to supplement existing military construction projects. Congress first authorized the program in fiscal year (FY) 1984. This test allows each Service to enter into a limited number of domestic leases to determine if its housing needs can be supported at a lower life-cycle cost (LCC) than military construction of housing units. Under the 801 program, the turnkey contractor, chosen under the competitive system previously described, purchases land and constructs the project.

Operation and maintenance is conducted under a separate contract with the developer or with another contractor.[a]

The contractor leases the entire group of units to the Service for a period of no more than 20 years. Ownership of the units is transferable, as long as the new owner agrees to adhere to the original conditions of the lease agreement and with approval of the government. The contractor benefits from the tax incentives of interest deductions and depreciation.

The DOD provides a relatively small number of specifications for housing built under this program. These are the requirements set by Congress on the number and size of the rooms for particular grades of personnel, site density, and community amenities. Local and national codes must be met, and local guidelines for construction methods, materials, and quality are followed. The build-lease project costs must not exceed 95% of the cost of housing acquired under military construction programs, based on net present values. The Service pays utility costs.

The Section 802 is a rental guarantee program that differs from the 801 program in that the lease agreement is made between the individual occupying the unit and the contractor. The units may be built on or off base, but economics have dictated that only on-base projects will be successful. Again, the net present value of the housing costs must be lower under this program than those of a comparable military construction project. The individual makes lease payments from his or her BAQ and possibly his or her VHA. The Service guarantees debt service payment up to an occupancy level of 97%. Lease periods cannot exceed 25 years.

The Section 2667 program has even fewer restrictions than the 801 or 802 programs. It provides a general leasing authority to make land available to developers. The RFP lists the minimum and maximum number of units desired, the number and grade of anticipated occupants, and an upper limit on the rent that may be charged. Community amenities are required, and are described. The successful contractor leases land from the service for a nominal fee for

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(a) The site must be within one hour driving time of the base. The 801 program also allows the base to option nearby land transferable to the developer selected to construct the project.

40 to 50 years. Following local codes and national standards, the contractor builds the housing units.

Under 10 CFR Part 436, all federal agencies are required to make acquisitions in accordance with life-cycle cost effectiveness criteria for energy conservation features. The energy standards applied to MILCON housing are currently required to be those established by DOE and discussed in this report. For 801, 802, and 2667 housing, the specific requirements vary between the Services. Sometimes, but not always, the Service will use its regular energy criteria in the procurement of housing under these programs.

## 4.2 AIR FORCE HOUSING PROCUREMENT PROCESS

The Air Force's overall family housing procurement process is established by Air Force headquarters. Headquarters also establishes the approach for addressing energy efficiency in family housing. Responsibility for implementing both the procurement process and the incorporation of energy efficiency requirements in that process, however, resides primarily with the individual commands. Section 4.2.1 discusses the Air Force's overall procurement process and Section 4.2.2 addresses energy-efficiency requirements. The discussion is based on interviews with Air Force headquarters, Air Training Command (ATC), and SAC staff.

### 4.2.1 Overall Air Force Procurement Process

The Air Force has followed the general procurement policies developed by DOD. This section presents a brief description of the specifics of the approach as implemented by the Air Force.

The need for new housing is determined at Air Force bases through a needs assessment. Typically, two people conduct a housing survey spanning about 6 months. The survey aims at housing needs 6 to 7 years into the future. The needs are reviewed at the command level and, if approved, forwarded to Air Force headquarters. Approximately one person-day is required at the command level for the review.

Headquarters, working with Congress, prioritizes projects across commands. Congress makes a decision about the appropriate procurement process: MILCON (called P711 for the Air Force), 801, or another process. At

the time this demonstration project was being conducted, Air Force projects were predominantly 801 procurements.

Once a procurement approach has been selected, the details depend on the procurement type. In general, the procurement process can take between 2 and 5 years before the housing units are procured and constructed. Designers must invest a considerable amount of time and resources in developing their proposals. Agency evaluation teams are set up, usually consisting of representatives from the base and command, and including engineers and architects. Evaluation teams usually comprise six to eight people and the initial evaluation takes about two to four weeks. Most of the responsibility for the projects is centered on the base associated with the project. One typical base office responsible for family housing employs two mechanical engineers, two electrical engineers, two or three civil engineers, and two architects. While military staff involved with housing procurement turn over about every three years, civilian staff may stay from 5 to 25 years. However, at most bases, an individual may be involved in only one project in a 10-year period.

### 4.2.2 Air Force Process for Setting Energy-Efficiency Requirements and Evaluation

One criteria for evaluation of proposals submitted under all the procurement programs is energy efficiency. The Air Force is committed to improved energy efficiency and the use of renewable energy forms whenever these techniques are shown to be reliable and cost-effective.

Since 1982, the Air Force has implemented energy-efficiency requirements through the "Residential Energy and Economic Evaluation Manual" (REEEM). A manual is developed for each specific project, and over 25 are now available for Air Force bases in the United States and overseas. The REEEM is usually about 80 pages in length. It provides a common method for proposers to evaluate the energy and economic performance of their designs. It also provides design guidelines as a starting point. REEEMs require designs to show positive LCC savings to be in compliance with Air Force cost-effectiveness criteria for energy conservation.

Each manual includes design guidelines on subjects such as site planning, building envelope design, interior design, mechanical equipment, and energy saving combinations. These guidelines are base-specific, resulting from energy design calculations made with the climate data for the area. Each manual is "tuned" to the specific climate characteristics of the base. The manuals provide procedures to calculate heating and cooling requirements, life-cycle costs, and an example for the base climate.

The RFP typically defines a heating and cooling energy budget by unit type and location. It references the REEEM as the method to use to demonstrate compliance. The designer must complete a set of precalculation worksheets that document the information needed to estimate heating and cooling energy consumption. This information is transferred to a worksheet for calculating estimated energy consumption. The characteristics of the proposed design, such as wall area, are entered into the worksheet along with data, such as U-values, corresponding to proposed components. Those data are taken from tables in the REEEM. Separate worksheets must be completed for each unit type, and also for heating and cooling.

Cost information is next entered into the REEEM cost analysis worksheets. These worksheets allow designers to estimate the effect of their designs on LCC. As noted earlier, the proposed design must reduce LCC compared with a base-case building. The design must also meet an energy consumption target established by the Air Force.

The designer may repeat this process until the best possible design is achieved. The completed worksheets and documentation are part of the mandatory submission requirements of the RFP for all procurement programs.

The REEEM documents are prepared for use in each specific project by an A&E firm under contract to the Engineering and Service Center, Air Force headquarters. Consequently, no preparation costs are imposed on the command or base staff. Air Force personnel spend approximately one person-day of effort to incorporate the REEEM into the procurement package; the only other direct cost is for reproduction to include it in the RFP.

In proposal evaluation, energy efficiency nominally accounts for about 15% to 30% of the total score assigned to proposals. Each evaluation team

decides if and how to assign extra credit for energy savings. The effort spent on evaluating energy efficiency appears to vary from facility to facility, and project to project. The evaluation team may spend from 1 day to 4 or 5 days reviewing the REEEM submittals. Often, energy calculations are not reviewed in great detail, but in one case studied the base engineer spent nearly two weeks reviewing calculations submitted with proposals and had to contact the command staff on several occasions. Special proposals, such as for photovoltaic systems, may require additional thought and analysis during the evaluation.

## 4.3 ELLSWORTH AIR FORCE BASE DEMONSTRATION PROJECT

The Air Force project selected for this demonstration was developed under the auspices of the SAC at Offutt Air Force Base (AFB) in Nebraska. This section describes the project.

### 4.3.1 Project Characteristics

The housing project was procured under the build-to-lease 801 process. The project was located near Rapid City, South Dakota, at Ellsworth AFB. As noted earlier, this location was a "cold" or "very cold" climate.

The project consisted of 200 total housing units: 47 single-story ranch houses, 124 split-level houses, and 29 two-story houses. Construction on these units began in August 1989 and was completed in August 1990.

### 4.3.2 Designer and Builder

The contractor for this project was located in Rapid City. The project designer was from Mt. Rushmore, South Dakota. It was not possible to obtain the participation of the original designer in the demonstration of the DOE standards, so another firm with extensive experience in military family housing was hired to conduct the redesign.[a]

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(a) This firm conducted redesigns for two additional housing projects included in this demonstration of DOE's standards. As explained in the sections describing the two other projects, the original designers were not available to participate in the demonstration.

### 4.3.3 Energy-Efficiency Requirements

Only the most common unit type in this housing project, the split-level house, was analyzed during the demonstration. The project designer proposed the original energy conservation measures in accordance with the REEEM process, described earlier. Table 4.1 lists the conservation measures for the original design.

In addition to the measures shown in Table 4.1, the REEEM also required that 1) passive solar must contribute 25% to the space heating load or 30% to

TABLE 4.1. Conservation Measures in Original Design, Ellsworth AFB

| Component | Measure Level |
|---|---|
| Ceiling insulation | R-value = 38 |
| Wall insulation | R-value = 24 |
| Floor: | |
| Type | Crawl space |
| Insulation | R-value = 19 |
| Infiltration control | Average |
| Glazing: | |
| Number of panes | Two |
| Sash type | Wood |
| Glazing area (% of floor area) | 10% |
| Heating equipment: | |
| Fuel type | Natural gas |
| Rated efficiency | 0.80 AFUE |
| Cooling equipment: | |
| Rated efficiency | 10.3 SEER |
| Water heating: | |
| Fuel type | Natural gas |
| Label value | $176 |
| Refrigerator/freezer: | |
| Label value | $74 |

AFUE = annual fuel utilization efficiency
SEER = seasonal energy efficiency rating

the lighting load or 2) active solar must contribute 25% to space heating or 35% to the domestic hot water load. This requirement was introduced by Air Force headquarters. This requirement appeared to be difficult to implement and project documents suggest that it was met by the designer through a mixture of quantitative and qualitative recommendations for passive solar design strategies. Infiltration and heating, ventilation, and air conditioning (HVAC) measures were as required in the REEEM.

## 4.4 IMPACTS OF THE U.S. DEPARTMENT OF ENERGY STANDARDS

The impacts of the DOE standards on the Air Force were assessed based on information provided by Air Force personnel at headquarters, the commands, and the base participating in the demonstration. Impacts on the designer were determined from information provided by the designer hired to conduct the redesign of this project; as noted earlier, this was not the project's original designer. This section discusses the standards' impacts on the processes used by the agency and designer first, followed by monetary and energy impacts.

### 4.4.1 Effects on Air Force Housing Procurement Process

The DOE standards would affect the Air Force at two points during the procurement process: RFP preparation and proposal evaluation. This section discusses the effects of the standards during these activities.(a)

#### 4.4.1.1 RFP Preparation

If the Air Force used the DOE standards during procurement package development, the standards would require the agency to run the COSTSAFR program and generate the point system for each building type being considered. This step would replace that of preparing the REEEM under the Air Force's current approach.

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(a) Every attempt was made to make each test application of the standards as realistic as possible. As has been noted before, however, most information from the case studies is based on a test of the standards rather than a full-blown application during an actual procurement. Consequently, the reader should be aware that it was not possible to ensure that all impacts were identified that might occur in an actual application.

It appears that generating the point systems with COSTSAFR could be substituted for preparation and incorporation of the REEEM early in the acquisition process with no difficulty. Concerns were mentioned, however.

One concern that arose in initial discussions with Air Force headquarters staff was a lack of personal computers (PCs) to run COSTSAFR. When the demonstration was conducted in the field, however, PCs were readily available to the field office staff.

Several people indicated they would like to continue, as REEEM currently does, to set requirements in terms of energy consumption as well as energy costs. Although the DOE standards are based on energy costs, rather than energy consumption, PNL developed and then modified the CAPS program during the demonstration in response to such comments so that it provided energy consumption targets that the Air Force and others could use.

The DOE standards could have another effect on the overall Air Force procedure. Currently, headquarters takes responsibility for developing the REEEM for each project. In this demonstration, however, headquarters delegated the running of COSTSAFR to SAC staff and, presumably, would do so in actual applications of the standards. This shifts some of the burden to the command or base level. Although the DOE standards might shift the task of developing the energy efficiency requirements to the command and base level, it appeared that the impacts would be minimal. One participant commented "Though I am not enthusiastic about doing anything new such as using the DOE standards, to me a computer program is the way to go; it's the state-of-the-art."

Using COSTSAFR requires obtaining input data that may not be immediately accessible; this is a step not required under the current procedure. One demonstration participant felt it would be helpful if the necessary data were provided to the user. In the demonstration project, the actual level-of-effort expended by Air Force staff to generate energy-efficiency requirements with COSTSAFR was relatively small. About one hour was spent learning how to use the software, and four hours were spent generating the point systems. Most of the four hours was spent obtaining the correct inputs.

The agency was not required to test the alternative compliance procedure. Consequently, agency comments on the ACP were very limited. In the RFP preparation phase, however, the ACP would probably not require a significant effort by the agency. The interviewees seemed to have an adequate understanding of the energy and cost principles that underlie the ACP and they would probably be able to implement it effectively during this phase of the procurement process.

A potential future problem in using the DOE standards was noted. Several people commented that the cost data and other data in the software needed to be updated and if the Air Force had to update this information it would be a major effort.

#### 4.4.1.2 Proposal Evaluation

During proposal evaluation, two primary criticisms were voiced about the Air Force's current procedure. One was that it was disproportionately time consuming considering the points awarded for energy efficiency. One participant commented that "some contractors go overboard on the quantity of material that is submitted. These proposers' REEEM sections can be several inches thick, and still might be incorrect." Another noted that "many proposers work with REEEM only once. Thus it should be easy to use and not require special training." The second concern was that the method did not address unusual technologies, such as photovoltaics, well, if at all. Even the passive or active solar technologies required in some projects were difficult to evaluate.

These comments were useful when assessing the effects of the DOE standards. Housing procurement staff felt that, compared with the current procedure, the DOE standards would reduce the amount of time evaluators would have to spend on energy-efficiency analysis. One staff person commented that "COSTSAFR appears to support the requirements for proposal evaluation and the software seems simpler and more direct than current practice."

Several respondents, however, believed that the DOE standards demonstrated no special capability to handle unusual energy technologies. In fact, there were concerns that the standards were incapable of handling efficiency measures that were important to the Air Force, but difficult to

analyze, such as passive solar. Headquarters staff noted early in this demonstration project that COSTSAFR needed to do a better job with passive solar, and that the Air Force had already developed an approach to evaluate this option. In the field, staff noted that, although CAPS simplified the evaluation process, it did not provide detailed information about solar and infiltration control requirements. In particular, it did not allow the evaluator to determine whether a proposed design met the Air Force's requirements for the solar contribution in meeting the heating load.[a]

The DOE standards' alternative compliance procedure (ACP) provides the flexibility to assess innovative or uncommon energy-efficiency technologies or systems. Unfortunately, a thorough test of the ACP was not possible in the demonstration so not much information is available on the impacts of the ACP during proposal evaluation. Extrapolations from Air Force experience in evaluating solar technologies under the current process, however, suggest that using the ACP during evaluation would be time consuming and challenging. Nevertheless, the ACP might introduce a consistent framework for evaluating innovative technologies.

There was a general concern at both the Air Force headquarters and field level that the DOE standards did not provide a simple measure of energy efficiency. In part because of such concerns at the headquarters level, PNL created the CAPS program and added to it an energy consumption estimate (Btu per square foot per year) for proposed designs. Even with the addition of energy budget information, there was a desire for more information that could provide guidance about cost-effective design choices, such as a graphical presentation of cost-effective U-values.

### 4.4.2 Designer Impacts

As with two other demonstration projects, the original designer was unavailable to conduct the redesign. It was necessary, therefore, to obtain information on design process effects from another design firm. This section discusses the standards' effects on the design process and the design changes that were proposed to meet the DOE standards.

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(a) A similar comment was voiced about the difficulties of using the current Air Force approach to evaluate the solar contribution.

#### 4.4.2.1 Effects on Design Process

The designer indicated that a relatively small effort was required to learn how to use the paper point system. Learning to use the point system, collecting the necessary information (determining window areas, obtaining water heater and refrigerator label numbers, etc.), and filling out the point system took less than five hours. Once the paper version was understood, learning to use CAPS took about one-half hour. Because the DOE standards require the designer to do fewer calculations and collect less information, the DOE procedure should require less effort by the designer than the current Air Force procedure.

Generally, the designer considered the documentation to be clear and adequate. It was noted, however, that the documentation did not define all of the technical terms used, for example, how the floor area should be calculated.

Several interpretation problems were mentioned that would affect the designers' ability to properly use the standards. One problem was how buildings that are not aligned with a North-South axis should be treated. Another definitional issue, which was related to the operation and application of COSTSAFR, was how to handle real buildings with an unusual mix of design features, e.g., a building with a slab-on-grade, a crawl space, and a basement. Such issues would probably require the agency procurement staff to make a judgment about how to apply the DOE standards and provide an interpretation to designers.

Actual use of the point systems did not pose any significant difficulties. The designer noted that the paper point system contained many ECMs that were unlikely to be used, and these made the form unnecessarily long. Some confusing language was noted in the point system. CAPS was found to be easy to use, making the written documentation almost unnecessary. It was suggested that a "help" feature be added to CAPS to allow the user to access documentation while using the program.

Use of the DOE standards did not appear to complicate the design process. The main negative comment about the design requirements was that the minimum

energy-efficiency levels required by the standards seemed outdated when compared to other standards and current practice. Because the minimum requirements of the DOE standards were not very strict, it was felt that it would be easy to produce designs satisfying them. The designer noted that updates should be made to the economic and technical data in the standards to ensure that they are current and, he commented, the user agencies are not likely to make these updates because of the risk of making errors or unfamiliarity with the program.

It was felt that the paper point system and CAPS could be helpful in selecting design options to comply with the standards, but there were definite limits on their usefulness. For one, the paper point system gives no indication of the effect of selecting a different ECM until the designer is finished. Although CAPS provides this information immediately, it was felt that a graphical presentation would be more effective than CAPS's current approach.

The designer also had several comments on the general usefulness of the point systems during the design process. He commented that CAPS was easy to use, but did not feel that it was as flexible as other energy analysis tools. The main limitation was that the point system provides no information to the designer about the cost of various conservation measures. It was felt that designers would benefit from knowing the first costs used by COSTSAFR in its analysis. With this information, the designer and builder could determine the measures for which they had a cost advantage (cost per point-system point) when they compared their costs to those used by COSTSAFR. It was also stated that the point system should not be the sole tool available for the designer to use to show compliance. Other, private-sector tools were identified that were considered to be more flexible, powerful, and accurate.

Two comments were made about the assignment of points in the standards' point system. First, the points for different levels of a particular ECM were identical, even though one was more energy-efficient than the other.[a] It

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(a) This occurs in the point system because of round-off errors and limitations on the number of significant digits. The latest version of COSTSAFR, Version 3.1, contains more significant digits, thus alleviating this problem.

was felt that designers would always pick the least energy-efficient level in such cases because they would receive no credit for the higher level. Second, the designer commented that the point system should capture the benefits of "concerns other than life cycle costs, such as national security, environmental impact, and public image. Federal requirements should be leading current practice, not falling five to ten years behind it."

The designer also noted that several ECMs not incorporated in the point system should be included as options for the designer to use. Such options included energy-efficiency measures such as water heater wraps, energy-efficient lighting, low-flow faucet aerators and shower heads, microwave ovens when electric stoves are allowable, setback thermostats, permanent and movable shading devices, and gas-filled windows. The designer also recommended including active solar water heating and space heating systems, combination space and water heating systems, motion sensors on exterior lighting, and air-lock entryways.

For designers who want to analyze and incorporate innovative technologies that are not covered by the point system, the standards offer the ACP. The redesigner's comments suggested, however, that it would probably not be possible for the A&E firm to implement the ACP during the time allowed to prepare a proposal. It was also observed that most firms would not have the expertise needed to run the energy analysis program required by the ACP.

#### 4.4.4.2 Redesign of Ellsworth Units

The COSTSAFR analysis for this project was based on a natural gas price of 20 cents/therm and an electricity price of 7.2 cents/kWh. The resulting point systems reflected these prices. Because the gas price, in particular, was quite low compared to common residential rates, the energy-efficiency levels in the houses as-built were higher than those required by COSTSAFR. (See Chapter 8 for a detailed discussion of this.) The standards required a total of 67 points in the COSTSAFR point system; the actual design achieved 79.5 points.

The A&E firm was asked to submit two redesigns corresponding to two different ways the designer might have responded to the DOE standards' requirements. One redesign was selected to slightly exceed the minimum point

total requirement from the standards; thus it should have minimized first cost. The other achieved the same point total and energy cost savings as the original design, but at the lowest estimated first cost.

In the first redesign, the A&E firm reduced the ECM levels selected in the original design to match the DOE standards' minimum point total requirement as closely as possible. Changes made under this modification included using R-19 ceiling unfaced batt insulation in place of R-38; substituting 2x4-in. wall studs with R-11 batt insulation for 2x6-in. studs with R-19 batt insulation and rigid insulation; decreasing the floor insulation from R-19 to R-11; and substituting double-pane, aluminum frame windows for wood frame windows. Table 4.2 compares the design selections for this case with the original design and minimum selections generated by COSTSAFR.

Compared with the original design, this redesign was estimated to decrease capital cost to the Air Force by about $2,100 per unit. Because the units would be less energy-efficient than the units as built, the discounted present value of life-cycle energy costs would have increased about $814 per unit.

The second case considered was with each unit designed to meet the original point total, but with ECMs selected to minimize the capital cost. This entailed making three design changes: 1) substituting low-E glazing for conventional glazing, 2) replacing the wood frames with aluminum, and 3) eliminating the rigid wall insulation. Table 4.3 compares this redesign with the COSTSAFR minimum point total and original designs.

Compared with the original design, the estimated cost of each unit decreased by about $615. The discounted life-cycle energy cost also decreased, by about $16 per unit.

Figure 4.1 illustrates the design changes made in the case where the units were designed to meet the minimum points required.

TABLE 4.2. Comparison of Conservation Measure Levels for the Ellsworth AFB Split-Level Unit Using the Minimum Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceilings | R-38 batt | R-19 batt | R-19 batt |
| Walls | R-19 batt, R-6 rigid | R-11 batt | R-11 batt |
| Foundation | R-19 crawlspace; R-5, 4 ft. slab | R-5, 2 ft. slab | R-11 crawlspace; R-5, 2 ft. slab |
| Windows | | | |
| Panes | Double | Double | Double |
| Sash type | Wood | Aluminum | Aluminum |
| Infiltration control | Average | Average | Average |
| Heating equipment | Natural gas, 0.80 AFUE | Natural gas, 0.75 AFUE | Natural gas, 0.80 AFUE |
| Cooling equipment | 10.3 SEER | 7.0 SEER | 10.3 SEER |
| Domestic hot water | | | |
| Fuel | Natural gas | Natural gas | Natural gas |
| Energy Label | $176 | $176 | $176 |
| Refrig./Freez. | | | |
| Energy Label | $74 | $74 | $74 |
| Total points | 79.5 | 67 | 69.3 |

AFUE = annual fuel utilization efficiency
SEER = seasonal energy efficiency rating

TABLE 4.3. Comparison of Conservation Measure Levels for the Ellsworth AFB Split-Level Unit Using the Original Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceilings | R-38 batt | R-19 batt | R-38 batt |
| Walls | R-19 batt, R-6 rigid | R-11 batt | R-19 batt |
| Foundation | R-19 crawlspace, R-5, 4 ft. slab | R-5, 2-ft. slab | R-19 crawl-space R-5, 4 ft. slab |
| Windows | | | |
| Panes | Double | Double | Double, low E |
| Sash type | Wood | Aluminum | Aluminum |
| Infiltration control | Average | Average | Average |
| Heating equipment | Natural gas, 0.8 AFUE | Natural gas, 0.75 AFUE | Natural gas, 0.80 AFUE |
| Cooling | 10.3 SEER | 7.0 SEER | 10.3 SEER |
| Domestic hot water | | | |
| Fuel | Natural gas | Natural gas | Natural gas |
| Energy Label | $176 | $176 | $176 |
| Refrig./Freez. | | | |
| Energy Label | $74 | $74 | $74 |
| Total points | 79.5 | 67 | 79.7 |

AFUE = annual fuel utilization efficiency
SEER = seasonal energy efficiency rating

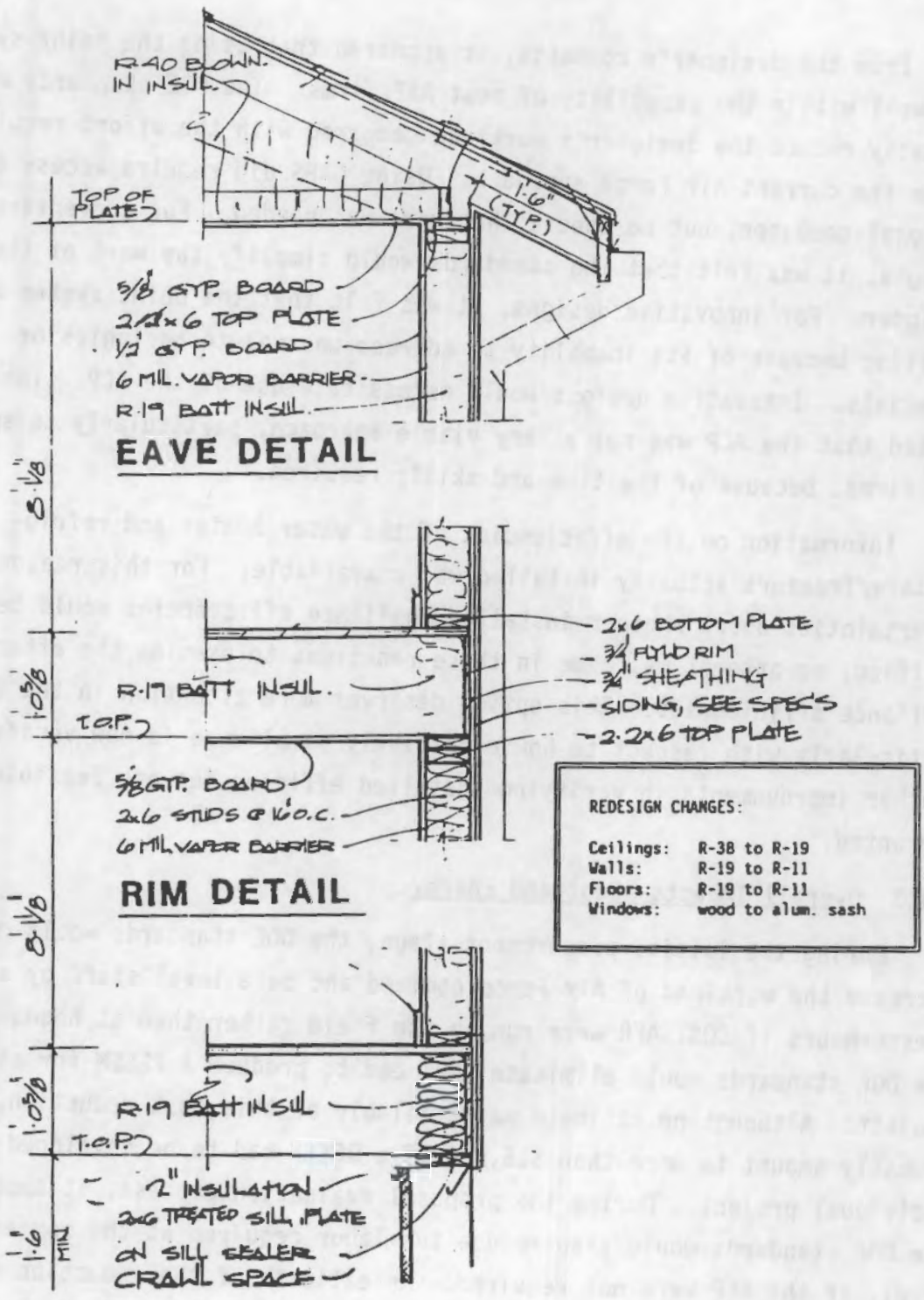


FIGURE 4.1. Ellsworth AFB, Split-Level House Design Changes, Minimum Points

From the designer's comments, it appeared that using the point system was well within the capability of most A&E firms. The DOE standards would probably reduce the designer's workload compared with the effort required under the current Air Force approach. Using CAPS did require access to a personal computer, but no special hardware was needed. For conventional designs, it was felt that the standards would simplify the work of the designer. For innovative designs, it was felt that the point system was limiting because of its inability to address unusual technologies or materials. Innovative designs would necessitate use of the ACP. The designer stated that the ACP was not a very viable approach, particularly to smaller A&E firms, because of the time and skills required.

Information on the efficiencies of the water heater and refrigerators/freezers actually installed was unavailable. For this reason and uncertainties about whether installed appliance efficiencies would be verified, no attempt was made in these redesigns to examine the effect of appliance efficiencies. This option deserves more attention in the future, particularly with respect to how effectively compliance is now verified and whether improvements in verifying installed efficiencies are feasible and warranted.

### 4.4.3 Overall Impacts--Cost and Energy

During the initial procurement stage, the DOE standards would probably increase the workload of Air Force command and base level staff by a few person-hours if COSTSAFR were run in the field rather than at headquarters. The DOE standards would eliminate the need to produce a REEEM for each project. Although no estimate was available of this cost reduction, it would probably amount to more than $15,000 if a REEEM had to be developed for an individual project. During the proposal evaluation process, it appeared that the DOE standards would also reduce the labor required at the command and base level, if the ACP were not required. An estimate of the reduction was not available from Air Force respondents but, based on the information provided, the labor savings would probably amount to about three or four person-days.

The costs to the designer of using the point system were also minimal. Compared to the current Air Force approach, the DOE standards should reduce the labor designers must devote to preparing their proposals.

The only situation in which the DOE standards might increase costs to the agency and designers would be if innovative technologies were proposed for a project and designers requested use of the ACP. The DOE-2 simulation model would have to be run to estimate the energy consumption and energy cost of the housing units. Who would do the runs would depend on how the agency chose to implement the ACP. After receiving data and information from the designers, the agency would have to verify it. All these steps would increase the costs of applying the standards. No primary data were collected to estimate these costs, but the agency might have to spend between 5 and 10 additional person-days and each proposer might need to spend a similar amount. If similar technologies were proposed under the current Air Force approach, however, a comparable additional effort might be required. Therefore, using the DOE standards would not necessarily increase the effort required when innovative technologies were being considered.

In terms of construction costs, the demonstration redesigns indicated that capital costs could have been decreased if the split-level houses were designed to just meet the DOE standards. Based on the redesign subcontractor's estimates, first costs would have declined about $2,100 per unit, or about $260,000 for the 124 units built. Life-cycle energy cost would have increased about $814 per unit ($110,000 for all 124 units), however, because the houses would have been less energy-efficient. Therefore, the DOE standards would have decreased overall life-cycle costs for each unit $1,286, or about $150,000 for all 124 units.

If the designer had used the DOE standards to select ECMs to minimize capital costs while maintaining approximately the same energy efficiency as the original design, total capital costs could have been decreased about $76,000. The discounted life-cycle energy cost also would have decreased in this case, but by an insignificant amount.

In terms of energy consumption, the first approach would have increased energy consumption compared with the original design. The increase for each

house would have been about 9%, or 19 million Btu per year. Increased energy use was estimated to be 18.6 million Btu of natural gas and 0.3 million Btu of electricity end-use consumption per year. For all 124 houses this would be equivalent to an increase of about 2.3 billion Btu per year. The second approach would have had a negligible effect on energy consumption.

# 5.0 ARMY CORPS OF ENGINEERS CASE STUDIES

Procurement of family housing for the Army is conducted by district offices of the Corps of Engineers. The district offices selected for the demonstration were located in Fort Worth, Texas, and Sacramento, California. A recent family housing project procured through each of these offices was selected for the demonstration. The Fort Worth housing project is at Fort Polk in Louisiana and the Sacramento project is at Fort Irwin in California. This chapter reviews the procurement process for the Army, provides descriptions of the projects conducted for both district offices, and discusses impacts of the DOE standards on the projects.

## 5.1 ARMY CORPS OF ENGINEERS FAMILY HOUSING PROCUREMENT PROCESS

The Army has 41 district offices with responsibility for implementation of new housing procurement. Only eight or nine of the offices are currently active in procurement of Army family housing. The main divisions within district offices which may be involved in housing procurement are Construction, Engineering, Contracts, and Real Estate. The construction and engineering divisions within the district offices are responsible for MILCON projects. The Real Estate division is in charge of 801 projects. A description of the Army Corps of Engineers' typical procurement process is given below. A detailed description of the Department of Defense turnkey procurement is given in Section 4.1.

### 5.1.1 Overall Army Procurement Process

Once the request for a family housing project has been approved through Congress and budgeted, the actual procurement process takes approximately two years. The first step entails the preparation of a RFP. The RFP is based on and modelled after the Procurement Procedure Manual for Army Family Housing (DAEN-ECC-A, 1985). Preparing the RFP involves 10 people from the district, 1 from Headquarters, 1 at the division, 1 in the major command, and 10 from the installation. Of these contributors, 1 person may spend 50% of a year, while the balance of the people spend about 15% of a year on average. The RFP takes at least 4 months to develop.

Public notice of the RFP is issued, the RFP is distributed, and proposals are received as described in Section 4.1. The Corps of Engineers holds a bidders' conference to allow contractors to ask questions pertaining to the RFP. Bidders must provide 20% to 35% of the total architectural design in their proposal. A proposer will typically spend between $80K and $100K on its proposal.

The preliminary review for technical compliance is conducted by the construction support section of the district office. Each proposal is reviewed by an architect, mechanical engineer, electrical engineer, civil engineer, and structural engineer. The entire technical review takes about one day per person per proposal. The evaluation team often relies on the mechanical engineer's recommendations concerning a proposal's energy efficiency element because the other team members may not have expertise in this area.

The final selection evaluation is conducted by a team with a total of seven votes. For MILCON projects the votes are distributed among team members at the following levels: national evaluation team - three votes; division - one vote; major command - one vote; district - one vote; and the installation - one vote. (For 801 projects, the division and national levels are not involved). A vote may be shared by two or more people representing different parts of one organization. If two or more are sharing a vote, the vote is based on an average of their independent evaluations. The project manager from the district level usually serves as the team chairman. The teams are mostly made up of architects.

Evaluating all of the proposals for a project usually takes about a week, with two to five proposals typically received. The district office prepares an evaluation plan that specifies how points are to be awarded for various housing features for each project. The criteria the proposers must meet are contained in the RFP. Soon after the contract is awarded, 50% of the design is required, with 100% of the design required a few months later.

### 5.1.2 Army Process for Setting Energy-Efficiency Requirements and Evaluation

The Army prefers to use a mix of prescriptive and performance criteria, relying on the judgment of the district engineers for some of the requirements. The mechanical engineer in the district military design branch typically prepares the site-specific requirements for HVAC equipment and energy features for the RFP and verifies that proposals meet the requirements.

Headquarters staff mentioned that field offices have flexibility in setting energy-efficiency requirements. However, staff in the Fort Worth field office stated they have no role in setting the energy-efficiency requirements, only in checking to see that they were met. They also said energy-efficiency requirements are usually not modified at the district level.

The key points of the energy-efficiency requirements as specified in the Procurement Procedure Manual for Army Family Housing (DAEN-ECC-A, 1985) are covered in the remainder of this section. These are taken straight out of Part IIIB from the manual and put in the RFP as Part IIIB, although individual requirements can be modified or superseded in Part IIIA by the RFP preparer.

Ceilings are required to have a U-value no greater than 0.026 (about R-38). Overhanging floors and floors over unheated spaces must have a U-value no greater than 0.05 (about R-19); there is no requirement for slabs. Gross wall U-values depend on the heating degree-days as shown in Table 5.1.

TABLE 5.1. Army Wall U-Value Requirements

| Heating Degree-Days | Gross Wall U-Value[a] |
|---|---|
| < 1000 | 0.31 |
| 1000-2000 | 0.23 |
| 2001-3000 | 0.18 |
| 3001-4000 | 0.16 |
| 4001-6000 | 0.13 |
| 6001-8000 | 0.12 |
| > 8001 | 0.10 |

(a) Locations with more than 2,000 cooling degree-days must have wall U-values no greater than 0.16.

Double-glazed windows with thermal breaks are required. In colder climates the north window area is limited to 10% of the north wall area. For all climates, the total window area must not exceed 15% of the total wall area unless specifically designed to admit only low-angle winter sun. Shading is required between 9 a.m. and 5:30 p.m. from April 30 to October 1 on all glazing not facing north. Air infiltration control requirements are limited to caulking, gaskets, or other means to prevent leaks at windows, doors, sill plates, and electrical switches and outlets. Furnaces are required to have an annual fuel utilization efficiency (AFUE) of 71% or greater for gas and 80% or greater for oil. Electric air conditioners must have an energy efficiency ratio (EER) of 8.0 Btu/watt or greater. Heat pumps must meet the requirements shown in Table 5.2.

Where local codes exist, both the Army requirements and the local codes must be met or exceeded. The Army may set minimum energy efficiency requirements that exceed the local code by reviewing available technology in catalogs and selecting average values. Although they exceed local code, the selected levels are not necessarily the best technology available.

The mechanical engineer requires about a day to do the preliminary review on a proposal, and about 15% of that time is spent reviewing the energy requirements. If the proposal has extremely complex energy requirements more time may be required. The evaluation team relies on the mechanical engineer's recommendations from the preliminary evaluation to determine the proposer's compliance with energy requirements.

TABLE 5.2. Army Heat Pump Efficiency Requirements

| Certified Cooling Capacity | Min SEER | Min HSPF | Min SEER & HSPF[a] |
|---|---|---|---|
| up to 19,000 Btu/h | 7.6 | 5.6 | 13.7 |
| 19,000 Btu/h and up | 8.0 | 6.0 | 14.5 |

(a) Both the individual SEER and HSPF efficiencies and the combined SEER and HSPF efficiency must be met or exceeded.
SEER = seasonal energy efficiency rating
HSPF = heating season performance factor

No extra credit is given to proposers for surpassing U-values or exceeding efficiency requirements. In the past, the Army has paid builders a bonus of up to $2,500/unit for exceeding a minimum energy savings from passive solar design. Although the practice of encouraging solar energy technologies has declined over the years, the Army still gives extra points for a good passive solar design.

A separate category for energy efficiency is usually not established in proposal evaluations. Rather, credit for energy conservation-related measures might be given through a higher rating in the HVAC category or in the miscellaneous category. Usually energy efficiency will contribute 40 to 50 of the overall total of 1,000 points. Army representatives stated that, while energy conservation is important, comfort requirements come first.

In addition to the above-mentioned energy efficiency requirements, the Fort Worth District office also included a building design energy budget based on Btu per square foot per year in the Fort Polk RFP. The Sacramento office, however, has not used this approach.

## 5.2 FORT POLK DEMONSTRATION PROJECT

The project selected from the Fort Worth district is a family housing development at Fort Polk near Alexandria, Louisiana. The Fort Polk climate region falls into the "hot and humid" category. This housing project was selected because it is a recent project and was recommended by the district.

### 5.2.1 Project Characteristics

The Fort Polk project involved the development of 350 family housing units. Table 5.3 presents the different housing types included in the project. Construction of the housing project started on September 15, 1988, and was completed on August 6, 1990.

### 5.2.2 Designer and Builder

The original designer/contractor was not available to participate in the demonstration project. An A&E firm with experience in military housing design was retained to perform the evaluation in their place. The results of the redesigns are described in Section 5.3.

TABLE 5.3. Fort Polk Housing Units

| Housing Unit Type | Number |
|---|---|
| Townhouse: 6-family units | 21 |
| Townhouse: 4-family units | 27 |
| Townhouse: 2-family units | 37 |
| Townhouse: 3-family units[a] | 14 |

(a) The three-family units were one-story buildings.

### 5.2.3 Energy-Efficiency Requirements

The energy requirements stated in the RFP for the housing project at Fort Polk followed the Procurement Procedure Manual discussed in Section 5.1.2, with the following modifications:

- An energy budget calculation was required for each type of housing unit, with the additional requirement that the energy budget not exceed 81,900 Btu/sq.ft./yr.
- The use of air-to-air heat pumps was required.
- A wall U-Value of 0.160 was selected because Fort Polk is geographically located in an area that has more than 2,000 cooling degree-days.
- Passive solar system cost and performance calculation worksheets were not required.
- Orientation of all housing units within 20 degrees of true south was not required.

Table 5.4 shows the conservation measures that were included in the original design.

## 5.3 IMPACTS OF U.S. DEPARTMENT OF ENERGY STANDARDS

The DOE standards set the minimum level of energy efficiency required in new federal housing projects. This section describes the impact the standards program might have had on the 350-unit development at Fort Polk in the following areas:

TABLE 5.4. Conservation Measures in Original Design, Fort Polk

| Component | Measure Level |
|---|---|
| Ceiling insulation | R-value = 38 |
| Wall insulation | R-value = 19 (R-13 batt, R-6 rigid) |
| Floor: | |
| Type | Slab |
| Insulation | R-value = 0 |
| Infiltration control | Tight |
| Glazing: | |
| Number of panes | Two |
| Sash type | Aluminum + thermal break |
| Heating equipment: | |
| Fuel type | Electric, heat pump |
| Rated efficiency | 7.0 HSPF |
| Cooling equipment: | |
| Rated efficiency | 9.6 - 10.2 SEER[a] |
| Water heating: | |
| Fuel type | Electric |
| Label value | $406 |
| Refrigerator/freezer: | |
| Label value | $61 - $63[a] |

(a) Actual value depended on whether townhouse was single- or two-story unit.
HSPF = heating season performance factor
SEER = seasonal energy efficiency rating

- the agency procurement process
- the developer's architectural and engineering designs
- the energy efficiency and capital costs of the project.

### 5.3.1 Effects on Army Housing Procurement Process

The DOE standards would affect the Army procurement process at two points during the procurement process: RFP preparation and proposal evaluation. This section discusses the effects of the standards during these activities.[a]

#### 5.3.1.1 Request for Proposal Preparation

The mechanical engineer who participated in the demonstration took 20 hours to learn to use COSTSAFR and 4 hours to produce the compliance forms. He did not find it necessary to exclude any conservation measures or levels, modify the point system forms, or make any other modifications or additions to the requirements to make them compatible with other, non-energy requirements that were specified for the project. He did not encounter any problems with the software or user's manual. However, he stated that the cost data, fuel escalation rates, and discount rates are seriously out of date. He suggested that this information would need to be updated annually. In addition to these comments, he recommended that the software be made easier to install and that the program include a duplex house type.

The mechanical engineer indicated that running the COSTSAFR program to produce point system forms for inclusion in the RFP would not be a difficult task. Additionally, he argued that it could be accomplished just as easily by the project manager since only basic project information, such as location and applicable fuel prices, must be input. The mechanical engineer and project manager interviewed at the Fort Worth district office agreed that including a narrative description of the standards in the RFP would be easily accomplished, requiring a minimal amount of effort.

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(a) Every attempt was made to make each test application of the standards as realistic as possible. As has been noted before, however, most information from the case studies is based on a test of the standards rather than a full-blown application during an actual procurement. Consequently, the reader should be aware that it was not possible to ensure that all impacts were identified that might occur in an actual application.

#### 5.3.1.2 Proposal Evaluation

During proposal evaluation, members of the full evaluation team would probably spend no more time than they currently spend on energy efficiency. Under the DOE standards, the designer would be required to submit the completed paper point system or CAPS compliance forms, or utilize the ACP. Staff at the district office in Fort Worth believed that the output forms generated by CAPS would facilitate and improve the evaluation procedure. They stated that the need for engineering judgment and guesswork would be eliminated because the CAPS point totals would give a clear indication of compliance. In addition, they noted that their current Btu per square foot per year methodology only indicates energy consumed on a generic basis and does not provide cost information, whereas the DOE standards are based on life cycle cost calculations and take fuel costs and fuel type into account, resulting in energy-efficiency requirements stated in energy dollars. This, they stated, is important when trying to compare the energy efficiency of radically different proposed designs. In addition, an observation was made that the CAPS format makes it easier for proposal evaluators not trained in engineering to understand the energy performance of proposals.

Concerning the ACP, the staff at Fort Worth felt the designer would never run a complex simulation model like the DOE-2 model, which is required to use the ACP, because of the time and effort involved. The designer might be more inclined to use an easier (and less expensive) load calculation technique such as a bin calculation method. Fort Worth's staff commented that there is not enough motivation for the designer to put the time and money into running a complex compliance program.

### 5.3.2 Designer Impacts

As with two other demonstration projects, the original designer was unavailable to conduct the redesign. It was necessary, therefore, to obtain information on design process effects from another design firm. The following sections discuss the designer's observations concerning the standards' effects

on the design process and the design changes that were proposed to meet the DOE standards.[a]

5.3.2.1 Effects on Design Process

The designer stated that the point system was easy to understand, especially when compared to other conservation standards. He also stated that CAPS encouraged experimentation allowing different options to be examined.

The designer raised several concerns pertaining to the paper point system and CAPS. As with other case study projects, he noted that one of the building designs could not be fully evaluated with the standard options offered by the point system. This was because the combination of foundation and insulation types did not cover buildings with combined floor types (e.g. a building with a slab on grade, a crawl space, and a basement). He commented that the User's Guide does not adequately address this type of problem. The designer also mentioned that the formulas used and points assigned in the paper point system do not make intuitive sense and have the appearance of a "magic numbers" calculation procedure.

The designer observed that the optimum equipment efficiencies identified in the point system compliance forms and CAPS are below new federal appliance standards and, therefore, are not available.[b] He stated that the same appears true for insulation levels. Consequently, the designer raised a concern about the maintenance of the DOE standards' databases.

He pointed out that the validity of the values in the point system are entirely dependent upon accurate material costs, labor costs, energy prices, projected inflation rates, and interest rates. The designer noted that new energy-efficiency measures will be developed over time and existing measures will become less costly. He observed that the economic assumptions for fuel

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(a) Because the A&E firm that redesigned this project was the same as the firm the redesigned the project discussed in Chapter 4, the reader is referred to that chapter for more detailed comments. Only designer information and comments specifically related to the Fort Worth project are presented here.

(b) The minimum appliance efficiency levels available in Version 3.1 of the COSTSAFR program have been updated to reflect the new minimum federal appliance standards.

escalation rates could change regularly. In addition, it was noted that the agency (district office) using the DOE standards is responsible for updating or overriding the program default values at the time the points are generated. However, it was the designer's contention that most agency personnel will not update the values because of unfamiliarity with the program or concern about making a mistake.

The designer easily met the COSTSAFR point total requirements for the Fort Polk redesigns and noted that the modest efficiency requirements might induce contractors to select less efficient conservation measures to reduce their capital costs. In the particular townhouse design evaluated, reducing the ceiling insulation from R-19 to R-11 did not reduce points or increase the life-cycle energy cost. The designer believed that results like this could send the wrong signals to developers, that only reducing construction costs is important.[a]

The designer expressed the opinion that the point system should not be the sole tool available for developers to use to show compliance with the standards. He suggested that many private-sector tools are on the market that are more flexible, powerful, and accurate than the paper point system compliance forms or CAPS (e.g. SUNCODE, REM/DESIGN, MICRDPAS, CALRES). Further, he felt that developers should be allowed to use these tools to demonstrate compliance with the DOE standards.

5.3.2.2 Redesign of Fort Polk Prototypes

The COSTSAFR analysis for this project was based on an electricity price of 5.9 cents/kWh in the winter and 5.7 cents/kWh in the summer. The resulting point system compliance forms reflected these prices. The designer performed redesigns of the single-story townhouse and a two-story townhouse end-unit. (The single-story townhouse was modelled by using the ranch house prototype in the point system.)

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(a) The equivalent point assignment for R-11 and R-19 in this case was the result of a deficiency in the COSTSAFR program which resulted in point assignments of less than one being set to zero. This rounding of points to zero has been eliminated in Version 3.1.

The original single-story townhouse design point total (103.5) was essentially equal to the minimum required by COSTSAFR (103); thus, the original design just met the DOE standards. Because the efficiency of the original design was so close to the level required by the standards, the goal of the single-story townhouse redesign was to decrease the capital cost by eliminating fairly expensive options and adding other inexpensive options so that the total points remained about the same. Because the designer did not have access to the true capital costs for the project, he used Means cost data instead (Means 1990).

The original townhouse end-unit design achieved 66.9 points in the point system for the DOE standards, exceeding the minimum 55 points required by the standards. Two redesigns were performed which met the minimum point total. The first decreased the energy efficiency level by selecting ECMs that resulted in a point total near the minimum requirement of 55 and reduced the capital cost of the project to the maximum extent possible. The second redesign aimed to decrease the capital cost while maintaining the 66.9 point total and therefore the energy performance characteristics of the original design. This was accomplished by offsetting the elimination of fairly expensive options through the addition of inexpensive options that kept the total points approximately the same.

Table 5.5 compares conservation measure levels and the corresponding point totals for the original design, COSTSAFR optimal design, and demonstration project redesign of the single-story townhouse. Changes made under this redesign included using R-19 ceiling unfaced batt insulation in place of R-38, omitting the 1-in. rigid insulation on the exterior walls, replacing a dark-colored roof with a light-colored roof, replacing the thermal-break double-pane aluminum frame windows with single-pane aluminum frame windows, and adding R-5 foundation insulation to the perimeter of the uninsulated slab to a depth of 2 feet.[a]

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(a) Note that staff at the Fort Worth district office disagreed with the energy savings estimated for slab-on-grade foundation perimeter insulation in certain locations. The estimated savings used in DOE's standards were derived from DOE-2.1 analyses, and the Fort Worth staff claimed that the BLAST model they used gives lower estimates. This is an empirical issue that can only be resolved with additional research.

Figure 5.1 shows the design changes that would have occurred for the single-story townhouse units built to the minimum point total requirement.

The net effect of this redesign, which maintained the same point total as the actual design, was to decrease the life-cycle energy cost by approximately $18/unit and reduce the capital cost by an estimated $880/unit, for a total decrease in life-cycle cost of $898 for each unit. The total life-cycle cost savings from the redesign equals $37,716 for just the 42 one-story townhouse units in the housing project.

TABLE 5.5. Comparison of Conservation Measure Levels for the Fort Polk Single-Story Townhouse Using Original Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceiling | R-38 batt | R-19 batt | R-19 batt |
| Walls | R-13 batt, R-6 rigid | R-11 batt | R-11 batt |
| Foundation | R-0 slab | R-5, 2 ft. slab | R-5, 2 ft. slab |
| Windows | | | |
| Panes | Double | Double | Single |
| Sash type | Aluminum + thermal break | Aluminum | Aluminum |
| Infiltration control | Tight | Tight | Tight |
| Heating equipment | Electric heat pump, 7.0 HSPF | Electric heat pump, 7.0 HSPF | Electric heat pump, 7.0 HSPF |
| Cooling equipment | Heat pump, 10.2 SEER | Heat pump, 9.22 SEER | Heat pump, 10.2 SEER |
| Domestic hot water | | | |
| Fuel | Electric | Electric | Electric |
| Energy Label | $406 | $406 | $406 |
| Refrig./Freezers | | | |
| Energy Label | $61 | $61 | $61 |
| Total points | 103.5 | 103.0 | 103.8 |

HSPF = heating season performance factor
SEER = seasonal energy efficiency rating

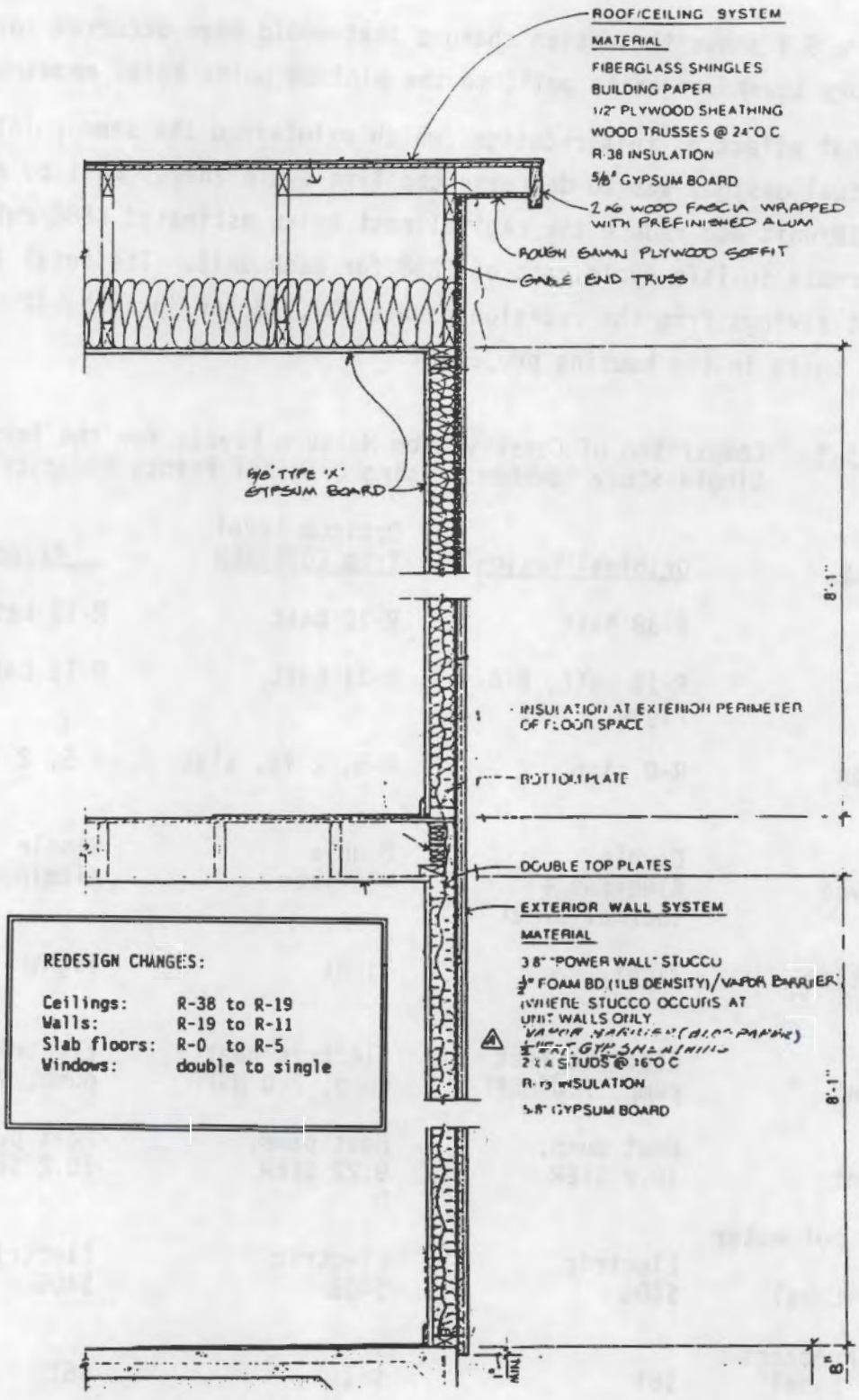


FIGURE 5.1. Fort Polk, Single-Story Townhouse Design Changes, Minimum Points

The original design points (66.9) well exceeded the minimum points required by the DOE standards (55) for the two-story unit. To redesign these units, therefore, the designer had the flexibility to relax energy-efficiency levels to still meet the requirements while reducing capital costs. The designer chose to eliminate the 8-mil infiltration wrap on all exterior walls, dropping infiltration levels from "tight" to "average;" substitute R-11 unfaced batt ceiling insulation for R-38; substitute single-pane aluminum frame windows for the thermal-break double-pane aluminum frame windows; and delete the 1-in. insulation on the exterior walls. Table 5.6 shows the energy-efficiency levels included in the original design, the optimal levels selected by COSTSAFR, and the levels used in the redesign.

With this redesign, the total points still exceed the minimum requirement by over 2 points and the estimated capital cost is decreased by $1,940 per unit. The life-cycle energy cost increases over the original design by $1,360/unit; thus, the net effect is a reduction of $580 in total life-cycle cost per unit. There are 308 units of this type in the development; therefore, the estimated overall savings from this redesign equal $178,640.

For the second redesign of the two-story townhouse, the goal was to decrease the capital cost of the project while maintaining the original energy performance. The elimination of fairly expensive options was balanced by adding other inexpensive options so that the total points remained approximately the same.

To this end, R-5 rigid foundation insulation was added to the uninsulated slab floor to a depth of 2 feet. R-11 unfaced batt insulation was used in place of R-38 in the ceiling, and the thermal-break, double-pane aluminum frame windows were replaced with single-pane, aluminum frame windows. Table 5.7 shows the energy-efficiency levels from the original design, the optimal levels selected by COSTSAFR, and the levels selected for the redesign.

With this redesign, the life-cycle cost of energy decreases by approximately $135 per unit, and the estimated capital cost decreases $1,119 per unit. The net change in life-cycle cost is a decrease of $1,254. There

TABLE 5.6. Comparison of Conservation Measure Levels for Fort Polk Two-Story Townhouse Using Minimum-Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceiling | R-38 batt | R-19 batt | R-11 batt |
| Walls | R-13 batt, R-6 rigid | R-11 batt | R-11 batt |
| Foundation | R-0 slab | R-5, 2 ft. slab | R-0 slab |
| Windows | | | |
| Panes | Double | Double | Single |
| Sash type | Aluminum + thermal break | Aluminum | Aluminum |
| Infiltration control | Tight | Tight | Tight |
| Heating equipment | Electric heat pump, 7.0 HSPF | Electric heat pump, 5.5 HSPF | Electric heat pump, 7.0 HSPF |
| Cooling equipment | Heat pump, 9.6 SEER | Heat pump, 7.03 SEER | Heat pump, 9.6 SEER |
| Domestic hot water | | | |
| Fuel | Electric | Electric | Electric |
| Energy Label | $406 | $406 | $406 |
| Refrig./Freezers | | | |
| Energy Label | $63 | $63 | $63 |
| Total points | 66.9 | 55.0 | 57.1 |

HSPF = heating season performance factor
SEER = seasonal energy efficiency rating

are 308 units of this type in the development; therefore, the total estimated savings from this redesign are $386,232.

In none of the three redesigns of the Fort Polk houses did changes in the water heater or refrigerator/freezer efficiency levels occur. This was due in part to the fact that the project was redesigned by a different A&E firm than the one that prepared the original design. Even if the designer had changed water and appliance efficiency levels, there is uncertainty about how the efficiency levels of installed equipment compare with the intended levels.

TABLE 5.7. Comparison of Conservation Measure Levels for Fort Polk Two-Story Townhouse Using Original-Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceiling | R-38 batt | R-19 batt | R-11 batt |
| Walls | R-13 batt, R-6 rigid | R-11 batt | R-19 batt |
| Foundation | R-0 slab | R-5, 2 ft. slab | R-5, 2 ft. slab |
| Windows | | | |
| Panes | Double | Double | Single |
| Sash type | Aluminum + thermal break | Aluminum | Aluminum |
| Infiltration control | Tight | Tight | Tight |
| Heating equipment | Electric heat pump, 7.0 HSPF | Electric heat pump, 5.5 HSPF | Electric heat pump, 7.0 HSPF |
| Cooling equipment | Heat pump, 9.6 SEER | Heat pump, 7.03 SEER | Heat pump, 9.6 SEER |
| Domestic hot water | | | |
| Fuel | Electric | Electric | Electric |
| Energy Label | $406 | $406 | $406 |
| Refrig./Freezers | | | |
| Energy Label | $63 | $63 | $63 |
| Total points | 66.9 | 55.0 | 67.8 |

HSPF = heating season performance factor
SEER = seasonal energy efficiency rating

### 5.3.3 Overall Impacts--Cost and Energy

Early in the procurement process, the DOE standards would have required a Fort Worth mechanical engineer to spend about three days learning the DOE standards and generating requirements to put in the RFP. Most of that time, however, would be devoted to learning how to use the standards and would not have to be repeated for future projects. The actual time required to generate the standards appeared to be very comparable to the time devoted to selecting efficiency requirements in the Army's current process, so the standards would impose little or no additional time requirements during this phase.

During proposal evaluation, the standards would probably minimize the time required to evaluate energy-efficiency performance. Using the point system compliance forms or CAPS to check that proposals had met the minimum requirements would probably require no more time than is required under the current approach used by the Fort Worth office.

If designers chose to use the ACP, the amount of time required during the evaluation process could be considerably longer. The Fort Worth staff believed, however, that designers would probably not use the ACP because of the effort they would have to expend.

In the Fort Polk project, the original (as-built) designs complied with the DOE standards. For the single-story townhouse, the original design just barely complied. The original two-story townhouse design, on the other hand, was considerably more energy-efficient than required by the DOE standards. The observation that one of the original designs was very close to the minimum requirements of the DOE standards while the other was much more efficient than the minimum requirements is illuminating. It reflects the fact that the DOE standards account for specific conditions, such as building configurations and fuel prices, in setting their requirements; whereas, more prescriptive standards, such as the existing Army requirements, aim at achieving energy-efficiency based on very general conditions. From the agency perspective, the specificity inherent in the process that produces the DOE standards could lead to houses that were designed to be more cost-effective than required by the Army's current procedure. However, the simplicity inherent in the more general uniform, prescriptive requirements now used would be sacrificed.

The redesign activity showed that had the developer used the compliance forms provided by the DOE standards when performing his original design, it is possible that he would have built to less efficient levels to lower his costs. Overall, however, these changes could have reduced the single-story townhouse capital costs by $880 per unit and the two-story townhouse capital costs by $1,940. The single-story townhouse life-cycle energy costs would have decreased $18 per unit, but the two-story townhouse life-cycle energy costs would have increased by $1,360 per unit. The changes in net life-cycle costs would have been decreases of $898 and $580 per unit for the single-story and two-story townhouses, respectively.

By applying CAPS or the paper point system, the redesign process also illustrated that the standards' tools could have been used to reduce energy consumption as much as the original design, but at lower first cost. For example, in the second redesign of the two-story townhouse, R-5 rigid foundation insulation was added to the uninsulated floor to a depth of 2 feet. This incremental measure was balanced by reducing the ceiling insulation from R-38 to R-11 and replacing the thermal-break, double-pane aluminum windows with single-pane aluminum frame windows. This trade-off resulted in almost identical levels of energy conservation (identical point totals) with an estimated reduction in capital costs of $1,119/unit.

In the one case where energy consumption would have changed significantly, the two-story townhouse designed to the minimum requirements of the standards, energy consumption would have increased about 11%. Annual consumption per unit would have increased about 5.8 million Btu per year. Because electricity was used for both heating and cooling, the additional energy used would have been electricity. For the 308 two-story units the increased energy consumption per year would have been about 1.8 billion Btu.

## 5.4 FORT IRWIN DEMONSTRATION PROJECT

The project selected from the Sacramento district is a family housing project at Fort Irwin near Barstow, California. The Fort Irwin climate region falls into the "hot" category. This housing project was selected because it was recently built and was recommended by the district office.

### 5.4.1 Project Characteristics

The Fort Irwin project involved the development of 270 family housing units. Table 5.8 presents the different housing types included in the project. Construction of the housing project started on December 23, 1988, and had not been completed when final data collection for the demonstration occurred.

### 5.4.2 Designer and Builder

The services of the original designer of the 270 units were obtained for the demonstration project. This designer is a private architect with past experience in military housing procurement.

### 5.4.3 Energy-Efficiency Requirements

The energy requirements stated in the RFP for the Fort Irwin housing project followed the procurement procedure manual discussed in Section 5.1.2. Additionally, the California Title 24 Energy Code had to be met, requiring a forced-air heating system seasonal efficiency of 72% or greater and an air conditioning energy efficiency ratio of 8.5 or greater. Table 5.9 presents the original conservation measures installed in the ranch houses constructed at Fort Irwin.

## 5.5 IMPACTS OF U.S. DEPARTMENT OF ENERGY STANDARDS

Implementation of the standards would have affected both army staff and the designer if they had been used for the Fort Irwin project. This section describes the impact the standards might have had on the 270-unit development at Fort Irwin in the following areas:

TABLE 5.8. Fort Irwin Housing Units

| Housing Unit Type | Number |
|---|---|
| One-story detached | 26 |
| Two-story detached | 54 |
| Two-story duplex | 31 |
| Four-plex townhouse | 32 |

TABLE 5.9. Conservation Measures in Original Design, Fort Irwin Ranch House

| Component | Measure Level |
|---|---|
| Ceiling insulation | R-value = 38 |
| Wall insulation | R-value = 17 (R-13 batt, R-4 rigid) |
| Floor: | |
| Type | Slab |
| Insulation | R-value = 0 |
| Infiltration control | Average |
| Glazing: | |
| Number of panes | Two |
| Sash type | Aluminum |
| Heating equipment: | |
| Fuel type | LPG |
| Rated efficiency | 0.71 AFUE |
| Cooling equipment: | |
| Rated efficiency | 8.9 SEER |
| Water heating: | |
| Fuel type | LPG |
| Label value | $141 |
| Refrigerator/freezer: | |
| Label value | $61 |

AFUE = annual fuel utilization efficiency
SEER = seasonal energy efficiency rating

- the agency procurement process
- the developer's architectural and engineering designs
- the energy efficiency and capital costs of the project.

### 5.5.1 Effects on Army Housing Procurement Process

The Sacramento district office provided information on the potential impacts of the DOE standards on its procurement process. This section discusses those impacts.[a]

#### 5.5.1.1 Request-for-Proposal Preparation

The project manager (an architect) who participated in the demonstration took 16 hours to review the documentation for the standards, use the software, and fill out the demonstration questionnaire. He commented that it would have been necessary in an actual procurement to have a mechanical engineer provide the input. The project manager would, however, have handled the actual generation of the paper point system. Overall, he felt the standards fit in with the RFP structure used by the office.

The project manager found the user's manual clear, understandable, and well written. He stated that some of the text relating to keystrokes could be written more clearly and that "movable insulation" should be defined more clearly. His principal suggestion about the documentation was that the Disk Operating System (DOS) should be discussed in more detail. He was not familiar with DOS and had problems understanding the DOS commands, which are not part of the COSTSAFR software.[b] In fact, he suggested that, if the documentation were not improved, everyone should take a course in DOS before using the software.

The Sacramento official had little difficulty with the COSTSAFR software, but felt there were some minor problems. He noted that not allowing the user to overwrite an existing point system file was inconvenient (COSTSAFR currently will append point systems on to an existing file if the file name already is being used). He had some problems with input files located on a

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(a) As noted before, every attempt was made to make each test application of the standards as realistic as possible. However, most information from the case studies is based on a test of the standards rather than a full-blown application during an actual procurement. Consequently, the reader should be aware that it was not possible to ensure that all impacts were identified that might occur in an actual application.

(b) A section on DOS commands and operations has been added to the User's Manual for Version 3.1 of COSTSAFR.

different drive on his computer (this was a DOS-related difficulty). An additional comment was that the page breaks on the point system printout did not occur where they were supposed to. Also, the Sacramento office had concerns about having the resources to duplicate the CAPS diskette for distribution to interested bidders (up to 200 requests for bid packages may be received).

The Sacramento office staff mentioned that the DOE standards would not have any impacts on construction costs or conservation in California because contractors have to meet the tighter Title 24 requirements. He submitted that the conservation levels required in the DOE standards were low and might be unacceptable to the Army. He suggested that market fuel prices should be used rather than the low fuel prices paid by the military bases to beef up conservation levels.

#### 5.5.1.2 Proposal Evaluation

The Sacramento officials stated that not much importance is put on energy conservation by the Army right now and this needs to change. They would find a way to give more extra credit for a design that was good in terms of energy performance. They believed the specificity of the point system will help make evaluations easier and did not foresee any difficulties using the completed point system in the evaluation stage. They did note that they were not sure what the points in the compliance forms and CAPS represented and they were not sure how to interpret them.

### 5.5.2 Designer Impacts

This section discusses the designer's response to using the DOE standards. The original project designer participated in the redesign.

#### 5.5.2.1 Effects on Design Process

Overall, this designer had a very favorable reaction to the point system, calling it "great." The designer spent 30 minutes learning how to complete the paper point system and 15 minutes learning the CAPS software. The designer stated he liked the simplicity of both the paper format and the CAPS program and could not think of any major drawbacks. He liked the feedback provided from making ECM selections and seeing the impact of these

selections on the point total. He felt that using the DOE standards' point system would be much quicker than completing the paperwork for the present Army or Navy conservation requirements. The designer did not use the point system documentation because he felt the paper point system and the CAPS program were self explanatory. However, the designer was very inexperienced with personal computers and did have problems getting the CAPS software started, although he reported no difficulties actually using CAPS.

The designer did feel that some of the equations in the paper point system forms were unclear. For example, he was unsure whether blank lines indicated a division operation. He also noted that the point system neglected to include solar screens on windows as an option.

The designer felt the point system could be useful as a design aid. In particular, the designer liked the ease with which he could evaluate options. To give CAPS more power as a design tool, he suggested providing cost estimates with each ECM. This would allow the designer to obtain instant feedback on cost impacts.

However, the designer felt that, given the relatively loose minimum requirements established by the DOE standards, the approach would eliminate energy conservation as a competitive factor unless some type of bonus credit was established by the federal agency procuring the new housing. He commented that the DOE method will tell designers the minimum package they are required to meet, and that designers would not exceed this minimum without the proper incentive.

#### 5.5.2.2 Redesign of Fort Irwin Prototypes

The software analysis for this project was based on a liquid petroleum gas (LPG) price of 39 cents/gallon, a natural gas price of 42.9 cents/therm, and an electricity price of 3.1 cents/kWh. LPG was used as the space heating and water heating fuel. All three fuel prices were relatively low compared to typical market prices.

The designer completed the point system for eight house designs using the ranch, two-story, and townhouse prototypes. The designer provided actual project costs for a number of ECMs for use in the redesign. The redesign, however, focused on only the single-story ranch house. Ceiling, wall, and

window measures were reduced and slab insulation was added in a hypothetical redesign. (This redesign assumes California's Title 24 standard does not apply.) Table 5.10 shows the conservation measures and point totals for the original design, the optimal COSTSAFR design, and the redesign.

Although the redesign is less energy-efficient than the original design, it is still more efficient than the minimum levels required by the DOE standards. This is because the designer did not choose to consider low efficiency options such as R-11 ceiling insulation in his analysis. The

TABLE 5.10. Comparison of Conservation Measure Levels for Fort Irwin Ranch House Using Minimum-Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceiling | R-38 batt | R-11 batt | R-19 batt |
| Walls | R-13 batt, R-4 rigid | R-11 batt | R-11 batt |
| Foundation | R-0 slab | R-5, 2 ft. slab | R-5, 2 ft. slab |
| Windows | | | |
| Panes | Double | Single | Single |
| Sash type | Aluminum | Aluminum thermal break | Aluminum |
| Infiltration control | Average | Average | Average |
| Heating equipment | LPG, 0.71 AFUE | LPG, 0.75 AFUE | LPG, 0.71 AFUE |
| Cooling equipment | 8.9 SEER | 7.0 SEER | 8.9 SEER |
| Domestic hot water | | | |
| Fuel | LPG | LPG | LPG |
| Energy Label | $141 | $129 | $129 |
| Refrig./Freezers | | | |
| Energy Label | $61 | $61 | $61 |
| Total points | 71.2 | 69.2 | 71.9 |

AFUE = annual fuel utilization efficiency
SEER = seasonal energy efficiency rating

redesign, therefore, still exceeds the minimum point total requirement of the DOE standards.

Unlike some of the other projects included in the demonstration, this redesign included an increase in water heater efficiency from the original level. This provided credits in the point system compliance forms that could compensate for some of the efficiency reductions that occurred. However, the extent to which the Army would verify the efficiency of the installed equipment was not determined.

With this redesign, the total points would increase by 0.7, decreasing the life-cycle cost of energy by approximately $52 per unit.(a) The capital cost would decrease by around $2,700 per unit. (Elimination of R-4 rigid wall insulation accounts for much of the cost reduction. This feature of the original design provided a surface necessary for the stucco exterior that was applied.) Overall, the design changes would reduce total life-cycle cost about $2,752 per unit.

5.5.2.3 Redesign Using Thermal Mass Walls

The Fort Irwin designer was specifically asked to provide feedback on the usability of the thermal mass wall option that was added to the latest version of the point system for the standards. The Fort Irwin project was selected to study heavyweight exterior walls because the climate was the most appropriate climate, of the five locations studied, for this type of construction. The designer noted that he was not familiar with thermal mass walls ever being used in military family housing and that "thermal mass is not a viable option in the affordable housing market place." The designer provided estimated costs for such a design, however. His data indicated that, for the ranch house, a house with brick veneer walls would cost about $3,000 more than a house using more conventional construction (batt insulation plus rigid foam) and having comparable energy efficiency. No comments or suggestions were given about the treatment of thermal mass walls in the point system.

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(a) As noted in Section 2.1.2, one point equals $100. The apparent discrepancy between the numbers 0.7 and $52 is due to rounding.

Figure 5.2 illustrates the design changes that would have occurred in the Fort Irwin ranch house design to meet the minimum points required.

5.5.2.4 Redesign with Corrected Fuel Prices

After the redesign and analysis was completed, it was discovered that the agency had used incorrect fuel prices in the COSTSAFR runs.(a) The prices were too low for both LPG and electricity. The correct LPG price should have been 49 cents/gallon and the electricity price should have been 8.5 cents/kWh.

PNL ran COSTSAFR using the correct fuel prices and found that the minimum requirements of the standards would have become more energy efficient. The optimum conservation measure levels would have been the following: R-19 ceiling insulation, R-11 wall insulation, two feet of R-5 slab insulation, double-paned windows with aluminum frames, a furnace AFUE of 0.75, and an air conditioner efficiency of an 8.0 SEER.

Compared with the requirements based on the erroneous fuel prices, the estimated space heating and cooling energy consumption would have decreased 10%. Compared with the redesign generated by the designer, the estimated heating and cooling energy consumption would have decreased by over seven percent, and compared with the actual design of the buildings it would have decreased five percent. In all comparisons, the requirements of the standards would have increased energy efficiency if the correct fuel prices had been used.

5.5.3 Overall Impacts--Cost and Energy

During RFP development, the Sacramento division office would have to invest a day or two learning about the DOE standards. It appeared that doing the necessary software runs would require only a few hours. Overall, the time required during RFP preparation would be very comparable to the time required by the current process; thus the standards would probably impose little or no additional burden on district office staff.

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(a) When the error was discovered, the person who had performed the agency runs had taken another position and it was not possible to reach him to obtain further information on his choice of fuel prices.

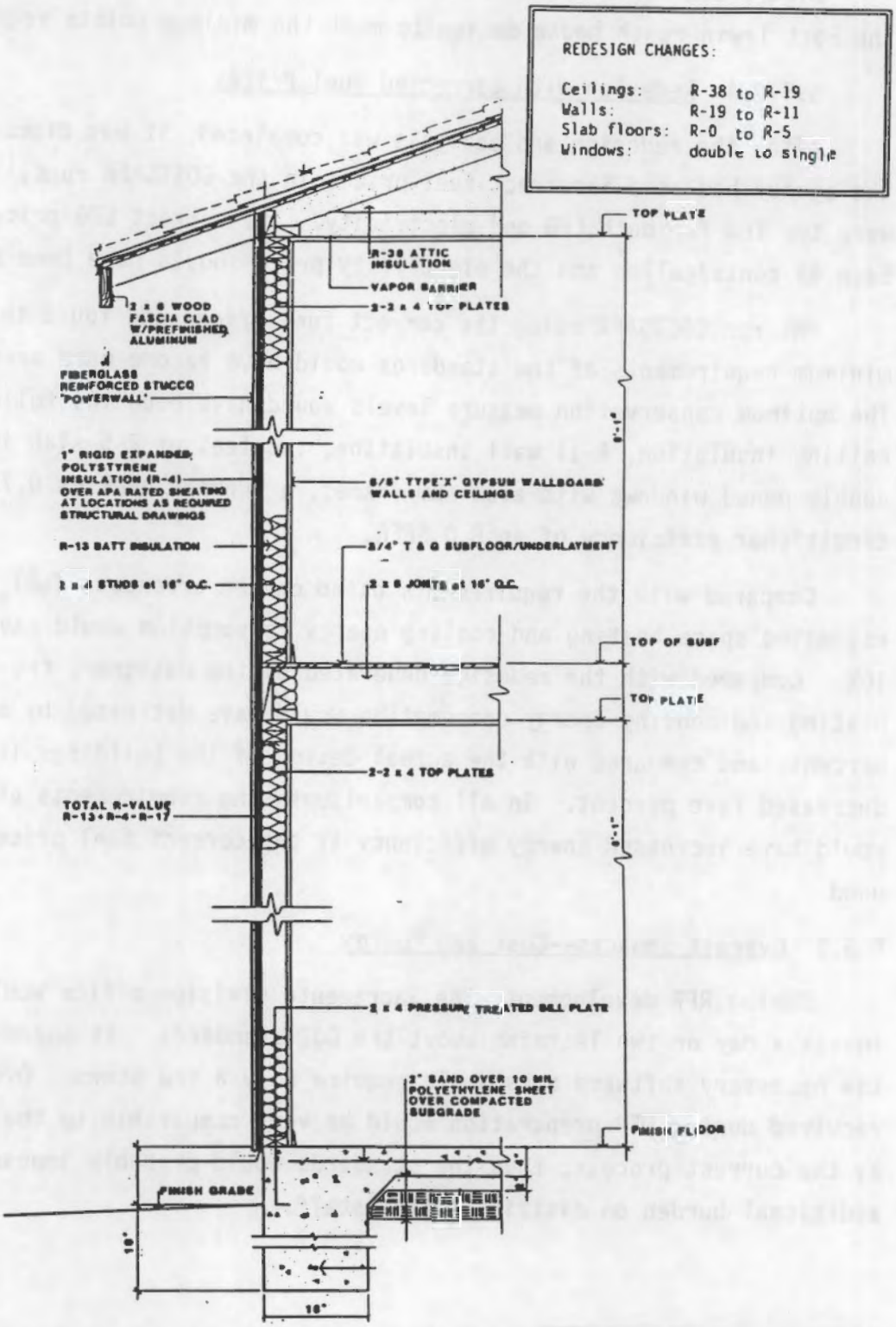


FIGURE 5.2. Fort Irwin, Ranch House Design Changes, Minimum Points

During proposal evaluation, it also appeared that the standards would not increase the workload any significant amount. The staff also noted that the point system forms for the standards might provide a convenient way to establish extra credit for designs that did better than the minimum efficiency requirements.

Using the standards, the designer redesigned the houses in this project at lower capital cost, and with reduced energy costs. For the ranch house, capital cost could have been decreased about $2,700 per unit, and life-cycle energy cost would have decreased about $52 per unit. The large decrease in unit cost was due primarily to elimination of the relatively costly "power-wall" construction, which appeared to be an aesthetic as well as energy-efficiency feature. The overall change in total life-cycle cost would have been a decrease of $2,752. The reader should note that the designer in this case chose a redesign strategy that produced a design with better energy efficiency than required by the standards. Unlike most other cases in this demonstration, the resulting design reduced energy consumption compared with the original design.

Energy consumption for these houses would have decreased by about 1.4 percent. For each house, energy consumption per year would have decreased about 1.3 million Btu. LPG energy savings would have been about 1.5 million Btu per year, but electricity consumption would have <u>increased</u> about 0.3 million Btu per year. Most of the LPG energy savings would result from the improved water heater efficiency. For the 26 ranch houses in the project, the decrease in annual energy consumption would have been about 34 million Btu.

Finally, the results of this demonstration project were affected by the fact that the agency personnel used incorrect fuel prices in their analysis with COST5AFR. There were two consequences of this. First, the use of fuel and energy prices lower than those actually available to the facility produced less stringent efficiency requirements than should have been applied. As a result, the redesigned buildings should have saved more energy than the estimated amounts. Second, the use of incorrect fuel prices illustrated a need to communicate to agency users the importance of obtaining and using the most accurate fuel and energy prices when applying the standards. Even with

PNL's direct involvement with the agencies during this demonstration, improper fuel prices were used in the analysis.

# 6.0 NAVY CASE STUDY

The Navy was the first government agency outside of DOE to have firsthand experience with the DOE standards. Without training or assistance from DOE, the Navy attempted to apply the standards to housing procurements in the mid 1980s, several years before this demonstration of the standards began. In part because they did not receive DOE training and support, the Navy's initial experience with the standards was not successful and has made the organization reluctant to use the standards again.

Unlike the other agencies discussed here, the Navy did not actually conduct a test of the standards during the demonstration project. However, its experience with the standards prior to the demonstration project has provided a considerable amount of useful information; in a sense, the Navy's observations are even more pertinent than the other case studies because the observations are based on its attempts to apply the standards to actual housing procurements rather than to hypothetical redesigns of housing projects. Nevertheless, the reader should keep in mind that the Navy's early experiences with the standards occurred under less than ideal conditions and many of the problems identified could have been resolved through closer involvement with DOE and PNL.

In addition to their observations based on earlier experiences, the Navy also provided information on its procurement process and the impacts that the standards would have on the process. An A&E firm was hired to apply the standards to a hypothetical redesign of this case study housing project and to report on the design impacts. All of these findings are reported in this chapter.

Like the other military services, the Navy follows a housing procurement approach that is defined primarily by the overall DOD approach. More information on the general approach is available in Chapter 4. This chapter presents information about the Navy housing procurement process, based on information from Navy headquarters and two engineering division field offices, and details of a demonstration housing project in Alameda, California.

## 6.1 NAVY HOUSING PROCUREMENT PROCESS

The Navy's overall family housing procurement process is established by headquarters. Headquarters also establishes the approach for addressing energy efficiency in family housing. Responsibility for implementing both the procurement process and the incorporation of energy-efficiency requirements in that process, however, resides primarily with the field offices. Section 6.1.1 discusses the Navy's overall procurement process and Section 6.1.2 addresses energy-efficiency requirements. The discussion is based on interviews with Navy Headquarters, and Division offices, and on material taken from Military Handbook 1190, and Navy Handbook NAVFACINST 11101.85F.

### 6.1.1 Overall Navy Procurement Process

The Navy follows the general procurement policies developed by DOD. Housing procurements begin with a station's or base's request for additional housing. In some instances, Congressional action begins the process. Overall, the process requires about five years before construction begins. Station needs are documented in a Base Facilities Requirements (BFR) planning document. The BFR lists what housing is currently available and what is needed. Based on the BFR, the station initiates a project request.

Once Headquarters approves the request, and selects the acquisition approach, the project becomes part of DOD's acquisition request to Congress. About 98% of acquisitions are MILCON, 1% are 801, and 1% are other miscellaneous approaches.

After a site is selected, a Site Engineering Investigation (SEI) begins. An SEI is typically completed by a contractor at a cost of $75K to $100K. The SEI includes an inventory of topographic features and utility needs. In addition to the SEI, an environmental assessment is completed by a contractor at a cost of about $100K, and, if needed, a contractor completes a hazardous waste assessment at a cost of about $50K plus special expenses. These documentation, approval, and study phases of the project require about four years.

After the site studies are complete, the RFP process begins. Headquarters dictates the number of units to be built and dollar volumes, and reviews the RFP before it is released. This process involves issuing an RFP,

advertising for contractors, evaluating proposals, negotiating the contract, and awarding the contract. This process takes about one year to complete, costs from $30K to $35K, and requires one person to administer it. Many of the in-house consultants do not charge to the project. These consultants may include "activity" people for community involvement. Activity people would add about $5K to the project cost.

Building contractors submit a conceptual plan for evaluation and a final proposal after being chosen. Bidders usually have about 120 days to respond to the RFP. The submittal represents about 35% of the design effort. The conceptual submittal includes simple plans, a listing of building materials, catalog descriptions of appliances, an outline of specifications, site development plans, contracts, prescriptive energy-efficiency information (R-values), and costs.

Bidders invest about $75K to $125K to develop their proposals. Four to eight proposals are typically submitted, depending on the location. The Northern Division Field Office reported that of the proposals submitted, only two or three typically comply with the RFP.[(a)] Any corrections or modifications to proposals are completed before the final award.

Proposals are evaluated in three steps. A Technical Evaluation Board, on which headquarters reserves the right to sit, lists conforming and non-conforming proposal technical features, and then lists the best proposal for each feature. A Source Selection Board is made up of high-level personnel and completes a comprehensive balancing of the proposals' pros and cons. Headquarters may also choose to sit on this board. Finally, a Selecting Official makes the final decision. The Assistant Secretary of the Navy may be the Selecting Official for projects with large dollar volumes.

### 6.1.2 Navy Process for Setting Energy-Efficiency Requirements and Evaluation

Energy requirements that are the result of DOD policy are established by headquarters. However, field office staff generally take the lead in recommending changes. For example, the Navy's Western Division established

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(a) The Navy is concerned that additional requirements, such as the DOE standards, could erode the number of bidders that make submissions.

efficiency requirements based on the State of California's energy standard. These requirements were adopted by headquarters. Northern Division staff noted that 99% of the changes are initiated at the field office level.

When issuing an RFP, about two hours are spent establishing energy criteria. At the initial submittal stage, about one hour is spent on each proposal to review, but not recalculate, energy-related forms. After a contractor is chosen, and the final design is being established, the proposed energy calculations are recalculated to ensure compliance. This recalculation requires about one day of a mechanical engineer's time.

Energy efficiency comprises about 3% of the total score assigned to proposals. At the time information for this study was collected, however, the Navy had started to move away from a quantitative evaluation of proposals toward an "adjective" evaluation.(a)

In 1989, the Navy adopted two options for meeting energy-efficiency requirements. Navy headquarters now offers the field offices the option of either using CDSTSAFR or a set of minimum prescriptive requirements combined with an energy budget developed by the Navy in 1989. The second option combines prescriptive standards with a building energy budget. The budget is expressed in Btu per square foot. The energy budget figure includes hot water heating and lighting and is adjusted for the local climate. The builder must meet both the minimum energy-efficiency levels and the budget to qualify. Contractors may install whatever energy features they wish, while still complying with the minimum levels, but the over-all package must meet the energy budget. Engineering Field Divisions verify and recalculate these figures at the final design of an acquisition. Performance and compliance is demonstrated using worst-case consumption of a proposed residential unit.

In July, when the demonstration project interview with Northern Division staff occurred, they had applied the energy budget approach to only their most

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(a) In the adjective evaluation the Technical Evaluation Board does not award points to various features of a design. Rather the board indicates whether the design complies with Navy requirements and indicates which proposal best meets the requirements.

recent project. Contractors had trouble complying with the budget and the requirement levels were relaxed to match proposed building plans.

Navy energy conservation requirements are given in the NAVFACINST Manual 11101.85F, Design-Build (Turnkey) Standards for New Family Housing Projects. Energy-related requirements are in Sections 2.D, 2.E, and 2.G. Minimum requirements from the handbook for insulation are shown in Table 6.1. The energy budget is drawn from a table in Military Handbook 1190. The budgets vary by climate zone, and the zones are defined differently than those used for the Navy's minimum requirements. The energy budget for housing is shown in Table 6.2. Northern Division staff noted that the budget does not account for the energy use of appliances. However, minimum efficiency requirements do cover water heaters, refrigerators, and heating and cooling equipment.

Other requirements include an air infiltration barrier and an air-to-air heat exchanger for climates above 6,000 heating degree-days. A vapor barrier is required for all locations. Total window area must be 16% or less of floor area and all windows must be double-glazed, with low-emissivity coating. The SEER of the air conditioner must be from 9.5 to 11.0 or greater, as specified by the Field Division. Gas furnaces must have an AFUE of 91% or greater. An energy budget in Btu per net square foot per year for heating and cooling is established by the field office.

TABLE 6.1. Navy Minimum Insulation Requirements

| Heating Degree-Days | Ceilings | Walls | Floors | Slab |
|---|---|---|---|---|
| < 2000 | R-30 | R-11 | R-11 | R-5/2 ft. |
| 2000-4000 | R-30 | R-19 | R-11 | R-5/4 ft. |
| 4001-6000 | R-30 | R-19 | R-19 | R-5/4 ft. |
| 6001-8000 | R-45 | R-19 | R-19 | R-10/4 ft. |
| > 8000 | R-60 | R-24 | R-30 | R-10/8 ft. |

TABLE 6.2. Department of Defense Energy Budgets for Family Housing

| Climate Zone | Heating Degree-Days | Cooling Degree-Days | Energy Budget KBtu/sq.ft./yr |
|---|---|---|---|
| 1 | > 7000 | < 2000 | 60 |
| 2 | 5500-7000 | < 2000 | 50 |
| 3 | 4000-5500 | < 2000 | 45 |
| 4 | 2000-4000 | < 2000 | 45 |
| 5 | 0-2000 | < 2000 | 40 |
| 6 | 0-2000 | > 2000 | 60 |
| 7 | 2000-4000 | > 2000 | 60 |

## 6.2 ALAMEDA NAVAL AIR STATION DEMONSTRATION PROJECT

The project selected for this demonstration was developed under the auspices of the Western Division of the Naval Facilities Engineering Command (WESTDIV NAVFACENGCOM), located in San Bruno, California. This section describes the project. At the time of the demonstration, the Western Division was undergoing a reorganization, which made it difficult for the field office to participate. In addition, the Navy requested funding from DOE for a full month of labor to participate in the demonstration. The project budget could not support this level of funding nor could the schedule accommodate the amount of time the Navy proposed to complete the demonstration. Consequently, an alternative approach was devised to collect the necessary information.

### 6.2.I Project Characteristics

The housing project was procured under the MILCON process. The project was located at the Alameda Naval Air Station in Alameda, California. This location represents the "mild" climate category, as defined for this demonstration. The project consists of 300 total housing units, all of which are townhouses. The plans for the project were approved in March of 1990, and construction is under way.

### 6.2.2 Designer and Builder

The builder for this project is located in Texas. The original project designer is located in Southern California. It was not possible to obtain the participation of the original designer in the demonstration of the DOE standards, so another firm with extensive experience in military family housing was hired to conduct the redesign. This same firm conducted the redesigns of two other demonstration projects.

### 6.2.3 Energy-Efficiency Requirements

Only the most common townhouse type was analyzed during this demonstration. The project designer proposed the original energy conservation measures in accordance with the Navy's prescriptive standards. Table 6.3 lists the conservation measures incorporated in the original design.

## 6.3 IMPACTS OF U.S. DEPARTMENT OF ENERGY STANDARDS

The impacts of the DOE standards on the Navy were assessed based on information provided by Navy personnel at headquarters and the field division offices. Impacts on the project design were determined from information provided by the designer hired to conduct the redesign of this project; as noted earlier, this was not the project's original designer. This section discusses the standards' impacts on the processes used by the agency, the design process, and overall monetary and energy impacts.

### 6.3.1 Effects on Navy Housing Procurement Process

As noted earlier, Navy headquarters currently includes the DOE standards as one of two options for division offices to use in housing acquisition. The standards would affect the Navy's process during RFP preparation, proposal evaluation, and the final design phase of the project. This section discusses the effects of the standards during these activities.

It must be noted that the observations reported here have to be qualified by the fact that information was not gathered during a procurement in which the standards were actually applied. This is true of all the case studies reported here. In the case of the Navy, however, the reader should take into account the additional fact that, when this demonstration was conducted, the

TABLE 6.3. Conservation Measures in Original Design, Alameda Naval Air Station

| Component | Measure Level |
|---|---|
| Ceiling insulation | R-value = 30 |
| Wall insulation | R-value = 19 |
| Floor: | |
| Type | Crawl space |
| Insulation | R-value = 19 |
| Infiltration control | Tight |
| Glazing: | |
| Number of panes | Two |
| Sash type | Aluminum |
| Glazing area (% of floor area) | 12.6% |
| Heating equipment: | |
| Fuel type | Natural gas |
| Rated efficiency | 0.91 AFUE |
| Cooling equipment: | |
| Rated efficiency | None |
| Water heating: | |
| Fuel type | Natural gas |
| Label value | $176 |
| Refrigerator/freezer: | |
| Label value | $63 |

Navy was the only agency that had attempted to apply the standards to housing procurements.

As mentioned earlier, the Navy used the standards during all of 1986 and parts of 1987 and 1988, applying them to fewer than 10 housing procurements. Although the Navy took a leading role in applying COSTSAFR, the division offices did not receive the initial documentation, instruction, or technical help that PNL provided during the demonstration, and intends to provide in future applications. Consequently, the Navy's experiences were not based on the same conditions that applied to other agencies during the demonstration.

Also, as stated earlier, DOE was unable to arrange with the Navy for its full participation in the demonstration. Limited Navy involvement in the demonstration makes assessing impacts on the Navy more difficult than assessing the impacts on the other agencies studied. However, the Navy's insights resulting from its early applications of the standards have been informative and illustrate the importance of working with the agencies during implementation of the standards.

6.3.1.1 Request for Proposal Preparation

Field office staff report that about two person-hours are currently spent in preparing the energy requirements of an RFP. If the minimum energy requirements/energy budget approach is used, prepared lists of the requirements and energy budget worksheets are simply attached to the RFP, indicating the energy budget for the appropriate climate zone. Using the DOE standards instead would require the agency to run the COSTSAFR program and generate the point system for each building type being considered. This step would replace the list of minimum insulation and efficiency requirements and an energy budget.

In its experience in the mid 1980s, the Navy had a great deal of difficulty applying the DOE standards. At one division field office, the staff found a copy of the COSTSAFR software, but never located supporting documentation. Therefore, headquarters staff generated a point system worksheet for a housing project. Even working together, however, headquarters and field office staff could not fully explain the requirements to contractors. In one project, energy-efficiency requirements were finally dropped and contractors were told "to do the best you can."

At another division field office, two staff members spent a total of about 100 hours to learn COSTSAFR, then about 2 hours to run the software for a housing project. In general the problems the Navy encountered led it to conclude that the process was often incorrect, illogical and/or unusable. However, these problems resulted in part from an incorrect understanding of how to operate the software.

Across all the Navy interviews, the issue was raised of the bulkiness of point system reporting forms. Navy staff stated that they were unsure how

many point systems must be generated for each procurement. Staff pointed out that window orientations and complex designs could require individual point systems for each unit included in a procurement. In one instance, a word processor was used to reduce the size of the point system by eliminating what seemed to be unnecessary conservation measures. However, portions were deleted that were needed to comply. The Navy felt that a large quantity of paperwork would intimidate bidders and conflict with the Navy's approach of keeping the RFP process simple. At one field office, staff asked, "How are we supposed to send out 40 pages of compliance forms when the whole technical section of the RFP is only about that long now?"

Much of the concern about point system complexity and length was addressed by the introduction of CAPS. If CAPS were used in place of the paper point system compliance forms, the amount of materials sent out could have been reduced greatly. Unfortunately, CAPS was not available when the Navy first applied COSTSAFR.

The Navy does not predetermine the housing types to be included in a project. This process allows contractors to propose building types and design the sites accordingly. In order to run COSTSAFR, however, housing types must be identified. To permit the flexibility currently allowed by the Navy, point systems would have to be provided to designers for all possible housing types and this increases the amount of paperwork included in the RFPs.

Closely related to these issues are COSTSAFR's limitations in simulating complex designs that include two or more housing types within one structure. For example, complex buildings could include single-story, two-story, and three-story units combined in one building. COSTSAFR does not include options for such hybrid buildings.

Navy staff indicated that COSTSAFR may have limitations in keeping up with new energy technologies and data. Headquarters staff noted that COSTSAFR would negate the possibility of cost-effective energy savings because it does not include some very cost-effective design options in its database. Vinyl sashes, ceiling fans, whole-house fans, wall sheathing, and 2x4-in. construction with rigid insulation were all techniques the Navy encounters in the

field and would like to see included in COSTSAFR.[a] Headquarters stated that COSTSAFR maintenance and updates could be problematic. As an example of rapid changes, headquarters staff described a new (at the time the interview was conducted) DOD requirement to purchase only water heaters that cannot exceed 120°F. The Navy would prefer to not see the rulemaking process required every time COSTSAFR is updated.

The Navy suggested that it would be very useful for the point system to provide energy consumption information. In part because of such concerns at DOD headquarters, PNL created the CAPS program for use during the demonstration and added to it an energy consumption estimate (Btu per square foot per year) for proposed designs. As mentioned before, however, the Navy's experiences with the standards occurred before CAPS was developed.

Division field office staff pointed out that because of micro-climates within cities, and the distance of some Navy bases from cities, it was difficult to select climate cities to represent military bases. Navy staff asked if it would be possible to build climate files using data from military bases. Some staff stated, however, that this was a minor issue, possibly not worth worrying about.

#### 6.3.1.2 Proposal Evaluation

Field office staff indicated that currently about one hour is spent evaluating each proposal for energy requirements. This evaluation consists of a review of the proposal to ensure that minimum energy requirements are met and that the energy budget calculations indicate compliance. The energy budget is not recalculated at this time.

The Navy did not provide actual time requirements to use the DOE standards at this stage of an acquisition. The Navy had a great deal of difficulty interpreting COSTSAFR results and, as mentioned earlier, simply eliminated consideration of energy conservation requirements from one project because staff were unable to apply the point system properly.

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(a) Vinyl sash windows have been added to the point system for COSTSAFR Version 3.1.

The Navy made the important observation that current "good building practice," as illustrated by local building codes such as those used in California and in the Navy minimum requirements, often exceed the minimum insulation levels required by the standards. The Navy's prescriptive requirements also often exceed the DOE standards' minimum requirements. While the DOE standards' requirements usually would result in a construction cost reduction, Navy staff seemed to think the energy savings were more important.

Specific issues raised by the Navy about using the standards during evaluations included the following:

- Similar building types, such as apartments and townhouses, resulted in drastically different point totals.
- In mild climate areas, such as southern California, water heating and refrigerator/freezer points dominated the point systems. The Navy feels these appliances are short-lived in comparison with structural features, and may be replaced with less efficient equipment. Thus, relying on appliances for energy conservation is risky.

The Navy liked the flexibility that the DOE standards gave contractors to make tradeoffs based on their actual costs while ensuring energy efficiency. The Navy's prescriptive requirements and the Btu energy budget do not take into account life-cycle cost features. Thus, the DOE standards provide a more thorough analysis (as required by law) than the other approaches.

Field office staff indicated that the Navy's minimum energy requirements/energy-budget approach requires about eight person-hours to recalculate the energy budget and ensure that minimum energy requirements are met. The Navy has not successfully used the DOE standards at this stage of an acquisition and did not provide an estimate of the effort this would require.

### 6.3.2 Designer Impacts

The original designer for this project was unavailable to conduct the redesign under the demonstration project. As with two other projects, it was necessary to obtain redesign information from the same firm that performed the redesign on those two projects.

#### 6.3.2.1 Effects on Design Process

The general comments of the designer are presented in Section 4.4.2.1 and Section 5.3.2.1 and are not repeated here. The reader is referred to these sections for comments on the design process that applied to this project.

#### 6.3.2.2 Redesign of Alameda Units

The DOE standards analysis for this project was based on a natural gas price of 57 cents/therm and electricity price of 7.6 cents/kWh. The resulting point systems reflected these prices. The standards required a total of 34 points in the COSTSAFR point system, whereas the actual design achieved 47.1 points.

The A&E firm was asked to submit two redesigns that corresponded to two different ways the designer might have responded to the DOE standards' requirements. One redesign was selected to slightly exceed the minimum point total requirement of the DOE standards while minimizing first cost.

The other redesign would have achieved the same point total and energy cost savings as the original design, but at the lowest possible estimated first cost. However, the designer found that, short of starting over and creating a passive solar housing design, there were no cheaper ways of achieving the same energy performance as the original design. This was because there was no cooling equipment, the heating equipment was very efficient, the insulation levels were fairly high, and the windows were energy-efficient. Thus, only the redesign that minimizes first cost is discussed here.

In the least-cost redesign, the A&E firm reduced the ECM levels selected in the original design to match the DOE standards' minimum point total requirement as closely as possible. Changes made under this modification included using R-19 ceiling insulation in place of R-30; decreasing the floor insulation from R-19 to R-11; removing a polyethylene vapor retarder sheet for infiltration control to move from "tight" to "average" infiltration control measures; substituting single-pane, aluminum frame windows with no coatings for low-E, double-pane aluminum frame windows; and installing a less efficient furnace. Some of these features would not comply with the Navy's current

minimum requirements. Table 6.4 compares the design selections for this case with the original design and optimal minimum selections generated by COSTSAFR.

Because neither the Navy nor the original designer nor builder participated directly in the demonstration, little information was available about the water heater or refrigerator/freezer efficiency levels in the actual project. For this analysis, it was assumed that the most efficient choices were installed and so no tradeoffs involving equipment efficiency levels were investigated. The issue of whether equipment with the intended efficiency levels would be installed at the construction site was not resolved, although the Navy has started placing performance requirements on equipment and probably does a reasonably good job of assuring compliance.

Compared with the original design, this redesign was estimated to decrease capital cost to the Navy by $2,386 per unit. Because the redesigned units would be less energy-efficient than the actual units, the discounted present value of life-cycle energy costs would have increased about $1,122 per unit. Thus, overall life-cycle cost would have decreased about $1,264 per unit.

Figure 6.1 illustrates the design changes made in the Alameda Naval Air Station redesign to meet the minimum points required.

### 6.3.3 Overall Impacts--Cost and Energy

Because neither the Navy nor the original designer participated in the redesign, it is difficult to draw valid conclusions about overall impacts. Findings from the other demonstration projects discussed here indicate that the Navy's original experience with the DOE standards is not representative of how the standards would affect the acquisition process, given adequate training and support. While this section is based on the Navy's experience before the demonstration project, it also reflects the experience of other agencies who have received at least an introduction to the software, have the proper documentation, and have access to technical support if it is needed. The discussion about designers and the Alameda housing project is based on the work of an A&E firm that did not design the original project.

TABLE 6.4. Comparison of Conservation Measure Levels for the Alameda Naval Air Station Townhouse Using the Minimum Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceilings | R-30 batt | R-19 batt | R-19 batt |
| Walls | R-19 batt | R-11 batt | R-19 batt |
| Foundation | R-19 crawlspace | R-5, 2 ft. slab | R-11 crawlspace |
| Windows | | | |
| Panes | Double | Double | Single |
| Sash type | Aluminum | Aluminum | Aluminum |
| Low E | Yes | No | No |
| Infiltration control | Tight | Average | Average |
| Heating equipment | Natural gas, 0.91 AFUE | Natural gas, 0.75 AFUE | Natural gas, 0.80 AFUE |
| Domestic hot water | | | |
| Fuel | Natural gas | Natural gas | Natural gas |
| Energy Label | $176 | $176 | $176 |
| Refrig./Freezers | | | |
| Energy Label | $63 | $63 | $63 |
| Total points | 47.1 | 34.0 | 34.7 |

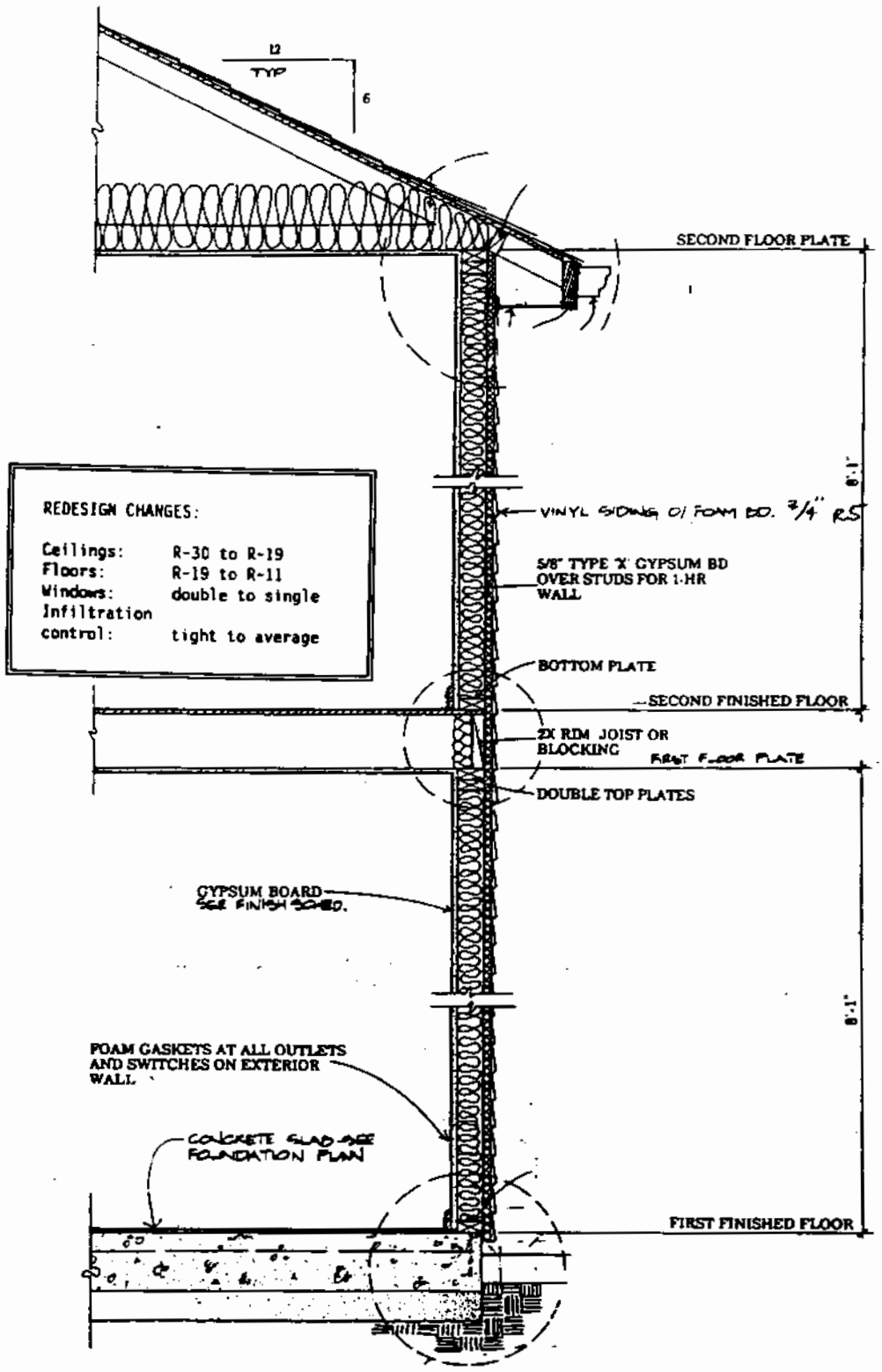


FIGURE 6.1. Alameda Naval Air Station, Townhouse Design Changes, Minimum Points

During the initial procurement stage, the DOE standards would probably increase the workload of division field office staff by several person-hours if the DOE standards were used rather than the Navy's minimum requirements/energy budget approach. The standards would require field office staff to prepare point systems for expected residential unit types. Navy division office staff indicated that about 100 hours were required to learn COSTSAFR and about two hours were needed to run the software. Using the Navy's minimum requirements/energy budget approach, a worksheet is simply attached to the RFP, requiring a minimal effort.

During the evaluation process, it appeared that the DOE standards would slightly reduce the labor required at the field office level. If proposers used CAPS to show compliance, Navy evaluators would have needed only to check point totals to confirm compliance. Innovative designs, however, would require use of the ACP and additional work. Section 2.2 describes the ACP process for innovative approaches.

After the selection of a proposal, COSTSAFR and CAPS may save as much as 7 or 8 hours of field office labor. Navy staff reported that using the minimum requirements/energy budget approach required about 8 person-hours to recalculate the energy budget and ensure that minimum requirements were met. CAPS could provide this information in a one-page printout.

The costs to the designer of using the DOE standards' point system are likely to be minimal. Compared to the Navy minimum requirements approach, the DOE standards may increase the labor designers must devote to preparing their proposals. However, the Navy also requires that designers calculate an energy budget in Btu per square foot. The DOE standards' CAPS program automatically fulfills this function. Overall, the standards allow the designer greater flexibility than is permitted with the Navy's minimum requirements. Thus, the overall impact of the standards on designers should be negligible. Additional information on impacts on designers, including those resulting from innovative technologies, are discussed in Section 4.4.2.

As part of the demonstration, the townhouse apartment was redesigned to just meet the DOE standards. The redesign reduced first-time capital costs by an estimated $2,386 per unit, or about $715,800 for the 300 total units built.

Because the houses would have been less energy-efficient, life-cycle energy cost would have increased by $1,122 per unit, or about $337,000 for the entire development. The DOE standards would have decreased the estimated overall life-cycle costs for these units by about $379,000 (total capital cost savings minus the life cycle energy cost increase).

In terms of energy consumption, the redesign to meet the minimum requirements of the DOE standards would increase energy consumption compared with the original design. The increase for each house would have been about 11.2 million Btu per year, or an estimated 3.36 billion Btu per year for all 300 houses. Because the houses had no cooling equipment, the change in energy consumption was all in the form of natural gas.

# 7.0 PUBLIC HEALTH SERVICE CASE STUDY

The housing project selected for this case study was the Indian Health Service (IHS) staff quarters for the Rosebud Sioux Tribe located in Rosebud, South Dakota. The Department of Health and Human Services (DHHS) requires housing for staff who work at IHS facilities in remote locations. The IHS is a branch of the Public Health Service (PHS) which is under the DHHS Secretary. The IHS does not have the architectural and engineering capabilities to procure the residential housing themselves and, therefore, relies on the PHS regional Offices of Engineering Services (OES), located in New York, Dallas, and Seattle to perform the procurement.

This chapter will present information on the PHS procurement process, focusing on the Seattle DES; provide a description of the case study housing project; and discuss the possible impacts of the DOE standards on the agency, designer, and energy efficiency and economics of the project.

## 7.1 PUBLIC HEALTH SERVICE HOUSING PROCUREMENT PROCESS

The process PHS uses to procure and develop IHS housing is established at DHHS headquarters. The housing is built primarily for civil servants and officers located in remote areas where the local community cannot provide adequate housing. At most, 200 units are built in a year. Approximately 300 units total are currently planned for the future. The housing is predominantly detached; however, OES staff indicated that the trend is toward multi-family units such as apartments. Almost all housing construction occurs under programs to build new units; few programs involve renovations of existing buildings.

A recent order, resulting from an Inspector General review, requires PHS to conduct a market survey establishing the need to construct new IHS housing. After the need for residential housing has been confirmed, IHS headquarters prescribes the number of units and square footage required to meet the need. The OES then works with IHS to prepare a program justification document or program of requirements document. These programming and planning documents set the budget limit and physical specifications of the project, including the

type of buildings, number of bedrooms, bathrooms, etc. The IHS initiates the procurement process for design and construction by requesting the services of an OES regional office. The Seattle OES has two Architectural/Engineering branches: the North Western Branch, which covers Washington, Oregon, Idaho, and Alaska; and the Northern Plains Branch, which covers North Dakota, South Dakota, Nebraska, Wyoming, Minnesota, Michigan, Wisconsin, and Iowa. These branches, supported by a Contract Administration Branch, have primary responsibility for managing the procurement process.

### 7.1.1 Overall Public Health Service Procurement Process

The Seattle OES uses the traditional design/bid/construct procurement process in which two separate contracts are implemented, one for design and one for construction. This contrasts with the integrated turnkey approach used by the military (see Section 4.1) where a single agreement is reached with a developer who provides both design and construction services.

The first step of the two-step process is to select an A&E firm. A five- or six-member OES source selection board is responsible for developing the criteria for selecting the design firm and preparing the "design" RFP. The design RFP is published in the Commerce Business Daily for 30 days. Competing A&E firms submit standard forms describing their qualifications and experience. The source selection board reviews these preproposals and develops a short list. The OES source selection board conducts interviews with each A&E, and a final ranking is developed based on these interviews. The final ranking goes to IHS for review and approval.

The OES prepares and issues a "request for proposal" (RFP) to the highest rated firm on the final selection list. This RFP spells out the scope of work to be provided by the designer including the following elements: pre-design, conceptual design, schematic design (which includes an energy conservation report and a value engineering report), and complete design and construction documents. The designer submits a proposal to the OES in response to the RFP. If a fair and rasonable cost for the required services is presented as submitted or after negotiations have been conducted, a contract will be awarded. If a fair and reasonable cost for the required services is not presented to OES by the highest rated firm after negotiations

have been exhausted, contract negotiations will be terminated and the second highest firm will be contacted and a RFP mailed for their response.

After the designer is retained, OES assigns a project management team, made up of architects, mechanical engineers, civil engineers, and electrical engineers, to the project. The people involved are primarily civilians, although PHS has some uniformed PHS officers who may participate. The entire design process usually takes from 12 to 15 months including the 3 to 6 months to select the A&E.

The second step in the procurement process takes place after the construction documents are complete. An OES contract specialist and the project manager prepare an invitation for bids for construction which is published in the Commerce Business Daily. Generally, local construction contractors bid on the projects. The selection of a contractor is primarily based on bid price.

Construction typically takes one year. The A&E firm that designed the project is prohibited from bidding on the construction work; however, the firm is normally kept under contract during construction to monitor the performance of the builder. Along with OES, the A&E observes each housing unit about once each month as the construction progresses. On larger projects, continuos on-site observation is required.

Public Law 93-638 allows the Indian tribes to take responsibility for either the design or construction process. If a tribe is successfull in their petition for the effort through the rules governing Public Law 93-638, all of the federal requirements are passed on to the tribe. The Rosebud Sioux tribe applied for authority under this law to manage the IHS Rosebud Staff Quarters project which is the subject of this case study. The tribe was granted authority to manage the design and construction elements of the project.

### 7.1.2 Public Health Service Process for Setting Energy-Efficiency Requirements and Evaluation

Seattle OES staff described their method of establishing energy-efficiency requirements in housing projects as one that is "very flexible and stays away from being prescriptive." Staff stated that they rely on local A&E

professional expertise to develop regionally accepted energy-efficiency construction requirements. The requirements are largely based on those that were successfully implemented in previous projects within a specific region. They also mentioned that "we have become more energy conscious."

Energy-efficiency requirements are introduced in the OES scope of work. The OES scope of work requires the designer to prepare an "Energy Conservation Report" as follows:

a. Review DOE's Interim Energy Conservation Standards for New Federal Residential Buildings, 10 CFR Part 435, and establish specific standards and requirements pertinent to this project. Evaluate the cost consequences of the Interim standards for this project and recommend deviations as may be appropriate.

b. Develop an energy budget statement including descriptions of energy consumption and conservation options. Project total energy usage of the building in Btu per square foot per year.

c. Incorporate details and results of this report into value engineering work for the development of the building envelope.

The designer is also required to prepare a "value engineering report" which is described in the RFP as follows:

a. Provide an independent analysis by a certified value specialist of alternative materials, systems, and system components for the building. Describe in detail first cost and long-term operating and maintenance cost comparisons of alternate proposals. Convert costs to constant dollars for a precise evaluation assumed at midpoint of construction. Costs shall include impacts on project scheduling and design as appropriate. Integrate energy conservation report into value engineering.

b. The report shall include, but not be limited to, recommendations for the following materials, systems, and system components:

   - foundation
   - structural framing
   - building envelope including exterior walls, finishes, and roofing systems
   - mechanical and electrical systems.

In addition to these requirements, which appear in the scope of work schematic design requirements, the RFP's major system narrative portion states that information on project energy efficiency is also required during the conceptual design phase, as follows:

- Discuss energy consumption and fuel alternatives. Recommend a fuel type, to be based on a fuel study and energy conservation methods.
- Discuss mechanical and electrical systems, energy management, basic concepts for power distribution, and lighting and special systems.

As can be seen above, the scope of work requires the designer to review the DOE interim standards and "establish specific standards and requirements pertinent to this project." It appears that the OES branch that prepared the RFP expected the designer to conduct the bulk of the analysis required under the DOE standards, rather than having the branch perform the initial analysis as the standards intended. This suggested that proper training is necessary for government agencies involved in the procurement of housing to ensure that the DOE standards are implemented properly.

## 7.2 ROSEBUD STAFF QUARTERS DEMONSTRATION PROJECT

The Rosebud Staff Quarters project, developed for the Rosebud Sioux Tribe in Rosebud, South Dakota, was selected as the second demonstration project representing the "cold" or "very cold" climate category. The project was managed by the Rosebud Sioux Tribe with the support of the Seattle OES.

### 7.2.1 Project Characteristics

The Rosebud Staff Quarters project was originally planned to produce a total of 76 units. Table 7.1 presents the different housing types intended to be included in the project.

The construction contract was signed June 15, 1988, and construction began on June 28, 1989. Some problems arose during construction and, as of the writing of this report, a completion date has not yet been established.

### 7.2.2 Designer and Builder

This housing project was designed by an A&E firm from Albuquerque, New Mexico. The project construction work was awarded to a construction

TABLE 7.1. Rosebud Staff Quarters

| Housing Unit Types | Number |
|---|---|
| 1-Bedroom Attached Units | 12 |
| 2-Bedroom Attached Units | 12 |
| 2-Bedroom Detached Handicapped Units | 4 |
| 2-Bedroom Detached Units | 19 |
| 3-Bedroom Detached Units | 29 |
| TOTAL | 76 |

contractor located in South Dakota. The original designer participated in the redesign conducted for this demonstration.

### 7.2.3 Energy-Efficiency Requirements

The original designs of the three-bedroom ranch house and one-bedroom townhouse were evaluated in this demonstration. Both designs were developed in accordance with OES's process. Table 7.2 shows the energy conservation measures that were included in the original three-bedroom detached single-story ranch house design and those included in the one-bedroom townhouse design. The only difference between these two houses was the foundation. During the demonstration it was determined that both designs exceeded the DOE standards' minimum requirements.

## 7.3 IMPACTS OF U.S. DEPARTMENT OF ENERGY STANDARDS

This section describes the impacts the DOE standards might have had on the Rosebud Staff Quarters project in the following areas:

- the agency procurement process
- the A&E firm's design process and final designs
- the energy efficiency and capital costs of the project.

### 7.3.1 Effects on the OES PHS Housing Procurement Process

Because the competitive process to select a designer does not explicitly involve energy efficiency, the DOE standards do not affect the OES procurement process during preparation of the design proposal or during the process of ranking an A&E. Once a designer has been selected, however, the standards

TABLE 7.2. Conservation Measures in Rosebud Staff Quarters, Three-Bedroom Single-Story Ranch House and One-Bedroom Townhouse

| Component | Measure Level |
|---|---|
| Ceiling insulation | R-Value = 30 |
| Wall insulation | R-Value = 19 |
| Ranch House Floor: | |
| Type | Basement |
| Insulation | R-Value = 19 |
| Townhouse Floor: | |
| Type | Crawlspace |
| Insulation | R-Value = 30 |
| Infiltration control | Tight[a] |
| Glazing: | |
| Number of panes | Two |
| Sash type | Vinyl-clad wood |
| Glazing area (% of floor area) | 10% |
| Heating equipment: | |
| System Type | Ground source heat pump |
| Fuel type | Electricity |
| Rated efficiency | Not shown in blueprints[b] |
| Cooling equipment: | |
| System type | Ground Source Heat Pump |
| Rated efficiency | Not shown in blueprints[b] |
| Water heating: | |
| Fuel type | Electric |
| Label value | Not shown in blueprints[b] |
| Refrigerator/freezer: | |
| Label value | Not shown in blueprints[b] |

(a) The designer noted that she did not specify several infiltration control measures that are "required construction measures" under the standards. Using information in the DOE standards, however, the design was still adequate to meet the "tight" infiltration control level.

(b) For space heating and cooling equipment, domestic water heaters, and refrigerator/freezers, the designer used estimated values based on typical values given in the "Point System User's Guide" (Lucas and Lee 1990).

would impact the preparation of the agency's scope of work, the subsequent contract negotiations with the designer, and the management of the design contract.

The designer is affected by the implementation of the standards in at least three ways. First, he or she must estimate the cost associated with reviewing the DOE standards and learning the paper and automated point system (CAPS). The designer would include the associated costs in his or her design proposal. Second, the designer must study the standards and learn to use the paper point system, CAPS, or both. Finally, the designer must apply the DOE standards to his or her design.

7.3.1.1 Request for Proposal Preparation

As mentioned above, the scope of work prepared by the OES consists of a detailed description of deliverables the designer is required to produce, including a section requiring the designer to address the DOE standards. As noted earlier, this approach requires the designer, rather than the agency, to take the first step in implementing the standards. Staff at OES indicated that including this language in the scope of work requires little effort.

An engineer at OES estimated that producing the standards' COSTSAFR forms for inclusion in the scope of work would require approximately four hours. An architect and an electrical engineer at OES spent about 20 hours and 10 hours, respectively, learning the COSTSAFR program. Therefore, it can be estimated that the process for generating the COSTSAFR forms the first time (with no prior training) would take about 3 or 4 person-days total.

Using COSTSAFR will also require OES staff to obtain input data (fuel costs, area cost multiplier, and price escalation figures) not required under the current procedure. The OES project manager determined that the fuel cost data could be easily accessed through the IHS Area Office where the housing project is to be built, and that he would probably use default data for the remaining information.

The OES staff pointed out that designers will require time and money to learn, and then apply, the paper point system and CAPS. Staff members were concerned about these incremental costs. It was recommended that a government

estimate of the average cost to learn and use the automated and paper point systems be established to facilitate the negotiation of this item with designers.

7.3.1.2 Proposal Evaluation

Staff at the OES estimated that they currently spend a total of no more than three days on energy-efficiency issues throughout the design process. They could not state definitively whether implementation of the standards would significantly increase or decrease the amount of time dedicated to energy-efficiency matters. It was agreed, however, that CAPS output data generated by the designer would provide the OES with summary information on the designer's recommended conservation measures and on the design's ability to comply with the standards. In addition, it was noted that concentrating a building design's energy-efficiency information onto one page, and presenting the information in terms of energy dollars, provides a solid reference point to quickly and accurately compare various design alternatives.

Staff at the Seattle OES stated that they would benefit from using COSTSAFR/CAPS as a design tool rather than solely as a "last minute, post design, pass/fail test." They proposed that the schematic documents stage (when the design is approximately 20% complete) would be the best time to use CAPS as a design aid because the orientation of the units could still be accounted for. Then CAPS would be run for a second time at the proof stage (construction documents 99% complete) to ensure compliance of the final design. The OES staff anticipated that using CAPS as a design tool in the early design stage would probably increase the A&E's time and effort; however, the incremental cost could not be quantified without experiencing the process.

Staff also mentioned that, under their current procurement process, inconsistencies can arise across projects because the OES project manager changes from one project to the next. They theorized that more standardization of designs might reduce costs across projects, and reported that attempts are being made to increase standardization. In the case of a design being re-used in a different climate zone, the use of the DOE standards will ensure that the new project's energy efficiency reflects the new climate conditions, fuel prices, and equipment costs. The OES has asked the designer

to use CAPS to evaluate seven different building orientations of the modified Rosebud design.

OES staff also had several more general comments on the usability and implications of the DOE standards. One main comment was that the standards appeared to be designed around the design/build procurement process rather than the design/bid/construct process employed by PHS and possibly other non-DOD agencies. Although this did not greatly affect the usefulness of the standards to PHS, it did pose some issues of compatibility.

As staff at the other participating agencies did, PHS staff noted that the minimum conservation levels required by the standards were well within current practice. This comment suggested that the standards would probably not be difficult to implement and comply with, but they would also not lead to substantial efficiency improvements.

Also consistent with concerns of other agencies, PHS staff commented that a process should be instituted to update the standards, when necessary, to include new technologies and conservation measures. They also noted that, although the latest version of the standards could give credit to sun-tempered designs, appropriate exposed thermal mass was not always a design option.

The PHS participants also mentioned three technical problems. One was that the software required a working knowledge of DOS, and users would not always be familiar with DOS. The second was that it was cumbersome to have to run the POSTSAFR program to generate the input file for CAPS.[(a)] The third technical problem was that the point systems (both paper compliance forms and CAPS) included window areas only down to 10% of floor area. They claimed that actual project window areas may be almost as little as half this amount.

One final question raised by PHS staff was whether the energy analysis results had ever been confirmed with measured post-construction data. They noted that as-built conditions may perform worse than predicted based on computer analysis because of incorrect operation, faulty construction, etc.

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(a) As noted earlier, the latest version of the standards released in 1991 has eliminated the need for POSTSAFR altogether.

### 7.3.2 Designer Impacts

The A&E firm that had done the original Rosebud housing project design was available to conduct a redesign. The following sections include the designer's observations about the effects of the DOE standards on the design process and describe the results of a redesign using the standards.

#### 7.3.2.1 Effects on Design Process

The A&E firm participating in the demonstration project reported that the DOE standards would not affect its ability to competitively bid on housing projects, pointing out that all contractors would have to meet the same requirements.

The A&E also indicated that the DOE standards would not impact its ability to design housing projects, stating that its designs already meet the standards. The designer suggested that the use of the point system may cut housing construction costs because there will be no need for "margin of error," implying that energy-efficiency levels currently being utilized may be tighter than absolutely necessary to ensure compliance with all codes.

When asked to compare the point system tools to the process currently followed to select energy features, the designer stated that

> "[with the current process,] there is always some confusion as to whether a design meets the criteria or not. It usually involves a fair amount of research and interpretation of codes and materials. Design flexibility is limited to knowledge and information on materials. Similarly, the point system design is limited to choices given, so design flexibility directly relates to information available."

The designer found that the point system definitely requires less expertise and time than the current process and also stated that the point system probably allows more accurate interpretation of requirements.

The designer preferred the CAPS tool to the paper point system compliance forms. She noted that it gave instant feedback on the effectiveness of proposed conservation measures and could be used as a design tool. She pointed out two technical limitations with CAPS. One was that it did not allow interpolation of conservation measures, for example to

insulation levels between those included in CAPS. The second was that CAPS did not permit saving a point system for later recall to make revisions.

The designer spent three hours learning to use and applying the paper point system, and 15 minutes doing the same with CAPS. The designer stated that one of the reasons CAPS took so little time to learn and use was because she learned the paper point system first and, therefore, had all the requisite project data compiled and at hand.

In the two-step procurement process the designer has no way of knowing what specific equipment, appliances, and materials the construction contractor will use. However, designers usually specify performance requirements for appliances and equipment. Unfortunately, performance specifications do not always include energy-efficiency criteria and, therefore, when completing paper point system forms, or CAPS, designers may need to make educated estimates of the efficiencies of HVAC equipment and refrigerators based, for example, on a sampling of manufacturer's literature. These estimates may or may not exactly match the performance of the equipment that eventually is included in the housing units. It is possible that, to ensure compliance in the future, designers may simply include energy-efficiency performance specifications for HVAC equipment, domestic hot water heaters, and refrigerators that equal or exceed the values they entered into CAPS compliance runs.

#### 7.3.3.2 Redesign of Three-Bedroom Ranch House

The redesign analysis of these housing units was based on a relatively low electricity price of 3.5 cents/kWh. Although this price was about half the state-wide average, it was the rate available for houses constructed under this project. For the three-bedroom house, the standards required a total of 92.0 points in the point system compliance forms, whereas the original design achieved 110.0 points (assuming equal glazing orientation in all directions). Consequently, the A&E's original design was more energy-efficient than the minimum level required by the DOE standards.

The designer was asked to redesign the units to just meet the requirements of the standards. Based on the DOE standards point system

compliance forms and CAPS, the designer considered several possible options to reduce capital costs and still meet the DOE standard's requirements as listed below:

1. removal of the insulation in the flooring between the ground floor and basement
2. removal of air-infiltration barrier
3. replacement of wood window frames with aluminum frames.

In the Rosebud project, the designer did not have energy performance information on the refrigerator, domestic hot water heater, and HVAC equipment installed by the construction contractor. Estimated efficiency values for this equipment were provided by the demonstration project team.

Table 7.3 compares the conservation measures in the original design with the minimum requirements established by the DOE standards and the measures selected in the redesign. The redesign would have reduced construction costs by about $1,200/unit compared with the actual design. For the 29 three-bedroom houses originally scheduled for construction, the total reduction in construction costs for these units would have been an estimated $35,000. However, the redesign would have increased the life-cycle energy costs by about $1,462 per unit, producing an estimated net life-cycle cost increase of about $262 per unit. Life-cycle energy costs for the 29 houses would have increased about an estimated $42,398, and overall life-cycle costs would have increased about $7,308. These results suggest that, although the redesign choices made by the designer would have reduced capital cost, other choices could have been made that would have reduced total life-cycle cost as well.

The designer also looked at the effect that glazing distribution, or orientation, would have had on costs and energy consumption. This analysis was illuminating because this was the only project in the demonstration where the effects of orientation were explicitly considered.

The designer used CAPS four times to analyze four alternative building orientations. Table 7.4 summarizes these results by presenting data for the same building type facing each of the four cardinal directions. It presents the points from the standards' point system compliance forms for the original

designs and the redesigns, and it shows the change in life-cycle energy costs and capital costs.

The changes in capital costs are the same for all orientations because exactly the same construction changes are made. The changes in life-cycle energy costs also are equal for all orientations. This is because the energy

TABLE 7.3. Comparison of Conservation Measure Levels for Rosebud Staff Quarters Three-Bedroom Ranch House Using the Minimum Points Redesign

| Components | Original Design | Optimum Level from COSTSAFR | Redesign |
|---|---|---|---|
| Ceilings | R-30 batt | R-30 batt | R-30 batt |
| Walls | R-19 batt | R-19 batt | R-19 batt |
| Foundation | R-19 basement | R-11 basement | R-0 basement |
| Windows | | | |
| Panes | Double | Double | Single |
| Sash type | Wood | Aluminum | Aluminum |
| Infiltration control | Tight | Tight | Average |
| Heating equipment[(a)] | Heat pump (water source) 7.0 HSPF | Heat pump (air source) 5.5 HSPF | Heat pump (water source) 7.0 HSPF |
| Cooling equipment[(a)] | Heat pump (water source) 11 SEER | Heat pump (air source) 7.2 SEER | Heat pump (water source) 11 SEER |
| Domestic hot water | | | |
| Fuel | Electric | Electric | Electric |
| Energy Label | $460 | $460 | $460 |
| Refrigerator/Freezers | | | |
| Energy Label | $90 | $61 | $90 |
| Total points | 110.0 | 92.0 | 92.7 |

(a) Note that the original design called for installation of a water source heat pump and this type of equipment is not included in the point system compliance forms for the standards. Assumptions were made here for the appropriate efficiency measures for the water source heat pump. The text discusses this issue.

HSPF = heating season performance factor
SEER = seasonal energy efficiency rating

TABLE 7.4. Results of Redesign of Three-Bedroom Detached House[a]

| Orientation[b] | Original Design Points | Redesign Points | Life-Cycle Cost Change Capital Cost | Energy |
|---|---|---|---|---|
| North[c] | 112.1 | 94.8 | +$1462 | -$1210 |
| East | 108.8 | 91.5[d] | +$1462 | -$1210 |
| South | 109.3 | 92.0 | +$1462 | -$1210 |
| West | 110.0 | 92.6 | +$1462 | -$1210 |

(a) Direction front of house faces.
(b) The point total required to meet the standards is 92.
(c) With the front of the house facing north, the window area equals 26% north, 0% east, 63% south, and 11% west.
(d) The redesign does not comply in this orientation. With the front of the house facing east, there is no south-facing glazing and energy-efficiency is decreased.

consumption effects of glazing orientation are the same in the original design as they are in the redesign, so the effects cancel out when the difference is calculated.

The results for the different orientations bring up an important issue. While three of the orientations comply, the redesigned building facing east fails to comply as a result of having no south-facing glazing. This reflects the fact that the minimum point total established by the standards is based on a building with glazing facing equally in all four directions. This result may pose a problem for agencies and designers using the standards.

The DOE standards allow designers to get credit to meet the standards if they want to take advantage of beneficial glazing orientation. While this is possible, the standards do not require agencies to take orientation into account; in fact, the point system for the standards is generated assuming that orientation is random. The results from this redesign suggest that special steps must be taken if orientation is to be considered.

At the least, agencies may need to investigate whether the orientations of proposed layouts are likely to have large enough negative effects on energy consumption that should be alleviated. One alternative is for agencies to

require that buildings with the worst possible orientation comply with the point system requirement of the standards. Whatever the approach, this demonstration project highlights the fact that glazing orientation may require further attention and effort on the part of agencies and designers.

This redesign raised another important issue. The actual project used a water source heat pump for space heating and cooling. The standards, however, do not contain the data necessary to analyze water source heat pumps directly, only air source heat pumps. Water source heat pumps are not included because no adequate performance test data were available when the standards were developed. Although the designer might have been able to use the ACP approach to evaluate water source heat pumps, it is unlikely that she would have done so for a real project. This particular case highlights one of the limitations of the current standards.

The designer indicated she did not have good information on or control over the energy-efficiency of water heating equipment, refrigerators/freezers, or even space heating and cooling equipment. Although this issue arose in other projects in this demonstration, it is more of an issue with the design/bid/construct process where the actual equipment supplied by the contractor is not available until after award of the construction contract.

Figure 7.1 illustrates the design changes made in the Rosebud Staff Quarters redesign to meet the minimum point total required.

### 7.3.3 Overall Impacts--Cost and Energy

The Seattle OES staff indicated that once trained in the use of the standards, they would spend approximately four person-hours to produce a COSTSAFR output for a new project. They stated that this would have a minimal impact on their procurement process.

Staff indicated that training at the OES level would be very important, and went on to state that "if all project managers and engineers will eventually be required to work intimately with the software, a two-day (hands-on) seminar would be recommended." Staff indicated that approximately 22 engineers, architects, and project managers at the Seattle OES would attend the training.

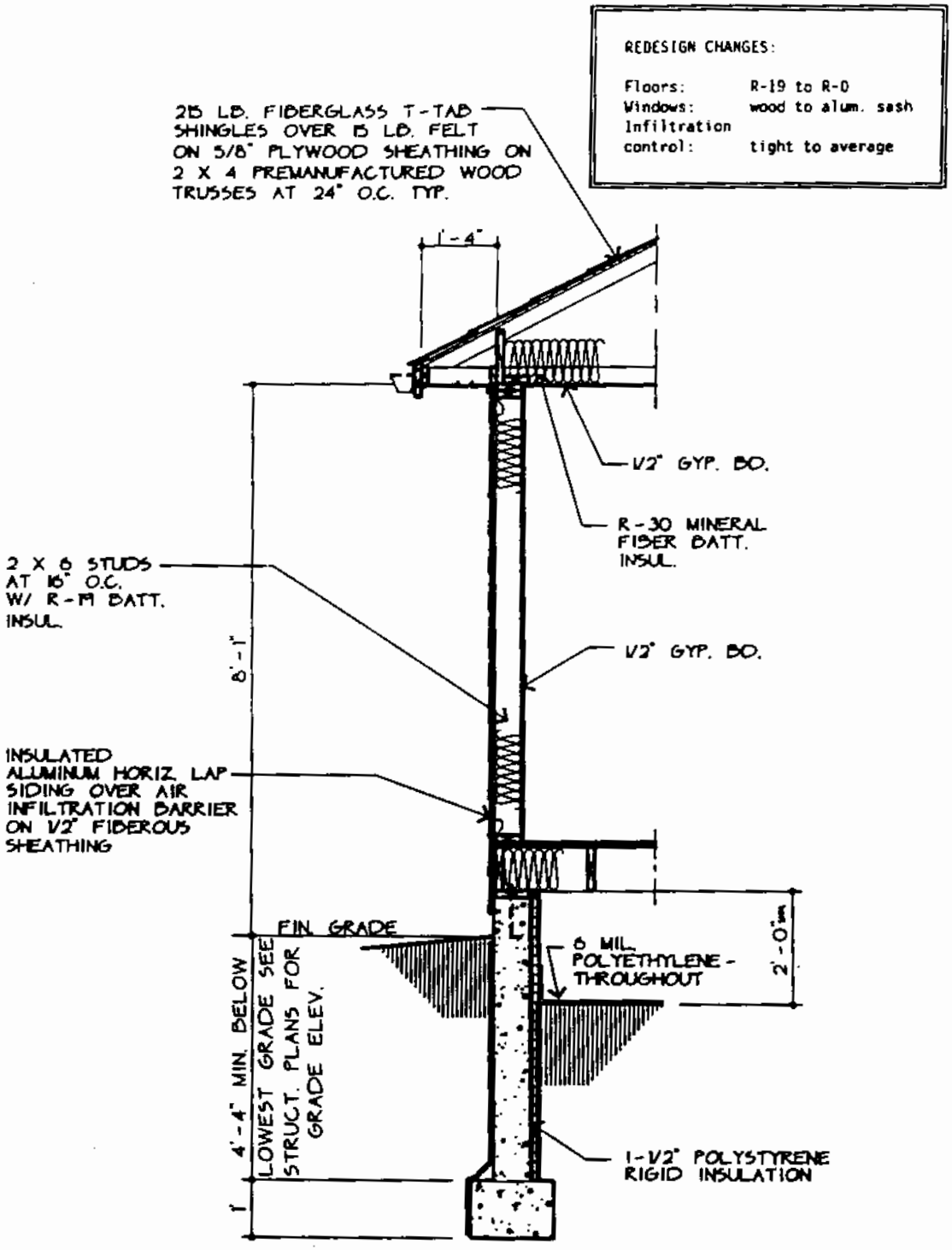


FIGURE 7.1. Rosebud Staff Quarters Design Changes, Minimum Points

Staff at the OES also stated that a two-day hands-on working session for designers, focusing on the mechanics of running the software, would be very valuable.

In regards to the ACP, staff predicted that it would probably not be used in PHS projects. Staff stated that it is not very practical and that designers have no experience with DOE-2 or other simulation models. The designer, however, mentioned that she might consider using the ACP when employing innovative design approaches not covered by CAPS.

In terms of construction costs, the demonstration redesigns indicated that capital costs could have been decreased if the three-bedroom houses were designed to meet, but not exceed, the DOE standards. Based on the designer's estimates, first costs would have declined about $1,200 per unit, or about $35,000 for the 29 units projected for construction. However, life-cycle energy costs would have increased by approximately $1,462 per house, resulting in an estimated aggregate life-cycle energy cost of approximately $42,400. Combining the capital and energy cost effects, costs would have increased about $262 per unit, or about $8,000 for the 29 units.

In terms of energy consumption, the original design was more energy-efficient than the redesign to meet the minimum requirements of the DOE standards. If redesigned, annual energy consumption would have increased by about an estimated 11.5 million Btu per unit, or 335 million Btu per year for all 29 houses.

Although the designer participated in the redesign for the demonstration, her comments suggested that in an actual procurement she might have proposed the original design features even though the standards permitted less stringent conservation measures. Representatives of the design firm stated emphatically that they design for a quality product as close to the cost budget as possible and do not design to meet minimum energy standards.

Unlike the military agencies, the Indian Health Service does not typically cover housing and utility expenses of their staff living in housing such the Rosebud Staff Quarters. The legislation that required DOE to conduct this demonstration stated that impacts on low- to moderate-income consumers

must be examined. Consequently, it was necessary to examine the impacts of the standards on the housing costs of the occupants.

According to the PHS, the occupants of IHS housing are usually nurses and doctors. Therefore, they are likely to be in the moderate- to high-income category. PHS also indicated that rental charges to the occupants are set by headquarters and are not necessarily tied to the construction costs. The only likely effect of the standards on the occupants, therefore, would arise through impacts on utility bills.

The houses in this project had electric space heating and cooling and the redesign was estimated to increase the annual energy consumption of each home about 11.5 million Btu. This is equivalent to about 3,400 kWh per year. At the prevailing electricity rate of 3.5 cents/kWh, this change would increase annual utility bills by about $118, or about $10 per month on the average.

# 8.0 DEMONSTRATION PROJECT FINDINGS

This chapter summarizes PNL's findings on the impacts of the Interim Energy Conservation Standards for New Federal Residential Buildings. These findings are based on the information collected during this demonstration. They document the effects of the standards on agencies that must use the standards and designers and builders who must comply with them. The findings document the process, energy, and cost impacts of the standards. They also provide information about DOE's role in implementing the standards.

## 8.1 PRESENTATION OF FINDINGS

The approach described in Section 3.6 was used to develop the findings. First, the project team defined a set of goals and objectives for the standards. Second, the team determined which comments, observations, and data collected during the demonstration were related to each objective. Third, the team determined how well the standards satisfied each objective based on the specific comments, observations, or quantitative data relevant to the objective.

For presentation of the findings in this chapter, the objectives were grouped into specific categories. The first category involves how well the standards achieved energy savings and the use of renewable resources. The second set involves impacts of the standards on the agencies required to apply them. The third set addresses impacts of the standards on designers and builders. The final set involves DOE's role in implementing the standards.

The findings presented in this chapter are based on the information from each demonstration project, or case study, described in Chapters 4 through 7. The findings generalize the case study information. Findings that are consistent across the demonstration projects are emphasized here, but findings that are unique to specific projects or agencies are also presented. These findings provide the basis for the recommendations presented in Chapter 9.

## 8.2 IMPACTS ON ENERGY EFFICIENCY AND USE OF RENEWABLE RESOURCES

The DOE standards' impacts on energy efficiency and use of renewable resources in federal housing were assessed based on six of the objectives discussed in Chapter 3. These objectives were derived by DOE and PNL largely from Congressional directives in the Energy Conservation Standards for New Buildings Act of 1976 (Public Law 94-385). Congress called for "federal policies and practices to assure that reasonable energy conservation features will be incorporated into new commercial and residential buildings. . ." This Act also called for the development of

> "performance standards for new residential and commercial buildings which are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of nondepletable sources of energy."

Sections 8.2.1 through 8.2.4 discuss how well the standards met the six objectives. Section 8.2.5 summarizes the findings of this demonstration project related to energy efficiency and use of renewable resources.

### 8.2.1 Achieving Maximum Practicable Improvements in Energy Efficiency

All five federal agency housing projects included in the demonstration showed that the minimum conservation levels needed to comply with the DOE standards were less stringent than or equal to the levels actually used in the projects. Most of the agency personnel interviewed during the demonstration expected the DOE requirements to be very strict and were somewhat surprised to find that the requirements were comparatively low.[(a)] This result was not anticipated before the demonstration project began.

Although this result is surprising, other information is necessary for the reader to understand its significance and implications. The following section describes how the standards' requirements are established and the important role played by economic factors. Subsequent sections discuss other aspects of the standards that affect their impacts on energy-efficiency requirements and how the requirements of the standards can be interpreted.

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(a) For example, in the Army's Fort Irwin project, Army personnel stated that the DOE standards' minimum requirements may be unacceptably low and difficult to build (as the insulation levels were below levels California builders are used to).

#### 8.2.1.1 Establishing the Standards' Energy-Efficiency Requirements

The law under which DOE developed the standards called for the standards to achieve the "maximum practicable improvements" in energy efficiency. As noted earlier, Congress also called for "federal policies and practices to assure that reasonable energy conservation features" (emphasis added) were incorporated in new federal residential buildings. One of the first steps in developing the standards was to determine what was meant by "maximum practicable" energy-efficiency improvements and "reasonable" conservation features. DOE chose to use an economic test to determine which efficiency improvements were reasonable and the maximum practicable.

Because all federal agencies are required to use life-cycle cost analysis in their procurement decisions, DOE used the life-cycle costing procedure to identify those efficiency improvements deemed to be reasonable and the maximum practicable. The life-cycle costing process and assumptions, including period of analysis (25 years) and discount rate, are specified by the Federal Energy Management Program (FEMP).[a] In a life-cycle cost analysis, capital costs to install more efficient components are weighed against energy cost savings to determine optimum efficiency levels.[b]

The DOE standards identify optimum conservation measures, i.e., those calculated to minimize the building's life-cycle cost, for a specific building. The standards use these optimum measures to establish an energy-efficiency target that federal housing projects must meet or exceed. In line with DOE's intent to establish standards that were consistent with the objective of minimizing cost, the target set by the standards is in terms of energy bills (energy consumption times energy cost), rather than energy consumption alone.

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(a) Note that in 1991, FEMP lowered the real discount rate to be used in the procedure from 7% to 4.7%. DOE's demonstration of the standards was initiated prior to the rate reduction and, therefore, all results reflect the 7% rate. If the new rate had been used instead, the minimum efficiency requirements set by the standards would have been higher than those discussed in this report. Version 3.1 of COSTSAFR incorporates the new discount rate.

(b) This basic approach is essentially the same as that used to set numerous state and regional residential conservation standards, although discount rates and input assumptions vary.

When federal housing project fuel and energy price data were collected during the demonstration project, it became evident that some federal agencies can obtain fuel and energy at exceptionally low prices.[a] For example, Ellsworth Air Force Base purchases natural gas at about 20 cents/therm, which is less than half the national average price for residential natural gas. Table 8.1 shows the fuel prices that applied to all the demonstration projects and they were, in almost all cases, comparatively low.

The reduction in utility bills caused by energy-efficiency improvements depends on utility and fuel prices, as well as the amount of energy saved. Although a specific conservation measure saves the same amount of energy regardless of energy prices, the utility bill reduction is less if energy prices are less. Because the FEMP procedure currently requires the life-cycle cost analysis to use the actual utility and energy prices paid by federal agencies, the relatively low energy prices paid by some agencies reduce the economic benefits of investing in higher efficiency levels.

TABLE 8.1. Actual Federal Housing Fuel Prices

| Federal Housing Project | Nat. Gas $/therm | LPG $/gal. | Electricity $/kWh |
|---|---|---|---|
| Fort Irwin, CA[a] | N/A | 0.39 | 0.031 |
| Fort Polk, LA | N/A | N/A | 0.058 |
| Ellsworth, SD | 0.20 | N/A | 0.072 |
| Alameda Naval Air Station, CA | 0.57 | N/A | 0.076 |
| Rosebud Staff Housing, SD | N/A | N/A | 0.035 |
| FEMP 1990 Average[b] | 0.56 | 0.84 | 0.079 |

(a) As noted in Chapter 5, erroneous fuel prices were used by the agency in its analysis. The correct prices are $0.49/gal. for LPG and $0.085/kWh for electricity.
(b) This is the national average for the residential end-use sector, calculated under DOE's Federal Energy Management Program.

(a) The low rates appear to result from the fact that many military facilities buy electricity and fuels in such large quantities that they receive large discounts. This issue is discussed later.

During the demonstration project, this approach resulted in the standards setting lower efficiency requirements than they would have had energy costs been closer to prevailing market prices. Thus, the principal reason the DOE standards' minimum energy-efficiency requirements are comparatively low is that they are based on tradeoffs between efficiency investments and energy cost savings calculated using federal agency utility rates and fuel prices that are below prevailing residential market prices.

As noted earlier, many agency personnel expressed surprise at the modest requirements of the DOE standards. One agency representative suggested that the standards should be based on prevailing residential market prices rather than the bulk rates paid by federal agencies. One designer suggested that the federal government should take a societal perspective in its decision-making. He stated that using fuel and energy prices that are below societal costs is inconsistent with making decisions from a societal perspective. The designer referenced indirect costs, or the costs of "externalities" that society bears, such as pollution or foreign oil dependence. These effects are very difficult to quantify, but are clearly real and would justify higher energy-efficiency levels.

Two important questions arise from this issue. First, why are the fuel prices paid by agencies so low? Second, why do typical agency residential efficiency requirements currently exceed the cost-effective levels calculated based on the fuel and energy prices paid by the agencies?

The prices that agencies paid for a unit of energy in several of the demonstration projects were well below standard residential customer prices. Inadequate information was available during this project to determine why the prices were so low in each specific case. However, military facilities often provide their own energy system infrastructure components, such as electricity sub-stations and transmission and distribution systems. Standard residential customer rates must cover these infrastructure costs because the utility has to provide this infrastructure; rates to military facilities, on the other hand, can be lower because the utility does not have to recover these costs. Although no detailed research was done during this project on the issue of the full energy costs faced by federal agencies, this one factor is probably the major reason that agencies often pay considerably less to energy suppliers

than residential customers for each unit of energy delivered. Because actual residential customer rates do include the infrastructure costs, local energy prices are probably better initial indicators of the full cost of energy for new federal housing than are the unit prices that agencies pay.

The second question is why current agency residential efficiency requirements exceed the cost-effective levels based on agency energy prices. One explanation is that the agencies may have implicitly included the costs discussed above in their energy-efficiency assessments. Another factor may be that the agencies consider certain minimum efficiency requirements (for example, dual-pane windows) to be necessary to ensure adequate comfort, construction quality, and other non-energy characteristics. A third factor, supported by comments from several agency project participants, may be that the agencies look to current local codes as guidelines for suitable efficiency levels. All these reasons have probably played a role in motivating the agencies' behavior. Although this project did not attempt to identify what reasons the agencies had for setting efficiency requirements and the role played by each reason, additional research with the agencies could answer this question.

Based on the evidence from this demonstration project, DOE believes that, from the perspective of direct economic impacts on federal agencies, the standards reflect the congressional directives 1) to achieve maximum practicable energy savings and 2) to ensure the incorporation of reasonable conservation features. Nevertheless, there is adequate evidence that higher efficiency levels are achievable, they could probably be justified by taking into account the full cost of energy to federal agencies, and higher efficiency would provide societal benefits beyond those resulting from the minimum efficiency levels required by the DOE standards.

In addition to these issues, the fact that one agency participant used incorrect fuel prices in the demonstration of the standards raised another important issue about communicating to agencies the importance of using the proper fuel prices in their analyses. PNL worked closely with the agencies during the demonstration, but even so the wrong values were selected for the analysis in one case. The incorrect prices were so far from the proper values

that the energy-efficiency requirements of the standards were substantially different than they would have been had the correct prices been used.

8.2.1.2 Indirect Effects of the Standards on Energy Efficiency

The DOE standards have a number of features which may help improve energy efficiency in ways not taken into account under the individual practices and requirements currently used by different federal agencies.

One strength of the DOE standards is that they set performance-based rather than prescriptive requirements for energy efficiency. The law required DOE to take this approach. Performance standards allow the designer and builder to choose how the standards will be met, rather than forcing the designer and builder to select specific conservation measures. Prescriptive requirements, for example, those used by the Army Corps of Engineers, may produce more energy savings but they are much more likely to exceed or fall short of the economically optimum requirement for specific housing projects. The DOE standards, on the other hand, permit better targeting of the requirements.

The DOE standards also consider all major contributors to residential energy loads in an integrated framework. These contributors include all aspects of envelope resistance to heat loss, heating and cooling equipment efficiency, water heater efficiency, and refrigerator/freezer efficiency. In some cases, the requirements of the federal agencies are less comprehensive. For example, the Army and Navy do not require slab foundations to have perimeter insulation, overlooking what can be a major conservation opportunity.

Federal agencies also do not have consistent requirements for including water heater efficiency in new housing. Some agencies ignore water heating entirely, while others have specific requirements. In some locations, particularly those with mild climates, water heating can comprise a major energy end-use. To achieve overall maximum practicable energy savings, therefore, it is important to establish efficiency requirements for water heating. The DOE standards take water heating into account and establish water heater efficiency requirements based on life-cycle cost, consistent with the methodology used for the building envelope. Although some agencies expressed

reservations about the effectiveness of imposing water heater efficiency requirements, particularly since water heaters will be replaced about every 10 to 20 years after the house is constructed, an energy-efficient water heater produces energy savings so cost-effectively that this measure should be included in residential energy standards.

Unlike most existing agency procedures, the DOE standards also provide a tool (the point system paper compliance forms and CAPS) that agencies can use to make decisions about the value of different conservation options. In fact, PHS OES staff mentioned they would prefer to use COSTSAFR and CAPS as design tools early in the architectural design process. The point system is an effective way to award credit for more energy-efficient designs, because each point represents energy cost savings. The point system allows tradeoffs between conservation measures and accounts for the fuel cost and the local climate. The Air Force and Army Corps Fort Polk project redesigns showed that the point system compliance forms could be used to select designs that could potentially reduce capital cost while maintaining the original energy savings levels. The CAPS software should give the federal agencies and the designers a sophisticated and useful tool for selecting conservation measures consistent with any desired energy savings level.

#### 8.2.1.3 Role of the Standards

An important issue relating to the energy savings resulting from using the DOE standards is what role they can serve best for federal agencies. Some personnel at military family housing headquarters have suggested that they be exempt from using the DOE standards because they believed, as the limited number of cases studied have shown, that their agencies' requirements produced more energy-efficient designs. On the other hand, OES personnel felt that the standards provided useful guidance on energy conservation, and they were receptive to using the standards.

Rather than specifying an absolute energy-efficiency requirement, the DOE standards can be understood to set a minimum requirement for energy conservation. Therefore, their basic role is to ensure that all federal housing meets or exceeds a minimum efficiency level. This does not directly prevent federal agencies from setting tighter standards. In fact, the

standards have a feature that would allow agencies to establish minimum efficiency requirements for any building component. The "set minimum values" option in COSTSAFR enables agencies to disallow ECMs below selected levels from the point system, such as single-paned glazing. A prescriptive set of minimum ECMs, such as those used by the Army and Navy, can be set in the DOE standards, with the point system providing designers some design flexibility.

An important qualification about using the DOE standards is that they apply only in cases where no state or local energy-related codes apply. For housing built on non-federal land, local codes would have to be met. The limited applicability of the DOE standards was not clearly understood by all demonstration project participants.

### 8.2.2 Updating the Standards to Include New Energy-Efficiency Technologies

Many participants in the demonstration project expressed concerns about the maintenance of the DOE standards to ensure that new data and technologies were incorporated as they became available. While demonstration results showed that the standards covered most conventional design and construction options, comments were received about expanding the options available in the COSTSAFR software to include shading devices, whole-house fans, and low flow shower heads, among others. Also, some participants suggested that more insulation R-value levels were needed, or that an interpolation feature should be added to the paper point system and CAPS that would allow any insulation level to be selected. For example, a popular type of wall construction in some federal housing is "power walls," where 2x4-in. studs and R-13 batt insulation are combined with external rigid insulation. This specific wall design is not currently included in the point system compliance forms (although it can be approximated by the R-19 wall insulation option).

For energy-efficiency measures that are not included in the point system compliance forms, the standards offer the option of using the alternative compliance procedure (ACP). The ACP allows designers to show that buildings with innovative measures and technologies meet the requirements of the standards. Both agency and designer demonstration participants, however, generally indicated the ACP was not very viable within the constraints of the

procurement process. Criticisms of the ACP included the amount of time it would take to learn and use and its complexity.

### 8.2.3 Accommodating and Encouraging Use of Renewable Resources

Small-scale renewable resource technologies for residential buildings are largely limited to passive and active solar space and water heating systems. Incorporating passive solar design and construction techniques in houses is a proven method of using solar energy.

Federal agencies experimented with active solar systems for space and water heating in the early eighties and were largely disenchanted by the experience. In recent years, active solar collector systems have rarely been incorporated in new federal housing projects. During this demonstration project, agency participants referred to difficulties in maintaining solar systems. Also the initial cost of the solar systems was reported to be high. Several years ago, the Army performed a study to determine the economic feasibility of active solar as a function of fuel price. Based on this study, the Army determined that active solar systems were not generally cost-effective.

The agencies presently have varying degrees of requirements relating to passive solar design (e.g., window layout, external shading, etc.). The Air Force energy conservation analysis procedure treats passive solar design in detail and has requirements for the solar contribution to heating and lighting loads. The Army has brief requirements for window orientation and shading, while the Navy and DHHS have no requirements relating to passive solar design.

Two of the objectives of the demonstration project were to assess how well the DOE standards accommodated existing renewable resources and whether they encouraged their use. Accommodation of renewable resources in the typical application of the DOE standards is limited to inclusion in the point system compliance forms of sun-tempered designs (which arrange windows in favorable orientations). Although the point systems allow a designer to receive credit for favorable orientations, orientation is not optimized in the actual COSTSAFR analysis. Therefore, the minimum efficiency requirements established by the standards do not take the benefits of good orientation into account.

One aspect of passive solar design available in the point system is the use of heavyweight construction. When asked, however, most of the personnel interviewed stated that building houses with thermal mass wall construction (i.e., brick or concrete) was prohibitively expensive. Even in southwestern states where that type of construction is common in the private sector, thermal mass walls are very rarely constructed for federal housing.

The standards' point system compliance forms include no treatment of renewable resource technologies other than passive solar designs. The only way to obtain credit for additional renewable resource technologies is to use the ACP, although none of the designers indicated they would be inclined to take this approach.

The third demonstration project objective relating to renewable resources was how well the standards would accommodate new renewable resource technologies. There was no indication during the demonstration that agency or designer participants believed that the standards accommodated new renewable resource technologies. The designers did not alter their designs to obtain credit from any new technologies. Again, the ACP is the only method of accommodating new renewable technologies without a major update of the COSTSAFR tool, and there was considerable reluctance to use the ACP.

### 8.2.4 Achieving Compliance with the Standards

The existence of the standards does not necessarily mean that the efficiency levels specified by the standards will be met in federal housing. The agencies have been generally reluctant to use the standards. As noted earlier, one argument they have made is that the standards are more lenient than some agencies' current requirements. Another has been the belief by agency participants that some of the economic data employed by the standards are out of date. If the agencies feel that they are working with outdated data, their confidence in the standards will be undermined and they will resist fully implementing them. The disappointing early experiences the Navy had using the standards without DOE help also undermined agency acceptance of the standards.

Although agency personnel did present such reasons for not using the standards, it was also clear during the demonstration project that some personnel had considerable resistance to changing their existing processes. The standards do provide a way for the agencies to continue using existing processes and avoid using the exact procedures in the standards. Part 435.303 (53 FR 32545-46) of the standards permits heads of federal agencies to establish more stringent requirements in lieu of using the specific requirements of the DOE standards. This is the approach several agencies claimed they were following.

Unfortunately, if each agency sets its own requirements, even if they exceed those of the DOE standards, there is no guarantee that the legislative intent will be met. For example, unlike the DOE standards, some current agency requirements are not performance-based and do not reflect local climate and economic conditions. In addition, if each agency continues to use its own procedure, the potential benefits of standardization will be lost.

Even if the agencies use the standards, the standards will not achieve their desired goal without adequate enforcement during construction. The demonstration, as designed, did not include a construction phase and field verification to determine whether housing was built to the standards. However, representatives of each of the federal agencies were queried as to how they currently verify that builders have installed proposed energy conservation measures. The responses ranged from minimal inspection of projects to having a final inspection occur before the contractor was paid.

Technically, the Air Force requires its contractors to be responsible for quality assurance and, therefore, verification of compliance. However, Air Force officials are concerned about construction practices because they must deal with any problems for years to come. The projects are checked by procurement agents, base staff, and subcontractors, such as the Army Corps of Engineers. For the Air Force's Ellsworth Air Force Base project, three inspections occurred. Infiltration testing was done on 10% of the homes; base officials reviewed the plans at the 65% completion point; and command personnel reviewed the base's findings.

Inspections generally occur with Army housing projects. At the Sacramento division office, the builders have to submit catalog cuts and other information on the appliances and equipment they select before it can be installed. Inspections are conducted during construction. At Fort Worth, there is a review process after the award of the bid to see if what was listed in the contract was incorporated into the final design. The personnel at Fort Worth said there is some quality control during construction, but much is left up to the good faith of the contractor. For 801 build/lease projects there is a certification process to ensure that a building is occupiable and built to specifications. For most projects there is one final review before the contractor gets paid.

The Navy reviews final plans and specifications; however, the contractor is responsible for general quality control. Some on-site construction supervision is also done.

The Public Health Service usually hires the A&E firm that designed the project to monitor the performance of the builder during construction. Inspections are done by the A&E firms and the Office of Engineering Services on each unit being built about once per month.

The DOE standards are unlikely to affect current agency compliance verification directly. If the standards are effective, however, in increasing agency attention to energy efficiency, then agencies might increase their verification efforts. The compliance forms (paper point system and CAPS) could be used as starting points for creating verification check lists. Under the DOE standards, one area that may be problematic is ensuring that refrigerators/freezers and space heating, space cooling, and water heating equipment of the required efficiency levels are installed. Because the DOE standards take equipment efficiency into account, it is very important that the planned efficiency levels are met. Builders frequently purchase appliances and equipment just prior to installation and agency verification procedures may not always ensure that equipment with the proper efficiency level is installed.

### 8.2.5 Summary of Findings: Impacts on Energy Efficiency and Use of Renewable Energy Resources

This section summarizes PNL's major findings from the demonstration project that involved impacts of the standards on energy efficiency and use of renewable resources.

**Finding 1: The DOE standards establish a procedure that meets the intent of the law with regard to energy-efficiency requirements.** The standards use a test based on the economic impacts that investments in residential energy efficiency have on federal agencies. This test defines what efficiency requirements are both reasonable and the maximum practicable, taking into account only the direct economic effects on federal agencies.

**Finding 2: When a federal agency pays relatively low fuel and energy prices, the minimum energy-efficiency requirements established by the DOE standards are low compared with recent federal agency requirements and some local standards.** The agencies may fail to recognize the importance of fuel prices in the analysis for the standards and may fail to obtain the correct prices. At the low fuel and energy prices paid by some federal facilities, high energy-efficiency levels cannot be justified by the economic impacts calculated based on the agencies' direct incremental fuel and energy costs alone. Taking the full costs of energy use into account would increase the minimum efficiency requirements that would be justified. There is some evidence that agencies may even fail to use the correct direct incremental costs.

**Finding 3: The standards alone do not strongly promote increases in federal housing energy efficiency.** In situations where agencies obtain low fuel and energy prices, the relatively lenient minimum energy-efficiency levels imposed by the standards will not encourage agencies and designers to increase federal housing energy efficiency. Under such conditions, the minimum requirements produced by the standards would not necessarily motivate agencies to "strengthen their efforts to improve the efficiency...of energy use in Federal buildings" as proposed in the National Energy Strategy (DOE 1991). The standards accommodate most but not all commonly used energy conservation measures and do not provide an effective way to give credit to new energy-efficiency technologies.

**Finding 4: The standards provide tools that can assist with the design of energy-efficient federal housing.** Although the energy conservation technologies covered by the standards are incomplete, the tools for implementing the standards, such as CAPS, provide a good starting point for assisting agencies and designers in making efficiency improvements to federal housing.

**Finding 5: The DOE standards partially meet the intent of the law with regard to renewable energy resources.** The standards accommodate the most feasible and commonly used renewable resource technology for federal housing, sun tempering. They do not accommodate active solar

technologies and other less developed renewable resource technologies, except through the ACP, which few designers and agencies appear willing to use in its current form.

Finding 6: The effectiveness of the standards has been limited by agency unwillingness to implement them and may be limited in the future by possible inadequacies in user-agency enforcement procedures. At the time of this demonstration, agency implementation of the standards had been almost negligible. Although the agencies have given reasons for not using the standards and the regulation provides them an option to continue using their current requirements, the need to use performance-based requirements that reflect local energy prices and climate is not being satisfied by most of the agencies' current approaches. In addition, agency procedures to verify that intended conservation measures are actually installed vary considerably. When agencies use the standards, it is possible that intended energy conservation measures will either not be installed or will be installed ineffectively if adequate inspections do not occur during construction. This may be a particular problem with equipment and appliances required to meet specific efficiency levels.

## 8.3 IMPACTS OF THE U.S. DEPARTMENT OF ENERGY STANDARDS ON FEDERAL AGENCIES

The DOE standards' impacts on agencies were identified using three of the objectives established for the standards. The primary objective was to minimize disruptions to existing agency procurement processes and simplify agency use of the standards. The second was to promote a consistent approach for increasing energy efficiency across the agencies and develop consensus on the benefits of using the standards. The third objective was for the standards to fit into the agencies' procurement processes in a way that would encourage the collection and feedback of information on any problems that were encountered in applying them. Fulfilling this final objective would permit timely updates and revisions to the standards.

In addition to these three objectives, this section briefly discusses economic impacts of the standards on occupants of housing built to the standards. The legislation required DOE to examine the impacts of the standards on low- to moderate-income households, but this turned out to be largely irrelevant in the case of federal housing.

Information from each of the demonstration projects was reviewed to identify significant effects of the standards that were consistent across the agencies. Effects were also documented that were unique to a limited number

of agencies, but were significant. This section relies primarily upon the comments and data provided by agency personnel.

### 8.3.1 Compatibility of the Standards with Agency Processes and Consistency of Effects Across the Agencies

The overriding issue regarding agency impacts is the general compatibility of the standards with the agencies' processes. If the standards are relatively easy to use and cause minimum disruptions to existing agency procedures, then they should be compatible with the agency procurement processes. Furthermore, if consensus exists on the impacts of the standards, then the need for multiple approaches should be reduced. If a basically uniform approach is suitable across the agencies, then less tailoring of the standards to individual agencies will be required and more consistency will exist in the treatment of energy efficiency in federal housing procurements.

As stated earlier, the standards may affect the agency housing procurement process at three stages: formulation of the energy-efficiency requirements, evaluation of alternative proposed designs, and confirmation of compliance.[(a)] The following discussion addresses these procurement stages.

With the exception of the Navy, the federal agencies participating in this demonstration have yet to use the DOE standards in an actual housing procurement and, consequently, their impressions come directly from the experience gained in the demonstration. Based on these experiences, the agencies indicate that, compared with their current process, using the standards will likely decrease the amount of time and effort spent establishing energy-efficiency requirements.

The agencies' existing processes for establishing energy-efficiency requirements and incorporating them in their procurement requirements vary. The Army and Navy typically rely on a combination of prescriptive and performance requirements to set desired energy-efficiency levels. The Air

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(a) When and how these stages occur depends on the agency procurement process. For all three military branches participating in the demonstration, these stages occur sequentially and are distinct steps. For the Public Health Service, and possibly other agencies using a two-step, design/build process, actual efficiency requirements may be developed interactively through negotiations with a selected designer.

Force uses the project-specific REEEM procedure and prescriptive requirements. The PHS OES uses a performance-based approach that relies largely on judgment and past experience. The agencies spend between 2 hours and 2 to 3 days establishing energy-efficiency requirements for individual projects.

The COSTSAFR software is the primary tool that agencies are required to use under the DOE standards. For all agencies but the Navy, there was consensus that COSTSAFR was easy to learn and use. (The Navy was the only agency to use COSTSAFR before the demonstration. It did so without the complete documentation, instruction, and technical help that DOE and PNL provided during the demonstration. Consequently, the Navy's experiences were not based on the same conditions that applied during the demonstration.) Typically, agency staff needed about 15 hours to learn to use COSTSAFR and produce point system forms. The COSTSAFR 3.0 User's Manual (Lucas and Lee 1990) was described as clear and understandable, although staff members with PHS and the Army Corps suggested that the manual include a more detailed discussion of applying DOS commands when installing the program.(a) Several agency participants recommended that the use of DOS commands be eliminated altogether, thereby simplifying the use of COSTSAFR.

To generate the project point system, COSTSAFR requires housing procurement staff to input information on project location, fuel costs, and acceptable building and equipment types. Cost and price escalation data should also be input to allow COSTSAFR to better reflect local economic conditions. The agencies reported that the required information is readily available, but takes a few hours to acquire.(b) One agency staff member felt that as much COSTSAFR input information as possible should be provided to the agency.

As the agencies experimented with COSTSAFR, some common concerns and difficulties surfaced. Of primary concern was the maintainability and integrity of COSTSAFR's economic and technical databases. The agencies

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(a) A section on DOS commands and operations has been added to the User's Manual for Version 3.1 of COSTSAFR.

(b) In at least one case, an agency demonstration participant chose to use the default values provided in COSTSAFR, rather than take the effort required to collect up-to-date input values. Unfortunately, this approach can undermine the economic validity of the requirements generated by the standards.

expressed concern about the resources that would be required if they had to maintain the software and recommended that the databases be updated annually through a centralized procedure.

A common concern pertaining to the operation and application of the standards was how to handle building designs with an unusual mix of floor types or building types, such as single-story, two-story, and three-story units all combined in one building. Agencies anticipate that difficulties will arise because COSTSAFR does not have the flexibility required to analyze these unusual designs fully and it will be necessary for the agencies to improvise, potentially reducing the accuracy of the results, or to apply the ACP, increasing overall costs.

An observation specific to the Air Force was that COSTSAFR would not allow officials to evaluate solar designs adequately. The Air Force prescribes the level of passive and active solar contributions to residential space heating, lighting, and hot water loads. The DOE standards do not provide adequate technical information to allow the Air Force to confirm that their solar contribution goals are attained.(a) Because other agencies pay less attention to solar options in their current procedures, they had fewer concerns about how the standards handled solar designs. The Navy expressed concern that the point system does not seem to address the effect of various types of HVAC systems on energy consumption and life-cycle costs.

Several other relevant and valuable observations, comments, or suggestions made by the agencies about the application and use of COSTSAFR follow:

- Climate variations within cities made it difficult to select an appropriate climate city, potentially decreasing the accuracy of program output.
- The program requires a computer with a math coprocessor and this capability may not always be available.(b)

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(a) The Air Force case study illustrated that this problem has not been completely solved with the current procedure either.

(b) The new version of COSTSAFR, Version 3.1, no longer requires a math coprocessor.

- The COSTSAFR documentation does not describe the ACP methodology, thus leaving the agencies at a loss about how to apply it.

- From a procedural standpoint, there were concerns about the extent to which temporary or permanent modifications of cost data in COSTSAFR could be 1) documented and justified if a bidder contests them and 2) traced and duplicated later if necessary.

- Centralized support to the agencies would reduce the difficulties of using the standards. For example, information could be provided on area cost multipliers, price escalation indexes, and cost data updates.[a]

- There was confusion, particularly at DOD, as to whether the standards applied to all or only certain housing procurements.

The agencies indicated that including a section describing the standards and the point system in their procurement documents could be accomplished easily. However, the Navy did voice a concern about the large number of pages the point systems, covering all possible building prototypes, would add to their RFPs. The Navy was concerned that the quantity of paperwork might intimidate bidders and might conflict with their policy of keeping the RFP process simple. The agencies were also concerned about whether every possible glazing distribution for houses in a project would have to be analyzed individually to verify compliance. Staff at the Sacramento District Office of the Army Corps of Engineers raised a concern about their ability to duplicate CAPS disks for distribution with possibly several hundred RFPs per proposal.

Implementation of the DOE standards would have a slightly different effect on the overall PHS OES procurement process than it would on the military agencies' processes. OES currently uses a two-step procurement process. The design competition is limited to an assessment of designers' capabilities and selection of the top designer. Energy-efficiency requirements are not considered during this phase of the process. Energy-efficiency requirements are developed as part of the negotiations with the selected designer during the cost proposal phase. Although this process differs from that employed by the other agencies studied, PHS OES personnel stated that the DOE standards could be very useful during the cost proposal

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(a) This need was filled partially by DOE during the demonstration through a toll-free telephone number information service, or "hotline."

phase as the means for establishing the energy efficiency of the design. OES personnel commented, however, that the language in the standards' documentation was more oriented to the procurement approach used by military agencies and they would like to see more generic language used.

When federal agencies use the turnkey procurement approach, the designer and builder costs of using the DOE standards will be embedded in the overall bid price. Because the proposal process is already expensive, there is concern among the agencies that a perception that the DOE standards will require designers to spend more effort developing their proposals may prevent smaller or newer firms from bidding, thus reducing the number of bidders and possibly resulting in the federal government receiving a lower quality product overall.

The Navy felt that the freedom to choose energy options instead of using prescribed energy saving measures may result in designers engaging in a time-consuming and expensive trial-and-error process to come up with a design that meets the point value required by the DOE standards' point system.

In the two-step process, the designer and the agency will negotiate the costs of using the DOE standards up front during the design contract process. PHS OES staff are concerned that these costs might significantly increase the price that designers charge to meet energy-efficiency requirements.

The agencies strongly agreed that the one-page compliance form produced by CAPS will reduce the amount of time required to evaluate designs and verify compliance with the DOE standards. It was pointed out that the need for engineering judgement and guesswork would be eliminated because the point systems give a clear indication of compliance. In addition, it was noted that the Btu per square foot per year criterion currently used by several agencies only indicates energy consumed without accounting for costs, whereas the DOE standards are based on life-cycle cost calculations and take fuel costs and fuel type into account, resulting in energy-efficiency requirements stated in energy dollars. This is important when trying to compare the energy efficiency of fundamentally different proposed designs. A PHS OES staff member also commented on the effectiveness of CAPS, stating that proposal

evaluators not trained in engineering will be able to understand the energy performance of proposals easily with the CAPS format.

Although designers may use CAPS more often than the paper point system compliance forms, the agencies must be prepared to review either compliance methodology. In general, the agencies found that the paper point system was cumbersome, especially when compared to CAPS. For example, references were made to the fact that the thermal mass walls and moveable insulation sections consume one and one-half pages of the seven pages generated, but the conservation measures are rarely, if ever, used in housing projects they had seen.

Agencies were not required to test the ACP as a part of this demonstration and, consequently, agency comments on the ACP were limited. It can be surmised, however, that the DOE standards would increase costs to the agency and designers if technologies not covered by the standards were proposed and it was necessary to use the ACP. Most personnel expressed doubts that the current ACP could be used within the limitations of the procurement process. The DOE-2 simulation model would have to be run to estimate the energy consumption and energy cost of the housing units. Who would do the runs would depend on how the agency chose to implement the ACP. After receiving data and information from the designers, the agency would have to verify it. All these steps would increase the costs of applying the standards, but no data were available to estimate these costs. Although the ACP would be difficult to use, it would introduce a consistent framework for evaluating innovative technologies.

### 8.3.2 Feedback of Information

DOE and PNL believe that negative impacts of the standards on federal agencies can be minimized only through proper feedback of information on the experiences and problems agencies have implementing the standards. During the development of the standards, DOE and PNL had worked almost exclusively with the military agencies because they purchase the vast majority of federal housing. The demonstration provided an opportunity to get direct feedback from one non-DOD agency, the Public Health Service, as well as the military agencies.

All the agencies included in the demonstration delegate substantial procurement responsibility to field offices. This was a key finding during development of the demonstration research plan. Because of this finding, the demonstration focused largely on field offices.

The direct interaction of DOE and PNL with the field offices during the demonstration ensured that DOE would receive the necessary feedback. The Navy's experiences with the standards prior to the demonstration indicated another positive aspect of this interaction. Without direct contact with DOE and PNL, the Navy field offices did not get all the information they required to use the standards correctly. One possible consequence of having incomplete information is that field offices would find ways to work around the requirements of the standards, possibly undermining the purpose of the standards.

It also appeared that agencies did not have consistent ways for field offices to feed information back to headquarters. Most agencies appeared to handle procurement problems that came up in the field by seeking exceptions to standard procedures and only slowly revising general policies to resolve the problems. This may be particularly true of housing energy-efficiency requirements because of the relatively low priority placed on them by most agencies.

Prior to the demonstration, there was no formal mechanism for feeding information back to DOE. During the demonstration, a hotline phone number was set up and it was used by agency (and designer) staff participating in the demonstration. The hotline number is now being provided to all potential users of the standards.

The hotline and routine contacts with the agencies during the demonstration showed the usefulness of mechanisms for facilitating the flow of information to the agencies on the standards. The need for such information flow was clearly demonstrated as was the need for even more effective mechanisms.

### 8.3.3 Economic Impacts on Agencies and Low- to Moderate-Income Consumers

The case-study nature of this analysis precluded development of statistically representative estimates of the complete economic impacts of the

standards on federal agencies. The impacts on agency staffing needs and processes were discussed earlier, but no attempt was made to estimate possible resulting budgetary impacts. The most direct economic impacts would be caused by changes in capital and operating costs for federal housing.

Table 8.2 summarizes the estimated direct cost impacts of the standards on the projects studied. The requirements of the standards were generated based on the direct prices for fuel and energy that suppliers to the agencies charged. Each of the projects was redesigned to come as close as possible to meeting the energy-efficiency requirements of the standards without exceeding them. The redesigns reduced estimated capital costs from $1,200 to $2,700 per housing unit. On the other hand, estimated energy life-cycle costs increased by as much as $1,462 per unit. In one case, they decreased by $52. The net effect was life-cycle cost savings to the agencies ranging from $580 to $2,752 per unit.[a] Total direct economic impacts on the agencies would vary with the number of units built in a housing project. In general, using the minimum requirements of the DOE standards as the basis for federal housing energy-efficiency levels would reduce the capital costs of new federal housing about $2,500 per unit and would decrease the overall life-cycle cost an amount ranging from about $500 to $2,000 per unit.

The occupants of housing covered by DOE's standards are federal employees. In almost all cases, except for the PHS project, the housing expenses are covered by the federal government.

Occupants of the housing procured through the PHS OES are primarily nurses or doctors. Therefore, they are likely to be moderate- to high-income consumers. The occupants pay their utility bills and rent, and the rent is set by headquarters. For the specific PHS project studied, DOE's standards potentially would have <u>increased</u> the electricity bills by an average of about $10 per month.

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(a) In one case, the estimated life-cycle cost increased by $262 per unit because optimal selections were not made in the redesign.

TABLE 8.2. Comparison of Five Case Study Minimum Points Redesigns Showing Life-Cycle Costs and Savings per Unit

| Case Study | Housing Type | Redesign Savings | Life-Cycle Energy Cost Increase | Overall Life-Cycle Cost Savings |
|---|---|---|---|---|
| Air Force | split-level | $2,100 | $814 | $1,286 |
| Army, Fort Polk | two-story townhouse | $1,940 | $1,360 | $580 |
| Army, Fort Irwin | ranch house | $2,700 | -$52[a] | $2,752 |
| Navy | townhouse | $2,386 | $1,122 | $1,264 |
| DHHS | 3-bedroom house | $1,200 | $1,462 | -$262[b] |

(a) This is a cost savings, not an increase.
(b) This is a cost increase, not a savings.

### 8.3.4 Summary of Findings: Agency Impacts

This section summarizes PNL's major findings from the demonstration project involving the standards' impacts on federal agencies.

**Finding 7: Overall, the DOE standards should fit into federal agency procurement processes without either requiring agencies to make major process changes or imposing significant costs on the agencies.** There is a consensus that the standards can provide an acceptable means to establish energy-efficiency requirements for federal housing projects. Generally, the standards are likely to reduce the effort required to establish energy-efficiency requirements. Because the standards would have to replace (or supplement) existing procedures, the agencies initially would have to invest some resources in making any necessary adjustments to the new procedure. The negative impacts could be mitigated by tailoring certain features of the standards to meet individual agency needs.

**Finding 8: Agency representatives are concerned about how the standards could and should be modified to address unusual situations.** There are concerns about how COSTSAFR could be tailored to apply accurately to atypical buildings, such as mixed single-story and multi-story units. Agency staff are also concerned about how to address variations in possible glazing orientations. Agency staff feel that a centralized

procedure should be in place to prevent agencies from making changes to COSTSAFR that would undermine its validity.

**Finding 9: COSTSAFR is relatively easy to use.** Agencies commented favorably on both the software and documentation. One concern some agency personnel had was the need for a basic understanding of DOS commands to use COSTSAFR.

**Finding 10: The point systems are easy to use, although the paper point systems are lengthy, and they are effective tools for evaluating designs.** Agencies generally commented favorably on the point system compliance forms and documentation. Although some participants feel that the paper point system compliance forms are cumbersome, the automated point system, CAPS, is easy to understand and use. Some agency personnel consider the paper point system compliance forms to be excessively long, particularly if one must be sent out for each potential housing type. There are some concerns about the difficulty of duplicating and sending out both paper point systems and the CAPS program to potential project bidders.

**Finding 11: The alternative compliance procedure is inadequately documented and is cumbersome to use.** Inadequate documentation exists for the agencies to use the ACP effectively. Most agency personnel believed that using the ACP would burden the agencies (and designers) excessively and greatly complicate the process of assessing energy efficiency.

**Finding 12: A centralized source of information for agencies using the standards would ease implementation.** Most time spent in running COSTSAFR was usually devoted to collecting input information, e.g., local area cost multipliers. Although the documentation provides sources for the information, the time required to obtain the information may be more than field offices are willing to devote. One consequence is that the agencies may use default values, and this eliminates potential benefits of using the standards.

**Finding 13: There are not adequate assurances that agency procurement personnel will receive all necessary information on the standards or that DOE will receive feedback on critical implementation issues.** Existing mechanisms within the agencies may be inadequate for communicating information about the standards to field office procurement personnel. Likewise, the Navy experience prior to the demonstration showed that DOE guidance to the agencies is essential for successful implementation.

**Finding 14: The standards have essentially no impact on low- to moderate-income consumers.** For the projects studied, the only households required to pay utility bills are Indian Health Service employees living in housing procured through PHS. The standards would have increased utility bills in this case study by an average of about $10 per month, but the occupants were likely to be in the moderate- to high-income categories.

## 8.4 IMPACTS OF THE U.S. DEPARTMENT OF ENERGY STANDARDS ON DESIGNERS AND BUILDERS

The DOE standards' impacts on designers and builders were identified using two of the objectives established for the standards. The first objective was to minimize disruptions and simplify designer and builder use of the standards. The second was for the standards to fit into the design process in a way that would encourage the collection and feedback of information on any problems that were encountered in applying them. Data collection focused more on the impacts on designers than builders because the designers typically have the primary responsibility for energy-efficiency design choices.

Information from each of the demonstration projects was reviewed to identify significant effects of the standards that were consistent across the design firms. Effects were also documented that were unique to a limited number of firms, but were significant. As stated earlier, two design firms that originally worked on the housing projects included in the demonstration participated in the study and three were unable to participate. Another design firm that was experienced in federal housing projects was selected to provide information on the three latter projects.

This section discusses findings on how implementing the DOE standards would affect the process through which A&E firms develop proposals and designs for federal housing projects. Next, it discusses the opportunities available for information flow between designers and agencies on the effects of the standards. Last, it presents a summary of findings on the impacts of the standards on the designers and builders. The information presented primarily reflects the comments and data provided by the design firms.

### 8.4.1 Compatibility of the Standards with Designer/Builder Processes

The designers stated that the standards would not affect their ability to bid competitively on housing projects. This suggested that the process would not give an unfair advantage to firms of a certain size or with certain capabilities.

There was consensus among the designers that the use of the DOE standards would require a minimal effort by the designers. Typically, it took

designers only about three hours to learn and apply the paper point system and less than about one hour to learn to use CAPS. Designers commented that much of the time spent with the paper point system went to locating the required information on R-values, equipment efficiencies, window types and percentages, etc. Once this information was accumulated, learning and applying the point system and CAPS was described as easy.

However, several designers noted that difficulties would arise when a building design cannot be fully evaluated with the standard options offered in the point system compliance forms. The example mentioned most often referred to buildings with a combination of foundation types. It was also noted that the point system User's Guide did not provide any additional information or assistance for handling buildings with an unusual mix of design features.

There was consensus that the point system requires less time and expertise to establish compliance than typical methods currently in use. However, when comparing the point system to REEEM, the procedure used by the Air Force, one designer stated that more time is required to complete the REEEM calculation procedure, but REEEM provides greater levels of flexibility and deals with more understandable energy "consumption" terms rather than energy "dollar savings" terms.

The designers uniformly preferred CAPS to the paper point system, describing CAPS as easy to use, and agreeing that it encourages experimentation and allows the results of different options to be examined immediately. In contrast, designers found the paper point system non-interactive, primarily because recalculation by hand is required after each new option is selected. The use of manual calculations raises the possibility of making mathematical errors. The designers noted that this is not the case with CAPS, because all calculations are performed by computer.

There was concern that the DOE standards might affect the designers' ability to meet other energy-related or non-energy-related standards. The designers agreed that, at the levels of efficiency currently required by the DOE standards, this is not a problem. One designer cautioned that if the energy-efficiency levels were made considerably more stringent, careful trade-

off analysis between energy-related and non-energy-related features of the design would be required.

All the original case study designs complied with the DOE standards. The designers noted that the minimum requirements to comply using the point system seemed outdated. Several examples of low "optimal" efficiency levels were cited, including one case in which the minimum space conditioning equipment requirements were a furnace AFUE of 0.75 and an air conditioner SEER of 7.0. The designer said these values were well below the Federal Energy Efficiency Standards and were no longer even available for purchase [(a)].

One designer suggested that, because the minimum requirements of the standards were so minimal in some cases, implementation of the DOE standards might eliminate energy efficiency as a competitive factor (because competitors will provide the minimum package required) unless "bonus points" were allowed in the proposal evaluation process for designs which exceeded the minimum requirements.

One designer noted that the point system "optimized selections" could provide a starting point for a builder's design, and the cost per point for increasing and/or decreasing energy performance from the starting point could be determined for each energy-efficiency measure. He went on to state that determining the best design from the builder's standpoint might involve increasing conservation measures that have a low cost per point and decreasing measures that have a high cost per point in order to achieve the same total number of points for the lowest cost or to increase the number of points for the least cost. The designer concluded that CAPS becomes an essential part of the design process, since the effect of changes on overall points is easily investigated.

Designers found the Point System User's Guide (Lucas and Lee 1990) to be, in general, clear, easy to use, and well organized. However, it was pointed out that the guide did not define all the technical terms that are used with the point system. One designer was left asking questions such as "how should buildings that are not aligned with a North-South axis be

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(a) These efficiency levels have been updated in the latest version of the standards in COSTSAFR, Version 3.1.

treated?" He suggested that a glossary of technical terms would be a helpful addition to the guide along with an appendix containing diagrams that show the proper way to calculate ceiling, wall, floor, and window areas.

The designers surveyed in the demonstration project found CAPS self-explanatory, with the on-screen prompts providing all the support that was needed. One designer recommended, however, that the CAPS Quick Reference Guide (Baechler, Lee, and Lucas 1991) be made available as a "pop-up" on-screen help utility.

Several additional observations, comments, and suggestions regarding the point system were put forth by the designers including the following:

- The energy conservation measures available in the point system compliance forms exclude some commonly used measures such as low-flow faucets and shower heads, efficient lighting, permanent and movable shading devices, water source heat pumps, and active solar water heating and space heating systems.
- CAPS and the paper point system compliance forms are limiting because they do not allow interpolation between listed values.
- CAPS does not support the retrieval of previously completed and saved work sheet files.
- Estimated life-cycle energy cost information is not available "on-screen" in CAPS and this information would be informative.
- One designer stated that the formulas used in the paper point system make no intuitive sense and it seems that the interactions of energy measures in the point system are not rigorously accounted for.
- Another designer noted that uncommonly used measures, e.g., moveable insulation, should be listed on separate forms or in a special section at the end of the point system.
- A designer commented that CAPS was helpful as a design tool, but it could be more effective if it provided a more interactive and graphical format to show how changing various design options would affect the overall energy efficiency of the design.
- A designer noted that all of the critical assumptions regarding optimized design in the point system are hidden in the standards' conservation measures cost database. Designers and builders could minimize the project cost if the standards cost database was available for comparison with their costs.

The ACP is the method designers would have to use to show that energy-efficiency options not included in the point system compliance forms complied with the standards. Designers typically stated that they would consider using the ACP because of their interest in designs incorporating new or innovative technologies not covered by the point system. However, most indicated that they had little experience using the DOE-2.1 computer program (or similar programs), which they would have to use to apply the ACP. The designers also felt that the usual time constraints for responding to RFPs would not permit them to do the necessary computer analyses.

### 8.4.2 Feedback of Information

The demonstration provided little direct information about how effectively the standards would encourage the exchange of information about the standards among designers, builders, and agencies. The viability and success of the standards, however, will depend in part on how well designers and builders are able to inform agencies about any problems they encounter and, conversely, how effectively agencies are able to communicate information to designers and builders about the standards.

The Navy's experiences prior to the demonstration provided some useful insights about this issue. The Navy found that designers did have problems understanding the paper point system compliance forms and this information was forwarded to the agency. When the Navy implemented the standards, CAPS did not exist and the Navy proceeded without assistance from DOE or PNL. Consequently, it is not possible to determine if the problems the Navy bidders had would occur in the future. It appeared from the Navy experience, however, that designers will make the agencies aware of difficulties that occur.

The demonstration showed that, with the level of assistance and information provided by DOE and PNL, the designers were able to understand and correctly use the point systems. The designers used the telephone hotline to obtain information and DOE and PNL provided guidance when errors were identified in the way the designers were using the paper point system and CAPS.

### 8.4.3 Summary of Findings: Designer and Builder Impacts

This section summarizes PNL's major findings from the demonstration project involving the standards' impacts on designers and builders.

**Finding 15: Overall, the DOE standards should fit well into the design process.** Designers have the expertise and understanding necessary to apply the paper point system compliance forms and CAPS during their design process. There was consensus that implementation of the DOE standards would not disrupt their design or proposal process.

**Finding 16: CAPS is a useful design tool.** Designer comments about CAPS were generally favorable and they could envision using CAPS to provide fast feedback on the effects of alternative design options. Some suggestions were made about improvements that would make CAPS an even more effective tool.

**Finding 17: The paper point system is adequate for verifying compliance, but is cumbersome to use and impractical as a design tool.** The need to do repeated hand calculations limits the usefulness of the paper version of the point system.

**Finding 18: The relatively low minimum energy-efficiency requirements of the DOE standards may change the way designers consider energy impacts of their designs.** In almost all cases, the designers felt that the minimum requirements of the standards were low compared with current agency requirements. Some suggested that if the minimum requirements were coupled with a system for awarding credits for exceeding the requirements then the designers would use the point systems to make informed decisions about energy-efficiency levels.

**Finding 19: The point system approach does not impose unfair burdens on any types of designers or builders.** The standards' paper point system and CAPS are easy enough to use that all federal housing designers and builders should have no problems applying them.

**Finding 20: The alternative compliance procedure is unlikely to be used by any designers.** The designers indicated that they either did not have the expertise needed, or would not have the time required, to do the necessary DOE-2.1 runs for the ACP.

**Finding 21: Designers and builders are likely to alert the agencies to any problems encountered with the standards, but assistance should be provided to designers as soon as possible.** Although information flow to the agencies is certain to occur, if many problems arise the procurement process may be disrupted. The assistance level and mechanisms used by DOE and PNL during the demonstration appeared to be adequate.

## 8.5 U.S. DEPARTMENT OF ENERGY ROLE IN IMPLEMENTING THE STANDARDS

Several of the findings from the demonstration involved the role that DOE can play to ensure that the standards are successfully implemented. Seven objectives were developed to focus information collection and analysis on issues related to DOE's role.

Findings presented in this section discuss how the standards met the seven objectives. They are presented in the following order. Two objectives deal with the provision of appropriate training, support, and materials to agency personnel. Two objectives involve the provision of required training, support, and materials to designers and builders. Two other objectives deal with permitting DOE to track and monitor use of the standards and to facilitate necessary reviews and updates. The final objective involves facilitating public and industry comments on the standards. This chapter closes with a summary of the key findings on DOE's role.

### 8.5.1 Provision of Support and Materials to Agencies

Using the DOE standards to establish energy-efficiency requirements and evaluate proposed designs in residential procurements differs from the typical procedures federal agencies currently use. At the outset of the demonstration, DOE believed that some agency training and assistance would be required and that procedures had to be in place to ensure that the necessary materials reached the procurement officials. Because the standards rely largely on the computer program COSTSAFR, most of the training and support needs identified were related to the use of COSTSAFR. In part because no actual procurements were conducted as part of the demonstration, other needs that were identified, such as assistance with interpreting how to apply the standards to unusual building designs, were more speculative.

DOE requested that PNL be available during the demonstration to assist and train agencies, as needed. PNL concentrated on working with agency field offices because of the offices' key role in procurements, and most assistance was provided to the field offices, rather than agency headquarters. PNL also was able to ensure that field offices received all the materials necessary to use the standards.

In general, the training most needed by the federal agency personnel was related to running COSTSAFR, and the type of training required depended on the level of computer literacy of the users. For example, some of the personnel were not familiar with DOS commands for the PC; therefore, they had trouble getting started with COSTSAFR. Those who were familiar with DOS were able to begin operating COSTSAFR almost immediately.

Types of training and assistance preferred by the federal agency personnel varied considerably. Hands-on training seemed desirable, particularly by those unfamiliar with personal computers. Some suggested that a computerized tutorial program would be useful. A "Help" feature in COSTSAFR was also requested. Other suggestions included a newsletter to discuss updates and new techniques, and somebody to demonstrate the program, explain idiosyncracies, and provide advice on how to interpret the point system. Many expressed a feeling that the software was like a "black box." These agency personnel wanted documentation explaining how the analysis was performed and what assumptions were used to produce the requirements.

One major concern was how to apply the standards to unusual buildings, e.g., buildings comprised of multiple residential unit types (such as apartments and townhouses). Both the Army personnel for the Fort Irwin project and the Navy personnel who had tried to use the standards in actual projects raised the need for DOE assistance with this issue.

The Navy's experiences were particularly illuminating because of their attempts to use the standards before the demonstration was conducted and without DOE assistance. These experiences had the benefit of more realism than the demonstration projects. The Navy encountered a range of problems including 1) the uncertainties mentioned above about how to analyze buildings with multiple unit types, 2) difficulties designers had meeting the minimum requirements after the Navy deleted sections from the point system compliance forms, and 3) lack of complete documentation at the field office level.

The Navy's experiences and other agencies' experiences during the demonstration showed that assistance and training would be essential for successful implementation of the standards. During the demonstration, the agencies took advantage of the hotline provided by DOE, but not extensively,

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probably because the demonstration was not a real application of the standards. The level of assistance DOE provided during the demonstration would probably not be adequate once the standards are used on a widespread basis.

PNL identified another significant need during the demonstration. No single document exists that explains to the agencies how to implement the standards. Documents are available explaining the software, the technical basis for the standards, and the point system, but no document is available that summarizes the entire process agencies need to follow to use the standards. The lack of such a document was not an issue during the demonstration because PNL explained the process to each participating organization. When the agencies use the standards on a regular basis, DOE will not be able to provide as much guidance and assistance and such a document will be essential. The Navy suggested that DOE document a detailed application of the DOE standards to one specific project indicating all the steps involved. This could serve as an example to the agencies and show the advantages of the new DOE standards.

### 8.5.2 Provision of Support and Materials to Designers and Builders

Participating designers did not directly identify many specific needs for training, assistance, or materials. Their comments, however, suggested that particular kinds of assistance could be beneficial.

Although designer training was not an explicit component of the demonstration, the designers did obtain limited training and assistance during the demonstration by working with PNL. Designers used the hotline provided to obtain answers to questions about the paper point system compliance forms or CAPS. As part of the data collection process, frequent contacts occurred between designers and PNL, and information about the standards was passed along to the designers.

One frequent comment made by the designers was that clarifications were needed to help them understand the point systems. For example, one designer felt that the equations used in the paper point system were unclear. Others felt that CAPS did not provide enough information or that the number of points awarded to certain measures seemed unreasonable.

Concerning the materials provided, some designers stated that the CAPS and point system documentation was too long and cumbersome. On the other hand, some observed that CAPS and the documentation did not provide enough information about specific measures such as infiltration control. One designer felt that CAPS should have a "help" feature.

A major issue raised by designers was how to interpret the relatively low minimum energy-efficiency requirements of the standards. Designers were uncertain what factors determined the requirements. To resolve designer concerns, PNL found it useful during the demonstration to explain the methodology underlying the standards.

Even though the minimum requirements of the standards were relatively low, it appears that DOE could encourage cost-effective improvements in energy efficiency by providing certain materials, training, and assistance to designers. During the demonstration, designers found the point system, particularly CAPS, useful as design aids. Some designers noted that CAPS could be used to determine the benefits of specific energy conservation measures if certain additional data, such as first costs, were made available. This would be especially useful if the agencies used an approach to evaluate designs that gave credit for higher levels of cost-effective energy savings.

Although all designers received the necessary materials during the demonstration, it remains unknown whether they would do so during actual applications of the standards. The agencies have raised some concerns about the difficulty of distributing the materials, such as CAPS and the paper point systems, to all firms interested in a particular project. If distribution is difficult or cumbersome, implementation of the standards will suffer.

No information was collected during the demonstration on actual use of the ACP. From designer comments about how they might use the ACP, it was clear that they had inadequate information to use the ACP, and it was questionable whether they would be able to. If designers are to seriously consider innovative designs while required to comply with the standards, more information and, possibly, training in the use of the ACP will be necessary.

No builders were directly involved in the demonstration, although all participating design firms work closely with the builders of federal housing. There does not appear to be a significant need for builder training and assistance if the more conventional designs covered by the standards are built. If more innovative designs are used and analyzed with the ACP, then assistance, training, and materials may be beneficial.

### 8.5.3 Monitoring Use of the Standards and Updating

For successful implementation of the standards, DOE needs to monitor how the standards are being used, any problems that are encountered, the degree to which federal residential buildings are built to the standards, and their performance. The demonstration was designed to collect some of this information from both agencies and designers.

As the standards become more widely used, it will be important for monitoring to continue. Mechanisms to allow agency and designer feedback to DOE would facilitate such monitoring.

The agencies and some designers noted that updates of the standards should be performed on a regular basis. With on-going monitoring, DOE would be able to collect the information required to perform the necessary updates. Scheduled updates of data used in the standards, and updates of the methodology and procedure as required would help increase the value of the standards to the agencies. Agencies expressed a desire for DOE to make updates without having to go through the entire rulemaking process, which is complex and time-consuming. Involvement of the agencies and possibly the designers and builders in the updating process would help ensure that the appropriate changes occurred and would increase agency acceptance of the standards. Systematic analysis of the performance of buildings constructed to the standards would also help verify the effectiveness of the standards.

### 8.5.4 Public and Industry Comments

Public and industry comment and involvement provide the opportunity for affected or interested parties to state their perspectives and ideas about the standards. The demonstration was not designed to gather information about the public comment and involvement process. DOE did solicit and obtain public comment, however, in the course of rulemaking.

Summaries of public comments received in this process can be found in the Federal Register Notices of January 31, 1991 (FR 56 pp. 3764 - 3773) and August 25, 1988 (FR 53 pp. 32536 - 32555). Many of the comments received on the August 25, 1988, rulemaking establishing the interim standards, indicated that the COSTSAFR software was biased against the masonry and concrete industries. Other comments pointed out confusing and complicated aspects of COSTSAFR. These issues were addressed by DOE and changes to the standards were implemented in the January 31, 1991, amendments to the interim standards.

The public may also have an opportunity to comment about the standards' applicability to specific housing projects if the federal agencies building the projects conduct public meetings or accept written testimony. Some agencies indicated that these actions are typically not done, but may be undertaken if a site is not built on federal land. Environmental documents, such as environmental impact statements or environmental assessments, must be completed before design or construction on federal housing projects begins. These environmental processes also allow for public comment. This report to Congress on the demonstration project also represents an approach for receiving input from public representatives.

The public input process is an important component to designing energy standards that balance DOE's needs with those of users, suppliers, builders, designers, and public interests. Public comment helps ensure that societal values are represented in the standards and that the standards are not unintentionally biased toward a particular building style or analytic technique.

It is likely that agency experience and understanding of the standards gained in this demonstration will give them a strong basis for future comments. Agencies have had the opportunity to comment in the course of the case studies provided in this report. Furthermore, it is likely that the issues raised in this report, based on the evaluation of the standards, are likely to generate further public comment.

### 8.5.5 Summary of Findings: U.S. Department of Energy's Role

This section summarizes PNL's major findings from the demonstration project involving DOE's role in implementing the standards.

**Finding 22: Because much of the federal agency procurement activity occurs at the field offices, training and assistance in using the standards is needed most by the field office personnel.**

**Finding 23: Agency training and assistance needs fall into three categories. Specific improvements in the documentation for the standards are needed to help address some of the problems that agencies encountered. One key document needed is an overall guide for agencies on how to implement the DOE standards. A "help" feature in the software was also suggested. Materials and courses designed to educate agency users about the standards are also needed. In addition, mechanisms for providing general information to users, including how to interpret the standards in unique situations, are required.**

**Finding 24: There are no assurances that current agency processes will provide the necessary standards materials to the agency personnel who need them.**

**Finding 25: Some improvements could be made in the information developed about the standards for designers. Information clarifying the point systems is needed. A "help" feature in CAPS would be useful.**

**Finding 26: The standards provide a good starting point for DOE to work with the design community to promote cost-effective improvements in federal residential energy efficiency. Designers recognize the possibilities for using CAPS, and other tools, to identify cost-effective design options for saving energy. With the cooperation of the federal agencies procuring housing, appropriate training and materials could lead to federal housing designs that cost-effectively save more energy than the minimum requirements of the standards.**

**Finding 27: Designers may have some problems obtaining all required point system information from the agencies. Agencies may have difficulty duplicating and sending out paper point system compliance forms, CAPS, and documentation.**

**Finding 28: Existing information on the ACP and designer knowledge may be inadequate for designers to use the procedure successfully.**

**Finding 29: There is unlikely to be a need for builder training and assistance unless innovative energy-conserving features are incorporated in federal residential buildings.**

**Finding 30: Mechanisms for DOE to monitor agency use of the standards will be important for their successful implementation. DOE needs to know how the standards are being applied and what problems develop. It**

will also be important to verify that the standards are achieving the energy savings anticipated in buildings.

**Finding 31: Updates of the standards will be required to ensure their use as conditions change.** Certain changes are likely to be required on a regularly scheduled basis. Other changes may be required as specific needs arise.

**Finding 32: DOE has met its legal requirements for obtaining public input, but successful implementation of the standards will depend on the availability of mechanisms to continue obtaining public and industry comments.**

# 9.0 RECOMMENDATIONS

This chapter presents recommendations for steps to be taken to ensure that the DOE residential standards fulfill their goals and objectives. Recommendations are presented in five categories. Brief discussions synthesize the findings presented in this report and draw conclusions that are the basis for the recommendations.

The recommendations are directed primarily at DOE, but since the success of the standards depends on actions taken by other parties as well, some of the recommendations are aimed at organizations other than DOE. All recommended time periods start from the date DOE delivered this report to Congress.

## 9.1 INCREASING THE EFFECTIVENESS OF PARTICIPATION IN THE DEVELOPMENT AND IMPLEMENTATION OF U.S. DEPARTMENT OF ENERGY STANDARDS

The effectiveness of the interim standards and the final standards will depend on how closely involved agencies, designers, and others are in the development and implementation process. Agencies in particular need to play a significant role in helping DOE design and revise these standards, which directly affect them. DOE, in turn, needs to work with the agencies to resolve issues identified during this demonstration. This section presents six recommendations designed to increase the coordination among DOE, the agencies, and others, and to enhance the effectiveness of their efforts.

In 1991, Executive Order 12759 was issued requiring that agencies responsible for federal buildings "ensure that the building is designed and constructed to comply with the [DOE federal] energy performance standards....Each agency shall establish certification procedures to implement this requirement (Executive Order 1991)." As a result of the demonstration project, DOE is in a position to assist the agencies in meeting the requirements of this executive order. Through the demonstration, PNL has identified specific assistance that the agencies need to fully implement the standards.

**Recommendation 1: As soon as possible, DOE should begin assisting the federal agencies in implementing Executive Order 12759. DDE should work with the federal agencies to resolve any impediments to immediate implementation of the standards and to develop certification procedures.**

Several of the findings presented in Chapter 8 related to needs for improved communications among DOE and participating agencies, designers, and others. Formal groups that bring together representatives from DOE, the agencies, designers, builders, and equipment manufacturers would provide a channel for these parties to become actively involved with the standards, to review and comment on proposed components of the standards, to exchange ideas, and to identify any problems or issues that need to be resolved.

**Recommendation 2: During the next year, DOE should establish one or more committees or task forces to involve affected federal agencies, designers, product suppliers, technical experts, and interested members of the public in all aspects of the development and implementation process. Field office staff should be represented on the committees. One focus of the groups should be on how agencies can encourage increased energy efficiency through their housing procurement processes.**

Other communication mechanisms must be established to ensure that all affected groups and individuals are informed about updates on technical changes made to the standards; updates of climate, economic, and construction cost data needed to use the standards; how to apply the standards in unusual circumstances; and answers to questions about the implementation of the standards.

**Recommendation 3: During the next six months, DOE should establish a newsletter to communicate with users of the standards and other interested parties. The newsletter can be used to convey information about technical matters and interpretations of the standards. The newsletter can also be used to alert readers to upcoming events and meetings. In addition to the newsletter, DOE should establish a formal listing of interpretations for convenient reference.**

The demonstration also revealed that managing and monitoring information dissemination was an important requirement for making communications about the standards as effective as possible.

**Recommendation 4: Within six months, DOE should establish a system for distributing information on the standards to field offices, designers, and others who need to receive it. A method for tracking the flow of information should be instituted.**

One of the clearest findings of the demonstration was the field offices' need for technical training and information, as expressed in Findings 22

and 23.[a] Designers also showed an interest in improving their understanding of the point system and the standards overall, although they did not have significant difficulties using the standards during the demonstration.

> **Recommendation 5: Within one year, DOE should develop training materials and courses to educate agency personnel and designers in using the standards and general energy-efficient design principles. Training courses should be supplemented with materials such as video tapes and computerized tutorials to be distributed to the various users. Course participants could be issued certificates to verify their training in the standards and energy-efficient design practices.**

The demonstration showed that engineers and designers can respond creatively to energy-efficiency requirements. Nevertheless, energy efficiency is not usually a primary concern in engineering and designing buildings. The DOE believes that training and education must be coupled with future energy-efficiency standards if the energy performance of all buildings, including federal housing, is to continue to improve. Future standards will be implemented by today's architectural and engineering students. Therefore, these groups need to understand the significance of energy efficiency as part of overall building design.

> **Recommendation 6: Within 18 months, DOE should develop an energy-efficiency training program for use in architectural, engineering, and energy-planning academic programs. The materials developed for the standards should be used as the starting point for program materials. Within the next three years, DOE should work with selected representatives of educational institutions to design and implement the program.**

## 9.2 IMPROVING PROCEDURES AND PROCESSES

During the demonstration, changes were identified that could improve the procedures and processes used in the standards. The demonstration revealed that the most important procedural issue was how to determine the appropriate fuel and energy prices to use in the standards. Several other process or procedural changes deserving DOE's immediate attention were also identified.

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(a) All finding numbers referred to here correspond to the findings listed in Chapter 8 of this report.

Basing the minimum energy-efficiency requirements of the DOE standards on the direct prices that suppliers charge per unit of energy or fuel does not account for the full cost of energy. Finding 2 indicates that the efficiency requirements that result from using the supplier prices alone may be lower than current state or agency requirements if the agency's fuel or energy cost per unit is low, and Finding 3 suggests that basing the standards directly on supplier prices is unlikely to promote increases in federal residential energy efficiency. Finding 2 also suggests that agencies may not understand the importance of fuel prices in the standards and the need to obtain the correct prices.

**Recommendation 7: As soon as possible, DOE should begin joint research with federal agencies to examine the effects of energy and fuel prices on optimum energy-efficiency levels. DOE should investigate the sensitivity of optimum efficiency levels to fuel and energy prices. DOE should work with federal agencies to estimate their full cost of energy and fuel. Until such research is completed, agencies should use typical, local residential customer fuel and energy prices when applying the DOE standards. In addition, DOE should find ways to make certain that agencies understand the importance of using the correct fuel prices in the standards.**

**Recommendation 8: Within the next year, DOE should conduct a study to determine the external costs associated with the different fuel and energy types used in federal housing. DOE should conduct a joint study with the agencies to determine whether such external costs should be included when they apply the standards.**

During the demonstration project, DOE explained to the participating agencies what steps they needed to follow to implement the standards. It became apparent, however, that in the absence of this type of assistance, there was no single source of information to which the agencies could turn to guide them through the process. Finding 7 notes that the DOE standards procedure should fit into existing agency procurement processes, but that the agencies need a brief, comprehensive document explaining the DOE procedure. Finding 23 indicates that such documentation is one of the key needs of the agencies.

**Recommendation 9: Within six months, DOE should develop a brief document that describes all the steps that agencies need to follow to implement the standards. The document should refer agency staff to existing documentation for the standards and should be designed to**

**maximize the ease of using the standards. The document should also stress the importance of using the correct fuel prices in the standards.**

Two kinds of information were identified that agencies needed in the near-term to implement the standards successfully. One type of needed information (see Finding 12) is input data for construction cost multipliers, escalation rates, etc. The second kind is information on how to handle unusual building configurations such as combined building types (see Finding 8).

**Recommendation 10: DOE should work with the federal agencies to establish a centralized source of input data for agencies using the residential standards and such a data source should be instituted within one year.**

**Recommendation 11: Within the next year, DOE should conduct an analysis of the cost-effectiveness of different energy-efficiency requirements for mixed building types and buildings with different orientations. DOE should then provide the results to federal agencies with guidance on how to apply the standards to these situations.**

Findings 8 and 31 suggest that a procedure for updating the standards is very important to ensure that the standards do not become obsolete and that they are implemented successfully. A consensus exists among agency personnel that a clearly defined updating procedure is necessary.

**Recommendation 12: DOE should begin developing a policy and procedure for updating the standards on a scheduled basis and should establish policies and procedures for making critical updates as they are needed.**

## 9.3 REVISING INTERIM STANDARDS AND DEVELOPING FINAL STANDARDS

DOE will soon begin the process of developing the final standards, but until the final standards are available, DOE will need to revise the interim standards as needed and keep the interim standards up-to-date. Because resources are limited and not all changes can be made immediately, it will be important to prioritize desirable changes to the interim standards and other activities related to the final standards.

Three themes voiced by demonstration participants were that the standards should be 1) easy to use, 2) flexible, and 3) easy for users to understand. By addressing all three themes, DOE would increase the

acceptability and usefulness of the standards. These themes should be used to prioritize changes and standards development activities.

**Recommendation 13: During the next six months, DOE should review the findings from the demonstration and, if necessary, work with federal agencies and designers to identify significant improvements that can be made to simplify the standards and increase their flexibility. Within the next year, DOE should develop and begin implementing a plan to make changes to the standards that simultaneously meet both types of needs.**

**Recommendation 14: During the next six months, DOE should work with agencies and designers to prioritize the desirable modifications to the COSTSAFR software that were identified during the demonstration and identify additional modifications. The modifications should focus on making the software more understandable and increasing its ability to incorporate energy conservation measures not already included. DOE should then develop a work plan for making the necessary software modifications. Within one year, DOE should begin making the software changes.**

Findings 15, 16, and 17 indicate that the compliance tools--CAPS and the paper point system--are informative and useful to designers. The automated point system, CAPS, was considered more useful than the paper point system as a design tool.

**Recommendation 15: During the next six months, DOE should identify ways that CAPS can be improved as a design aid. DOE should find ways to make the paper point system shorter and easier to use. DOE also should work with the agencies and designers to develop a more understandable way to quantify the effect that conservation measures have on energy savings in the compliance tools.**

A simplified tool like CAPS can be designed to include most commonly used energy conservation measures, but a simplified tool can never incorporate all possible ways to improve energy efficiency. An alternative compliance procedure, such as the ACP, will always be required. As noted in Findings 11 and 20, the current ACP is unacceptable to both federal agency staff and the private industry designers. The ACP in the final standards must be technically sound and accurate and have no loopholes, while it minimizes impediments to the designers who are trying to create innovative energy-efficient designs.

**Recommendation 16: Within six months, DOE should initiate a research project to develop an accurate, consistent, flexible, and equitable alternative compliance procedure for innovative designs. DOE should review procedures developed by other organizations and work with the**

**task forces and committees established in Recommendation 2 to define and develop a methodology that allows innovative, energy-efficient designs to be analyzed without undue effort and provides adequate safeguards against misuse.**

In 1991, DOE is issuing private-sector voluntary residential standards for public comment. These private-sector standards and the interim federal standards use totally separate but similar software tools. These two standards will be implemented by different user groups, but are alike in many ways. In addition to these two standards, DOE and the Department of Housing and Urban Development (HUD) are currently in the initial stages of a major update of the HUD Minimum Property Standards. These three standards require very similar information, data, and techniques. Integrating the development activities for the final residential standards and these two other standards could reduce duplication and overall resource requirements.

**Recommendation 17: In the interest of cost savings and consistency DOE should combine the development activities for all three residential standards into an integrated research program. During the next three months, DOE should develop a plan for integrating the research and development required for these three standards. An approach for developing common software tools should be defined. The steps DOE takes to respond to Recommendations 13 through 16 should be conducted in a way that will maximize the sharing of information, research, and findings among the projects to develop the three standards.**

## 9.4 ACCOMMDDATING RENEWABLE RESOURCES AND NEW ENERGY-EFFICIENT TECHNOLOGIES

To meet the legislative directives underlying the standards, several steps can be taken to increase the use of renewable resources and new energy-efficient technologies in federal residential buildings. This section presents six recommendations addressing these directives.

Like most standards, the DOE residential standards focus on establishing minimum acceptable practices. Consequently, they do not inherently push the state-of-the-art in areas such as the use of renewable resources and new energy-efficient technologies. Designers, builders, and agency personnel would probably welcome creative approaches, such as design competitions, that were designed to promote innovation and could be implemented in conjunction with the standards.

**Recommendation 18: Within two years DOE should develop and conduct a competition for innovative energy-efficient designs in federal housing. The competition should include the participation of one or more federal agencies.**

The demonstration project showed that, except through the ACP, which few designers and agencies are willing to use, the standards do not accommodate solar domestic water heating and other less developed renewable resource technologies. Residential solar domestic water heating, however, is considered to be a proven renewable energy technology in many locations. National codes and standards exist for the testing, manufacture, installation, and inspection of these systems. Regional and local codes, typically more stringent than the federal codes, also exist in many states.

**Recommendation 19: DOE should continue current research that would provide the information and methodologies needed to incorporate solar domestic water heating in residential building standards. DOE should review existing codes governing the use of solar domestic water heating systems and work with federal agencies, designers, industry representatives, and others to select appropriate codes to govern their inclusion in DOE's building standards.**

The point systems for DOE's federal building standards accommodate the most feasible and commonly used passive solar residential construction technique, sun-tempering (the practice of orienting a building's long axis east-west and positioning most of its window area on the south side). The point system also accommodates sun spaces, which are solar collectors that double as useful building space (for example solariums). The methodology, however, does not cover all types of sun spaces that designers may want to include. Sun spaces and other more sophisticated passive solar design and construction techniques can be evaluated fully now only through the ACP, which, as noted before, designers and agencies are reluctant to use.

**Recommendation 20: Within the next year, DOE should perform an evaluation of relatively inexpensive passive solar techniques such as solar shade screens and other external shading devices to determine their applicability for inclusion in the standards. In addition, DOE should conduct the research needed to determine the applicability of including more sophisticated and capital-intensive passive solar technologies and design strategies into the COSTSAFR program, or improve the ACP to accommodate passive solar designs more easily.**

Government-sponsored pilot projects that integrate photovoltaic (PV) technologies into residential units have been underway for over a decade. In addition, numerous private-sector and utility-supported grid-connected PV systems have been installed in houses. Although PV systems are not yet cost-effective for use in grid-connected residential buildings without subsidization, the efficiencies of PV modules and auxiliary systems continue to improve and costs are gradually coming down. National codes and standards for PV systems, however, are not developed to the extent that they are for solar domestic water heating.

**Recommendation 21: Within two years, DOE should perform the research needed to assess the cost-effectiveness and applicability of grid-connected PV systems in federal housing projects built under the standards.**

Wind energy and geothermal systems are renewable resource technologies that are currently in use in isolated residential applications. It is possible that wind and geothermal systems could provide some of the energy needs of federal housing developments in certain parts of the nation. However, the application of these technologies requires in-depth feasibility studies and analysis.

**Recommendation 22: During the next 2 years, DOE should develop a mechanism to allow designers and developers to propose the use of wind and geothermal energy renewable technologies in geographic areas where their use is likely to be cost-effective.**

New and improved energy-efficiency technologies become available all the time, yet the standards currently have no method to assess the energy consumption impacts or cost-effectiveness of such technologies in a timely way. To encourage the use of new technologies, a process must be developed for quickly incorporating the technologies in the standards.

**Recommendation 23: During the next year DOE should develop a methodology for rapidly screening new technologies to determine their acceptability. A standardized methodology for quickly including new conservation measures in the standards, either through the ACP or point systems, should be established by DOE.**

## 9.5 MONITORING IMPLEMENTATION AND IMPACTS OF THE STANDARDS

During the demonstration, PNL worked very closely with agencies and designers to determine how the standards would be implemented and what their impacts would be. The demonstration provided invaluable information about how the standards would affect the agencies and designers. The exchange of information that occurred during the demonstration led to rapid modifications of the tools used in the standards (e.g., an energy budget was added to CAPS) as demonstration participants identified desirable changes. As more agencies begin to implement the standards, similar data collection and information exchanges should be continued so that DOE is able to monitor the effectiveness of the standards and make necessary adjustments.

Monitoring of the types of impacts that were tracked during the demonstration should continue. PNL developed a number of data collection instruments and approaches for obtaining this information and they should continue to be employed.

**Recommendation 24: As individual agencies begin implementing the standards, DOE should develop the necessary working relationships and protocols for collecting consistent, informative details about user experiences. DOE should utilize the methodologies developed during the demonstration as a starting point. In cooperation with the agencies, DOE should then collect and analyze the necessary information as the basis for potential modifications to the interim standards, development of the final standards, training approaches, etc.**

Findings 6 and 30 suggested that the evaluation of energy efficiency should not stop at the design stage. Information about the construction process and actual energy consumption of buildings is essential to guarantee that predicted energy savings are being achieved. Agencies and designers stated that actual energy consumption needed to be analyzed to verify the effects of energy-efficiency measures.

**Recommendation 25: During the next year, DOE should use the communication, training, and coordination mechanisms proposed in several other recommendations to develop a cooperative program for ensuring that builders are able to meet the requirements of the standards and that intended measures and equipment are being properly installed. DOE should also work with the agencies to develop an approach for monitoring and evaluating the energy consumption of federal housing so that the effectiveness of the standards can be verified and the agencies can demonstrate they are meeting their energy savings targets.**

## 9.6 CONCLUSIONS

The interim standards demonstration project has been completed and this report documents the steps in the demonstration, the findings, and PNL's recommendations. As Congress intended, the demonstration provided crucial information DOE needs for the development of the final standards.

The methodologies and tools that DOE and PNL developed for the interim standards were generally well received by agency personnel and designers alike. It was clear, however, that federal agencies in general have resisted implementing the standards or were uninformed about them. The demonstration allowed DOE to identify impediments to more extensive agency implementation of the standards. It also revealed the need for DOE to take steps to integrate the agencies, designers, and others more into the standards development process so that their needs were better met by the standards and the personnel played more of a role in the design of the standards.

The finding that was the most unexpected and had the largest impact was that the low direct fuel and energy prices paid by some agencies significantly reduced the energy-efficiency requirements of the standards. Although the methodology employed by the DOE standards was consistent with the legislative directives, the low prices that some agencies paid energy suppliers resulted in low efficiency requirements that were difficult to reconcile with other policies to increase energy efficiency. This report suggests that the fuel and energy costs used by the agencies when applying the DOE standards should reflect actual market prices, not the reduced prices some agencies pay.

The major overall step that should be taken now is to develop a coordinated, cooperative effort among DOE and the affected agencies as the agencies implement the interim standards and DOE develops the final federal residential standards. This report presents several recommendations aimed at facilitating such a coordinated, cooperative effort to ensure that maximum practicable energy savings are achieved in new federal residential buildings in the coming years.

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# APPENDIX A

## CURRENT AGENCY HOUSING PROCUREMENT PROCEDURE QUESTIONNAIRE

# QUESTIONNAIRE ON AGENCY PAST EXPERIENCES WITH DOE STANDARD

We would like to document the experiences you had using the DOE standard prior to the start of the DOE Demonstration Project. These questions address what happened when you tried to use the standard and will help us understand the effort required to use the standard, problems that you encountered, and what kind of assistance would have been helpful. The information you provide here will also help us design the questions that we will ask about your experiences during the test of the standard that you will be asked to conduct.

1. [This information should be available on the Summary of Housing Project Information form.] For the projects where you applied the standard: what were the project names, where were they located, when was the procurement contract signed, how many housing units were included, and what types of units were included (townhouses, single-family detached, etc.)?

2. How did your personnel learn how to use the DOE standard? About how many labor hours were spent on learning and training?

3. Did you encounter any problems, such as with the documentation or computer program, when you were learning how to use the standard? If so, what were they?

4. Was the required computer equipment available when you were ready to run the software program? If not, how did you obtain it?

5. Do you think that training or assistance would have been helpful when you were learning how to use the standard? If so, what kinds of training or assistance would have been helpful?

6. When you ran the computer program for specific projects, how did you obtain the inputs required to run it? Inputs include the climate city, fuel prices, location cost multiplier, inflation rate, etc. About how many labor hours did your personnel have to spend obtaining this information?

7. Did the computer program provide the flexibility you needed to tailor it to specific projects? What kind of variations in inputs and other selections in the program did you make to tailor it to specific projects?

8. When you ran the computer program for specific projects, did you have any difficulties with the program or the User's Manual that describes how to use it? If so, what were they?

9. About how many labor hours were required to set-up and run the program for a typical project?

10. Did you have any problems with the point system? If so, what were they? Did they vary by project? How did you solve these problems?

11. What steps did you go through to integrate the point system in your RFPs? What kind of documentation on the point system did you provide in your RFPs?

About how many labor hours were required to integrate the point system in your RFPs?

12. If you encountered problems in integrating the point system in the RFPs, what were they? How did you solve them?

13. Did builders responding to the RFPs have any difficulties understanding or using the point system? If so, what were they?

14. How did you evaluate bidders' point systems submitted with proposals? How many labor hours were required?

15. What problems, if any, did you encounter evaluating bidders' point system submittals?

16. Did you require assistance at any point in the process from anyone outside your field office, such as at headquarters or from a contractor? If so, please describe.

17. What do you consider to be the good points, advantages, or benefits of the DOE standard? In what ways, if any, did it improve how energy efficiency was included in your procurements? In what ways, if any, did it reduce the cost or effort required to included energy efficiency?

18. What recommendations would you make at this point for improving the computer program documentation? the other technical documentation? the software itself? the point system?

# QUESTIONNAIRE ON ORGANIZATION AND PROCUREMENT PROCESS

## Overall Organization, Procurement Process, and Level of Activity

A. Overall Organization and Procurement Process

These questions deal with the organization at your installation that handles the overall housing procurement process. They are being asked to gain an understanding of the structure of your organization and how it operates so that we can better understand the impacts the DOE standard may have and how they could be minimized.

1. Can you please describe the organization in your field office that is responsible for military family housing procurement. [Refer to an organization chart if one is available.] Who are the people involved in a typical procurement and what are their roles?

2. What geographic territory does your organization cover?

3. How does your organization get involved with other agencies in the procurement of federal housing? What, if any, housing procurement services do you provide to other agencies and what services do other agencies provide to you?

4. What types of housing procurement are you currently conducting (e.g., MILCON turnkey, Section 801, etc.) and what is the percentage of your housing that falls into each type? If your organization is involved in housing retrofits, please describe your current retrofit activity.

5. Please describe the steps in a typical housing procurement. [Refer to a flow chart of the process if available.] What approximate level of resources are required to conduct a housing procurement? calendar time? labor types and hours? dollars? How do the requirements vary by procurement type (e.g., MILCON, Section 801, etc.).

6. What materials are your contractors required to submit in their bid package for a typical housing procurement? What are the types of general criteria they are required to meet?

7. How does your organization test and introduce changes to your procurement process?

B. Level of Procurement Activity

The following questions will help us understand the types and amount of housing procurements that your organization conducts and the amount expected in the future. We need this information to help us select suitable projects for testing during the demonstration.

8. Please provide the following information on the housing projects that your organization has initiated since 1986 to the present: location, number of housing units in project, types of units included, the schedule for each project, and type of procurement. [Refer to Summary of Housing Project Information chart. Identify which projects, if any, were developed using the DOE standard.]

9. What are your forecasts and expectations for future construction?

Current Process for Including Energy Efficiency Requirements in Procurements

The following questions focus on your process of including energy-efficiency requirements in your procurements. The DOE standard will have the most direct effects in this area and your answers to the following questions will help us understand your current process and how the DOE standard might affect this process and your organization.

10. When your field office organization procures new housing, where do energy-efficiency requirements enter into the procurement process?

11. Within your organization, who is involved in establishing the energy-efficiency requirements for each project? Do these same people evaluate the energy-efficiency features in the proposals that are submitted? If not, who does?

12. What are the backgrounds and skills of your personnel involved with residential energy efficiency? What is the mix of civilian and military personnel?

13. What are the approximate turnover rates of the people involved with establishing family housing energy-efficiency requirements and evaluating the energy-efficiency measures in bidder proposals?

14. When you prepare and issue an RFP for a typical new housing project, about how many hours do the different people

involved spend to establish the energy-efficiency requirements and incorporate them in the RFP? Are there resources other than direct labor required? [Probe for computer support, subcontractor analysis, or indirect labor support.] If so, can you estimate the levels typically required? What do you think the total costs are to prepare and issue the energy-efficiency requirements for an RFP? Would any of the costs you are including in your estimate, such as the cost of specific computer analyses, be shared with other procurements?

15. When you evaluate contractor proposals for a typical new housing project, about how many hours do the different people involved spend on evaluating the energy-efficiency section of contractors' proposals? Are there resources other than direct labor required? [Probe for computer support, subcontractor analysis, or indirect labor support.] If so, can you estimate the levels typically required? What do you think the total costs are to evaluate the energy-efficiency section of contractors' proposals?

16. Please describe the current energy efficiency requirements that your residential construction contractors must meet. How were these requirements established? Were there assumptions about fuel prices, inflation rates, or other variables required in establishing these requirements? If so, how were these assumptions made?

17. Since we are interested in projects built since 1986, do the current requirements differ from what you required on any of the projects initiated since 1986? If so, what were the requirements for the earlier projects?

18. How much credit do you give for energy efficiency in your residential procurement evaluations? For example, what percent of the total points awarded for a proposal correspond to energy efficiency?

19. How do you verify that your builders have installed the energy-conservation features that they proposed to install? For example, do you inspect each building during construction?

20. What role do headquarters or other organizations within your service play in setting your energy-efficiency requirements? What role do they play in the evaluation of the energy-efficiency aspects of contractor proposals?

21. Does your group have any discretion in setting energy-efficiency requirements (for example, if you start with prescriptive requirements can you vary from them or can you choose to add requirements or emphasize certain requirements)? If so, what discretion do you have? Does your group have any discretion in evaluating the energy efficiency levels or features proposed? If so, what discretion do you have?

22. What do you see as the advantages of your current process for establishing and implementing energy-efficiency requirements?

23. What do you see as the limitations of your current process?

24. Are you familiar with DOE's federal residential energy standard? If so, how did you learn about the standard?

25. Do you have a copy of COSTSAFR? If so, how did you obtain it?

26. Were you aware that the standard became effective in February, 1989? If the standard has not been incorporated into your procurement process, what are the reasons it is not?

# APPENDIX B

## QUESTIONNAIRE ON AGENCY EXPERIENCES WITH DOE STANDARDS

# QUESTIONNAIRE ON AGENCY'S EXPERIENCES
# DOE INTERIM RESIDENTIAL STANDARDS

## INTRODUCTION

The DOE Interim Federal Residential Standards Demonstration involves applying the new DOE energy standard to recently built housing projects. The results will help DOE design the final standard so that it is most useful to the federal agencies. This demonstration will also give experience to your agency's personnel who will be responsible for implementing the standard.

During this demonstration, please try to use the standard as you would during an actual procurement. For example, please have the same people run the software who would run it to develop energy conservation requirements in an actual procurement. When answering the questionnaire, include any concerns or comments about how the standard will fit in with your overall procurement process.

Please review the attached questionnaire before starting the demonstration to acquaint yourself with the kinds of information that we are seeking from you. Your role in the demonstration involves the following four steps:

Step 1 - Use the DOE software (COSTSAFR) to create the compliance worksheets for the selected housing project, and use POSTSAFR (a one-step program) to create the input file needed for the automated point system (CAPS). In an actual procurement, the paper compliance forms, CAPS, and the file created by POSTSAFR would be included in the package going out to potential contractors.

Step 2 - Complete the attached questionnaire except for Section E, which will be completed after the contractor for the housing project has conducted the redesign for this demonstration project.

Step 3 - We will work with the contractor who originally designed the selected projects we are studying. The contractor will do a redesign of the energy-related construction features using the compliance forms you produce with COSTSAFR.

Step 4 - After we supply you with the compliance worksheets that have been completed by the contractor, complete Section E of the attached questionnaire (questions about the proposal evaluation process).

Call us at PNL for assistance in answering any questions about this demonstration project, this questionnaire, or the DOE standard in general. You can contact us at the following toll free number:

1-800-537-5685

Interpretation and policy issues that are not dealt with in the documentation may arise. For example, some of the design options in the standard may conflict with other important design features of the housing units such as aesthetic or architectural issues. Either make a decision on how to deal with issues based on your interpretation or contact us for discussion and/or clarification. Please do not try to avoid or skip any problems or issues that

clarification. Please do not try to avoid or skip any problems or issues that may arise. Remember, compiling information on the questions and problems you have during this test application of the standard is a major objective of this part of the demonstration project.

The questions are divided into the following five sections:

A. LEARNING HOW TO USE THE STANDARD

B. CHARACTERISTICS OF THE SELECTED PROJECT

C. USING THE STANDARO

O. CONTRACTOR COMPLIANCE WITH THE STANDARD

E. USING THE STANOARD DURING PROPOSAL EVALUATION

Sections A and C are designed to separate your experiences during the stages when you were learning to use the standard in general and when you specifically applied it to generate the compliance forms for the selected project. To the extent you can, please try to distinguish between your experiences in these two phases. Section O asks you to assess how the standard will affect contractors. When answering these questions, give your best guess of what you believe might happen in this part of the procurement process. Remember, you will fill out Section E later, after the project contractor has completed the point system you generate for the project.

Agency Name:_____

Agency Location:_____

## A. LEARNING HOW TO USE THE STANDARD

This set of questions deals with your experiences learning how to use the software for the standard. Your experiences using it to generate the point systems for housing projects are covered in Section C.

A.1. a) Has your organization had any experience before this demonstration using the DOE standard? ___Yes ___No

b) If you have had prior experience, please indicate what project(s) it was applied to and when?

| Base or Installation | Construction Time Frame | # and Type of units | Prime Contractor |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

A.2. What type of personnel (title, profession) were assigned to learn the standard for the current demonstration project, and how much time was spent?

| Name | Title | Profession | Time Spent |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

A.3. a) Was the required computer equipment available within your organization when you were learning how to use the standard? ___Yes ___No

b) If it was not available within your organization, where did you obtain it and what, if anything, did it cost?

_____

_____

A.4. When learning the standard for this project, what questions, problems, or issues were encountered with

a) The COSTSAFR User's Manual and supporting documentation

b) The COSTSAFR and POSTSAFR software

c) The computer hardware when using the COSTSAFR and POSTSAFR software

d) The paper point system and its documentation

e) The Computerized Automated Point System (CAPS) and its documentation

A.5. What recommendations would you make about minimizing the problems and cost of learning how to use the standard?

A.6. a) Besides the time spent learning to use the standard, and any equipment purchase costs, are there any other costs you incurred that would only occur the first time you used the standard? ____Yes ____No

b) If so, what were they?

A.7. a) Are there any ways in which the level of effort or costs required to use the standard might change as your organization became more familiar with it? ____Yes ____No

b) If yes, please explain how.

## B. CHARACTERISTICS OF THE SELECTED PROJECT

These questions relate specifically to the housing project that was chosen for study during this demonstration.

Project Name and Location: _____

B.1 How many total housing units were there in this project?_____

B.2. What housing types were included (e.g., townhouses, two-story detached, etc.) and how many were there of each type?

| Type | Number | Type | Number |
|---|---|---|---|
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

B.3. a) When was the contract signed?_____

b) When did construction start?_____

c) When was construction completed?_____

B.4. What were the original conservation-related requirements, e.g., required insulation levels, equipment efficiencies, equipment sizes, etc.?

insulation levels:

ceilings _____ walls _____

floors _____ other _____

windows (area, layers, etc.; is passive solar required?): _____

_____

_____

infiltration control: _____

_____

HVAC related (efficiencies, sizes): _____

_____

other (e.g., energy budget): _____

_____

## C. USING THE STANDARD

C.1. a) Beyond the initial training and learning necessary to use the standard, would you say there was any additional training required specifically for this project? ____Yes ____No

b) If so, what personnel (title, profession) spent additional time on training, how much additional time did each person spend, and what did this training involve?

| Name | Time Spent | Description |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

C.2. Who in your organization was involved in using the standard during this demonstration to develop the energy-efficiency requirements for this project and how much time did they spend?

| Name | Title | Profession | Time Spent |
|---|---|---|---|
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

C.3. a) Was the assistance or guidance of anyone outside your organization required during this demonstration for this project? ____Yes ____No

b) If outside help was required for this project, who provided it?

_____

C.4. a) Did you find it necessary to exclude any conservation measures or levels, modify the point system forms, or make any other modifications or additions to the standard to make it compatible with other, non-energy requirements that you wanted to specify for the project? ____Yes ____No

b) If so, what were these changes?

_____

_____

_____

_____

C.5. When implementing the standard for this project, what questions, problems, or issues were encountered with

a) The COSTSAFR User's Manual and supporting documentation

b) The COSTSAFR and POSTSAFR software

c) The computer hardware when using the COSTSAFR and POSTSAFR software

d) The paper point system and its documentation

e) The Computerized Automated Point System (CAPS) and its documentation

f) Interpretation and/or policy concerns

C.6. Based on your experiences in this demonstration, what recommendations would you make about improving the standard, software, paper compliance system, or CAPS for use in setting energy-efficiency requirements?

a) The standard in general

b) The COSTSAFR and POSTSAFR software

c) The COSTSAFR User's Manual and supporting documentation

d) The point system, in both paper and computer form

C.7. Please provide any other general recommendations that you feel would make the standard easier for your organization to use and more compatible with your procurement process.

## D. CONTRACTOR COMPLIANCE WITH THE STANDARD

PNL will provide the contractor with both the paper and computerized (CAPS) form of the point system for the redesign of this project. The contractor will also receive the CAPS Quick Reference Guide (a brief guide to using CAPS) and the comprehensive Point System User's Guide. Based on your past procurement experience and what you know about the standard, please answer the following questions.

D.1. a) For this specific project, do you feel that the contractors will need any additional information on the standard and how to meet it?

____Yes ____No

b) If yes, what information?

_____

_____

_____

D.2. What problems, if any, do you perceive contractors will have using the standard on this project?

_____

_____

_____

_____

_____

_____

D.3. What recommendations would you make for improving the standard for the contractors' use?

_____

_____

_____

_____

_____

## E. USING THE STANDARD DURING PROPOSAL EVALUATION

These questions are to be answered after the project contractor has revised his original design to meet the new standard. You will be provided with the paper point system filled out by the contractor and the CAPS output generated by the contractor for the project. Without actually conducting a re-evaluation of the project, consider how the information in the compliance forms would be integrated into the usual proposal evaluation process when answering these questions.

E.1. Who would be involved in evaluating the energy-efficiency features proposed by contractors for this project, how much time would each person spend, and what work would be involved in this evaluation?

| Name | Time Spent | Description |
|---|---|---|
| | | |
| | | |
| | | |

E.2. What problems might arise, if any, in using the standard during the proposal evaluation process for this project?

E.3. What recommendations would you make to improve the standard for implementation in the proposal evaluation process?

# AGENCY FOLLOW-UP QUESTIONNAIRE

## A. USE OF THE STANDARD DURING PROCUREMENT DEVELOPMENT

A.1. Please provide any additional comments on problems or issues that arose in running the computer programs for the standard including COSTSAFR, POSTSAFR, and CAPS. **[Review written comments submitted by agency.]**

Do you have any suggestions on how to improve the software?

Were there any hardware problems other than those you documented already?

Were you able to obtain the necessary input data to run COSTSAFR? What sources did you use?

A.2. Please provide any additional comments or suggestions on the documentation and manuals provided for the standard. Materials include the Technical Support Documents, User's Manual, and CAPS manuals.

A.3. Please provide any additional comments or suggestions on the paper point system and CAPS point system.

What do you think about the energy conservation levels required by the DOE standard?

A.4. What questions do you have about how to interpret the standard during procurement development? For example, were there or are there likely to be problems determining which prototype houses to analyze and which ones apply to the types of designs you have encountered?

Did you use the "minimum levels" feature in COSTSAFR and would you expect to use it in the future?

How did you, and how would you in the future, eliminate possible conflicts between the DOE standard's requirements and other requirements, such as state codes?

A.5. DOE has developed an alternative compliance procedure (ACP) that could be used by proposers who wanted to include materials and technologies not included in COSTSAFR **[Describe procedure]**.

Do you think that any proposers would want to use this approach? How often and for what types of materials and technologies?

What difficulties would you expect your agency to have using the ACP during the procurement development phase? How might they be alleviated?

A.6. How easily would the DOE standard fit into your procurement process during the development stage? What could be done to alleviate potential problems? What additional documentation or modifications to the standard are needed for this standard to become a functional part of your procurement development process?

B. QUESTIONS ON DESIGNERS' USE OF THE STANDARD
[Review designer's completed questionnaire and point system with agency personnel before answering these questions.]

B.1. What comments do you have on the way the designer completed the point system? Do the selections made raise any new concerns or issues?

B.2. What questions and difficulties, if any, can you envision coming from designers using the DOE point system?

B.2. From your experience, how well do you think the point system (both paper and computerized versions) will fit into the approach used by designers to develop their proposed designs?

C. PROPOSAL EVALUATIONS

C.1. Who would be involved in evaluating the energy-efficiency features proposed by designers for this project? How much time would each person spend evaluating these features and the materials provided by the DOE standard in their evaluation? What work would be involved in this evaluation?

C.2. How do you think the standard can be integrated with other evaluation criteria (e.g., tradeoffs with aesthetic matters, awarding extra credit for more efficient energy conservation measures)?

C.3. What problems might arise, if any, in using the standard during the proposal evaluation process for this project?

C.4. What recommendations would you make to improve the standard for use during the proposal evaluation process?

D. OTHER ISSUES

D.1. If you tested the CAPS computerized point system software, would there be any way you might use it in your procurement process? For example, would it be useful for setting prescritive energy-efficiency requirements? What about during proposal evaluation?

D.2. Are there areas in which training is needed to assist the federal agencies in implementing this standard? How could training help deal with personnel turnover in the agency? What type of training approaches and tools would be most useful--for example, videos, training software, and seminars?

D.3. What, if any, data, materials, or procedures in the DOE standard do you think should be updated regularly? What type of procedure would you like to see used and what would be the most useful way to provide you new information?

D.4. Are there any other comments, suggestions, or problems you would like to discuss?

# APPENDIX C

## QUESTIONNAIRE ON DESIGN CONTRACTORS' EXPERIENCES WITH DOE STANDARDS

CONTRACTOR REDESIGN QUESTIONNAIRE
FEDERAL RESIDENTIAL INTERIM STANDARD

## Study Objectives

The U.S. Department of Energy has developed a new energy standard for houses built by the federal government. In this demonstration project we want to evaluate how this standard may impact housing design, construction, and costs. We want to compare the original design and costs of a housing project with the design and costs of the same project if it had been built to meet DOE's new standard. At this time, we are primarily interested in effects on first-costs, that is costs to build the project, rather than lifetime costs that include operation and maintenance expenditures. We call this process a redesign because we are asking you to make new choices about the energy conservation features incorporated in the original design. We are not asking you to generate new design drawings, however. We also want to identify changes in contractor and government procedures that may result when DOE's standard is applied during actual housing procurements.

## How the Study Will Be Conducted

Your participation in this demonstration project has five steps, summarized as follows:

*Step 1: Review Point System Questionnaire and Redesign Worksheet* - You will use these two forms to document your experiences with this standard. Please read through them before you start the redesign.

*Step 2: Redesign the Project Using the Point System* - Completing the point system to show compliance with the DOE standard is the next step. The point system is a tool that a contractor can use to comply with DOE's standard. As you make decisions about what energy features of the house design to choose and change, you will use the point system to determine whether the revised design meets the point total requirements. You may want to start with the energy features in the homes as originally designed. When making changes, keep in mind that the design should still be as competitive as possible under the military's other criteria in effect when the project was first designed.

Contractors may use one of two approaches, either a manual "paper point system" that is completed using worksheets, or a computerized version that runs on a personal computer. The software version is called the Computerized Automated Point System (CAPS). The point systems allow you to select from a variety of energy options to meet the standard. We will ask you to complete either the paper point system or CAPS first and then repeat what you did with the other version of the point system.

*Step 3: Complete the Point System Questionnaire* - After completing both the paper point system and CAPS, please fill out the questionnaire. This questionnaire covers your experiences using the point systems.

*Step 4: Fill Out the Redesign Worksheet* - This worksheet documents the energy features in the original design and compares them to those you selected using

the point system. On the worksheet, provide the information requested on the energy features from the "new" design and the "old" design.

*Step 5: Follow-up Interview* - We'll telephone you at your convenience for a follow-up interview.

## Part 1 - REDESIGN THE PROJECT USING THE POINT SYSTEM

For complete point system instructions, refer to the two documents listed below:

*Point System User's Guide*

*CAPS Quick Reference Guide*

You can also call us on our hotline, toll free, at

1-800-537-5685

if any questions or problems arise. It is important for us to know about any problems or issues that arise, so please be sure to document them in the Point System Questionnaire when you fill it out.

## Part 2 - POINT SYSTEM QUESTIONNAIRE

Now that you have used the point system to "redesign" your project, please answer the following questions about your experience. We have provided space after each question for your response. If you need more space, please use a separate sheet of paper and indicate the question number. Please provide details to support your answers.

Who learned to use the point system for this demonstration and what was their overall role in the project (e.g., architect, builder).

| Name | Profession | Role in the project |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

### A. USING THE POINT SYSTEM

A.1. a) How much time did it take to understand and learn how to complete the paper point system?

_____

b) How much time did it take to understand and learn how to complete the automated (CAPS) point system?

_____

A.2. a) What difficulties did you have learning and using the paper point system?

_____

_____

_____

_____

b) What difficulties did you have learning and using the CAPS point system?

_____

_____

_____

_____

c) Did you have any difficulties obtaining the necessary hardware to run CAPS? What type of hardware did you use? Please explain.

A.3. a) Did your existing design comply with the DOE energy standard?

____Yes ____No

b) What difficulties did you have obtaining a satisfactory building design that complied with the point total requirements?

## B. DOCUMENTATION

B.1. Did the *Point System User's Guide* provide all the information you needed to understand and use the point systems? _____ Please explain.

B.2. Do you feel the *Point System User's Guide* was clear, easy to understand, and well organized? _____ If not, please describe which parts were difficult to understand or not well organized.

B.3. What changes or improvements could be made to make the *Point System User's Guide* easier to use and more useful?

_____

_____

_____

_____

B.4. Did the *CAPS Quick Reference Guide* provide all the information you needed to run CAPS? _____ Please explain.

_____

_____

_____

_____

B.5. Do you feel the *CAPS Quick Reference Guide* was clear, easy to understand, and well organized? _____ If not, please describe which parts were difficult to understand or not well organized.

_____

_____

_____

_____

B.6. What changes or improvements could be made to make the *CAPS Quick Reference Guide* easier to use and more useful?

_____

_____

_____

_____

## C. GENERAL QUESTIONS

C.1. a) What do you like about the paper point system?

b) What do you like about CAPS?

C.2. a) What are the drawbacks of the paper point system?

b) What are the drawbacks of CAPS?

C.3. What additional energy conservation measures or technologies do you feel need to be included in the point systems (e.g., other window or HVAC options)?

C.4. a) How could the format of the paper point system be improved?

b) How could the format of the CAPS point system be improved?

C.5. a) Was the paper point system useful as a design aid? _____ If so, please describe how.

b) How could the paper point system be improved to make it more helpful as a design aid?

c) Was the CAPS point system useful as a design aid? _____ If, so please describe how.

d) How could the CAPS point system be improved to make it more helpful as a design aid?

C.6. Are there aspects of the DOE standard that might make it difficult for you to meet any other federal agency requirements, either energy related or non-energy related? _____ If there are, please describe.

C.7. Compare using the point system tools to the process you followed to select energy features under the original federal requirements. Specifically, did you have more or less design flexibility? Did it take more or less time, require more or less expertise, etc? Please be specific.

C.8. How do you think using the DOE standard will affect your ability to competitively bid on housing projects?

C.9. How do you think using the DOE standard will affect your ability to design and build housing projects?

## Part 3 - REDESIGN WORKSHEET

### General Instructions

This worksheet compares the energy conservation measures you selected using the point system to those installed in the actual project. The purpose of this worksheet is to estimate the cost impacts of the new standard on a real housing project and to provide information on construction details. The worksheet should be filled out once for each different type of housing unit (ranch, two-story, apartment, etc.) and you should make as many copies of the worksheet as you will need. Redundant information does not need to be repeated on multiple worksheets, however.

Provide information for only those building components or equipment where you would have made a change from your original design. If no change would have occurred, enter "N/C."

### Costs

Provide the costs associated with each measure per housing unit. All costs should be in terms of the price charged to the federal government; i.e., costs should include material, labor, markup, G&A, etc. The cost provided for each component and piece of equipment should be the construction or installation cost. Incremental design and other one-time costs are requested at the end of this form. Please estimate all costs based on prices and costs in effect when you bid on the actual project. Do not use today's costs.

### Measurements

Areas refer to the areas of specific components. All areas should be in square feet. For foundations that are slab-on-grade or basements, the depth of the insulation is also needed.

### Terminology

"OLD" refers to the measures installed in the original design. "NEW" refers to the measures selected based upon use of the point systems.

If there is not enough room on the form to provide the requested information, please submit additional sheets with the information.

Project Name _____

Unit Description _____

Number of Units Built _____

**********

CEILINGS

OLD R-value = _____ Area = _____ (sq ft)

Total Insulation Cost = _____($)

NEW R-value = _____ Area = _____ (sq ft)

Total Insulation Cost = _____($)

Describe any construction changes and associated incremental costs, if any, resulting from the new insulation level:

_____

_____

_____

_____

**********

WALLS

Wall area should be the net area excluding windows and doors.

OLD R-value = _____ Area = _____ (sq ft)

Total Insulation Cost = _____($)

NEW R-value = _____ Area = _____ (sq ft)

Total Insulation Cost = _____($)

Describe any construction changes and associated incremental costs, if any, resulting from the new insulation level (account for wall changes due to window changes in the window section):

_____

_____

_____

_____

**********

## FLOORS

Type of Foundation: _____

OLD R-value = _____ Area = _____ (sq ft) Depth = _____ (ft)

Total Insulation Cost = _____($)

NEW R-value = _____ Area = _____ (sq ft) Depth = _____ (ft)

Total Insulation Cost = _____($)

Describe any construction changes and associated incremental costs, if any, resulting from the new insulation level:

_____

_____

_____

_____

**********

## INFILTRATION CONTROL MEASURES

OLD Cost = _____($)

Describe air infiltration control measures and associated costs:

_____

_____

_____

_____

NEW Cost = _____($)

Describe air infiltration control measures and associated costs:

_____

_____

_____

_____

**********

GLAZING (WINDOWS, GLASS DOORS, SKYLIGHTS)

OLD Glazing Area = _____ sq ft  Type of Glass: e.g., single, double, tinted, low-E, etc._____

Sash Type (e.g., aluminum, wood, etc.): _____

Describe passive solar design features (e.g., glazing area facing each direction, sunspace, thermal mass, shading devices)

_____

_____

_____

Glazing Cost = $ _____

Movable Insulation (circle one)? Yes No  R-value = _____

Movable Insulation Cost = _____ ($)

NEW Glazing Area = _____ sq ft  Type of Glass: e.g., single, double, tinted, low-E, etc._____

Sash Type (e.g., aluminum, wood, etc.): _____

_____

Describe passive solar design features (e.g., glazing area facing each direction, sunspace, thermal mass, shading devices)

_____

_____

_____

Glazing Cost = $ _____

Movable Insulation (circle one)? Yes No  R-value = _____

Movable Insulation Cost = _____ ($)

Describe any construction changes and the associated incremental costs, if any, resulting from the new glazings (include resulting changes to walls)

_____

_____

_____

**********

## HEATING EQUIPMENT

Unit cost should include only the cost of the equipment and related controls. Ducting costs should not be included.

OLD Type of system and fuel (electric furnace, electric baseboard, gas furnace, etc.)

_____

Rated Efficiency = _____AFUE (or HSPF for heat pumps only)

Rated Capacity = _____ Unit Cost = _____ ($)

NEW Type of system and fuel (electric furnace, electric baseboard, gas furnace, etc.)

_____

Rated Efficiency = _____AFUE (or HSPF for heat pumps only)

Rated Capacity = _____ Unit Cost = _____ ($)

Additional comments on heating system: _____

_____

_____

_____

_____

**********

## COOLING EQUIPMENT

OLD SEER Rating = _____ Unit Cost = _____ ($)

Rated Capacity = _____

NEW SEER Rating = _____ Unit Cost = _____ ($)

Rated Capacity = _____

Additional comments on cooling system: _____

_____

_____

_____

**********

WATER HEATER

OLD Fuel Type_____ Label Value = _____ ($)

Unit Cost = _____ ($)

NEW Fuel Type_____ Label Value = _____ ($)

Unit Cost = _____ ($)

Additional comments on water heaters: _____

_____

_____

_____

**********

REFRIGERATOR/FREEZER

OLD Label Value = _____ ($) Unit Cost = _____ ($)

NEW Label Value = _____ ($) Unit Cost = _____ ($)

Additional comments on refrigerator/freezers: _____

_____

_____

_____

## ADDITIONAL INFORMATION

Please provide any additional comments on construction and cost related issues that are not addressed above:

Please provide an estimate of any one-time changes in costs that might have occurred if you had used the DOE standard on this project instead of the original requirements. For example, if the standard would have required you to spend more effort designing any building components, please describe which ones and indicate the cost impacts. Also, if the standard would have required you to obtain information that you were not required to obtain originally, please indicate which information and the cost impacts.

Alternative Compliance Procedure Questionnaire

The basic method of compliance for the DOE standards is by meeting or exceeding the point total in the compliance forms (CAPS or paper point system). An alternative procedure is available however, which allows the bidder to use the DOE-2 computer program to show compliance. DOE-2 is a publicly available hourly simulation model which can be used to calculate the yearly space conditioning energy loads for the proposed house(s) based on construction materials, architectural design, operating conditions, and climate.

Bidders can request the use of the "alternative compliance procedure" if their proposed design has unusual or innovative features not given credit in the point system. The bidder must run the DOE-2 simulation model for the proposed design with basic assumptions about operating conditions, such as thermostat set points and internal gain schedules, specified by the federal agency.

The proposed design complies with the standards if the energy life-cycle cost (LCC) calculated from the DOE-2 simulations is equal to or less than the optimal energy LCC obtained from the compliance forms. The Federal agency will provide you either the LCC or a procedure to calculate it. If the alternative compliance procedure is used, the bidder will have to provide the Federal agency with documentation on the DOE-2 simulations and supporting material.

The following questions are intended to gather information on the adequacy of the alternate compliance procedure from the bidder's point of view.

1. Are you familiar with the DOE-2 simulation program? ____Yes ____No

2. Do you believe the use of a simulation model such as DOE-2 by bidders is feasible with the time constraints of the proposal process?
   ____Yes ____No

3. a) Do you feel there have been, or could be, housing projects where you would wish to show compliance using the more flexible alternative compliance procedure?
   ____Yes ____No

   b) For what reason(s) would you consider using the alternative compliance procedure?

   _____

   _____

   _____

   c) If you chose to use the alternative compliance procedure, would you have access to the DOE-2 computer program?
   ____Yes ____No

   Who would do the necessary DOE-2 runs?

4. a) Are there other widely-accepted simulation models (e.g., BLAST, SUNCODE) which you are familiar with? ____Yes ____No

b) What are these models?

c) Would you like to see any of these other models permitted in the alternative compliance procedure?
____Yes ____No

If yes, which other models would you like to see permitted?

d) Other than the point system or the use of a simulation model, are there any compliance paths which you would like to see included in the standard?

APPENDIX D

AGENCY COMMENTS ON DOE STANDARDS

# APPENDIX D

## AGENCY COMMENTS ON DOE STANDARDS

This appendix discusses the comments on drafts of this report received from the four federal agencies participating in the demonstration. The comments of each of the agencies are paraphrased in the following sections. Following the comments are discussions of how the remarks were addressed in this final report.

### D.1 AIR FORCE COMMENTS

The Air Force's comments were primarily wording and grammar changes; most of their comments were on Section 4.1 "DOD Procurement Process." This section was based on a report written for PNL by a subcontractor familiar with the DOD procurement process. The Air Forces's editorial comments were incorporated. The Air Force also made a general comment that their current methodology for energy conservation is better than the DOE standards because the Air Force methodology is based on energy consumption, while the DOE standards are based on costs, which are always changing. The DOE standards are based on climate and life-cycle costs. Life-cycle costs were chosen as the basis for the standards because Congress specified that federal agencies use life-cycle costs in their procurement process. In addition, DOE was required to analyze the economic impacts of the standards during the demonstration.

### D.2 ARMY COMMENTS

The Army had three main comments which were addressed as follows.

The Army asked who will maintain and update the COSTSAFR program. They questioned whether the program included the latest NIST economic criteria or the latest in technological advances. They also felt it was unrealistic and not cost effective to expect each office or agency to maintain and update the program. These concerns are addressed in Recommendations 10, 12, and 23 in Chapter 9 of the report.

The Army felt that use of the alternative compliance procedure was not realistic and that the limitations in energy-saving design features in COSTSAFR should be clearly recognized in the report. These comments were addressed in Findings 8 and 11 in Chapter 8 of the report.

The Army questioned the accuracy of the model on which PNL's foundation insulation assumptions were based. The Army uses the BLAST computer simulation. The DOE standards are based on the DOE-2 simulation model. A comparison of the two models was beyond the scope of this project.

Editorial revisions were made in response to the Army's editorial comments.

## D.3 NAVY COMMENTS

The Navy pointed out that their energy conservation standards are based first on an applicable energy target budget and second on life-cycle costs. The Navy also noted that their target energy figures include hot water heating and lighting and that the budget figures are adjusted for the local climate. The DOE standards account for hot water heating, but do not analyze lighting energy except to include it in internal loads used in the modeling of energy requirements. These aspects of the Navy's energy target budget are discussed in Section 6.1.1.

The Navy said that the proposed point system does not address HVAC equipment. This observation was added to Section 8.3.1 of the findings chapter. The Navy commented that the freedom to choose options offered by the proposed standards may cause designers to engage in time-consuming trial and error. They also observed that the seven-page-long point system forms produced by COSTSAFR may intimidate contractors. DOE developed the CAPS automated point system program, in part, to minimize the amount of paperwork required by the standards. The Navy's observations are noted in Section 8.3.1 of the findings chapter.

The Navy suggested that a detailed application of the standards to a specific project should be conducted and documented. The detailed documentation could be distributed to federal agencies to show the advantages

of the DOE standards; agencies could also use it as an example. This suggestion was added to Section 8.5.1 of Chapter 8.

## D.4 DEPARTMENT OF HEALTH AND HUMAN SERVICES COMMENTS

The comments of the DHS were primarily editorial or technical comments regarding the procedures of their programs. All of these comments were incorporated.

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