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REPORT BY THE U.S.

General Accounting Office

Energy-Efficient And Cost-Effective Equipment Should Be Installed In New Government Housing

Energy use in new Government residential housing can be substantially reduced if more efficient air conditioners, furnaces, and water heaters are installed. In turn, Government expenditures for utilities would be reduced and homeowners would benefit economically through reduced cash outlays.

GAO recommends that agencies that directly or indirectly pay the utility costs of housing they own or subsidize require the installation of higher efficiency equipment through administrative procedures.

GAO also recommends that installation of this equipment be encouraged among builders and buyers of Government insured and guaranteed housing.

EMD-81-93
SEPTEMBER 16, 1981

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

ENERGY AND MINERALS
DIVISION

B-204659

The Honorable Samuel R. Pierce, Jr.
The Secretary of Housing and Urban Development

The Honorable Caspar W. Weinberger
The Secretary of Defense

The Honorable Charles W. Shuman
Administrator of Farmers Home

The Honorable Robert P. Nimmo
Administrator of Veterans Affairs

We have evaluated the efforts being made and the actions that could be taken to make Government housing 1/ more energy efficient. The Federal Government, through its construction of, and assistance in, developing and financing new housing, can reduce residential energy consumption by requiring that more energy-efficient and cost-effective central air conditioners, furnaces, and water heaters be installed in such housing. Studies have shown that heating and cooling equipment account for as much as 70 percent of the energy consumed in a house. Much of the equipment now being installed is of low-to-moderate energy efficiency; whereas, equipment with higher energy efficiency is readily available in the marketplace. Installation of the more efficient equipment would reduce Government expenditures for utilities as well as provide economic benefits to home buyers through reduced cash outlays for combined mortgage and utility payments.

The results of our comparison of the life-cycle cost of owning and operating equipment meeting the Department of Energy's

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1/For the purposes of this report, Government housing is defined as that which is entirely owned, assisted through direct subsidies, and financed by Government guaranteed or insured loans. Government housing is in essence administered by the Departments of Defense and Housing and Urban Development, the Farmers Home Administration, and the Veterans Administration.

(DOE's) proposed intermediate appliance standards 1/ with equipment that is more energy efficient are contained in appendix I. Our analyses show that, in the extreme southern part of the country, central air conditioners consuming 7 to 33 percent less energy would be more economical than equipment meeting the proposed intermediate standards. In the northern part of the country, gas furnaces that consume 10 to 21 percent less energy would be more economical. Water heaters that consume 6 to 23 percent less energy would be more economical in all areas of the country.

Builders and developers of new houses are primarily concerned with installing equipment that adequately performs the required function at the lowest initial price. But they have little incentive to install the more energy-efficient equipment that has a higher initial price because it increases the total cost of the house, and results in a higher priced house for a potential buyer or reduced profits for a builder.

The Department of Housing and Urban Development (HUD), which is principally responsible for Government programs concerned with housing needs, sets construction standards through its Minimum Property Standards. These standards are also used by other Federal agencies in the design and construction of new housing. HUD has encouraged energy savings in new housing by developing and upgrading the standards for insulation and for storm doors and windows. The standards do not, however, prescribe any minimum energy efficiencies that must be met for central air conditioners, furnaces, and water heaters.

As indicated above, normal market forces, in themselves, do not encourage the installation of the most energy-efficient and cost-effective heating and cooling equipment. We believe that recognizing and promoting the benefits of installing more efficient equipment in Government housing could best be accomplished through the Minimum Property Standards. However, we understand that, as part of the administration's regulatory reform, HUD is examining the standards with a view toward eliminating them in favor of local standards.

The energy and cost benefits from installing more efficient equipment should not be lost in the process of regulatory reform. We believe that, at a minimum, those agencies that pay, either directly or indirectly, the utility costs of housing they own

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1/These standards, being developed in accordance with the National Energy Conservation Policy Act (P.L. 95-619), would prescribe minimum energy efficiencies that must be achieved by appliance manufacturers. DOE is phasing in the appliance standards by issuing two sets of standards, first an intermediate standard and then, 5 years later, a final standard. However, on February 17, 1981, the administration suspended the rulemaking process, announcing a reassessment of the proposed standards.

or subsidize should require the installation of higher efficiency equipment through administrative procedures. As shown in appendix I, the Defense Department and the Farmers Home Administration have already issued administrative procedures that recognize the importance of saving energy in homes that they either own or subsidize. For example, the Defense Department has issued administrative memorandums which require the installation of more efficient equipment for its housing. These requirements, however, have not been updated since their promulgation beginning in 1973 and do not include all types of heating and cooling equipment.

Concerning Government insured and guaranteed housing, we believe that agencies should, through their contacts with builders and buyers, promote the benefits, and encourage the installation of, higher energy-efficient equipment. The mechanisms for these contacts already exist. For example, both HUD and the Veterans Administration have approved forms that promote certain energy conservation actions among homebuyers, such as installing storm doors or windows and adding insulation to walls or ceilings. These forms could be modified to also encourage the installation of more efficient heating and cooling equipment.

RECOMMENDATIONS

We recommend that the Secretaries of Defense, and Housing and Urban Development, and the Administrator of Farmers Home continue and expand their energy conservation efforts by administratively requiring the installation of high-efficiency heating and cooling equipment in housing that they either own or subsidize. The level of equipment efficiency to be required should be determined in cooperation and coordination with the Department of Energy.

For Government insured and guaranteed housing, we recommend that the Secretary of Housing and Urban Development and the Administrator of Veterans Affairs promote, through their contacts with builders and buyers, the benefits and encourage the installation of high energy-efficient equipment.

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

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

At the conclusion of our field work, the matters presented in this report were discussed with responsible agency officials. All comments were considered during the report's preparation. In addition, we received official oral comments from Defense Department officials in which they agreed with our findings and recommendations.

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

J. Dexter Peach
Director

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ABBREVIATIONS

AFUE	Annual fuel utilization efficiency
Btu/h	British thermal units per hour
DOD	Department of Defense
DOE	Department of Energy
FHA	Federal Housing Administration
FmHA	Farmers Home Administration
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
kWh	kilowatt-hour
SEER	seasonal energy efficiency rating
VA	Veterans Administration

INTRODUCTION

This report discusses the efforts being made and the actions that could be taken to make Government housing more energy efficient. For the purpose of this report, Government housing is defined as that which is either entirely owned or assisted through direct subsidies, such as below-market interest rates, and housing financed by Government guaranteed or insured loans.

Residential energy consumption accounts for about 20 percent of the Nation's energy use. Studies have shown that heating and cooling equipment, including water heaters, account for as much as 70 percent of the energy consumed in a house. Conservation efforts have concentrated on the thermal envelope (e.g., insulation, storm windows and doors, and infiltration) of new houses with little attention focused on the energy efficiency of equipment that provides needed space heating, air conditioning, and water heating.

Although most housing is privately financed and developed without Federal assistance, the Federal Government, through its construction and assistance in developing and financing new housing, can have a significant influence on reducing residential energy consumption. Under programs administered by the Department of Housing and Urban Development (HUD), the Veterans Administration (VA), the Farmers Home Administration (FmHA), and the Department of Defense (DOD), energy conservation practices can be fostered in Government owned, subsidized, and insured housing.

HUD administers a variety of programs to help meet the Nation's need for decent housing for all Americans. During the last few years, HUD's single-family home mortgage programs have averaged approximately 100,000 new home starts each year. One of HUD's largest programs to encourage home ownership by facilitating construction and financing is the one-to-four-family home mortgage insurance program. The program is administered by the Federal Housing Administration (FHA) within HUD and is traditionally referred to as FHA insurance. HUD also provides mortgage insurance and interest subsidies for low-to-moderate income home buyers.

In addition to those programs to encourage home ownership, HUD also provides rent subsidies for lower income families to help them afford decent housing in the private sector. Eligible tenants pay no more than 25 percent 1/ of their adjusted income for utilities and rent. As a result, the Government may, in effect, pay a substantial portion of a tenant's utility costs. Although not owned by the Federal Government, subsidized housing must meet certain HUD standards. On the average, about 100,000 new units are constructed each year under this program.

1/Effective October 1, 1981, this maximum will be increased to 30 percent of adjusted income.

Another large Federal program to provide housing to Americans is administered by VA. The VA loan guaranty program enables veterans to purchase housing with little or no down payment. Since 1978, VA has guaranteed approximately 70,000 new home loans a year.

FmHA provides loan guarantees to private lenders or makes direct loans to individuals in open country or rural communities. Loans are guaranteed up to 90 percent or are financed directly at interest rates varying from 1 to 13 percent. In 1981, FmHA estimates that its program activity will assist in the purchase of about 48,500 new homes. Of these homes, approximately 36,000 are expected to be subsidized below the 13-percent interest rate.

DOD is the largest owner of family housing units in the Government. In fiscal years 1979 to 1981, DOD was authorized to construct 4,251 single-family housing units.

WHAT HAS BEEN DONE TO IMPROVE THE ENERGY EFFICIENCY OF HOUSING

The Federal Government has taken several actions to improve the energy efficiency of new homes. These actions include incorporating energy-efficiency requirements in minimum property standards, labeling and developing efficiency standards for appliances, and improving individual agency operating procedures.

Minimum property standards have been improved

HUD's Minimum Property Standards describe those characteristics in a property which will provide present and continuing utility, durability, desirability, economy of maintenance, and a safe and healthful environment. These property characteristics have been revised over the years, addressing such areas as safety, fire, plumbing, electrical, and energy concerns.

Minimum Property Standards are intended to provide a sound technical basis for the planning, design, and construction of housing under numerous HUD programs. Since the standards were first developed, they have been oriented to types of buildings rather than to programs or type of occupancy. As such, other agencies including VA, FmHA, and DOD have been able to use the HUD standards as a basis for their own programs.

HUD has changed the standards over the years to improve the energy efficiency of the housing envelope. The latest revision to the standards for improving the thermal efficiency of one- and two-family dwellings became effective on May 16, 1979. The standards do not, however, prescribe any minimum levels that must be achieved for home heating, air conditioning, and water heating equipment installed, but make reference to nationally recognized building industry guides and recommend that such publications be used as guidance.

Labeling appliances according to their energy efficiency

To help consumers reduce their energy costs and conserve energy, the Department of Energy (DOE) and the Federal Trade Commission are conducting an appliance-labeling program (EnergyGuide) in accordance with Section 324 of the Energy Policy and Conservation Act (P.L. 94-163). Since the spring of 1980, EnergyGuide labels have been required to be affixed to seven types of household appliances. The labels show the energy efficiency rating or the average yearly energy cost for the appliance. Refrigerators, freezers, dishwashers, clothes washers, and water heaters carry the labels. Energy efficiency information is also available for room air conditioners and home furnaces. However, this program would be of limited benefit to a buyer of a new home, since heating and cooling equipment is normally selected by the builder.

Proposed energy efficiency standards for appliances

In accordance with requirements of the National Energy Conservation Policy Act (P.L. 95-619) DOE proposed mandatory energy efficiency standards for nine types of major household appliances, including air conditioners, furnaces, and water heaters. The proposed standards precribe an energy efficiency level that must be achieved by appliance manufacturers. The proposal originally contained two levels of standards, an intermediate standard (effective July 15, 1981), and a more stringent final standard (effective Jan. 1, 1986). However, as part of the administration's plans to reduce regulatory programs, DOE announced, in February 1981, that the standards would be delayed. DOE plans to thoroughly review the analysis upon which the proposed standards were based before proceeding with finalization.

Individual agency efforts

Federal Departments have implemented some actions to improve the energy efficiency of housing under their purview. In August 1973, DOD issued a memorandum to the Assistant Secretaries of the Army, Navy, and Air Force requiring that all future central air conditioning systems of 60,000 British thermal units per hour (Btu/h) or less achieve an energy efficiency rating of 7.5 or better. In May 1975, DOD also issued a memo recognizing that the most efficient method of using electric power for heating is the water-source heat pump; the air source heat pump is DOD's second choice. It established a moratorium on the installation of all types of electric resistance heating for all personnel comfort space-heating applications. In addition to requiring more efficient heating methods, DOD's memo imposed minimum efficiency standards for air source heat pumps and prohibited the use of standing pilots on gas furnaces. These requirements, however, have not been updated since their issuance and do not include all types of heating and cooling equipment.

FmHA has adopted stricter thermal efficiency standards than HUD's Minimum Property Standards. FmHA standards require the same level of thermal efficiency for all houses, whereas the HUD standards have reduced requirements for homes using oil, natural gas, or heat pumps for heating.

FmHA has also promoted the use of solar energy in rural homes and has proposed an incentive program for builders who exceed the insulation or passive solar requirements or otherwise reduce energy consumption below a conventionally designed building.

HUD and VA have jointly developed a form designed to inform and encourage homebuyers to conserve energy. The form is filled out by an appraiser to promote certain energy conservation actions such as installing storm doors or windows and adding insulation to walls or ceilings.

OBJECTIVE, SCOPE, AND METHODOLOGY

Our objective was to determine what is being done and what more could be done to improve the energy efficiency of Government owned, subsidized, and insured housing. We limited our scope to new housing because of various Federal efforts already directed toward energy improvements in existing residences. For example, the Congress required DOD to study the feasibility of metering Government-owned military housing units. The National Energy Conservation Policy Act also requires HUD to conduct a study on the need for, feasibility of, and problems with mandatory thermal-energy-efficiency standards at the time of sale or exchange of a house.

Our review centered on the energy efficiency of equipment installed by builders of new homes--central air conditioners, natural gas furnaces, and water heaters. Heat pumps were not considered because, at the time of our review, standardized measures of energy efficiency had not been issued by DOE for this equipment. We sought to determine whether installation of more energy-efficient equipment would be cost effective over its expected life. Although less energy-efficient equipment is being installed, we compared energy consumption and costs of owning and operating available energy-efficient central air conditioners, furnaces, and water heaters with equipment meeting the intermediate standards proposed by DOE. This was done because at the time of our review, it was anticipated that all equipment manufacturers would be required to meet these standards.

To make such determinations, we used a well-recognized method known as life-cycle cost analysis to compare equipment of different energy efficiencies. Life-cycle costs include the cost of owning (purchase price) plus the discounted operating (energy cost) and maintenance costs over the estimated lifetime of the equipment.

We excluded the cost of maintenance from our calculations because of the absence of quantifiable maintenance data among models of different efficiencies. Some suppliers indicated that energy-efficient air conditioners may have lower maintenance costs. However, add-on devices for furnaces, such as vent dampers and electronic pilot ignitions, may entail increased maintenance expenditure at some point in the unit's expected life.

In order to consider purchase price and operating costs on a time-equivalent basis, all future operating costs were discounted to their present value. We used the 10-percent discount rate prescribed by the Office of Management and Budget in Circular A-94. Circular A-94 further requires all cost estimates be made in constant dollars. Our calculations included only projected future energy price increases above the rate of inflation. We used 1980 base year energy prices of 6 cents per kilowatt hour (kWh) and 40 cents per therm of natural gas as developed by DOE's Energy Information Administration and published in the Federal Register, October 27, 1980. We estimated energy price increases above the rate of inflation of 1 percent for electricity and 3 percent for natural gas.

We obtained estimated life expectancies of central air conditioners, natural gas furnaces, and water heaters from average equipment lifetimes developed by DOE. The following estimated life expectancies were used: 14 years for central air conditioners, 20 years for natural gas furnaces, and 10 years for water heaters.

Data were obtained on the energy efficiency rating, the operating cost, and the price of equipment from nine large suppliers of furnaces and/or central air conditioners 1/ and four large suppliers of water heaters. 2/

We

--interviewed HUD, FmHA, VA, DOD, and DOE headquarters officials and HUD field officials in Texas, Nebraska, Oklahoma, and Missouri and FmHA field officials in Oklahoma and Missouri responsible for, or involved in, residential energy conservation;

--interviewed individuals in the private sector--an architect-engineer, equipment manufacturers and distributors, and home builders--concerning thermal performance and energy efficiency of equipment in residential housing;

1/Bryant, Carrier, Coleman, General Electric, Heil Quaker, Lennox, Rheem, Sears, and SJC Corporation (Frigiking and Tappan).

2/A.O. Smith, Rheem, Sears, and State Industries.

--reviewed DOE, National Bureau of Standards, and private documents that used the life-cycle cost approach in determining the cost effectiveness of energy-efficient equipment;

--obtained data on DOE's proposed intermediate minimum performance standards for new residential equipment manufactured;

--reviewed HUD's Minimum Property Standards and FmHA and DOD documents and directives relating to thermal performance and energy efficiency of equipment in new residential housing; and

--researched thermal performance and equipment energy criteria, guidance and/or recommended standards published by several nationally recognized organizations--American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.; Air Conditioning and Refrigeration Institute; and National Association of Home Builders--and various State codes dealing with energy conservation in residential housing.

HIGHER ENERGY-EFFICIENT AND COST-EFFECTIVE EQUIPMENT SHOULD BE INSTALLED IN NEW GOVERNMENT HOUSING

New residential housing will consume substantially less energy if builders install more energy-efficient central air conditioners, furnaces, and water heaters. The equipment being installed is of low-to-moderate energy efficiency in relation to the more energy-efficient equipment which is readily available. Although the purchase price of the more energy-efficient equipment tends to be higher than that of less efficient equipment, the reduced operating costs can more than offset the difference in purchase price, thus making this equipment life-cycle cost effective.

The Federal Government, through its direct construction of, and assistance in, developing and financing new housing, has an opportunity for reducing the Nation's energy use as well as its own direct and indirect cash outlays for utilities by encouraging the installation of more efficient equipment. If more energy-efficient equipment were installed in those areas of the country where use is sufficient, home owners' energy use and monthly cash outlays for combined mortgage and utility payments could be reduced.

LOW-TO-MODERATE ENERGY-EFFICIENT EQUIPMENT IS BEING INSTALLED

Much of the equipment being installed in new Government owned, subsidized, and insured housing is of low-to-moderate energy efficiency. A home buyer usually does not have an opportunity to select the central air conditioner, furnace, or water heater to be installed in a new house. Such equipment is usually selected by a builder or developer and included in the total price of the house. FHA officials and builders advised us that equipment installed is usually of the low-energy-efficiency type because these units have a lower purchase price and help to hold down the initial price of the house. For example, a central air conditioner installed in a new FHA-insured house has a seasonal energy efficiency rating (SEER) 1/ as low as 6.5 although some equipment available on the market have ratings of 11 and higher.

Builders and developers are primarily concerned with installing equipment in new houses that adequately performs the required function at the lowest initial price. Manufacturers price central air conditioners, gas furnaces, and water heaters commensurate with their energy efficiency. That is, the more energy-efficient

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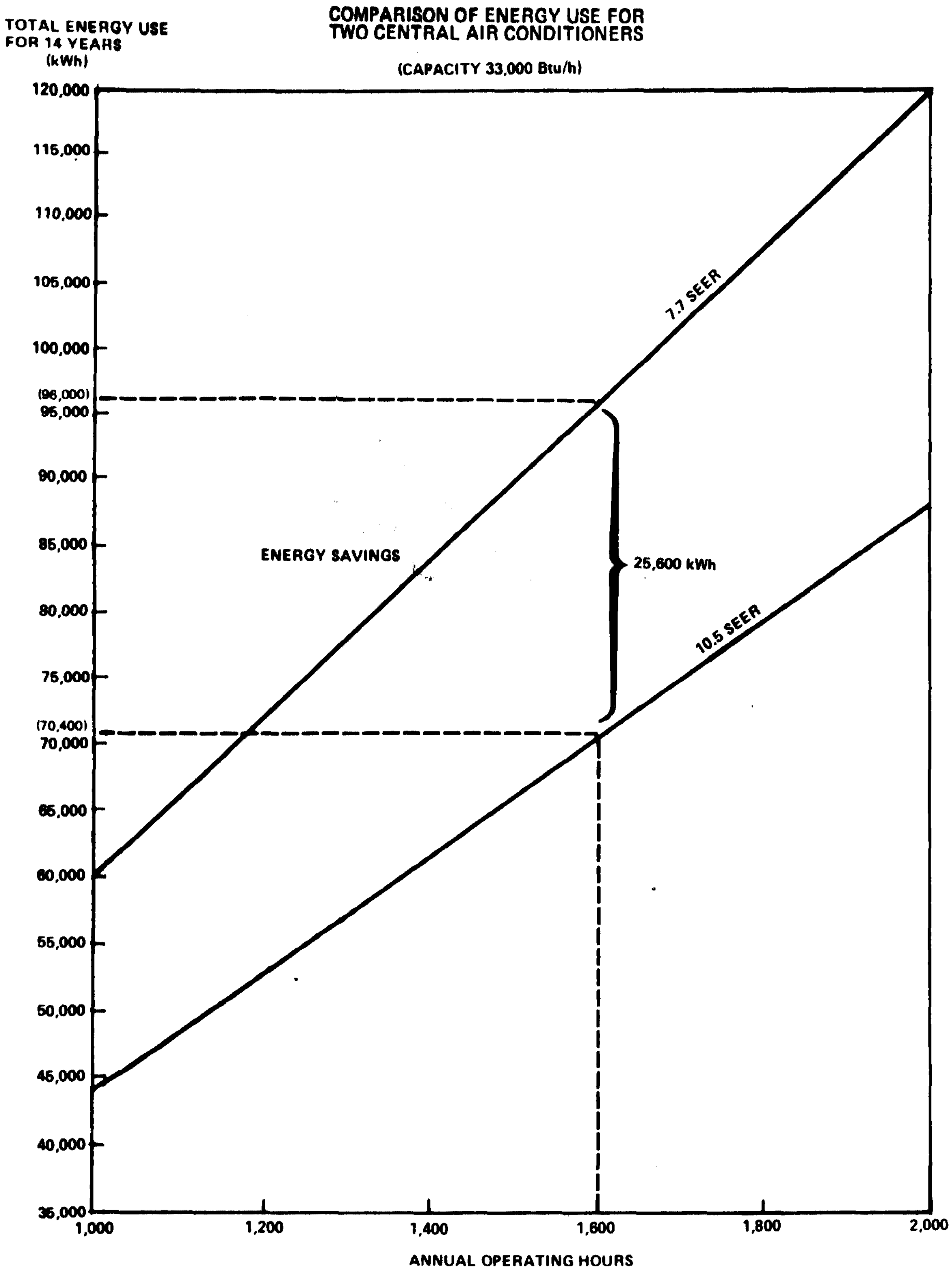
1/A term that designates the energy efficiency rating of air conditioners stated as a ratio of the cooling capacity divided by the energy required to operate the equipment. The higher the number, the more efficient the unit.

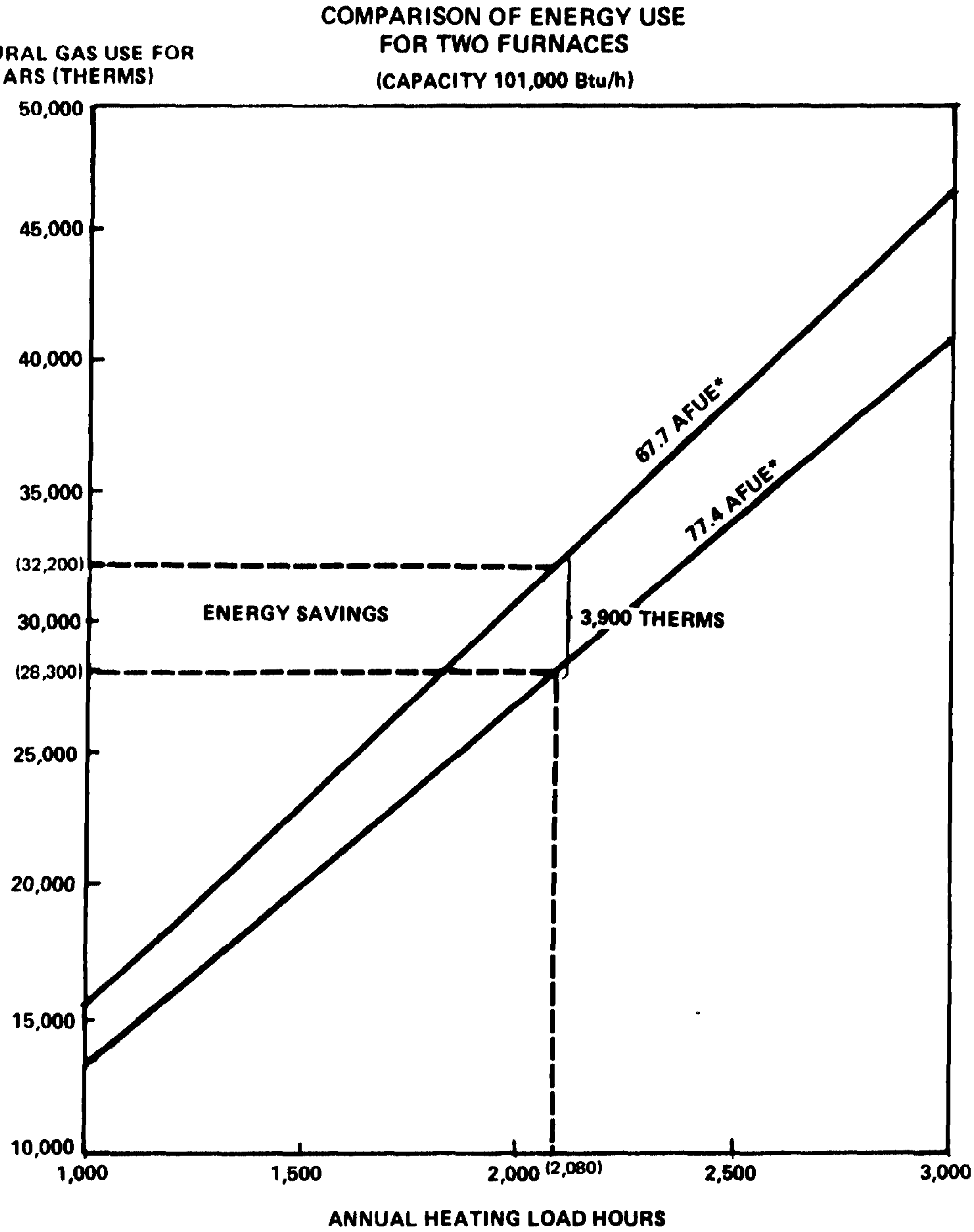
models are generally priced higher than lower rated models. Builders of new residential houses have little incentive to install the more energy-efficient equipment that has a higher initial price, increases the total cost of the house, and results in a higher priced house for a potential buyer or reduced profits for builders.

HIGHER ENERGY-EFFICIENT EQUIPMENT IS AVAILABLE IN THE MARKETPLACE

Through our contacts with equipment suppliers and home builders, we found commercially available equipment that had higher energy efficiency ratings than those required by DOE's proposed interim efficiency standards. In this respect, all of the higher energy-efficient equipment discussed in this report was available in the marketplace at the time of our review.

Energy savings from using more energy-efficient central air conditioners, gas furnaces, and water heaters, which are readily available in the marketplace, can be substantial. For example, a 33,000-Btu/h air conditioner with a 10.5-energy efficiency rating will consume about 27 percent less electricity than one of similar capacity with a 7.7 rating which essentially meets the intermediate standard proposed by DOE. A natural gas furnace with a 101,000 Btu/h capacity and a 77.4 efficiency rating will consume about 12.5 percent less energy than a similarly sized furnace with a 67.7 efficiency rating which meets the minimum standard proposed by DOE. The significance of this potential over the life of the equipment is illustrated in the following graphs which show total life-cycle energy savings of 25,600 kWh for two air conditioners we compared and 3,900 therms of natural gas for two furnaces, at the assumed operating hours of 1,600 and 2,080, respectively.


TOTAL ENERGY USE
FOR 14 YEARS
(kWh)
COMPARISON OF ENERGY USE FOR
TWO CENTRAL AIR CONDITIONERS
(CAPACITY 33,000 Btu/h)
120,000
115,000
110,000
105,000
100,000
(96,000)
95,000
90,000
85,000
80,000
75,000
(70,400)
70,000
65,000
60,000
55,000
50,000
45,000
40,000
35,000
7.7 SEER
ENERGY SAVINGS
25,600 kWh
10.5 SEER
1,000
1,200
1,400
1,600
1,800
2,000
ANNUAL OPERATING HOURS



*AFUE - Annual Fuel Utilization Efficiency - a term that designates the energy efficiency rating of furnaces.

IDENTIFICATION AND LIFE-CYCLE COST COMPARISON OF EQUIPMENT

We obtained data on the energy efficiency rating, the operating cost, and the price of equipment available from nine large suppliers of central air conditioners and/or furnaces and four large suppliers of water heaters. Equipment suppliers provided us with prices on their equipment that would approximate those charged to home buyers.

Our life-cycle-cost calculations compare equipment with high energy efficiency ratings to lower rated units offered by the same manufacturer or supplier that essentially meet DOE's proposed intermediate standards. We did not compare one manufacturer's units to other manufacturers' units because features other than energy efficiency can affect price. All suppliers get higher prices for their more energy-efficient units, but in some instances, higher efficiency units from one manufacturer cost less than lower efficiency units of the same capacity from another manufacturer.

Energy-efficient equipment can reduce owning and operating costs

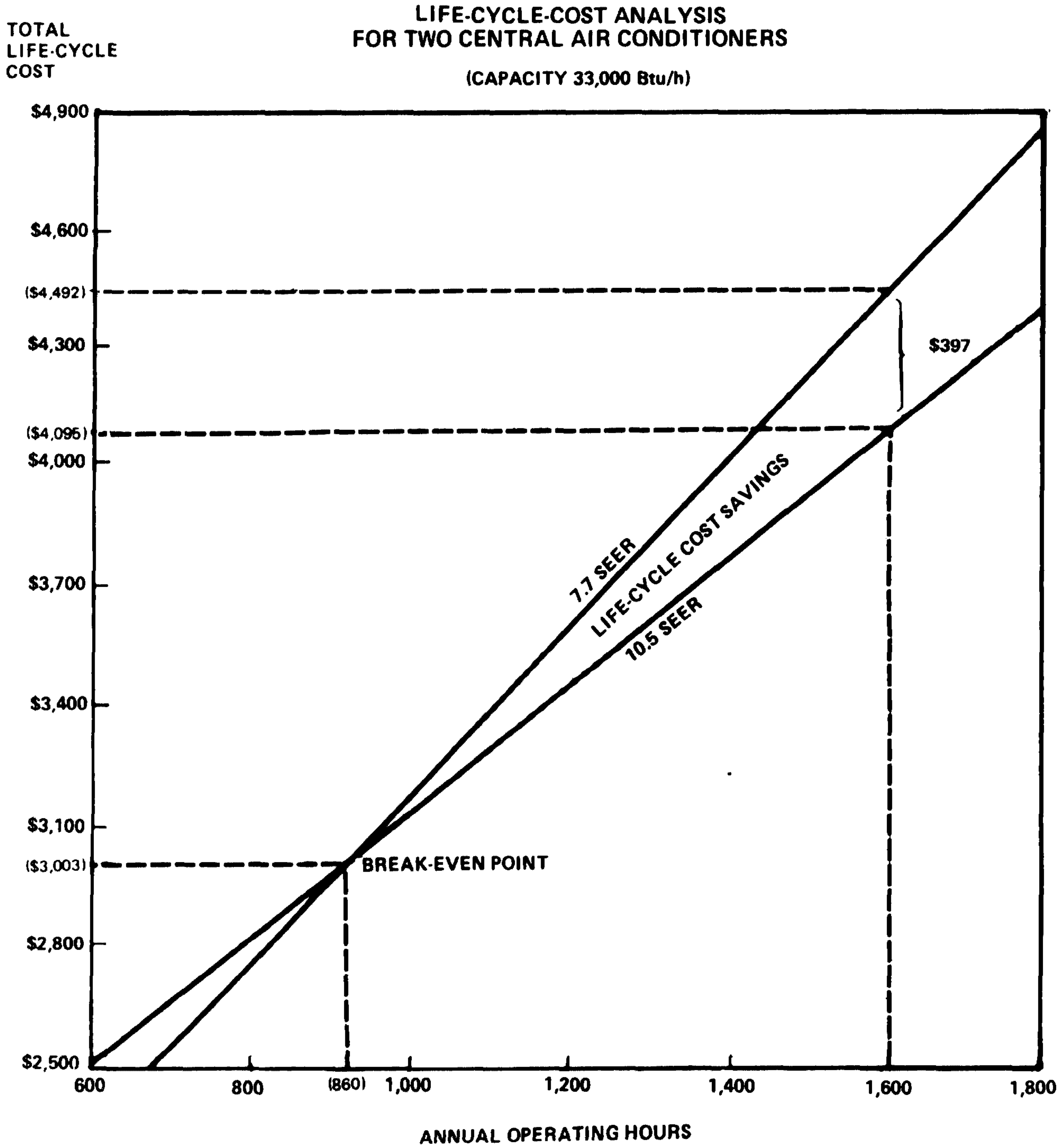
Installation of more energy-efficient equipment is economically justified on a life-cycle-cost basis; however, the extent of use is an important factor bearing on the life-cycle cost of each type of equipment. More energy-efficient air conditioners can be economically justified in the extreme South, where the hours of use normally are sufficient to consume substantial amounts of energy. Higher efficiency gas furnaces, on the other hand, tend to be more cost effective in the northern half of the country. More efficient gas water heaters would be economical in all areas of the country since the volume of water consumed, rather than the unit's location, affects cost effectiveness.

Other factors affecting the life-cycle costs of equipment include initial purchase price, capacity or size of the equipment, energy efficiency of the equipment, unit price of energy, useful life of the equipment, and discount rate used to determine the present value of future costs.

Central air conditioners

With few exceptions, more energy-efficient central air conditioners in the 23,000- to 49,000-Btu/h capacity range, having an SEER rating of about 9 to 11, cost less to own and operate than units rated at DOE's proposed intermediate standard of 7.8 SEER, assuming 1,600 operating hours or more a year. Such use is normally required in the extreme southern parts of the country. (See fig. I.) The higher rated units would consume 7 to 33 percent less energy than the lower rated units. The following graph shows a comparison of two 33,000 Btu/h air conditioners with a 27-percent energy efficiency improvement (7.7 SEER to 10.5 SEER).

At the asssumed operating load of 1,600 hours, the more efficient unit saves $397 over the system's life. In this case, the break-even point is reached with less than 1,600 hours use.



We selected six to eight units from each of the eight suppliers. The units selected are representative of those offered by each supplier. In making a comparative life-cycle-cost analysis of these central air conditioners, we used 1,600 cooling load hours as the operating hours of the units. The results of these comparisons are shown in table I on pages 22 and 23.

The following example illustrates the lower life-cycle cost of using a more energy-efficient central air conditioner.

Comparison of Two Central Air conditioners

(Capacity, 42,000 Btu/h)

	Lower efficiency unit	Higher efficiency unit
Life-cycle cost factors:		
Efficiency rating (SEER)	7.85	10.3
Annual cost of electricity (note a)	$514.00	$391.00
Discount factor (note b)	7.8243	7.8243
Life-cycle costs:		
Discounted cost of electricity	$4,019	$3,063
Retail price	1,059	1,749
Total life-cycle cost	$5,078	$4,812

a/Electricity used per hour x 6 cents/kWh x 1,600 operating hours.

b/A factor used to determine present value of operating costs over a 14-year system life, discounted at 10 percent plus a fuel price escalation above inflation at 1 percent per year.

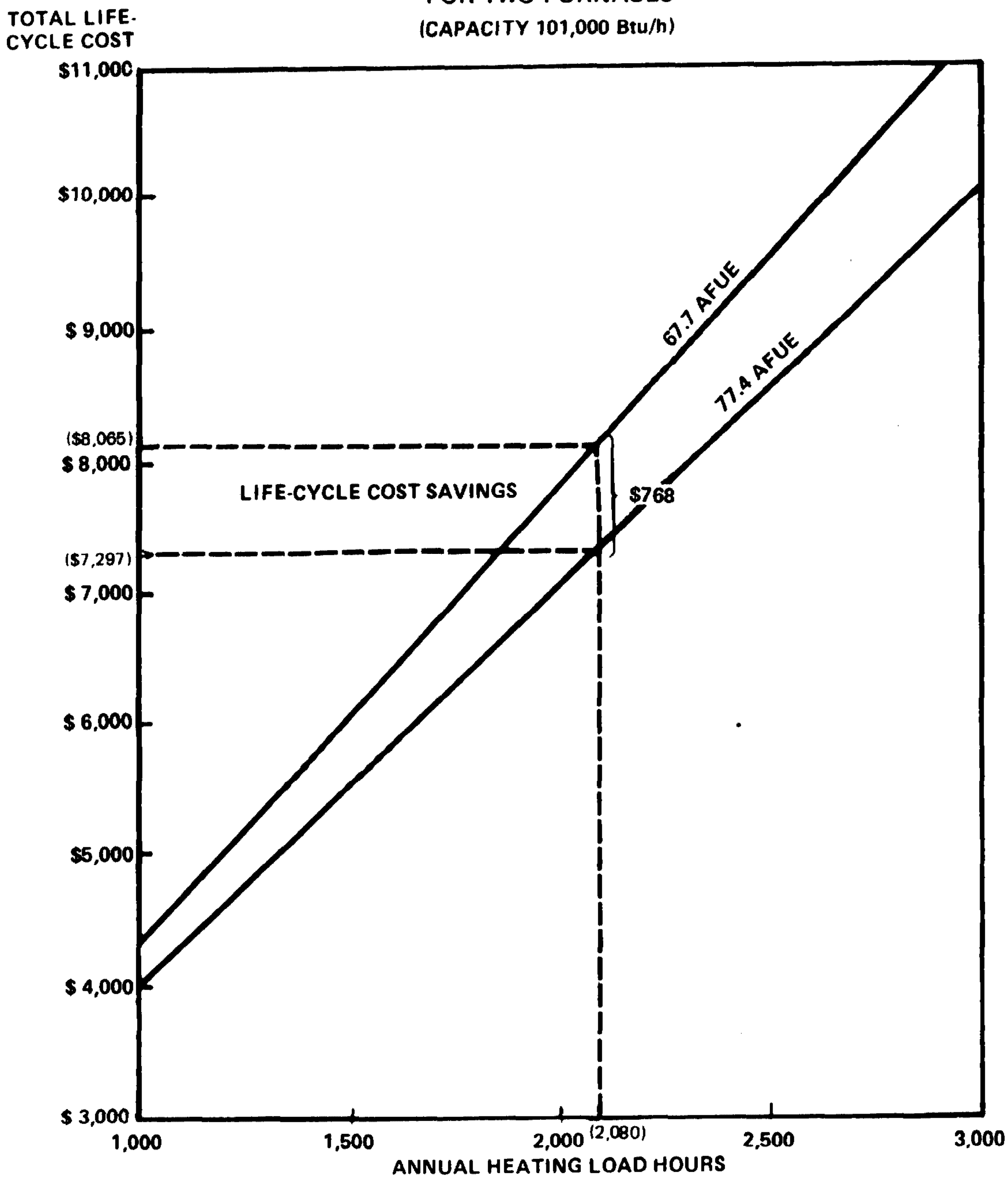
As illustrated above, although the higher efficiency unit is priced $690 ($1,059 to $1,749) more than the lower efficiency unit, the savings in operating cost of $956 ($4,019 to $3,063) more than offset the higher initial purchase price and results in a net savings of $266 over the unit's life. The cost savings result because the more efficient unit consumes 28,493 kWhs, or about 24 percent less energy than the lower rated unit over its expected life.

Natural gas furnaces

Furnaces in the 32,000- to 131,000-Btu/h capacity range with energy efficiency ratings of 75 to 86 percent are more economical to own and operate than furnaces meeting DOE's minimum standard of 65 percent, assuming at least 2,080 operating hours. Such operations are normally required in the northern half of the country. (See fig. II.)

The following graph shows the total life-cycle costs expected for two furnaces--one with an energy efficiency rating (67.7) near the DOE standard and the other rated 13 percent higher (77.4). At the assumed operating load of 2,080 hours, the more efficient unit saves $768 over the system's life. The break-even point, not shown on the graph, occurs at less than 1,000 hours.

LIFE-CYCLE-COST ANALYSIS FOR TWO FURNACES
(CAPACITY 101,000 Btu/h)



We selected for analysis natural-gas, forced-air, indoor furnaces with capacity ratings ranging from 32,000 to 131,000 Btu/h, which are designed to be the principal heating source for residences. This type of furnace is a common type used in new residential construction. The energy efficiency level of furnaces is generally expressed as a percentage, termed AFUE. (See footnote on p. 10.) DOE's intermediate proposed standards for forced-air, indoor furnaces require a minimum energy rating of 65 AFUE for furnaces with capacities of less than 225,000 Btu/h.

We selected 4 to 12 units from each of seven suppliers. In making comparative life-cycle-cost analyses of these furnaces, we used the national average of 2,080 heating load hours 1/ as the operating hours of the furnaces. The results of these comparisons are shown in table II on pages 25 and 26.

The following example illustrates the lower life-cycle cost of using a more energy-efficient furnace.

1/Heating load hours represent the amount of time a furnace operates during a year. They were developed by DOE for use in energy conservation test procedures. Heating load hours can be stated in terms of the more commonly known designation Degree Days, by use of the following formula:

$$\frac{\text{Degree Days x 24 hours per day}}{\text{65 degrees Fahrenheit - Outdoor design temperature}}$$

In the case of the national average of 2,080 heating load hours, the Degree Day equivalent would be:

$$\frac{\text{5,200 Degree Days x 24 hours}}{\text{65 degrees - 5 degrees}}$$

Comparison of Two Furnaces

(Capacity, 131,000 Btu/h) (note a)

	Lower efficiency unit	Higher efficiency unit
Life-cycle-cost factors:		
Efficiency rating (AFUE)	69.4	78.6
Annual cost of natural gas (note b)	$871.00	$774.00
Discount factor (note c)	10.7641	10.7641
Life-cycle costs:		
Discounted cost of natural gas	$ 9,376	$8,331
Retail price	742	867
Total life-cycle cost	$10,118	$9,198

a/Assumes heat loss of home at 90,000 Btu/h.

b/Assumes 40 cents per therm and 2,080 operating hours.

c/A factor used to determine present value of operating costs over a 20-year system life, discounted at 10 percent plus a fuel price escalation above inflation at 3 percent per year.

The above example shows that, although the higher efficiency unit is priced $125 ($742 to $867) more than the lower efficiency unit, the operating cost savings of $1,045 ($9,376 to $8,331) more than offset the higher initial price and result in a net savings of $920 over the system's life. The more efficient unit consumes about 12 percent less energy than the lower rated unit.

During our review, we observed that many furnaces are made to achieve higher energy efficiencies through the use of add-on devices, such as a vent or stack damper. A damper is a device used to reduce heat losses when the burner is off. The higher efficiencies are achieved only if the unit is located in conditioned space. For example, locating a furnace in an unheated garage would nullify the benefits of a vent damper device.

Water heaters

Both electric and gas water heaters with higher efficiency ratings are more economical than lower rated units. The higher efficiency rated units would consume 6 to 23 percent less energy than units meeting DOE's proposed intermediate standards.

We compared residential water heaters with tank capacities ranging from 30 to 65 gallons. The energy efficiency level for water heaters is expressed as an energy factor. DOE's intermediate standards prescribe a minimum energy factor that must be achieved for each capacity of residential water heater manufactured. The minimum energy factor for the water heaters compared ranged from 0.429 to 0.492 for gas water heaters and from 0.776 to 0.821 for electric water heaters.

We selected a total of 36 units from four large suppliers and, based on life-cycle-cost analyses, compared water heaters which essentially meet DOE's intermediate standards to more energy-efficient units. The results of these comparisons are shown in table III on pages 27 and 28.

The following example illustrates the lower life-cycle cost of more energy-efficient water heaters.

Comparison of Two 40-Gallon Water Heaters

	Lower efficiency unit	Higher efficiency unit
Life-cycle-cost factors:		
Efficiency rating	0.474	0.571
Annual cost of natural gas (note a)	$147.00	$122.00
Discount factor (note b)	7.0903	7.0903
Life-cycle costs:		
Discounted cost of natural gas	$1,042	$ 865
Retail price	293	304
Total life-cycle cost	$1,335	$1,169

a/Assumes 64.3 gallons of water use per day and 40 cents per therm.

b/A factor used to determine present value of operating costs over a 10-year system life, discounted at 10 percent plus a fuel price escalation above inflation at 3 percent per year.

The above example shows that the more efficient water heater, although initially higher priced, is cost effective when the operating costs are considered. The more efficient unit consumes about 18 percent less energy than the lower energy rated unit.

HOME OWNERS WILL REALIZE REDUCED CASH OUTLAYS

Home buyers who purchase a home with higher energy-efficient equipment can benefit through reductions in their monthly cash outlays for combined mortgage and utility payments. The following examples show how a home buyer's mortgage and utility payments are affected by installation of equipment of different energy efficiencies. In both examples, house A represents a $60,000 house built with lower energy-efficient equipment to minimize initial costs. The resulting mortgage and utility payments are compared to those of a similar house built with more energy-efficient equipment. This equipment costs the house owner $486 more in the first example and $140 more in the second. In both examples, a 5-percent down payment, a 12-percent interest rate, and a 30-year mortgage period are assumed. The down payment is $24 higher in the first example and $7 higher in the second example because of the higher cost of the more energy-efficient equipment.

The first example compares House A, which includes a central air conditioner and water heater that would essentially meet DOE's intermediate standards, to House B, which includes higher energy-efficient equipment.

	House	
Assumptions:	A	B
Energy efficiency ratings:		
Central air conditioner (SEER)	7.7	10.5
Water heater	.49	.57
Loan amount	$57,000	$57,462
Monthly expenses:		
Mortgage payment	$586.31	$591.06
Utility costs (1980 rates):		
Central air conditioner	34.25	25.17
Water heater	12.08	10.17
Combined mortgage payment and utility costs	$632.64	$626.40

The second example compares House A, which includes a gas furnace and water heater that would meet DOE's intermediate standards, to House B, which includes higher energy-efficient equipment.

	House	
Assumptions:	A	B
Energy efficiency rating:		
Furnace (AFUE)	67.7%	77.4%
Water heater	.49	.57
Loan amount	57,000	$57,133
Monthly expenses:		
Mortgage payment	$586.31	$587.68
Utility costs (1980 rates):		
Furnace	57.00	50.17
Water heater	12.08	10.17
Combined mortgage payment and utility costs	$655.39	$648.02

In both examples House B, with the more energy-efficient equipment, would reduce the home buyer's monthly cash outlay--$6.24 in the first case and $7.37 in the second case, or $74.88 and $88.44 a year, respectively. These results were based on operating the central air conditioner for 1,600 hours and the furnace 2,080 hours. The savings would increase with longer equipment operation.

CONCLUSIONS AND RECOMMENDATIONS

We believe that energy consumption could be substantially reduced in new housing if energy-efficient equipment were installed in Government owned, subsidized, and insured housing. Although Federal agencies have taken actions to conserve energy by reducing the heating and cooling loss through the housing envelope, most of the actions do not deal with the efficiency of furnaces, air conditioners, and water heaters.

As stated earlier, normal market forces, in themselves, do not encourage the installation of the most energy-efficient and cost-effective equipment. For example, the labeling program of the Federal Trade Commission does not appear to be fully effective for new home buyers. The developer of such housing, rather than the ultimate home owner, normally selects the heating and cooling equipment to be installed. Developers are primarily concerned with installing equipment that adequately performs the required functions at the least cost. The initial higher price of energy-efficient equipment generally results in their selecting the cheaper, less efficient equipment.

But in many cases, installation of relatively inefficient equipment results in higher costs for the home buyer. Where use is sufficient, the cost of owning and operating readily available energy-efficient equipment is less. The installation of such equipment frequently can reduce the home owner's monthly combined outlays for house payments and utility bills. Our analyses show that central air conditioners that consume 7 to 33 percent less energy would be economical in the extreme southern part of the country when compared to equipment meeting DOE's proposed intermediate standards, and gas furnaces that consume 10 to 21 percent less energy would be economical in the northern half of the country. Water heaters that consume 6 to 23 percent less energy would be economical in all areas of the country.

HUD, as the principal agency responsible for programs concerned with housing needs, sets construction requirements through its Minimum Property Standards. These standards are also used by many other agencies in the design and construction of new housing. The standards include energy conservation requirements for the thermal envelope of a house; however, they do not prescribe any level of energy efficiency for the heating and cooling equipment that is installed. We believe that recognizing and promoting the benefits of installing more efficient equipment in Government housing could best be accomplished through the Minimum Property

Standards. However, we understand that, as part of the administration's regulatory reform, HUD is examining the standards with a view toward eliminating them in favor of local standards.

The energy and cost benefits from installing more efficient equipment should not be lost in the process of regulatory reform. We believe that, at a minimum, those agencies that pay, either directly or indirectly, the utility costs of housing they own or subsidize should require the installation of higher efficiency equipment through administrative procedures. As shown earlier, DOD and FmHA have already issued administrative procedures that recognize the importance of saving energy in homes that they either own or subsidize. For example, DOD has issued administrative memorandums which require the installation of more efficient equipment in its housing. These requirements, however, have not been updated since their promulgation beginning in 1973 and do not include all types of heating and cooling equipment.

Concerning Government-insured and guaranteed housing, we believe agencies, through their contacts with builders and buyers, should promote the benefits, and encourage the installation of, higher energy-efficient equipment. The mechanism for these contacts already exists. For example, both HUD and VA have approved forms that promote certain energy conservation actions among home buyers, such as installing storm doors or windows, and adding insulation to walls or ceilings. These forms could be modified to also encourage the installation of more efficient heating and cooling equipment.

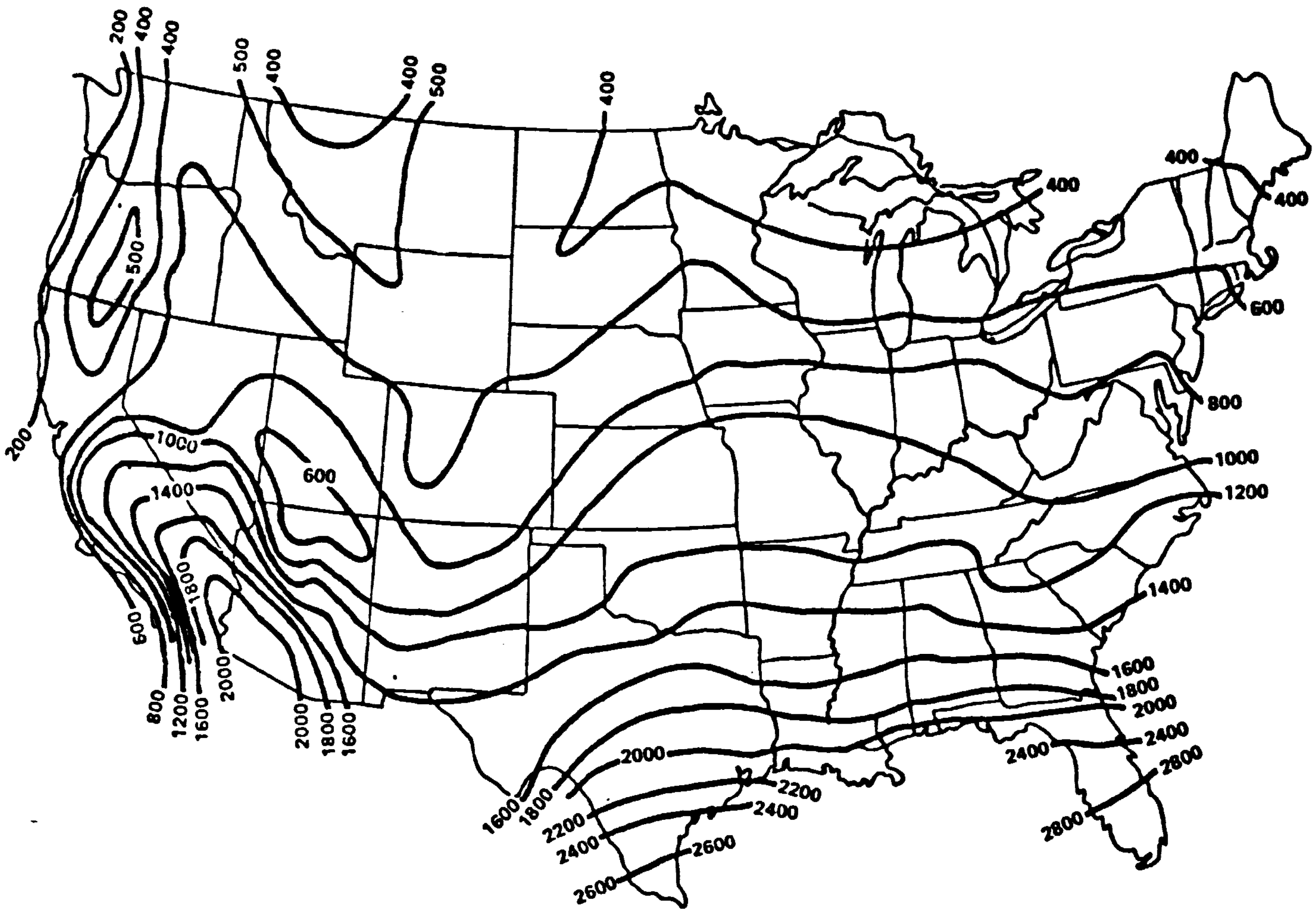
Recommendations

We recommend that the Secretaries of Defense, and Housing and Urban Development, and the Administrator of Farmers Home continue and expand their energy conservation efforts by administratively requiring the installation of high-efficiency heating and cooling equipment in housing that they either own or subsidize. The level of equipment efficiency to be required should be determined in cooperation and coordination with DOE.

For Government insured and guaranteed housing, we recommend that the Secretary of Housing and Urban Development and the Administrator of Veterans Affairs promote, through their contacts with builders and buyers, the benefits and encourage the installation of high energy-efficient equipment.

FIGURE I

DISTRIBUTION OF ACTUAL COOLING LOAD HOURS THROUGHOUT THE UNITED STATES



Alaska	— 0	Cooling	Load	Hours
Canal Zone	— 6,000	"	"	"
Guam	— 6,600	"	"	"
Hawaii	— 2,300	"	"	"
Puerto Rico	— 6,000	"	"	"
Samoa	— 6,600	"	"	"
Virgin Island	— 6,000	"	"	"

Source: Department of Energy

APPENDIX I

Table I
Comparison of Life-Cycle Cost
of Available Central Air Conditioners
Operating 1,600 Hours a Year

Units	Purchase price	Energy-efficiency rating	Energy-efficiency improvement	Capacity	Total life-cycle cost (14 years)	Present value savings
(note a)		(SEER)	(percent)	(Btu/h)	(note b)	
A	$ 886	7.9	-	23,400	$3,092	-
B	1,371	10.6	25	23,200	3,014	$ 78
A	841	7.9	-	23,600	3,085	-
B	925	10.15	22	24,000	2,671	414
A	748	7.9	-	23,800	3,011	-
B	1,034	9.65	18	25,000	2,886	125
A	734	8.2	-	24,800	2,969	-
B	912	8.85	7	24,400	2,983	(14)
A	869	8.1	-	27,800	3,410	-
B	1,360	10.0	19	27,400	3,418	(8)
A	870	7.9	-	29,000	3,627	-
B	1,634	11.7	32	29,400	3,496	131
A	860	8.1	-	30,000	3,642	-
B	1,306	10.1	20	31,000	3,536	106
A	899	7.85	-	31,400	3,904	-
B	1,500	9.75	19	32,200	3,919	(15)
A	1,273	7.7	-	33,000	4,492	-
B	1,734	10.5	27	33,000	4,095	397
A	916	7.5	-	33,400	4,261	-
B	1,194	10.15	26	33,400	3,666	595
A	973	7.5	-	34,000	4,378	-
B	1,285	10.3	27	34,200	3,764	614
A	1,019	8.7	-	35,000	3,954	-
B	1,418	11.1	22	34,000	3,719	235
A	997	7.75	-	35,200	4,409	-
B	1,537	9.2	16	35,800	4,411	(2)
A	1,243	7.55	-	36,400	4,685	-
B	1,800	11.2	33	34,600	4,120	565
A	1,550	7.65	-	39,000	5,379	-
B	2,198	9.7	21	39,000	5,218	161

Table I (con't)

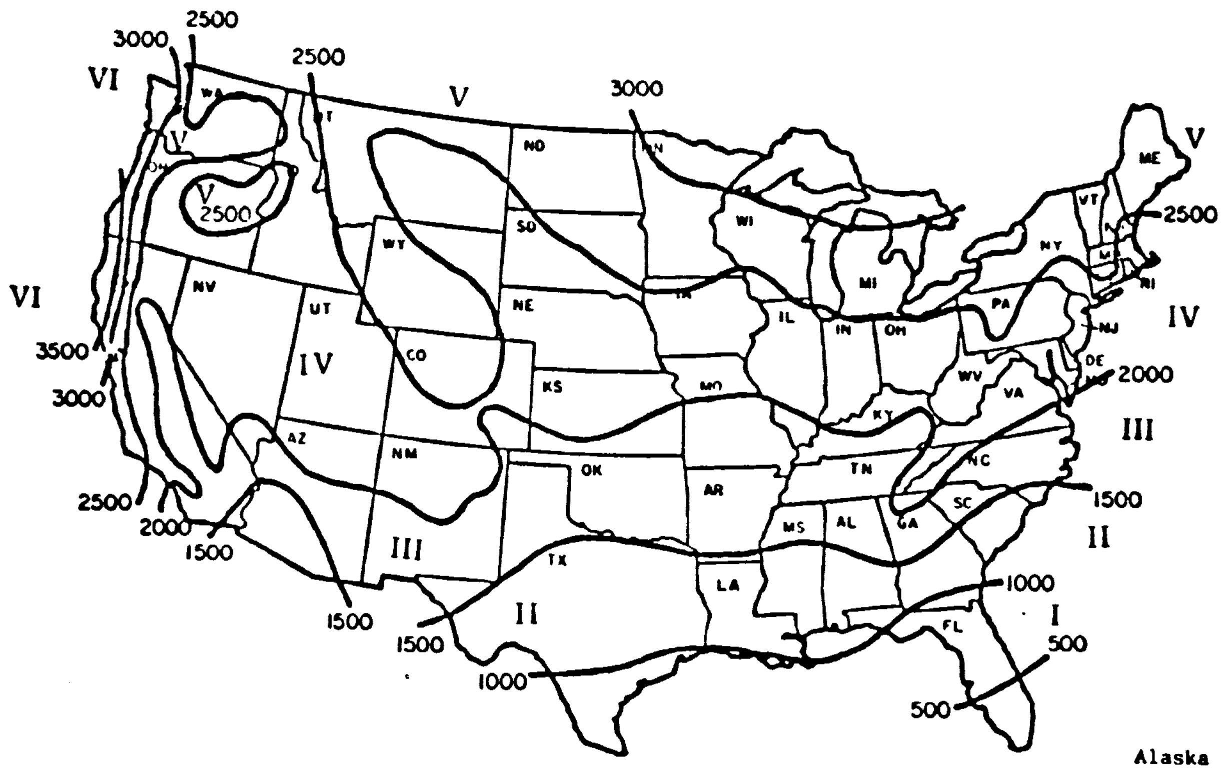
Units	Purchase price	Energy-efficiency rating	Energy-efficiency improvement	Capacity	Total life-cycle cost (14 years)	Present value savings
(note a)		(SEER)	(percent)	(Btu/h)	(note b)	
A	$1,492	8.3	-	40,000	$5,067	-
B	1,744	9.3	11	39,500	4,934	$ 133
A	1,223	7.6	-	40,000	5,176	-
B	1,838	9.1	16	40,500	5,140	36
A	1,509	8.7	-	41,000	5,049	-
B	1,569	10.3	16	42,000	4,559	490
A	1,059	7.85	-	42,000	5,078	-
B	1,749	10.3	24	42,000	4,812	266
A	1,692	7.65	-	42,000	5,768	-
B	2,275	10.25	25	41,500	5,316	452
A	1,314	7.8	-	43,000	5,455	-
B	1,499	8.95	13	43,000	5,108	347
A	1,388	8.2	-	45,000	5,510	-
B	1,620	9.7	15	46,000	5,105	405
A	1,670	7.9	-	45,000	5,949	-
B	1,975	8.5	7	47,000	5,952	(3)
A	1,344	8.2	-	47,000	5,649	-
B	1,778	9.35	12	47,500	5,553	96
A	1,466	8.05	-	47,000	5,572	-
B	1,956	10.3	22	44,000	5,165	407
A	2,066	7.65	-	49,500	6,878	-
B	2,630	9.9	23	49,000	6,348	530

a/"A" represents units with the minimum energy-efficiency rating acceptable under DOE's proposed intermediate standards. In some instances, we had to select units slightly below or above DOE's standard because units with the exact ratings were not available at a particular capacity. "B" represents units with higher energy-efficiency ratings.

b/Operating costs were calculated using the lower Btu/h capacity as the operating load for those units with slightly different rated capacities.

FIGURE II

DISTRIBUTION OF ACTUAL HEATING LOAD HOURS THROUGHOUT THE UNITED STATES 1/



This map is reasonably accurate for most parts of the United States but is necessarily highly generalized and consequently not too accurate in mountainous regions, particularly in the Rockies.

Alaska	-	3500 HLH
Hawaii and Territories	-	0 HLH

1/ Heating load hours were developed by DOE for use in their energy conservation test procedures for furnaces. See Federal Register dated May 10, 1978.

Source: Department of Energy

APPENDIX I

Table II
Comparison of Life-Cycle Cost
of Available Natural Gas Furnaces
Operating 2,080 Hours a Year

Units	Purchase price	Energy-efficiency rating	Energy-efficiency improvement	Capacity	Total life-cycle cost	Present value savings
(note a)		(AFUE)	(percent)	(Btu/h)	(20 years)	
A	$ 634	73.2	-	32,000	$3,207	-
B	788	81.5	10	32,000	3,113	$ 94
A	408	68.4	-	34,000	3,056	-
B	533	75.7	10	34,000	2,933	123
A	460	65.9	-	42,000	3,302	-
B	788	78.5	16	42,000	3,124	178
A	487	68.7	-	58,000	5,740	-
B	663	86.7	21	52,000	4,926	814
A	590	71.1	-	59,000	4,142	-
B	795	80.5	12	59,000	3,938	204
A	642	68.6	-	60,000	5,335	-
B	747	76.0	10	60,000	4,999	336
A	800	68.0	-	60,000	5,568	-
B	1,010	80.1	15	64,000	5,133	435
A	456	66.5	-	78,000	5,838	-
B	681	79.1	16	78,000	5,202	636
A	624	71.1	-	78,000	5,694	-
B	829	80.5	12	78,000	5,318	376
A	602	65.2	-	79,000	6,092	-
B	702	76.0	14	79,000	5,460	632
A	610	65.6	-	79,000	7,359	-
B	1,070	80.6	19	84,000	6,538	821
A	437	66.8	-	96,000	8,058	-
B	662	78.1	14	96,000	7,217	841
A	618	68.8	-	96,000	7,938	-
B	818	77.7	11	96,000	7,330	608
A	632	65.4	-	98,000	8,264	-
B	757	76.6	15	98,000	7,312	952
A	702	67.7	-	101,000	8,065	-
B	817	77.4	13	101,000	7,297	768

Table II (con't)

Units	Purchase price	Energy-efficiency rating	Energy-efficiency improvement	Capacity	Total life-cycle cost	Present value savings
(note a)		(AFUE)	(percent)	(Btu/h)	(20 years)	
A	762	65.9	-	105,000	8,297	-
B	1,114	78.5	16	105,000	7,486	811
A	458	69.1	-	108,000	10,835	-
B	801	85.5	19	104,000	9,488	1,347
A	722	65.6	-	112,000	9,473	-
B	922	76.6	14	112,000	8,435	1,038
A	702	69.1	-	113,000	8,937	-
B	817	78.5	12	113,000	8,104	833
A	742	69.4	-	131,000	10,118	-
B	867	78.6	12	131,000	9,198	920

a/"A" represents units with the minimum energy-efficiency rating acceptable under DOE's proposed intermediate standards or higher. "B" represents units with higher energy-efficiency ratings.

Table III
Comparison of Life-Cycle Cost of Available Natural Gas and Electric Water Heaters

Units (note a)	Purchase price	Energy-efficiency rating	Energy-efficiency improvement (percent)	Capacity (gallons)	Total life-cycle cost (10 years)	Present value savings
Natural gas						
A	$277	0.470	-	30	$1,326	-
B	310	.571	18	30	1,175	$151
A	271	.496	-	30	1,270	-
B	276	.581	16	30	1,127	143
A	280	.566	-	30	1,152	-
B	310	.621	10	30	1,104	48
A	140	.492	-	30	1,168	-
B	165	.571	14	30	1,030	138
A	225	.463	-	40	1,296	-
B	250	.547	16	40	1,150	146
A	303	.441	-	40	1,423	-
B	348	.547	20	40	1,256	167
A	293	.474	-	40	1,335	-
B	304	.571	18	40	1,169	166
A	306	.520	-	40	1,256	-
B	348	.566	7	40	1,220	36
A	195	.444	-	50	1,308	-
B	275	.524	15	50	1,211	97
A	383	.415	-	50	1,574	-
B	436	.524	19	50	1,379	195
A	370	.460	-	50	1,448	-
B	393	.551	16	50	1,286	162
A	275	.413	-	65	1,473	-
B	340	.533	23	65	1,269	204

Table III (con't)

Units (note a)	Purchase price	Energy-efficiency rating	Energy-efficiency improvement (percent)	Capacity (gallons)	Total life cycle cost (10 years)	Present value savings
Electric						
A	260	0.796	-	30	2,746	-
B	269	.920	14	30	2,421	$325
A	110	.798	-	30	2,584	-
B	135	.860	8	30	2,435	149
A	266	.767	-	40	2,843	-
B	291	.900	16	40	2,488	355
A	205	.829	-	40	2,588	-
B	175	.891	15	40	2,397	191
A	318	.755	-	52	2,933	-
B	340	.884	15	52	2,575	358
A	150	.767	-	52	2,720	-
B	180	.819	6	52	2,589	131

a/"A" represents units with the minimum energy-efficiency rating acceptable under DOE's proposed intermediate standards or higher. "B" represents units with higher energy-efficiency ratings.

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