

HOME DESIGNS

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SHOPPING ENERGY \$ENSE

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New homes today should be energy efficient. The cost of home heating and cooling has increased in the past few years and is predicted to continue to rise. If a house is designed properly, a great deal of energy and money can be saved during the winter and summer.

This booklet describes how the site, building orientation, landscaping, architecture, and interior design affect the energy efficiency of a house. It also provides information about energy saving features such as energy-efficient windows and heating systems, and proper amounts of insulation.

SITE

Energy-conscious design begins with choosing a building site, then placing the home and outdoor activity areas in proper relationship to climatic and other natural factors such as prevailing winds, precipitation, sun orientation, vegetation, soils, and slope. When selecting a building site, avoid low slopes and valleys where natural drainage occurs and where cold air, frost, and fog collect (see Figure 1).

Avoid hilltops and ridges, which may be affected by cold and high velocity winds in the winter.

A good site for an energy-efficient home is midway up a slope because cold air tends to move uphill during the day and to the valley bottoms at night.

Select a site on a south-facing slope. If the house is oriented correctly, solar gain in the winter will be maximized, solar collection devices will operate more efficiently, and overheating from the east and west summer sunlight will be minimized.

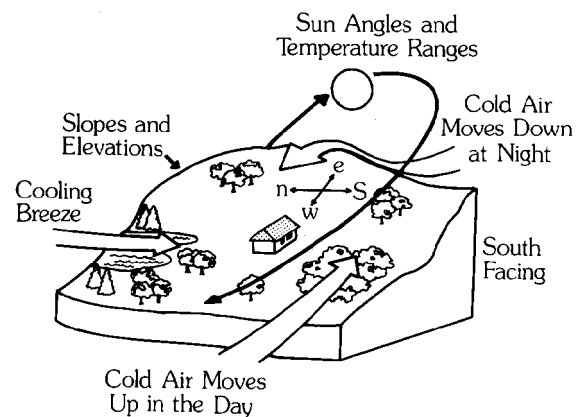


Figure 1. Selecting a Building Site.

If located near water (lakes and ponds), the home will stay cooler in the summer. Locations near water usually receive more cooling breezes during the day.

DESIGN

A home designed for energy efficiency will take advantage of the site, sunlight, view, and natural breezes. The floor plan and placement of windows are also considered when designing an energy-efficient home. In addition, an energy-efficient home will have adequate amounts of insulation, an efficient heating system, and high-quality windows and doors. It will also be sealed tightly against air leaks.

The **orientation** of a well-designed, energy-efficient home will take advantage of free energy from the sun (see Figure 2).

For energy efficiency, the house should be oriented so the long axis of the house is in an east-to-west direction so that the largest amount of wall surface and windows face south to take advantage of the lower angle of winter sunlight.

An appropriate home design places most-used rooms and outdoor activity areas on the south side to take advantage of useful heat from winter sunlight during the day (see Figure 3).

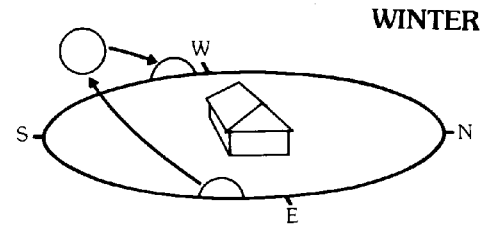


Figure 2. Orientation of Home for Sunlight.

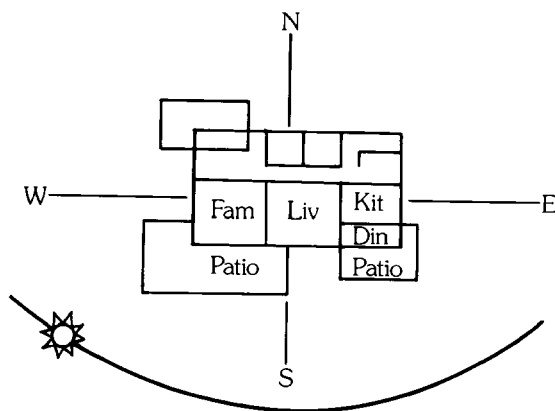


Figure 3. Placement of Most-Used Rooms.

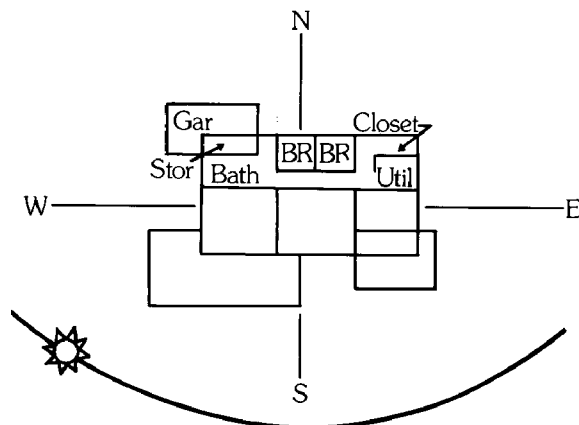


Figure 4. Placement of Least-Used Rooms.

Longer seasonal use of patios and other outdoor activity areas can also be assured by locating these areas on the south and west sides of the home.

The north, east, and west sides of the home should have the minimum amount of glass area necessary for light and ventilation.

Garages, utility rooms, and storage areas should be located to the north. Because these rooms are used less frequently than the home's living areas, they do not need continual heating (see Figure 4). These rooms can act as buffers against cold winter winds.

Heat can be collected from sunlight by a variety of methods, including large expanses of windows, a solarium, a sun space, or a thermal storage wall on the south side of the house.

A **solarium or sun space** attached to the main structure of the house increases the thermal resistance of the outside envelope in two ways: (1) it protects the main living areas from extreme outside temperatures (similar to the air-lock entry), and (2) it reduces infiltration around doors and windows because the main wall of the house is not directly exposed to the outside elements.

In a solarium or sun space, thermal mass materials such as brick, ceramic tile, and

concrete are used to absorb heat. They also retain heat so it can be radiated back into the house at night.

A **thermal storage wall** is also referred to as a Trombe wall (see Figure 5). Like the solarium and sun space, the Trombe wall uses large expanses of windows to collect heat. The Trombe wall should be constructed of a good heat-retaining material such as concrete, brick, or stone. Heat is distributed to the living areas by convection, conduction, and radiation.

Natural circulation of air is generated when the cooler room air at the floor level is drawn through lower vents, where it is warmed, rises, and enters the living space through the upper vents. Once the thermal mass material heats up, heat can be conducted through the wall into the living space on the other side of the wall. Heat is then radiated into the room from the wall.

In an energy-efficient home, **roof overhangs** must be wide enough to be effective (see Figure 6). A correctly designed overhang eliminates the need for deciduous trees on the south, east, and west sides of the house and shade walls and windows from the high and hot summer sun. If the overhang is designed correctly, it will allow the lower angled winter sunlight to enter the house through the windows and also block the summer sunlight from entering the windows.

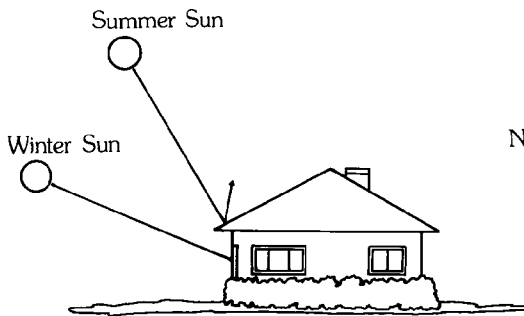


Figure 6. Roof Overhangs.

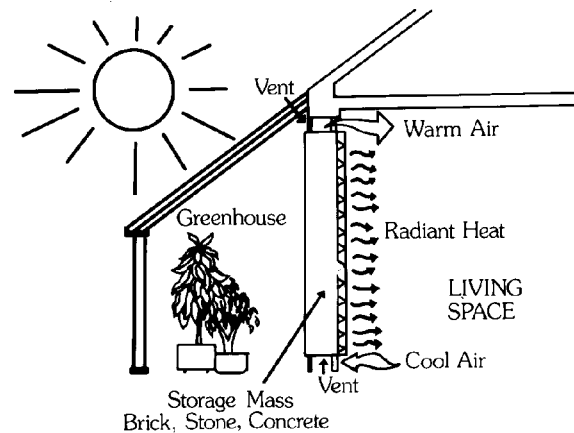


Figure 5. Thermal Storage Wall.

An **air-lock entry** keeps incoming blasts of cold or hot outside air to a minimum (see Figure 7). An air-lock entry is built into the interior of the house or added to the exterior. It reduces energy loss by the use of two doors, only one of which is normally open at any given moment. The two doors are separated by a small unheated or uncooled air space. An air-lock entry is an expensive method of saving energy, unless used for other purposes such as a mud room.

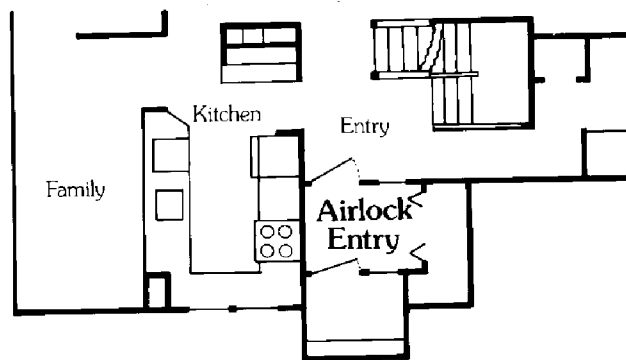


Figure 9. Air-Lock Entry.

AIR TIGHTNESS

Energy-efficient homes are designed and built to minimize air leakage. Special attention is paid to all potential leaks (Figure 8). Air leakage can occur through the walls, where window and doors are framed; where brick or siding laps the foundation wall; inside the basement, where the sill rests on the foundation; around any penetrations of the outside wall such as water faucets, electrical outlets, and water pipes; and where outside chimney or other masonry joins the house wall. Air leakage can also occur through the attic where insulation is inadequate or not installed properly. These areas must be sealed to reduce infiltration or exfiltration.

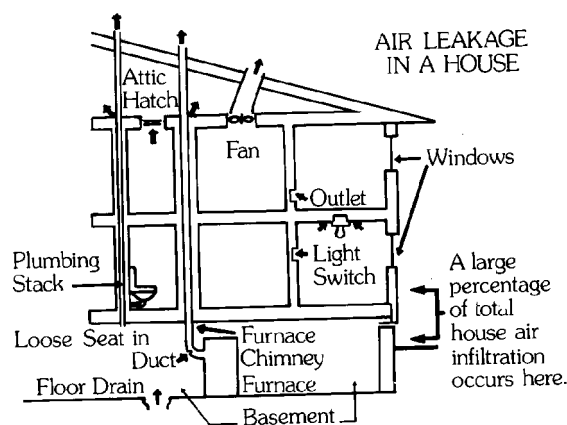


Figure 8. Air Leaks.

HIGH LEVELS OF INSULATION

An energy-efficient home has higher levels of insulation. This means the insulation in the ceilings is at least R-38 and in the walls is at least R-19. The floors over crawl spaces, slab floors, and concrete foundations should also be insulated (above ground to at least R-19 and below ground to at least R-11).

To appreciate insulation, you should understand R-value. The R-value designates the insulation's ability to resist heat flow. The greater the R-value, the greater the resistance, and the better the insulating ability. There are several types of insulation, and each has a different R-value (see Figure 9).

Type	R-11	R-19	R-30	R-38	R-39
Mineral Fiber or Batts	3.2–3.7	5.7–6.2	9–9.2	11.5–12	15–15.2
Fiberglass Loose or Blown	4–5.2	7–8.7	11–14	14–17.7	18–23
Rockwood Loose or Blown	3.5	6.2	9.7	12.2	16
Cellulosic Fiber Loose or Blown	3.7	6.5	10.5	13	17
Expanded Polystyrene Foam Bead Board	2.6–3.1	4.5–5.3	7.1–8.3	9.0–10.6	11.7–13.6

Figure 9. R-Values.

A **super-insulated** home has five characteristics: higher levels of insulation, quality windows, vapor barriers that reduce infiltration, controlled mechanical ventilation with heat recovery, and low energy requirements.

One problem with a super-insulated home is indoor air pollution. A super-insulated home is so airtight that there is little air infiltration. To solve this problem, a heat recovery

ventilation system, such as a fresh-air heat exchanger, brings in fresh air from the outside and heats it without greatly affecting the energy efficiency of the home.

In super-insulated homes the R-value should range between 50-70 for ceilings, 32-40 for walls, 20-35 for floors, and 10-20 for foundations.

In a super-insulated home, the window area should not exceed 10 to 15 percent of the total floor area with the majority of the windows on the south. Highly insulated homes use high-quality energy efficient windows that have three to four layers of glass.

WINDOWS

Windows play a major role in energy efficiency. Non-energy efficient windows can increase costs of heating and air conditioning by as much as 10 percent because of conduction and air leakage. Heat can be lost through the glass, the frame, and through the spaces between the frame and the rough opening (see Figure 10).

Before buying windows, check the windows infiltration rating, R-value, and U-value. Also, consider low “E” glazing (low emissivity) and window construction for energy efficiency.

Low “E” glazing is window glass that has had a thin, transparent, heat-reflective coating applied during manufacturing. Low “E” glazing allows light through the glazing but reduces ultraviolet light (see Figure 11).

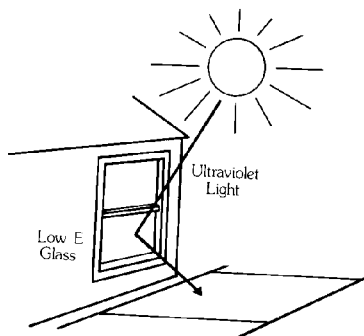


Figure 11. Low “E” Glazing Reflects Ultraviolet Light.

The energy efficiency of windows is measured in **R-values** and **U-values**. R-value is a measurement of resistance to heat flow, and U-value is a measurement of how easily a window conducts heat. R-values and U-values are fairly standard in the window industry. The lower the U-value, the better; while the greater the R-value, the better; as seen in Figure 13.

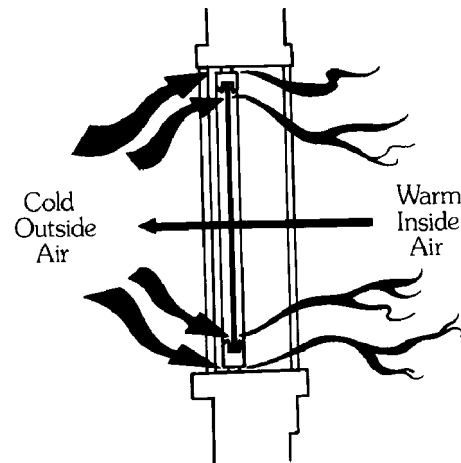


Figure 10. Heat Loss Through Windows.

With low “E” glazing, when the long-wave heat energy inside the house hits the glass, the coating on the glass acts as a mirror to keep the heat inside the home, which stays warmer (see Figure 12). An added benefit is the reduction of ultraviolet light transmitted through the windows, which fades interior furnishings, such as carpets, curtains, and furniture.

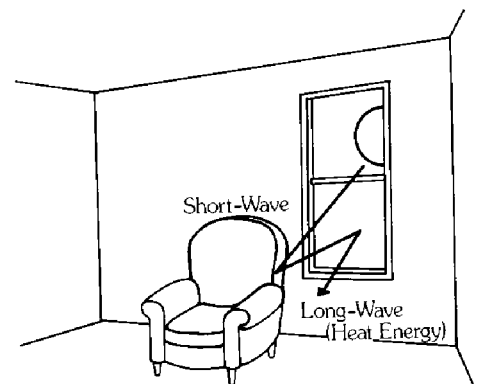


Figure 12. Low “E” Glazing Keeps Heat Inside.

	R-Values	U-Values
Single Glazing	.98	1.02
Double Glazing (1/2" air space)	2.04	.49
Triple Glazing (1/2" air space)	2.92	.39

Figure 13. Window R-Values and U-Values.

When looking for energy-efficient windows, the **window frame** is important. The material used for the frame will affect the amount of heat loss due to conduction. Make sure window frames are made of a low conductive material such as wood, vinyl, or fiberglass. If the frames are made of steel or aluminum, be sure they have a thermal break to reduce conduction through the frame (see Figure 14).

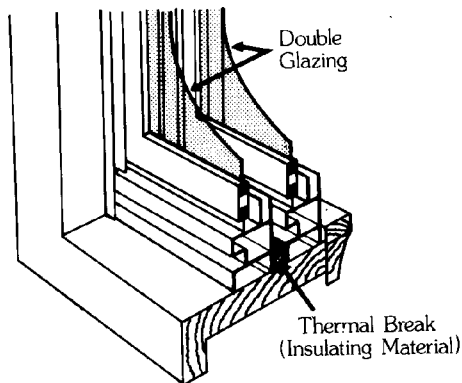


Figure 14. Window Thermal Break.

While R-values and U-values are very important features of window glazing, **air infiltration rates** are also important. Air infiltration is measured in cubic feet per minute per square foot. The assigned value indicates the amount of air leakage between the window sash and the frame. Lower numbers mean less infiltration and greater efficiency.

Operable windows, such as casement windows, tend to have lower air infiltration ratings than most sliding windows because of a tighter seal. Generally, most sliding windows, vertical or horizontal, have a greater tendency for infiltration because positive compression and clamping is difficult.

Windows should be placed for ventilation. Hot air that builds up in the house during the day automatically escapes to the outside through windows located high on the walls when the outside temperature cools.

DOORS

Pre-hung, foam core, entry doors generally provide better thermal performance than wooden solid-core doors. These pre-hung doors are usually better insulated, and the weatherstripping is made to fit the door properly. If the weatherstripping provides a good seal, air infiltration is reduced. Look for weatherstripping that has a durable, tight, air seal that makes a continuous and complete seal around the door.

HEATING SYSTEMS

One feature of an energy-efficient home is that it loses very little heat and therefore needs less energy, solar or otherwise, for heating.

In the Intermountain West, home heating accounts for the largest amount of energy

used in the home. Therefore, it is important to have an energy-efficient heating system. When selecting or evaluating a heating system, consider the following questions: For the type of heating system being considered, what are the fuel costs? Is the heating unit properly sized for the space it will heat? Is the heating system energy efficient? What is the payback in reduced energy costs for the heating system?

A reputable heating and cooling contractor can calculate the heating load to determine the proper size of heating unit for an energy-efficient home. When building a new house, have the heating and cooling load calculated using the house plans. Then, a heating unit can be selected that matches the needed heating load. The manufacturer's written specifications contain heating capacity figures or BTU output.

Another item to check is the fuel-utilization efficiency rating. The Annual Fuel Utilization Efficiency (AFUE) rating is determined by the Department of Energy. The higher the rating, the more energy efficient the heating unit. Do not confuse or compare AFUE ratings with other energy ratings because they are not the same. The AFUE rating is usually found in the manufacturer's literature. If you purchase a high-efficiency system, you can save from 30 to 50 percent on heating bills when compared to inefficient systems (see Figure 15).

In some cases, it is more cost effective to purchase a less energy-efficient heating system because the additional cost of a high-efficiency system may not pay for itself within a reasonable time period, especially, if you are not going to be in the house very long (see Figure 16). Also, the more energy efficient a home is, the less critical it is to have a high-efficiency heating system.

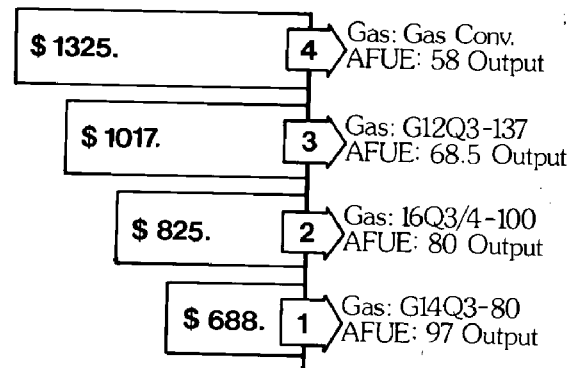


Figure 15. Heating Costs for Gas Systems.

Year	Cost	Notes
1	377	
2	754	
3	1,131	
4	1,508	
5	1,885	
6	2,262	
7	2,639	←New Heating System
8	3,016	Paid for Itself
9	3,393	
10	3,770	

Figure 16. Payback Period for Efficient Heating System.

Common heating systems are high-efficiency forced-air gas, oil, and propane furnaces; hydronic systems; and heat pump systems. The efficiency of the new forced-air gas heating systems ranges from 80 to 97 percent.

Hydronic systems have been around for a long time. They heat water that releases heat into rooms. A number of high-efficiency gas boilers are available that use hydronic distribution. Hydronic systems distribute heat through wall baseboard heaters or through water pipes in the floor (see Figure 17).

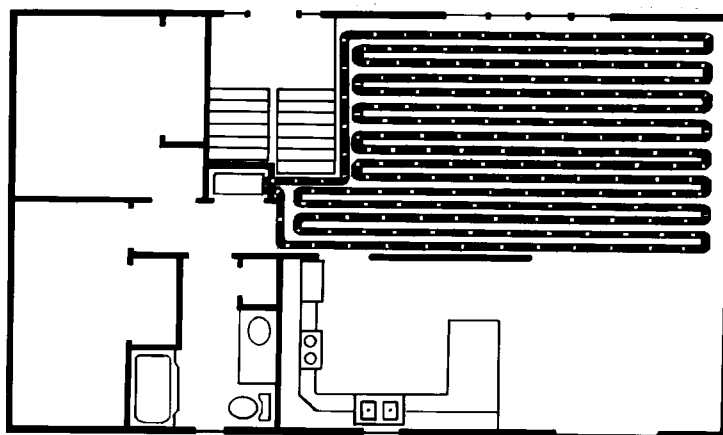


Figure 17. Floor Hydronic Heating System.

Some boiler units, called integrated systems, not only heat the home using water but also heat water for domestic use. This system can save space, energy, and money.

Electric baseboard, hydronic, and other room-by-room systems allowing each room to be independently thermostatically controlled. By turning down the temperature in rooms not used, energy can be saved.

INTERIORS

The interior environment is also an important aspect of an energy-efficient home. Both physical and psychological comfort are greatly affected by interior design. When planning an interior, consider color, floor coverings, window treatments, furnishings, and lighting.

Certain feelings we derive from **colors** relate directly to energy use. For example, bright red or yellow colors bring to mind candlelight, fire, sunshine, or burning coals. These colors actually “warm” rooms that are exposed to cool northern light. Blue and green can be used to “cool” rooms exposed to southern and western sunlight. Cool blues bring to mind cold water or ice.

Floor covering materials should be chosen for their comfort and energy efficiency. All floor treatments have some insulation value and can contribute to a different feeling in a home. When compared to most other floor materials and when placed over an uninsulated floor, wall-to-wall carpeting provides the greatest insulation. The denser the carpet fibers and the thicker the carpet padding, the greater the insulating effect.

Tile, brick, or concrete floors are used in solar design to absorb the heat from sunlight coming into the house through south-facing windows. These materials absorb daytime heat and radiate it back into the room during the night, when air temperatures are cooler (see Figure 18).

Unless covered with an **energy-efficient window treatment**, windows can be a source of heat loss in the winter and heat gain in the summer.

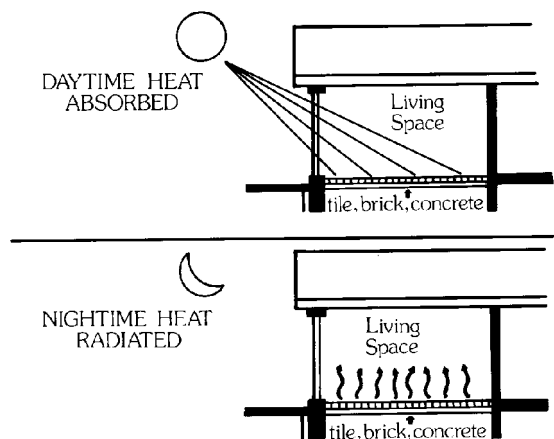


Figure 18. How Floor Materials Absorb and Radiate Heat.

An energy-efficient window covering is sealed on all four sides—the top, sides, and bottom (see Figure 19). Tightly fitting draperies or window coverings help keep heat inside at night or during cloudy periods and also help keep the house cooler during the summer.

When selecting an energy-efficient window covering, remember that several layers of fabric will reduce heat loss because the trapped air between the layers of fabric provides additional insulation. Drapery liners are an example of an additional layer of insulation.

Another method of increasing the insulation of a window area is to use a treatment with a vapor barrier. Vapor barriers control the movement of air through the window covering and the amount of condensation on the window glass.

There are many energy-efficient window coverings including insulated draperies, roman shades, shutters, and panels. Even ordinary roller shades can help reduce energy losses through windows, especially when they are used with another covering such as draperies.

Regardless of which type of window covering used, how it is managed improves its energy efficiency.

On a sunny, winter day, it is more energy efficient to have the window covering open on a south-facing window so the sunlight can warm the room. On cold nights, window coverings should be closed so the warm inside air does not escape.

If window coverings are not managed properly, rooms can overheat on hot, sunny days and lose heat on cold, cloudy days.

Furnishings are another consideration when planning an energy-efficient home. Closed-design furnishings, such as wing-back chairs, were initially designed to hold in heat radiated from a fireplace and protect the occupant from drafts. Recliners and ottomans were designed to keep feet off drafty floors.

It is no accident that we associate wicker and rattan with tropical climates. Their open design promotes movement of air around the body.

The placement of furniture can also be important to energy use and physical comfort. For physical comfort, furniture should be placed away from outside walls and close to interior walls.

Lighting accounts for 8 to 16 percent of the total electric bill. Generally, the use of lighting far exceeds basic needs. Lighting can be made more energy efficient by using task lighting, dimmer switches, or by installing fluorescent lighting.

Task lighting above a work surface costs less than lighting an entire room with a ceiling fixture.

Dimmer switches are easy to install and create flexible lighting. Dimmer switches can save energy as well as change the mood of an environment by allowing adjustment of light levels.

Fluorescent lights are 3 to 5 times more efficient than incandescent bulbs and can last 10 times longer. They also generate less heat—a plus during summer months.

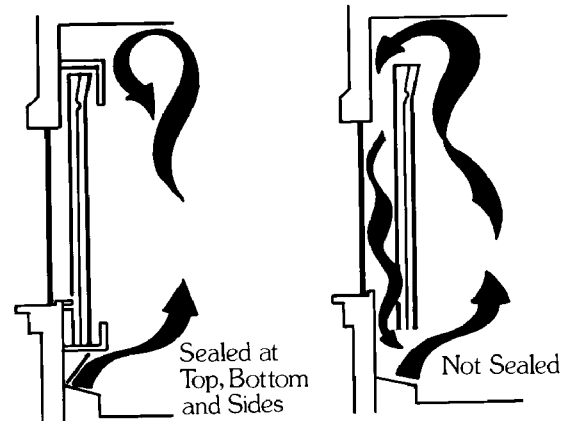


Figure 19. Energy Efficient Window Treatments Are Sealed.

LANDSCAPING

Winter winds, generally from the north and west, can be controlled by creating **wind breaks** using evergreen trees, shrubs, vines, fences, or earth berms. These wind breaks can be placed on the north and west sides of the home or along the perimeters of the lot (see Figure 20).

Evergreen trees or medium to tall evergreen shrubs should be planted on the north side of the house to block the north winter winds. These plants do not lose their foliage during the winter.

Earth berms and fences can channel winds away from the house and provide insulating features. Shrubs and trees next to the house can also provide protection by creating an insulating space next to the walls and by reducing infiltration through the windows and walls (see Figure 21).

Proper choices and placement of trees are important in **controlling sunlight** coming into the house. Shade trees should be selected by considering their expected height at maturity. If trees are not properly placed, they won't be very effective. Trees that are planted too close or too far from the home will not provide protection from sunlight.

Heat from summer sunlight can be reduced by planting deciduous trees and shrubs along the east, west, and south sides of the house. If deciduous trees are tall enough, they will not only shade the walls but also the roof.

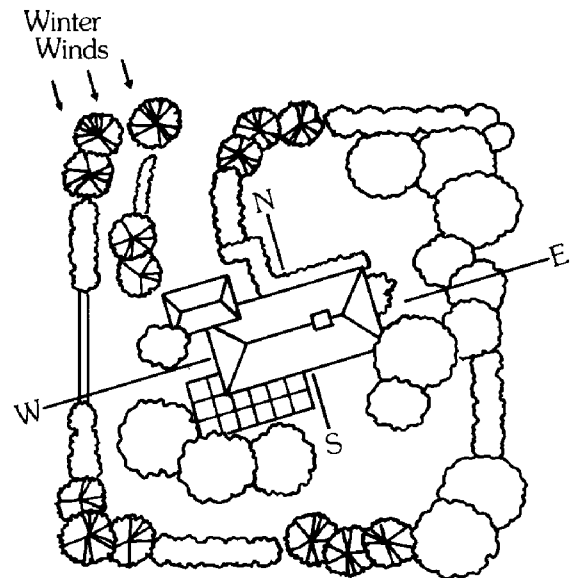


Figure 20. Landscaping for Wind Breaks.

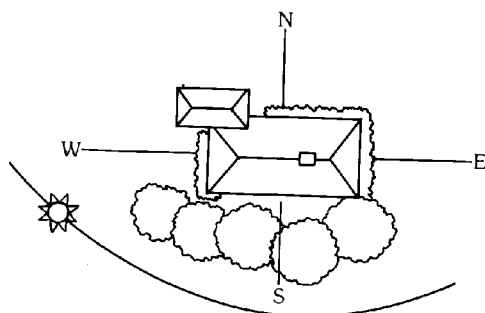


Figure 21. Protecting the House from Winds.

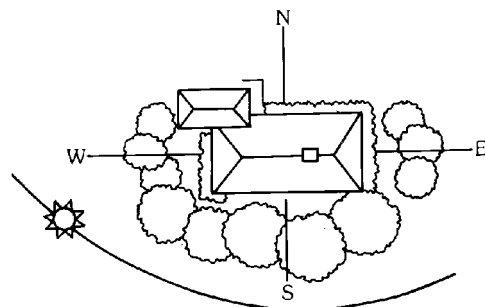


Figure 22. Landscaping for Shade.

The east and west sides of the home should have shorter deciduous trees or medium to tall shrubs to create shade from the hot morning and afternoon sunlight (see Figure 22).

Because their leaves drop in the late fall and winter, deciduous trees allow sunlight onto south walls and windows. However, if deciduous trees are planted too close to the house and in front of windows, some of the heat gain through the windows in the winter can be blocked by the bare branches.

Medium to tall deciduous shrubs along the east, west, and south walls are not only effective in shading walls and reducing temperatures in summer but are also effective in screening hot summer winds and channeling cooling winter breezes toward or away from walls, windows, and outdoor spaces.

The concept of **xeriscaping** (dry landscaping) is useful in conserving water and providing sun and wind control (see Figure 23).

Many homes have large expanses of entrance planting or front lawns that are often not used as activity areas. Seldom-used areas can be converted to drought-resistant ground cover requiring less frequent watering or to native species requiring no water.

In conclusion, in this booklet you have learned how the site orientation, design, and landscaping affect the energy efficiency of a home. You have also learned about the features found in energy-efficient homes, including energy-efficient windows, insulation, heating systems, and interiors.

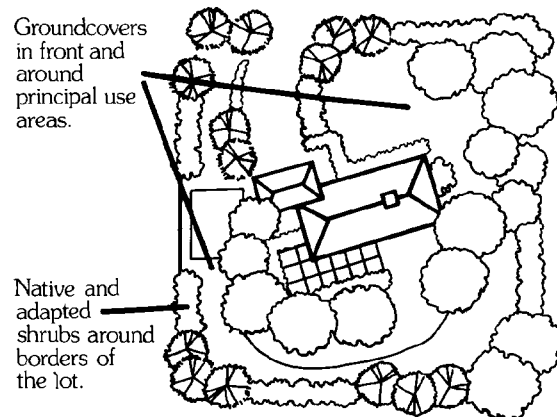


Figure 23. Xeriscaping (Dry Landscaping).

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