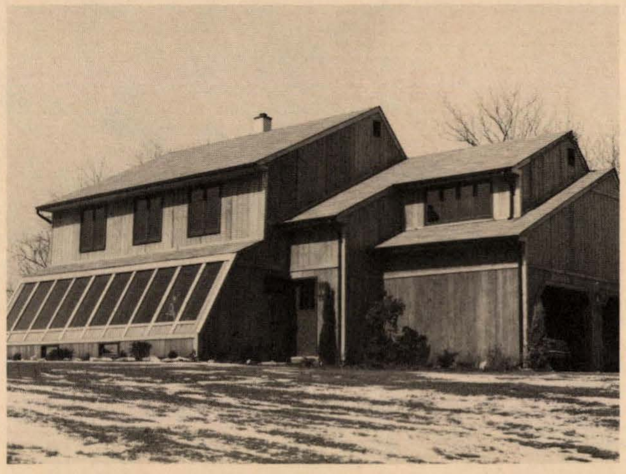
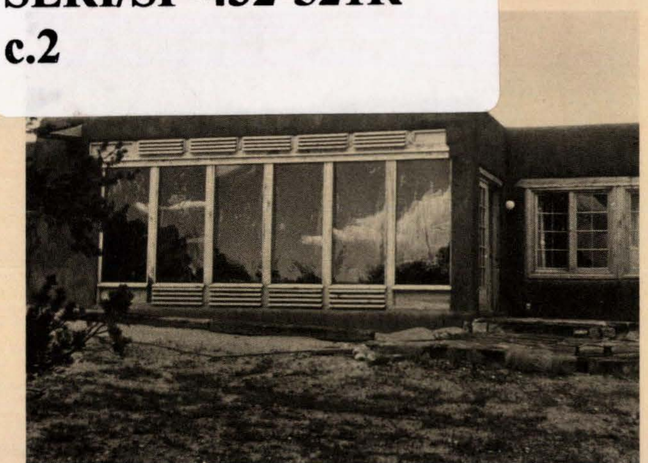
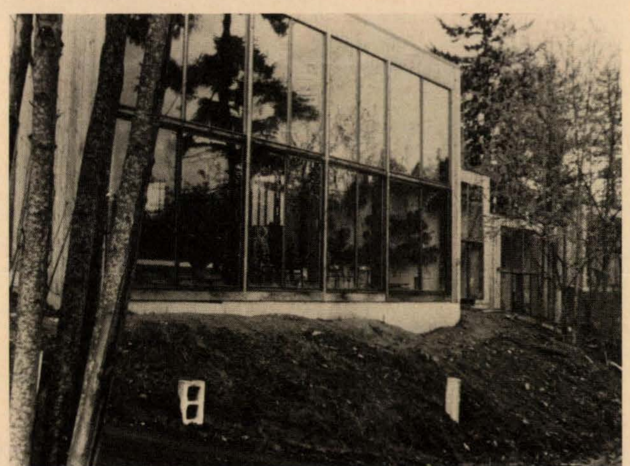
Passive Design: It's A Natural







SERI

Socrates . . . on passive solar design

"Now in houses with a south aspect, the Sun's rays penetrate into the porticoes in winter, but in summer the path of the Sun is right over our heads and above the roof, so that there is shade.

If, then, this is the best arrangement, we should build the south side loftier to get winter Sun and the north side lower to keep out the cold winds.

To put it shortly, the house in which the owner can find a pleasant retreat at all seasons and can store his belongings safely is presumably at once the pleasantest and the most beautiful."

c. 4th Century, B.C.

Photo — Sharyn Towle

Back Cover		Front Cover	
1	4	7	10
2	5	8	11
3	6	9	12

House Location; Photo Credit

1 Tolland, Connecticut; Dennis Davey. 2 Olathe, Kansas; Craig Eymann. 3 Madison, Wisconsin; Don Schramm PRADO. 4 Starkville, Mississippi; Sharyn Towle. 5 Dickson, Tennessee; Tennessee Valley Authority. 6 Mill Valley, California; M. Dean Jones, Architect. 7 Lakewood, Colorado; Solar Energy Research Institute. 8 Minneapolis, Minnesota; Rob deKieffer. 9 Santa Fe, New Mexico; New Mexico Solar Energy Association. 10 Waitsfield, Vermont; Circus Studios Ltd., Architects. 11 Unionville, Pennsylvania; Josef Revlock for Northeast Solar Energy Center. 12 Portland, Oregon; Sharyn Towle.

Some of the photographs and house descriptions in this booklet were taken with permission from **A Survey of Passive Solar Homes,** produced by AIA Research Corporation for the U.S. Department of Housing and Urban Development.

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Also available from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. $1.50/copy, $75/100 copies.

". . . a pleasant retreat at all seasons"

We are moving out of the era in which the flick of a switch or the turn of a dial protected us from the sometimes harsh weather of the four seasons. Realizing that cheap supplies of oil, natural gas, and electricity will not be at our fingertips forever, we are discovering new ways to live—with less reliance on these familiar energy sources, but without sacrifice of comfort or style.

Millions of our homes reflect the attitudes of a time when energy was cheap and available. Because they were built with little concern for the workings of nature, many have no place in an energy-efficient society.

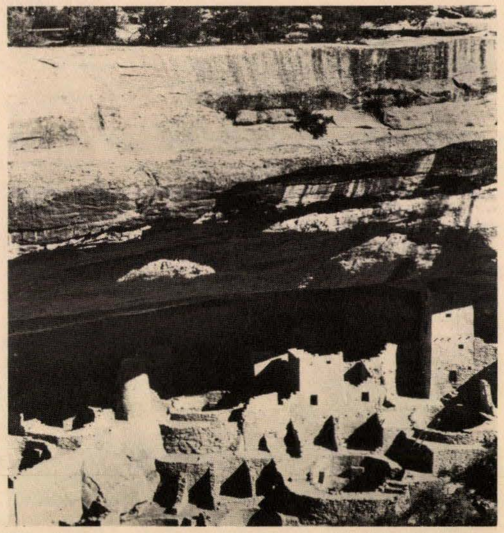
Today's homes and buildings must be constructed—or remodeled— to take advantage of the "free" energy in the warm winter sun and in cool, summer night breezes. Today, the most appealing homes are those that use the least energy while providing the most comfort.

Contemporary builders, designers, and homeowners of the 1980s are looking back in history to combine the best of the old with the best of the new. Through common-sense architectural techniques like passive design, we are rediscovering the importance of working with the Sun and the Earth to construct for ourselves "pleasant retreats at all seasons."

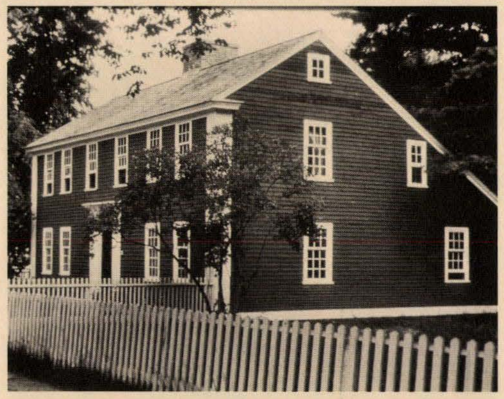
Simple. Effective. Beautiful. Economical. Passive design allows us to work with natural forces instead of battling against them. Passive design teaches us to build with the climate and the land, and to use materials that will collect heat, store it, and release it to living spaces when we need to be warm, and to the sky, ground, and atmosphere when we need relief from the heat.

The use of passive design to heat or cool our homes is hardly a new idea. Early civilizations depended on close and harmonious coexistence with the Sun, the wind, and the heavens for survival. Their dwellings, built to embrace the elements rather than fight them, are good examples of the passive solar principles we are rediscovering today.

There is nothing mysterious about passive design. Today's passive homes use contemporary versions of ancient principles and enhance them with proven methods of energy conservation and 20th century building materials. The end result? Pleasant retreats which draw their energy from the surrounding environment, taking in only what is needed for comfort and leaving the rest.



Throughout history, proper orientation to the Sun's path has been the key to a comfortable home. Cave and cliff dwellings, many of which still stand in the American Southwest, were open to collect and store the Sun's warmth and release it into living areas after sundown. Today, we use south-facing windows that admit the Sun's rays and protect us from less welcome intrusions by wind, rain, snow, and animals and insects. Materials such as brick, stone, adobe, or water provide heat-absorbing and -retaining thermal mass in today's passive homes. Photo — National Park Service



Traditional New England saltbox houses used sharply angled roofs to deflect cold northerly winds. A 2-story south face was designed to collect the Sun's warmth; the house's dark-painted surface also absorbed heat. Energy-conscious architects today design north walls with few windows or doors, and use strategically placed evergreen trees as windbreaks. Photo — Source Unknown

Southern plantation homes were built with broad verandas surrounded by large, leafy trees to provide shading from the summer Sun. House designs included interior hallways and doors that allowed for cooling cross-ventilation in nearly every room. Contemporary floor plans and the use of overhangs or trellises serve the same purpose today.

Before beginning construction of a passive solar adition, owners of this wood-frame house in Minneapolis, Minnesota, made major energy conservation improvements. Annual gas costs for 1978-79 were reduced from $750 to $300 after homeowners added attic and wall insulation, weatherstripping, caulking, water-saving showerheads, and movable window insulation. The house was then retrofitted with south-facing windows, a 2-story solarium, and thermal storage mass. These passive design improvements are expected to cut total heating bills by 45% to 50%.

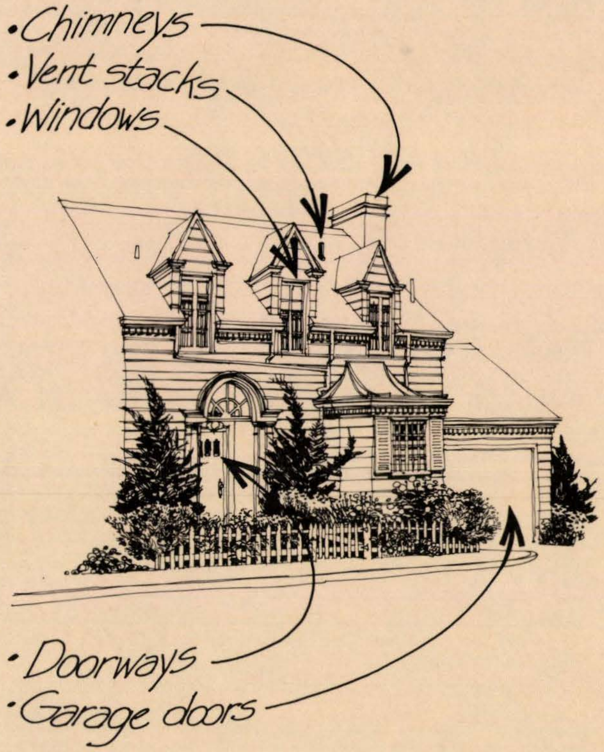
Architect—Peter J. Pfister, AIA, Architectural Alliance; Photo—Franz C. Hall

". . . to keep out the cold winds"

Simply incorporating passive design techniques into a new home or addition is no magic guarantee of year-round comfort. Passive design should be viewed as a supplement to energy conservation measures, not as a substitute for them. Ultimately, the proper teaming of both will yield the greatest savings of money and energy.

Protecting a house against the elements through energy conservation practices is the first crucial step in creating an inside environment that remains comfortable throughout the year. By using passive design techniques that open a house up to the warm winter Sun or cool summer breezes, a homeowner can further increase the benefits gained through energy conservation.

An energy-conserving home demands less energy than its drafty, uninsulated counterpart, necessitating a smaller, less expensive heating or cooling system of any type. Because the intermittent nature of solar energy does not lend itself to misuse or waste, incorporating passive design without relying heavily on sound energy conservation methods is senseless and a waste of money.



Heat leaking from a house travels in three basic ways. Heat lost through **conduction** travels through solid objects such as roofs, walls, or floors. Air moving through cracks around doors, windows, or electrical outlets carries heat with it via **convection.** Like a glowing fire, a warm house is constantly giving off heat to the atmosphere through **radiation.**

the nature of heat

Heat is predictable—given the chance, it will always flow toward a colder spot. The natural tendency of heat (whether generated by the Sun, a forced air furnace, or a radiator) is to sneak through walls, floors, and roofs, and around windows, doors, chimneys, and electrical outlets in a feeble attempt to moderate colder outside air. At the same time, cold air constantly seeps into a home. As much as one-half of a house's heating bill may go toward counteracting warm and cold air that won't stay put.

There is little sense in spending dollars and energy to heat a house that leaks like a sieve. Solution: increased wall and ceiling insulation, weatherstripping and caulking to plug up cracks and holes and keep cold air from sneaking in, and storm doors and double-paned glass to cut down on heat loss through heat-conducting windows and doors. Although most energy conservation practices focus on keeping houses warm in winter, they can also be effective in moderating inside temperatures during hot, summer weather.

Built in 1920, this house originally had virtually no wall or attic insulation and few south-facing windows. In their "new" passive home (photograph on opposite page), owners pay lower fuel bills and are able to enjoy their backyard view from sunny rooms.

beyond insulation

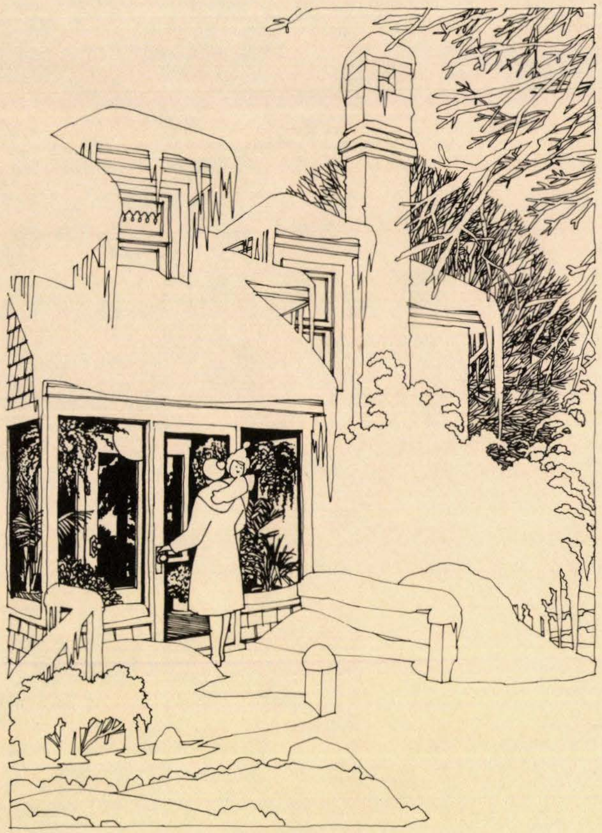
Well-designed passive homes incorporate energy-saving features beyond standard improvements such as insulation, weatherstripping, and caulking. Depending on the specific location and design of the house, a variety of methods are suitable for additional energy savings in both new construction and remodeling.

Residents of houses built into the side of a hill or surrounded on several sides with mounded dirt called **earth berms** are more likely to enjoy warm winters and cool summers. These berms provide excellent buffering, since the year-round temperature of earth below the frostline is considerably warmer than winter air and cooler than summer air. Partially underground homes, which are gaining in popularity, rely on the earth berming concept for maintaining comfortable indoor temperatures.

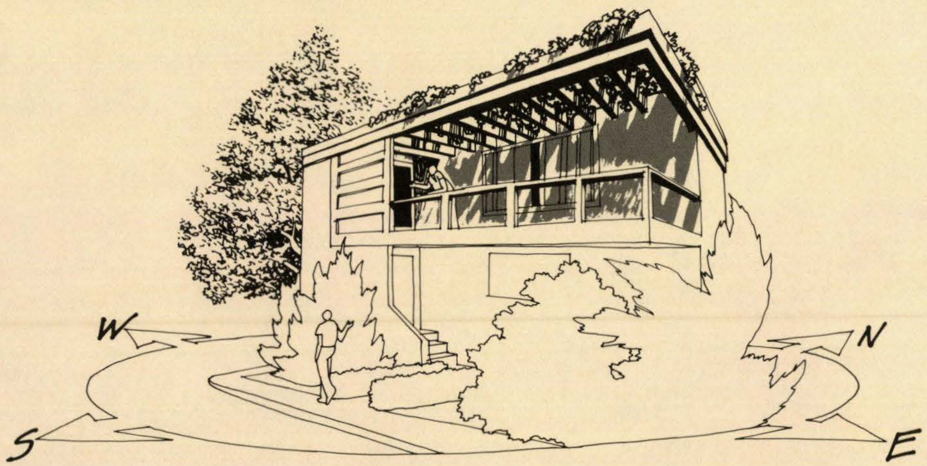
The temperature of a room or of an entire house is upset every time an exterior door is opened. **Air-lock entries** (most commonly known as vestibules) are reappearing as a popular way to keep incoming blasts of cold or hot outside air to a minimum.

Depending on the size of the entryway, it may be useful for storing recreation equipment, outerwear, and muddy boots or shoes. Simple air-lock entries can be added to most existing homes; some can be built as weekend projects by skilled do-it-yourselfers.

Effective placement of **vegetation** is a natural, simple way to protect a house from winter or summer extremes. Summer overheating problems can be partially solved using building **overhangs or trellises** of plants. Properly designed overhangs block the high, sharply angled summer Sun from entering south-facing windows and provide shade for building walls. Leafy plants provide summer shading and, once leaves have dropped off, allow winter Sun to penetrate windows. If year-round protection of walls, doors, or windows is desired, evergreen trees may be planted as a windbreak.



An air-lock entry made of double windows and located on the south side of a house becomes a mini-solar greenhouse, even with frequent opening and closing of doors. The solar heat collected in the entryway will keep hardy plants healthy and can provide a warm welcome on a cold, snowy day.



Leafy plants provide shading for this balcony and the room behind it during hot, summer months. When the plants have lost their leaves, the low winter Sun will shine directly onto building walls and windows.

windows: heat robbers

Heat slipping back out through the very windows that let it in is a major concern for a passive solar dweller. In a well-insulated home, the major source of heat loss is windows, which allow heat to escape through the glass and through cracks around window frames and panes. Even tiny cracks and holes which are hardly visible provide a passageway for cold air to seep in and warm room air to escape.

Tightly fitting movable window insulation helps keep heat in during nighttime or cloudy periods and also helps to keep a house cooler during the summer. Most designs can provide daytime privacy, too.

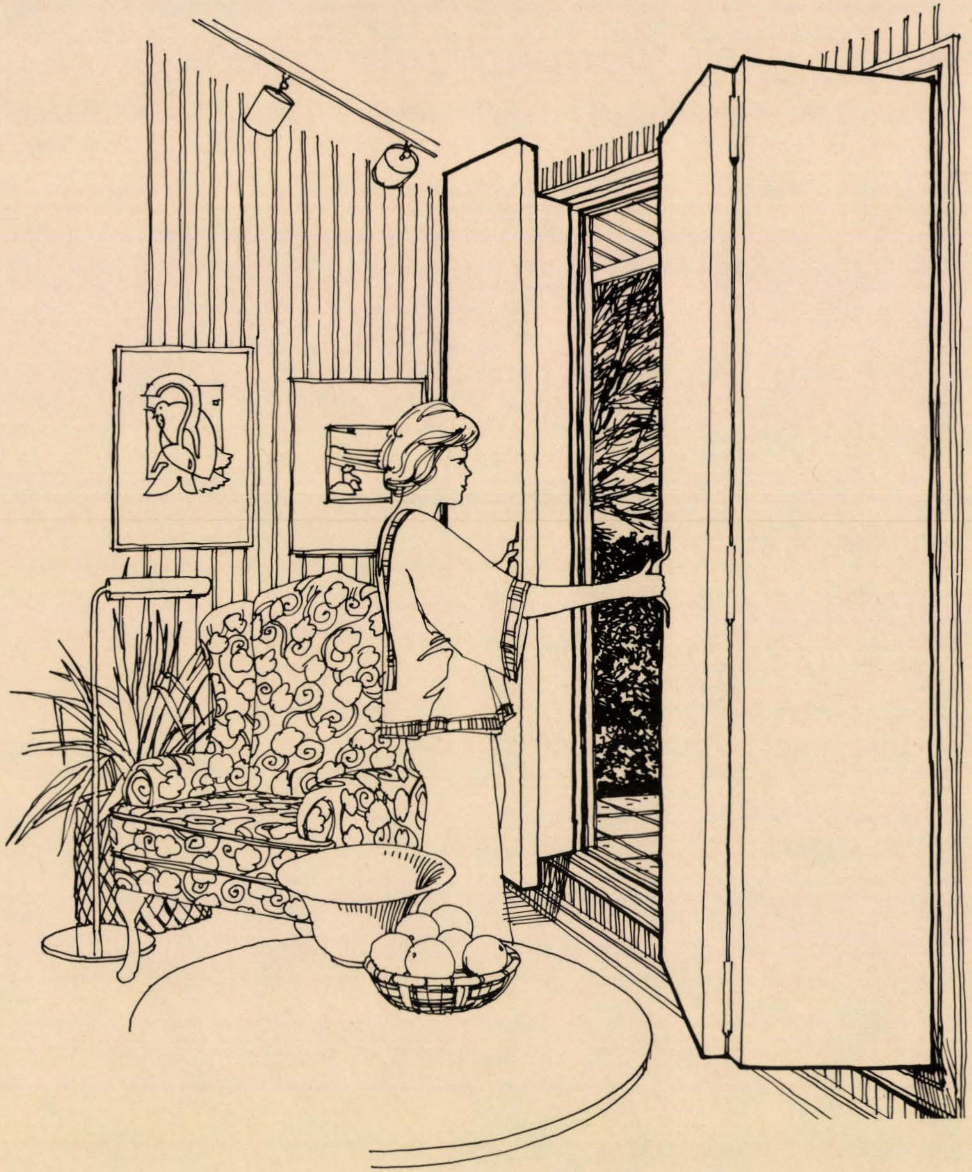
Movable insulation systems can be as complex or simple, as inexpensive or elaborate, or as functional or decorative as the homeowner wants. Most, however, are manually operated and fairly simple in design. The insulation can be used with single-paned windows or, in some situations, teamed with double-paned or storm windows for even greater effectiveness. More elaborate systems are available with small motors or temperature-controlled devices that automatically close the insulation during sunless times and open it so that the sun's rays can pass through for warming interior spaces.

Solar energy and conservation equipment suppliers, home furnishing stores, or hardware outlets sell a variety of movable insulation products; some designs are simple enough for the do-it-yourselfer.

Types of movable insulation include:

- Set-in-place or hinged panels made of fiberglass or rigid insulation, covered with wood or fabric;
- Shades, shutters, or drapes made of layers of insulating fabric that seal tightly at top, bottom, and sides, and may run on tracks for a snug fit;
- Specially designed louvers with heat-reflective surfaces. Some louvers may be dark on one side to absorb heat and "silvered" on the reverse to reflect the harsh summer Sun; and
- Foam beads blown between double windows and then sucked out by a small motor.

Like any energy conservation product or home improvement measure, movable insulation should be selected with a great deal of thought. Attention must be paid not only to providing the highest efficiency at the lowest cost, but also to choosing a product that complements home decor and inhabitants' lifestyles.



More complex movable insulation systems may incorporate heat-sensitive controls that automatically open or close, lift or drop insulation at appropriate times. However, the effective use of movable insulation takes little more time and effort than do putting the cat out at night and putting the coffee on in the morning.

". . .the sun's rays penetrate in winter. . ."

Most homes built in this country in recent years have been placed in neat, tidy rows with front doors all facing the same direction. A closer look may reveal that many were built with backyards or play areas situated on the north side of the house, or with long walls facing east and west. Often, shadows from adjoining buildings or trees allow little sunshine to fall on the house's walls and windows.

Increasingly, however, builders and homeowners are realizing that the direction a building faces (its orientation) plays a major role in determining the structure's ability to collect solar heat in the winter and reduce overheating in the summer.

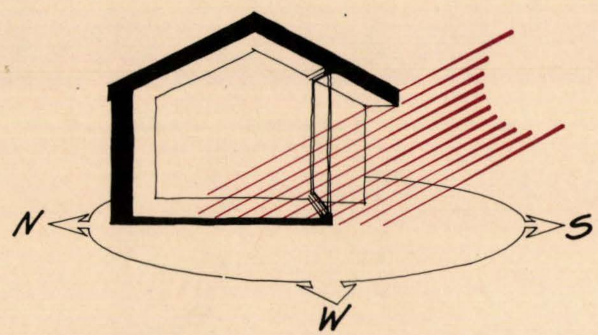
sun paths and angles

The tilt of the Earth as it revolves around the Sun is responsible for our seasons. The summer Sun rises slightly north of east, travels in a high arc across the sky, and sets north of true west. During winter months, when the Sun's angle is low, most solar radiation will fall on a building's south-facing walls or windows.

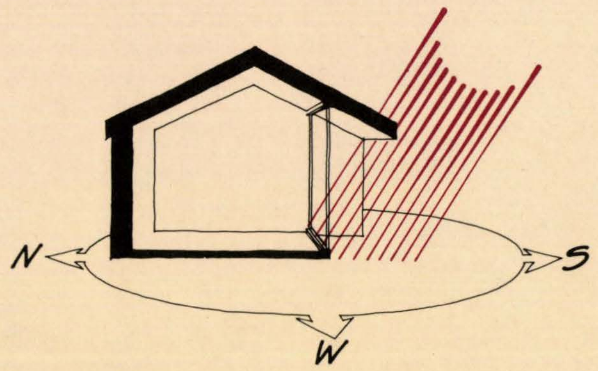
In summer, when the Sun's angle is high, the roof and east and west sides of a building receive the greatest amount of sunshine. Building a house with the smaller ends facing east and west will reduce the impact of the Sun when it is strongest. During the winter, the broad south-facing side of the house is exposed to the Sun for collecting solar heat.

Walls that face north and receive little direct sunshine should have as few windows or doors as possible; entryways should be located on a sunny side of the house. When it is necessary or strongly desirable to place doors and windows on the north side of a house, double entryways and movable insulation become increasingly important.

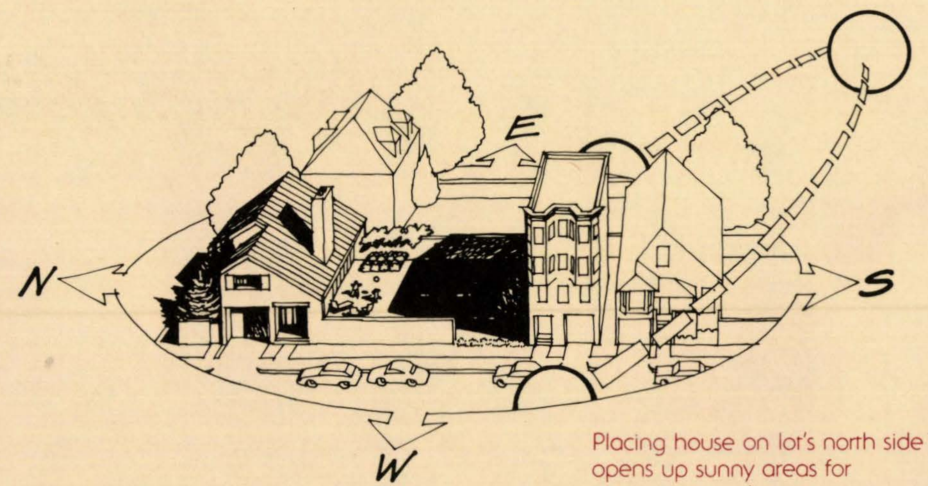
Attention must be given to the placement of a house on the building site. Generally, the north side of a house's yard receives little or no direct sunlight throughout the winter, making it inappropriate for play areas (except an ice skating rink!). Placing the house along the northernmost lot line opens up sunnier, southern areas for gardens and recreation. Care must be taken not to block southern Sun from neighbors to the north.



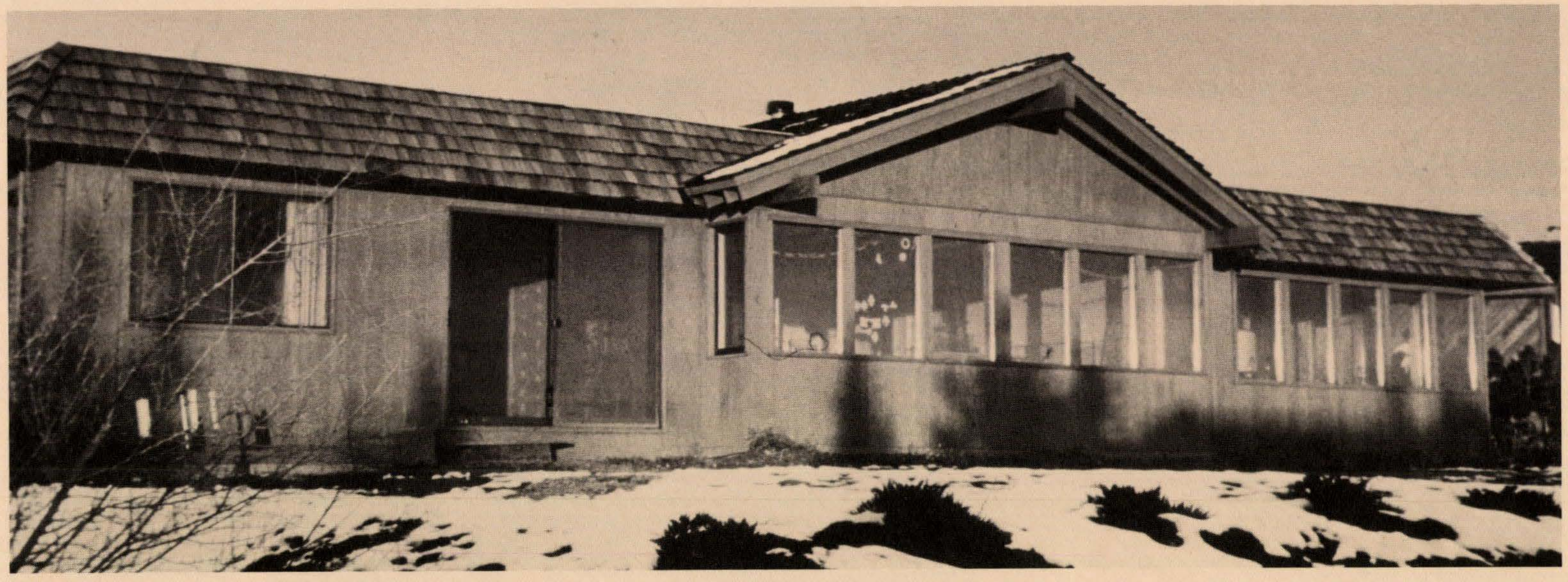
Windows on the south side of a house collect the greatest amounts of solar heat during the winter when the Sun is low in the sky.



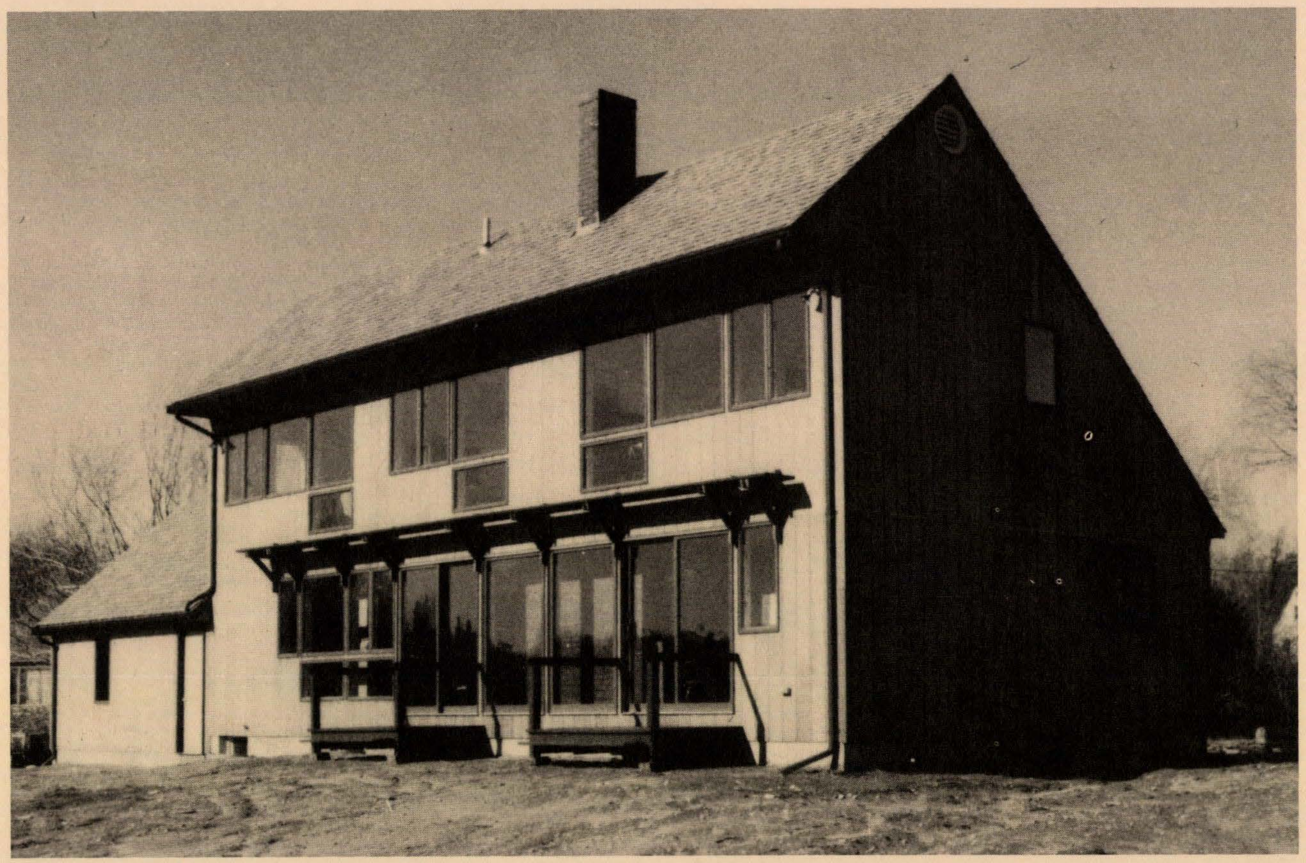
During hot summer months, a properly designed passive house will not overheat. Roof overhangs are one way of keeping the high summer Sun away from south-facing windows and other glass areas.



Placing house on lot's north side opens up sunny areas for recreation, gardening.



The importance of proper orientation can be illustrated in these homes in widely varying climatic regions of the country. Careful orientation and window placement provide this Yakima, Washington, house with 80% of the heat needed in winter, and summer temperatures that average 10° to 15° cooler than the outdoors. Heating bills for the 1979-80 winter season totaled $51, according to the home's owner, who says he "doesn't even know if the electric backup furnace works." Solar energy is collected by triple-paned south-facing windows and stored in a concrete floor; when necessary, an air-tight woodburning stove provides supplemental heat. According to the owner, cost of building the home was 8% below conventional construction costs in the area.
Owner/Builder—John Shaw; Photo—Western Solar Utilization Network



The passive design features of this Duxbury, Massachusetts, home supply more than half of the heat needed. An adaptation of the colonial New England saltbox, the house has a 2-story south-facing side, a sloping north roof, and few windows on north, east, and west sides. Bedrooms and living areas are on the south side of the house to take advantage of south-facing windows; less frequently used rooms such as bathrooms and storage spaces are placed to the north.
Photo — Allen & Mahone, Architects

passive solar, active solar

The words **passive** and **active** are commonly used to describe two approaches to solar energy use. Either type of solar heating or cooling system performs three key functions: collecting solar energy when it's available, storing it for use during times when it's not, and delivering it to spaces that need it. Both active and passive systems can heat or cool living spaces as well as heat water for laundries, baths, and kitchens, and can be combined to form **hybrid** systems.

Passive designs depend primarily on natural heat flows. In one type of passive system, warmth may be collected from the Sun shining directly through windows, and stored in the building's walls, floors, and interior—little additional energy is needed to operate a passive system. During hot weather, a well-designed passive home is shaded to minimize overheating. Carefully positioned vents or windows also allow hot air to rise out and away from living spaces.

Active systems, which use fans or pumps to transport sun-heated air or water, rely on electricity to operate.

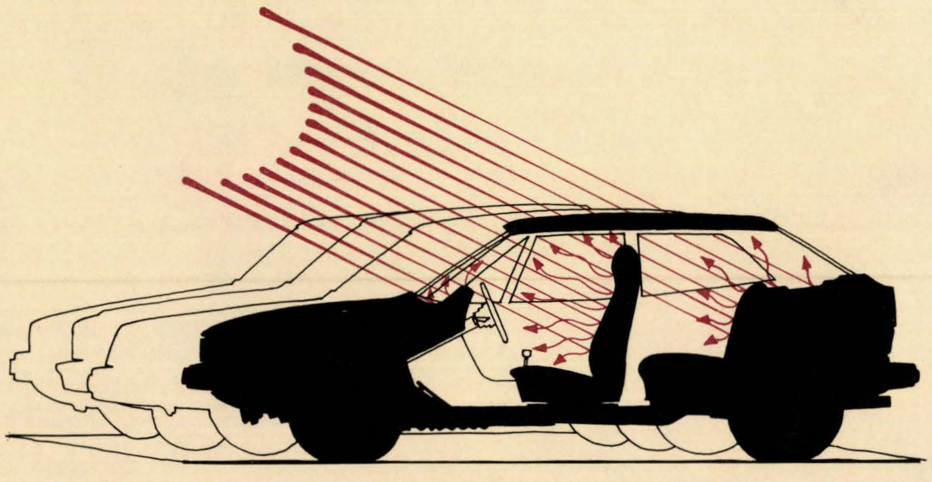
In many instances, it makes the most sense to incorporate both passive and active systems into new homes or additions. Specific site and construction details must be analyzed carefully to determine the best system—or mix of systems—for any given situation.

This prefabricated (panelized) home in Acton, Massachusetts, combines active and passive solar collection to supply an estimated 78% of the building's heating needs. The active system provides about 40% of the total, but contributes about 70% of the energy needed for heating domestic hot water. Passive solar collection through south-facing windows, sliding glass doors, and a small solarium provides the rest. Photo — © Acorn Structures, Inc.

heat collection and storage

Every structure collects some portion of the sunlight striking it; building materials and color, orientation to the Sun, and floor plan further influence a building's capability to trap warmth. A properly designed structure will take full advantage of this collection process and supplement it with heat storage, natural ventilation, and summer cooling capabilities.

Because of its properties, ordinary window glass is a key element in trapping the Sun's warmth and plays a major role in creating the "greenhouse effect." Most people have experienced the "greenhouse effect" in a car parked in the Sun. The glass in the windows of an automobile allows much of the sunlight to pass through. Once inside, sunlight is absorbed by seats, dashboard, and floor, and reradiated as heat, which does not readily pass back through the glass. Consequently, temperatures inside the car continue to build as the "greenhouse effect" is put into operation.



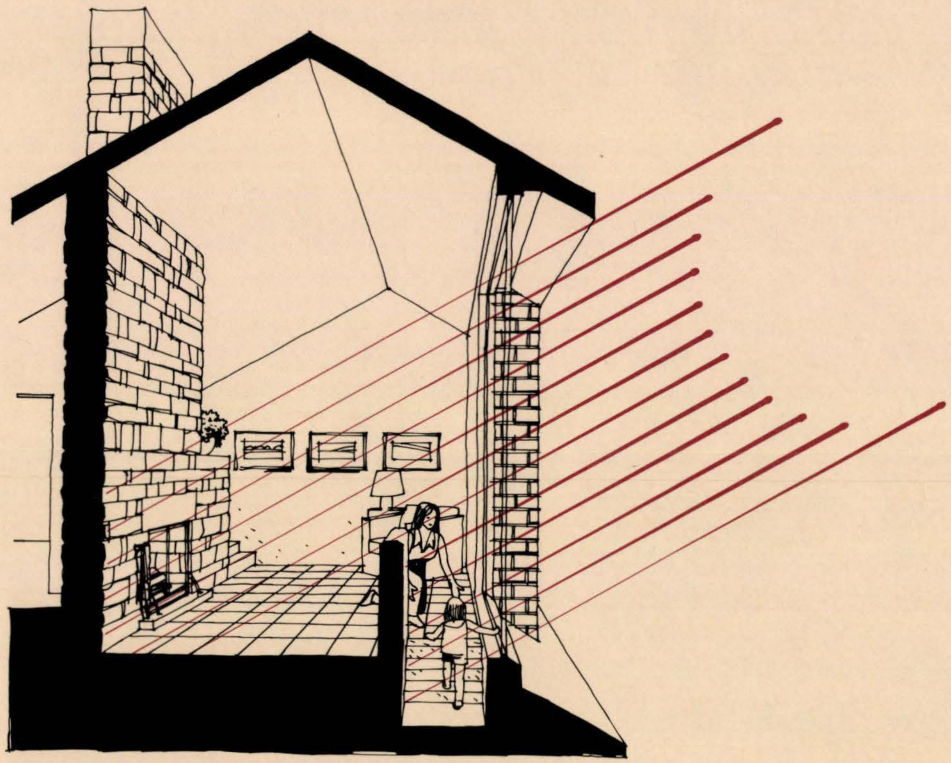
The "greenhouse effect" causes cars — and homes — to heat up naturally.

Many of today's conventional homes have south-facing windows that allow sunlight and heat to enter rooms. The daytime heating needs of these "sun-tempered" houses may be met using only the Sun's heat, but the buildings lack the storage component that typifies true passive homes. In well-designed passive homes, common materials that can absorb fairly large amounts of heat keep living spaces from overheating during the day and help to moderate temperatures over the course of an evening or cloudy afternoon.

Dense materials such as concrete, brick, adobe, or water, located in floors, walls, room dividers, fireplaces, or furniture exposed to the Sun provide thermal mass, soaking up enough heat to keep living spaces comfortable through a cold night or sunless period. Heat is transferred naturally to surrounding areas by radiation, conduction, or convection. The type, location, and surface area of thermal mass determine how quickly or slowly heat is absorbed and released to a living space. Local climate will also play a role in the technique's effectiveness.

Passive solar collection doesn't take place only through south-facing windows; neither is it necessary for the entire south side of a house to be covered with glass. In fact, the windows in many of today's conventional homes could help provide passive solar heating if they were simply moved from north, east, or west sides, and placed on the south. Solar energy may also be collected through skylights, clerestory windows, or through the glazed walls of attached greenhouses, solariums, or sunspaces. Sliding glass doors leading to terraces or patios are also solar collectors in a passive home. Properly placed, glass areas can take full advantage of the winter Sun yet be shaded from the harsher rays of summer.

The collection and storage elements of passive heating and cooling systems can be incorporated in a variety of attractive home designs. No one particular floor plan or architectural style is necessary—passive design works well with Cape Cod or contemporary, southwest adobe, or ranch styles. What will differ among passive homes is the placement and amount of south-facing double glass; size, type, and placement of thermal mass for storage; and use of vents, dampers, or fans for moving heated or cooled air from one place to another. The precise mixture of various elements will depend on the specific nature of the home site; further refinements can be made to match the tastes of individual dwellers.



Exposed to direct or reflected sunlight admitted by south-facing windows, concrete, tile, brick, adobe, stone, or water in containers can absorb and store heat.

In this Virginia home, a brick divider wall and tile floor serve as thermal mass, absorbing and storing heat from south-facing windows. East-facing windows at the right of the photograph provide early morning natural breakfast light. Exterior sliding wooden doors insulate the windows at night and during sunless periods.

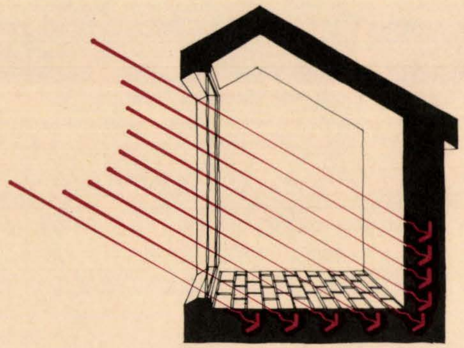
Architect — Billy Born; Photo - Tennessee Valley Authority

The terms **direct, indirect,** and **isolated** are used to describe approaches to designing and building passive structures. Depending on the individual house design, more than one approach may be combined for maximum efficiency, affordability, and aesthetics.

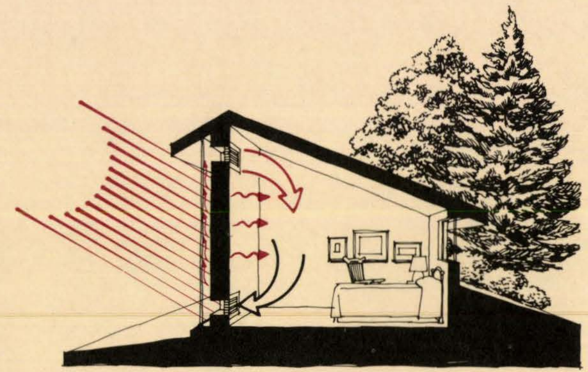
In a **direct** heating design, the simplest of all solar heating systems, solar radiation shines through windows directly into a living space, where it is absorbed and then converted to heat in floors or walls which serve as thermal mass. At night, stored heat flows from the warm mass surfaces to the cooler living space.

With the **indirect** approach, sunlight strikes thermal mass before it enters the interior living space. Heat is first absorbed by the water or masonry mass positioned directly behind south-facing glass, and then released to the room by radiation, convection, and conduction. Movable insulation between the mass and the double-paned windows may be used to lessen nighttime heat escape.

In an **isolated** heating system, solar heat is collected and stored in an area set apart from the living space. Because the living area is not directly exposed to the Sun, the amount of heat it receives can be more closely controlled than with other system approaches.

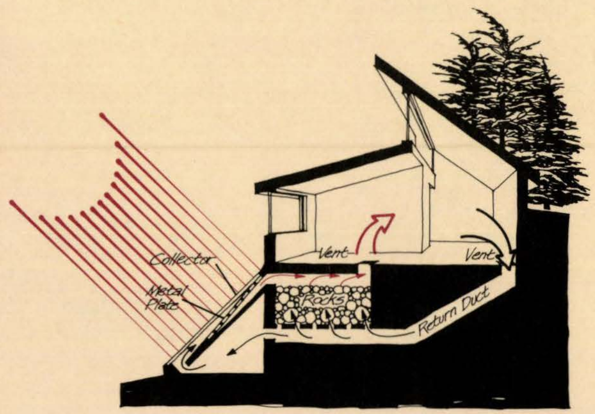


Direct heating can be as easy as opening insulated drapes or shutters and "letting the sun shine in."

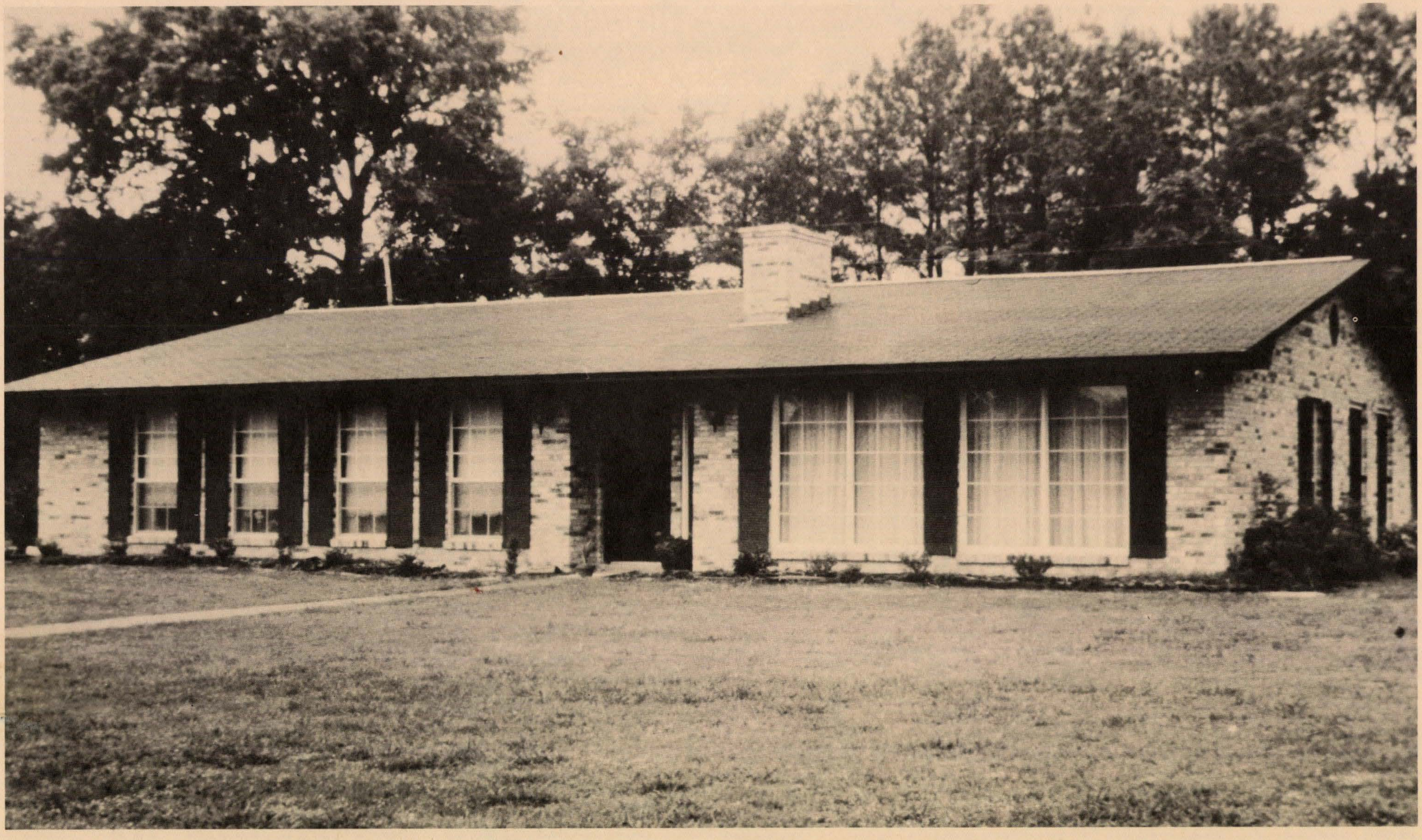


One **indirect** heating system uses a thermal storage wall. Heat is conducted through the wall and transferred directly into the room by air circulation through high and low vents.

This home in Los Alamos, New Mexico, collects solar heat directly through south-facing windows and skylights, and stores it in brick floors, adobe walls, and two rock beds under the floor. Skylights are fitted with insulating panels that open automatically when warmed by the Sun. Typical heating bills in the area may average more than $1000 annually; these homeowners, however, have never turned on their electric backup furnace. The Sun provides 90% of the heat needed; a woodburning stove and fireplace provide the rest. Photo — Gerrit Zwart, Architect



Example of an **isolated** system uses collectors mounted below living spaces. During the day, heated air rises naturally from collectors to either storage or living areas. At night, heat flows from storage to living areas.



The performance of this direct gain house in Starkville, Mississippi, proves that passive design works well in hot, humid, southern climates. In an area where the mean January temperature is 43°, owners of this subdivision home save 75% to 85% on winter heating bills. In the summer, air conditioning bills are cut by 30% to 50%, largely due to strategic window placement, overhangs that keep out the high summer Sun, and maximum insulation levels. The builder estimates that energy conservation measures added about $800 to the cost of this house in 1975; another $400 went for solar considerations such as increased south-facing windows and exterior movable shutters on east and west windows. He also estimates that energy-efficient homes such as this one are selling at 3% to 5% higher than nearby conventional homes of comparable size and style. Designer/Builder—Pablo Okhuysen; Photo—Sharyn Towle

A **thermal storage wall** (often called a Trombe wall after the French scientist who studied the concept extensively) is today's most popular use of a masonry storage wall in an indirect heating system. The wall, constructed of concrete, brick, or stone, absorbs heat on its dark-colored outer surface and, through conduction, moves the heat to the wall's inner face. Convection and radiation then distribute the heat to living spaces.

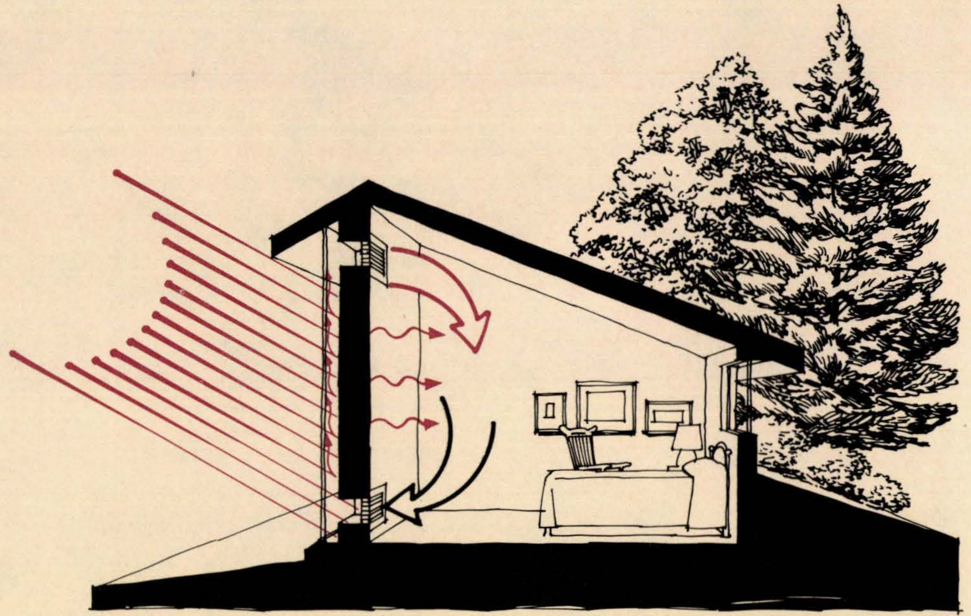
The daytime heat transfer process may be supplemented by adding vents at the top and bottom of the wall. A natural circulation process is generated when heated air in the space between wall and window rises and enters the living space via the upper vent(s). Cooler room air at floor level is drawn through the lower vent(s) where it is again warmed, rises, and returns to the room. Vents to the outside may be used to move hot air away from the living space during the summer.

A thermal storage wall can harmonize well with a variety of interior design schemes; the wall will still perform effectively with windows placed in it. Inner masonry surfaces can be plastered with stucco or other conductive materials, tiled, or decorated with small- to medium-sized pictures.

A **water wall** placed directly behind south-facing windows provides thermal mass for indirect heating. The sun's heat is absorbed in the water and transferred to the living space by radiation and convection. Nighttime or cloudy day heat loss can be cut down by using insulating drapes or curtains between the wall and the window, or by installing movable insulation on the outside of the wall. As heat is absorbed by the water, the container itself remains relatively cool to the touch. Containers for water walls may be purchased, or can be made from recycled barrels, tubes, or special-purpose water containers.

In the **roof pond** approach, transparent plastic containers much like water bed mattresses are placed on a flat metal roof and covered by movable insulating panels. During the heating season, insulating panels remain open during the day to allow the ponds to absorb solar heat. When the Sun goes down, insulating panels are closed, trapping the collected heat. Through radiation, warmth is then transferred to living spaces below.

The procedure is reversed in the summer. Insulating panels remain closed during the day to prevent unwanted collection of heat while the cool roof ponds absorb heat that has built up in the house below. At night, the insulating panels are opened so that heat absorbed by the water is released to the night sky. The simple cooling cycle can then begin again the next morning.



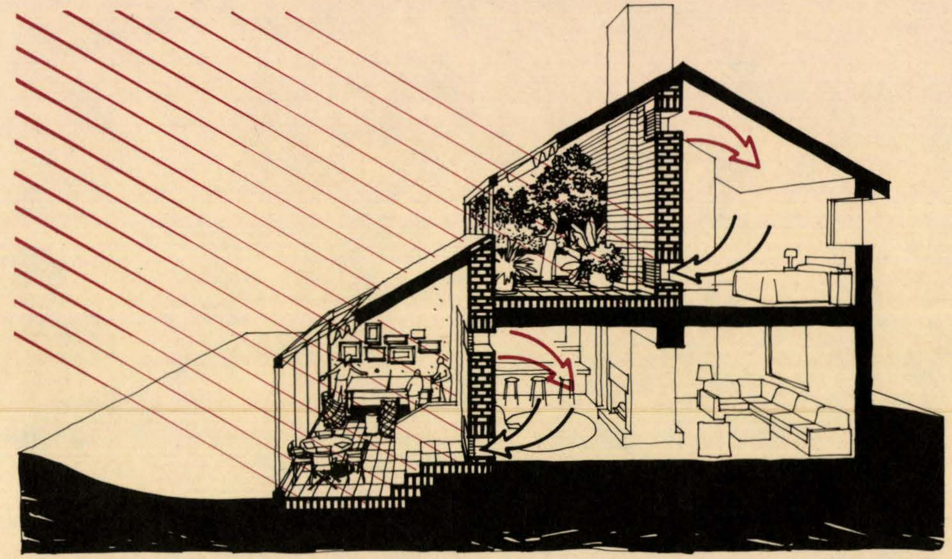
Air collected and warmed between the thermal storage wall and south-facing glass is transferred to the living space by conduction through the dense wall itself, and by way of a thermocirculation cycle set into motion via high and low vents in the wall.

A thermal storage wall blends in well with the conventional design of this 1,800-square foot home in Glen Mills, Pennsylvania. The inner surface of the wall is painted to complement the decor of the living room behind it; several well-placed windows admit sunlight. Residents of the house paid a total of $200 for heating and hot water during the 1978-79 heating season. The builder estimates the house cost $3 to $4 more per square foot than a conventional house in the area, yet homeowners can save 60% in heating bills. Designer—Jim Kries, Sunburst; Photo—NSHCIC

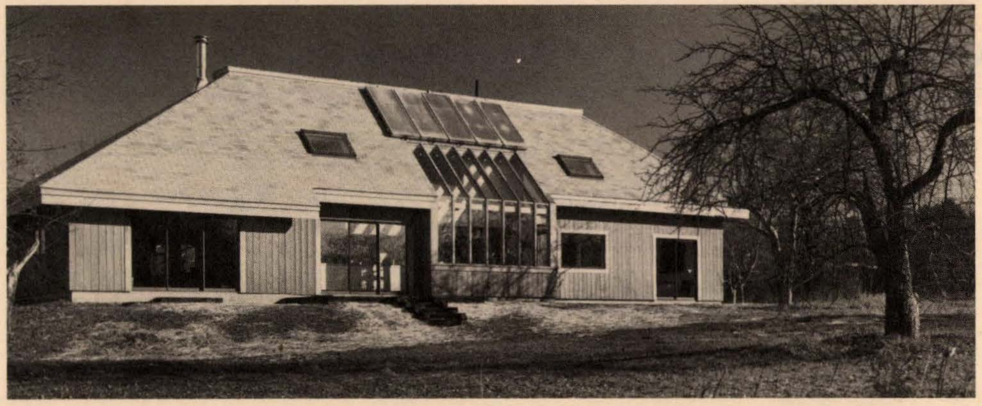
In Shelton, Connecticut, this home collects solar energy through clerestory windows and a 2-story solarium and stores heat in a unique system of water-filled glass blocks. The back wall of the solarium includes windows that admit sunlight directly and, when opened, help to transfer heat from the solarium to the house. In addition, a major portion of the separating wall is made of water-filled glass blocks that store heat for transfer via radiation and convection. An automatic insulating curtain prevents the glass blocks from losing heat to the solarium at night and during cloudy periods. Additional heat is stored in 160 5-gallon water containers stacked on the north side of the house behind a wall. Heat that collects at the top of the solarium is ducted past these water containers and integrated into the backup furnace's return-air handling system. About 85% of the home's heat is supplied by passive design; the owner uses a woodburner for most of the remainder. Photo—Carl Mezoff, Designer

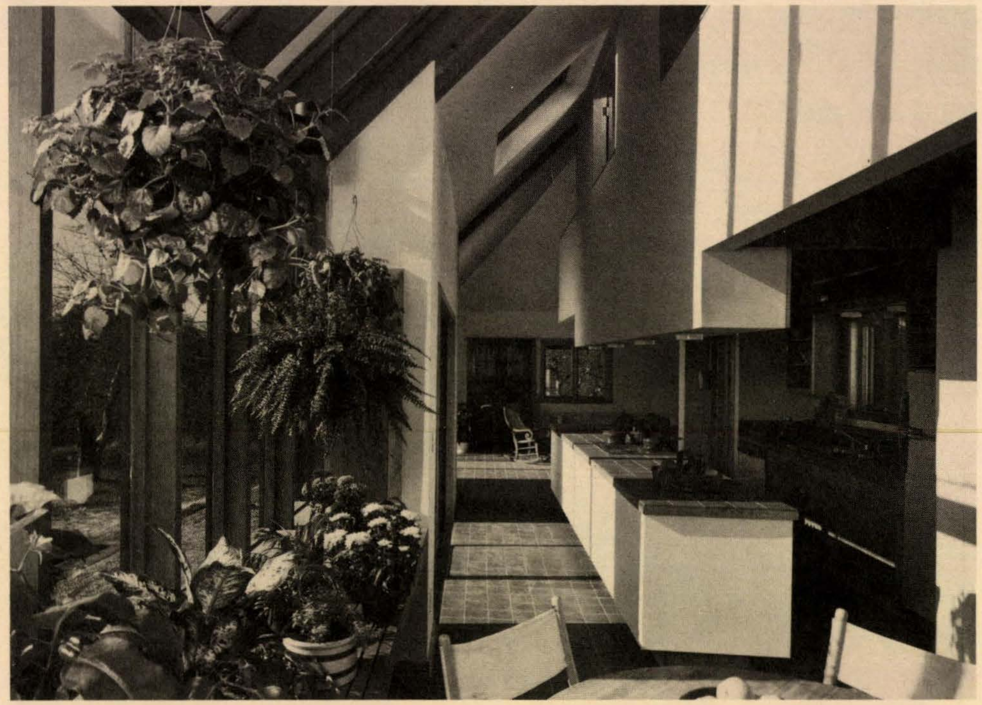
An add-on **solar greenhouse** is heated directly by the Sun, and, in turn, helps to heat the remainder of the house. Solar greenhouses or sunrooms are excellent ways to incorporate passive design into existing houses and can provide heat, flowers or vegetables year-round, and a sunny room addition. Vents or doors and windows allow natural circulation of warmer air into rooms.

Heat storage is found not only in walls and floors, but in greenhouse potting beds and planters or in containers of water. Movable insulation can be used to reduce heat loss and associated drops in greenhouse temperatures at night; vents to the outside are used to exhaust excess heat on mild winter days or in the summer.

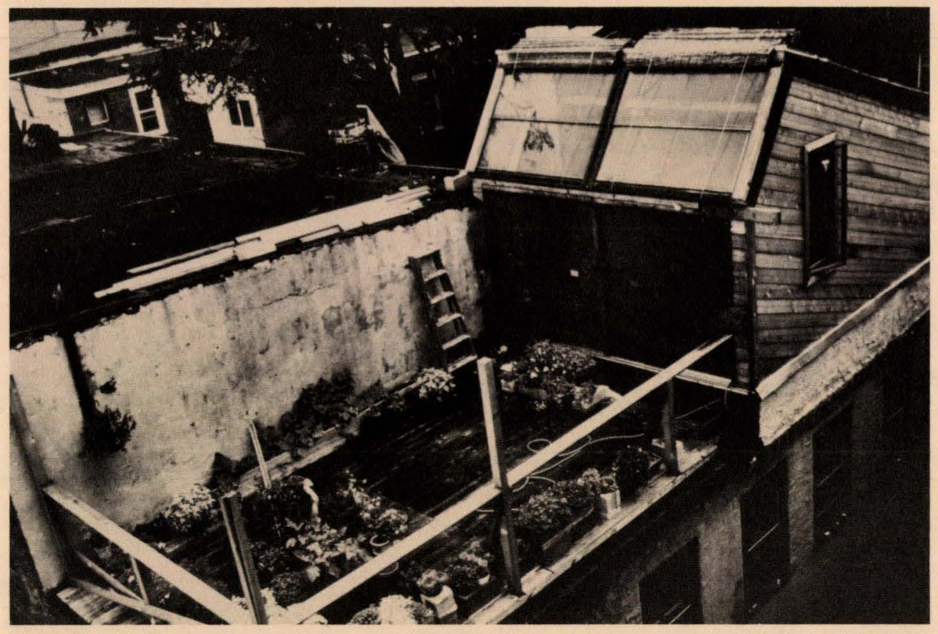


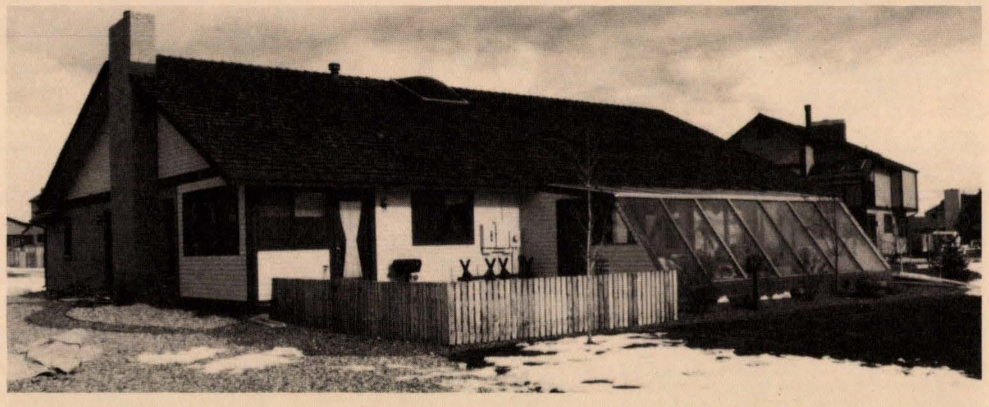
The heat collected naturally in solar greenhouses or sunrooms can be circulated to other rooms in the house through properly placed vents. A natural cycle will cause warm air to rise and flow through upper vents while cooler room air flows through floor vents back to the warmer area.



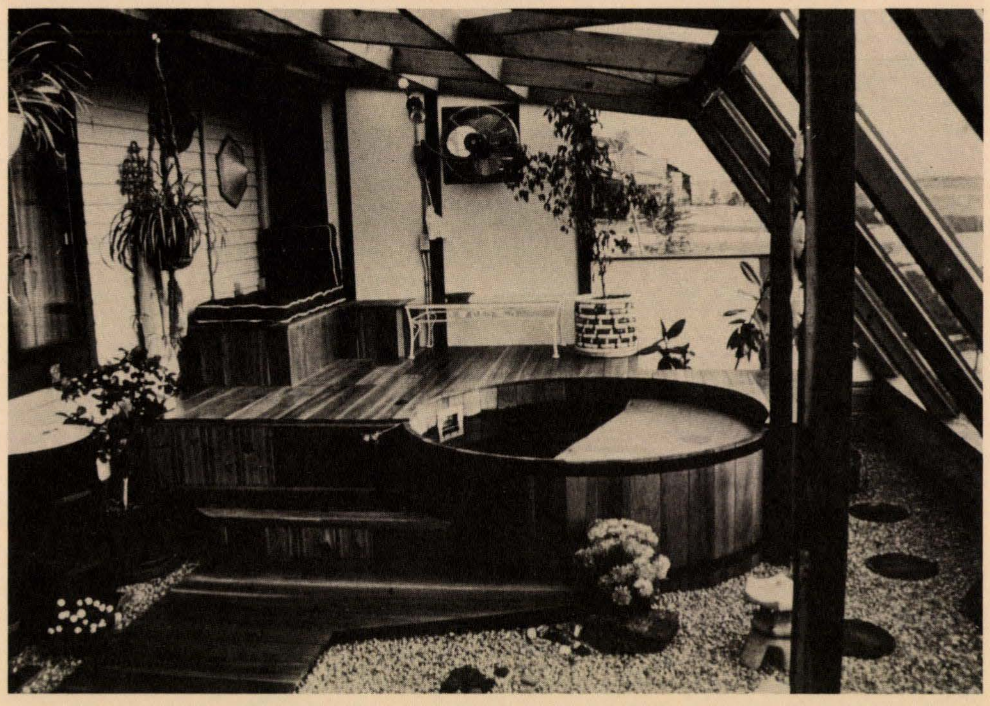


This Westford, Massachusetts, house uses active solar collectors for domestic hot water, and a central greenhouse, windows, skylights, and sliding glass doors for passive solar collection. The narrow design of the house allows all first-floor living spaces to take advantage of the Sun; the greenhouse, as shown, also serves as a breakfast area. Residents burn about 1½ cords of wood each year in a woodburning stove that provides supplemental heat when needed — the house has no conventional backup system. A heat exchanger coil carries solar-heated water from rooftop active collectors. Warm air pulled from the ridge of the house is passed over the coil for a temperature boost and is then ducted into a rock storage area below the house. Heat is then distributed by a thermostatically active blower. Overhangs, insulating shutters, and openings high on the north wall help control summer overheating.
Architect—Massdesign Architects & Planners; Photos—Steve Rosenthal

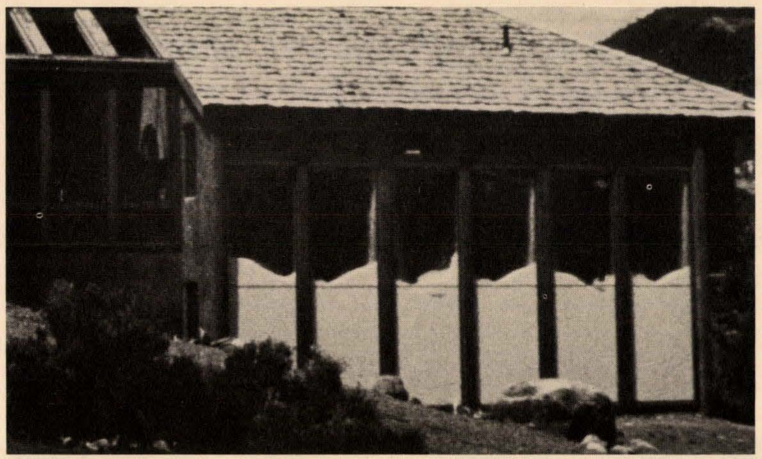




A Philadelphia, Pennsylvania, homeowner added a rooftop solarium after making energy conservation improvements to this 100-year-old rowhouse. The solarium provides a 25% increase in living space, a year-round garden, and a rooftop cedar deck. The south face of the solarium is made of double-paned vertical sliding glass doors and tilted double-paned windows. Heat is stored in 35-gallon drums and a 300-gallon tank filled with water. In the summer, bamboo shades are lowered to prevent overheating. In March 1979, the solarium temperature averaged in the middle 70°s during the day and never dropped below 64°. No electric backup heat was needed. When the temperature in the solarium reaches 85°, a fan system draws excess heat into the rooms below.
Designer—Richard C. Fredette III; Photos—Solstice Design and Building



A solar greenhouse was added to this home in Aurora, Colorado, to provide a source of supplemental heat for the rest of the house, additional family living space, and a year-round growing area. A thermostatically controlled fan keeps the greenhouse at 95° — excess heat is vented to the house through existing doors and windows. Interior view shows hot tub and water-filled drums for heat storage. Residents have enjoyed radishes and cucumbers even throughout the Rocky Mountain winter and plan to begin hydroponic gardening soon. Photos — Solar Technology Corporation



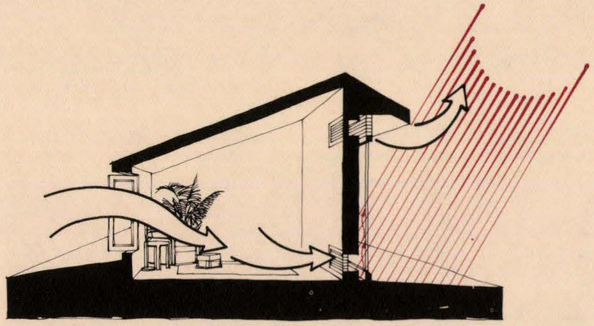
Solar energy supplies 60% to 80% of the heat needed for this house in Durango, Colorado, yet the house stays cool through mountain summers as well. Although the house was built with an electric backup furnace, residents prefer to use a woodburning stove to supplement solar heat collected by a solarium and 16" thermal storage wall. During the summer, the top row of windows in front of the thermal storage wall can be opened to vent rising hot air away from the house. A movable insulation system using foam beads blown between double-paned windows minimizes heat loss during sunless periods. A small motor sucks out beads to allow sunlight to penetrate windows. Inset photo shows windows half-filled. Architect—Brian Kesner; Photo—Paul W. Pixler

design for all seasons

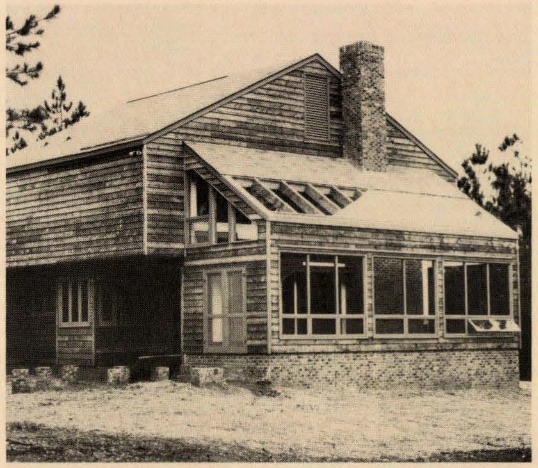
A well-designed passive home can be as comfortable during hot summer months as it is throughout the winter. The use of standard energy conservation techniques, coupled with careful attention to shading and opening and closing of properly located vents or windows, can go a long way toward keeping living spaces comfortable year-round.

Most energy conservation practices work two ways. Insulation in walls and roof prevents heat from escaping during the winter, and, in the summer, prevents heat penetration and maintains cooler temperatures. Movable insulation keeps heat in during cold, cloudy periods; in summer, insulation protects windows from the Sun's glare and heat. Leafless trees that permit sunshine to enter windows in the winter are full and lush for summertime shading; overhangs and vine-laden trellises block the summer Sun from both windows and walls. Overhangs on the south are effective because of the high position of the Sun during mid-summer days.

Since warmer objects radiate heat to cooler surroundings, the heat that unavoidably builds up in a house may be radiated to the cooler night sky. Wall, floor, or furniture materials which are cooled at night can act as heat absorbers to moderate indoor temperatures throughout the next day. Windows or vents placed low in the house draw in cooler air at night or from shady north sides, while upper vents or windows release hot, rising air. Air flow can be assisted by wind-driven attic fans.

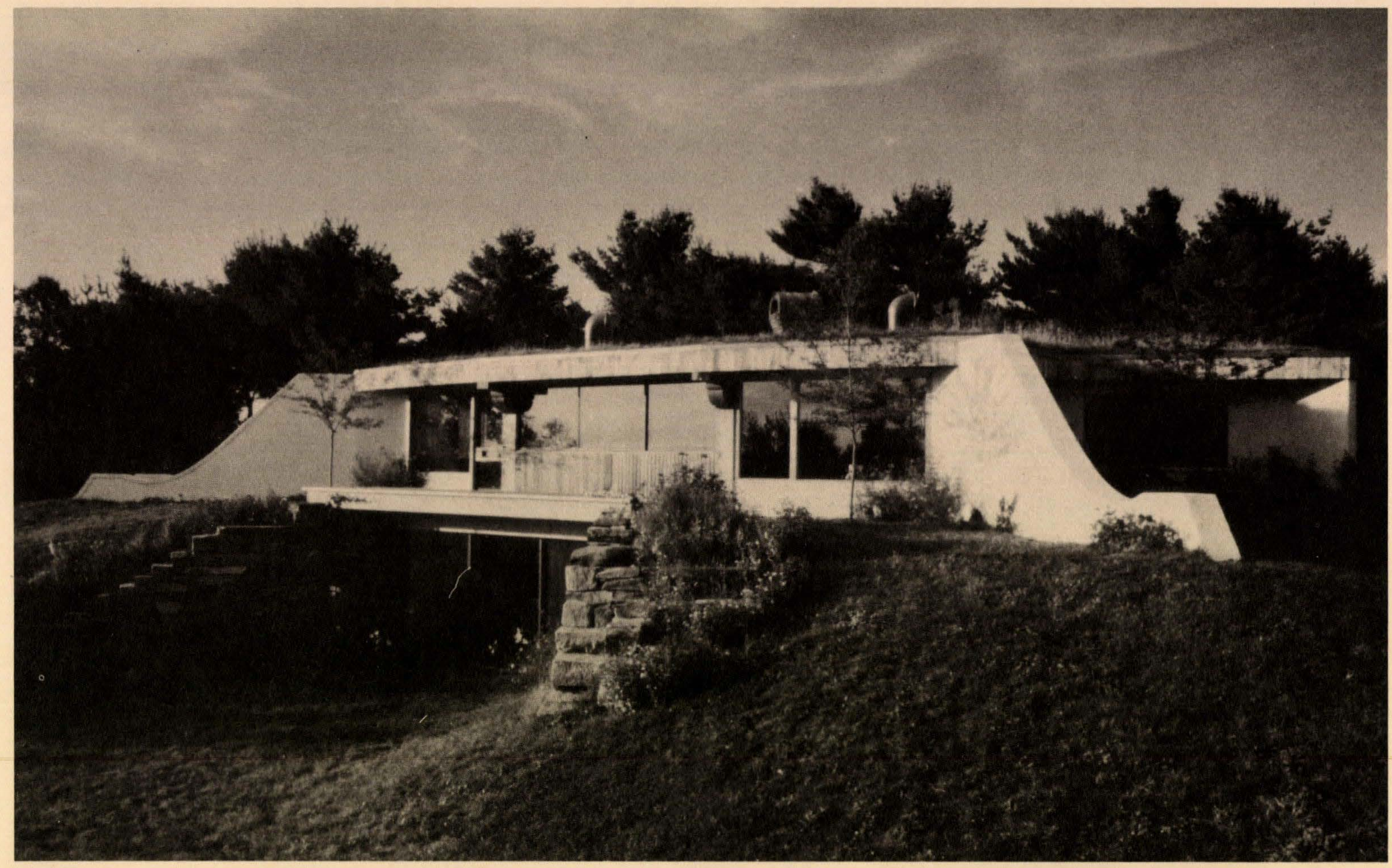


Cool air drawn in on the windward side of a house improves cross-ventilation. As part of the cycle, warm air rises and flows through high vents.



This Kershaw, South Carolina, home was designed for a climate where hot, humid days are followed by hot, humid nights. Heat collected in the solarium is vented to the attic and exhausted through the large vent next to the chimney; natural circulation is enhanced by a thermostatically controlled attic fan. Residents use conventional air conditioning only during periods of extreme temperature and humidity.
Photo — Dick Lamar, AIA

Thoughtful attention to landscaping can result in a cooler house throughout the hot summer season. The full summer foliage of vines, trees, or shrubs helps to block the summer Sun from south-facing windows and walls.
Photo — U.S. Department of Energy



Earth berms on the east and west sides and totally buried north walls help to moderate year-round temperatures in this New Hampshire underground home. Large areas of south-facing glass on both main and lower levels collect the heat of the Sun for storage in brick floors and masonry walls. Overhangs, fin walls, and wing walls protect the house from winds in winter while reflecting light into living spaces. These design features also provide summer shading and prevent overheating. Passive design accounts for nearly half of the home's heat. A central heating unit that operates on wood and/or oil and woodburning stoves in the living and dining rooms provide the rest. Windows on two sides bring the sun's warmth and natural light into the dining room, below. Photo — Ross Chapple for Don Metz, Architect

the next step . . .

Many elements of passive design are being used in underground houses that rely on buffering qualities of soil to keep interior temperatures moderate throughout the year. Hardly the dark cavernous places that many people associate with underground living, today's underground homes can be filled with light, fresh air, and growing plants. Many are built with north, east, and west sides set into the ground and a south face made almost entirely of double-paned glass.

for more information...organizations

Architects, designers, and builders around the country have already begun to incorporate passive design concepts in homes, apartments, and commercial buildings. To help interested homeowners or potential homebuyers locate the appropriate professionals in their city or state, various organizations at local, state, and regional levels offer referral and information services.

Solar professionals may be located through local or state chapters of the American Institute of Architects (AIA), National Association of Home Builders (NAHB), the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), or other **trade and professional organizations.**

Solar energy associations have been established in more than half of our states; some cover multi-state areas. Practically all provide referral services and many hold seminars, workshops, or meetings. Find them in the telephone book, through the National Solar Heating and Cooling Information Center, or from any **state energy office,** another good source of free solar energy and energy conservation information.

Energy Extension Service (EES) Centers may be associated with either of the above organizations or with other energy-related groups in all 50 states. They offer personalized service to people with questions on conservation, solar energy, or other renewable resources; state energy offices can give further information on specific EES programs.

Solar professionals may also be located through **local community colleges, adult education centers,** or **colleges and universities.** Many of these institutions may also offer courses for both the professional and the passive solar newcomer.

The U.S. Department of Energy and other Federal organizations are supporting the increased use of passive design for heating and cooling in homes and buildings and for commercial, institutional, and agricultural uses. Work being carried out at laboratories and other research centers around the country covers varied facets of passive design, from development of design tools and analysis methods through actual construction of demonstration buildings. Additional emphasis is being placed on the areas of communications and marketing, and on efforts to generate interest in passive design among designers and builders as well as consumers.

The following government or government-funded organizations are sources of additional information on passive design. Each may provide different information and technical assistance services; all can make referrals to solar energy organizations, state energy offices, or other local resources.

Solar Energy Research Institute (SERI)
1617 Cole Blvd.
Golden, CO 80401

Northeast Solar Energy Center (NESEC)
470 Atlantic Ave.
Boston, MA 02110

Mid-American Solar Energy Complex (MASEC)
8140 26th Ave. South
Bloomington, MN 55420

Southern Solar Energy Center (SSEC)
61 Perimeter Park
Atlanta, GA 30341

Western Solar Utilization Network (WSUN)
Pioneer Park Bldg., 715 S.W. Morrison
Portland, OR 97205

Tennessee Valley Authority (TVA)
Solar Applications Branch
715 Market St.
300 Credit Union Bldg.
Chattanooga, TN 37401

National Solar Heating and Cooling Information Center (NSHCIC)
P.O. Box 1607
Rockville, MD 20850
Toll-Free (800) 523-2929
From Pennsylvania (800) 462-4983
From Alaska, Hawaii (800) 523-4700

for more information...books

As passive design regains popularity, many excellent books are being written for both the novice and the professional. Listed below are some of the best publications available for general information on passive design. Many of them are available in local public libraries and bookstores, or through local or regional solar energy organizations.

The Solar Home Book: Heating, Cooling, and Designing with the Sun. Anderson, Bruce. Harrisville, N.H.: Cheshire Books; 1976

A comprehensive book that introduces the layperson to residential uses of solar energy. One chapter is devoted to "soft technology," the passive approach. Contains succinct, clear explanations of principles and concepts; numerous charts, diagrams, and drawings clarify text.

Sunset Homeowner's Guide to Solar Heating. Antolini, Holly Lyman. Menlo Park, Calif.: Lane Publishing Co.; 1978

Although sometimes underplaying passive solar performance, this book provides a comprehensive introduction to solar energy. Explains solar heating in the home for active and passive systems, domestic water heating, and pool heating. Using beautiful color photos of homes in the Southwest, emphasizes comfort and aesthetics.

The Passive Solar Energy Book: A Complete Guide to Passive Solar Home, Greenhouse and Building Design. Mazria, Edward. Emmaus, Pa.: Rodale Press, Inc.; 1979

Contains most of the information needed to design a passive solar building, presented in a way useful to the beginner as well as to the professional. Contents cover general solar theory and applications to system design and performance calculations.

Natural Solar Architecture: A Passive Primer. Wright, David. New York: Van Nostrand Reinhold Co.; 1978

One of the country's leading passive architects both explains passive design concepts and provides a philosophical statement of why environmentally compatible and energy-efficient architecture is the way we ought to build. Handwritten text makes scanning impossible; reading the book in its entirety is worth the time.

First Passive Solar Home Awards. Franklin Research Center. Philadelphia, Pa. (for the U.S. Dept. of Housing and Urban Development); 1979

Winning designs from the 1978 Residential Passive Solar Design Competition and Demonstration are presented—145 new home ideas and 17 plans for retrofit installations. Graphics, blueprints, technical information, and philosophy of design are presented for each. Free from the National Solar Heating and Cooling Information Center.

The Food and Heat Producing Solar Greenhouse: Design, Construction, Operation. Fisher, Rick; Yanda, Bill. Santa Fe, N. Mex.: John Muir Publications; 1976

An easily read, nontechnical, "what to do and how to do it" for designing, building, and operating a solar greenhouse. The work is an outgrowth of the Solar Sustenance Project; the passive greenhouses were specifically designed for the dry, high-altitude, high-sunshine, Rocky Mountain region.

Sun-Earth: How to Use Solar and Climatic Energies Today. Crowther, Richard L. et al. Denver, Colo.: Crowther/Solar Group; 1977

A survey of architecture and its relationship to the natural environment, emphasizing the holistic building design process and its components of people, climate, energy conservation, function, light, site, structure, and economics. Imaginative graphics and nontechnical language convey a lot of information in a very readable style.

Designing and Building a Solar House: Your Place in the Sun. Watson, Donald. Charlotte, Vt.: Garden Way Publishing Co.; 1977

This very practical, clearly written book covers not only passive, but all aspects of solar home design. Relates climatic areas to general building design and describes ways that local climatic information can be used in siting a home. Specifics of active and passive systems covered in nontechnical language.

Low-Cost, Energy-Efficient Shelter for the Owner and Builder. Eccli, Eugene, ed. Emmaus, Pa.: Rodale Press, Inc.; 1976

Spans the range from simple winterizing projects to full-scale design and construction, but emphasis throughout is placed on energy efficiency and aesthetic appeal. The 70-page solar section concentrates on principles for integrating and harmonizing the sun and natural environment into home designs.

A homeowner who has grasped the basics of passive design may want additional information on performance of actual homes or demonstration buildings. The following publications provide technical details and are a good follow-up to the introductory works.

Passive Solar Buildings: A Compilation of Data and Results. Stromberg, R.P.; Woodall, S.O.; Sandia Laboratories; August 1977. Available from NTIS*; #SAND-77-1204, $7.00. 1979 updated version to be available through NTIS.

Passive Solar Design: A Survey of Monitored Buildings. AIA Research Corporation; October 1978. Available from NTIS*; #HCP/CS-4113-2, $19.00.

Survey of Passive Solar Buildings. AIA Research Corporation; February 1978. Available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402; Stock #023-000-00437-2; $3.75.

A Survey of Passive Solar Homes. AIA Research Corporation; to be available from the Superintendent of Documents, Government Printing Office, in summer 1980. Contains 111 brief case studies organized geographically.

Solar Control and Shading Devices; and **Design With Climate.** Olgyay, Aladar; Olgyay, Victor. Princeton, N.J.: Princeton University Press. Written in 1957 and 1963, respectively, these two books are classics.

Man, Climate and Architecture. Givoni, B. London: Applied Science Publishers Ltd. This second edition of a textbook originally published in 1969 covers in detail the relationship between physiological, physical, and architectural aspects of building design in relation to the climate.

Passive Solar Design Handbook. Los Alamos Scientific Laboratory; Total Environmental Action; U.S. Department of Energy; March 1980. Available from NTIS*; #DOE/CS-0127/1-2, $13.25, $14.00, respectively. This 2-volume handbook assists designers from "rules of thumb" through construction drawings.

*National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

for more information...films

The following films are suitable for general interest audiences and may be borrowed, rented, or purchased for use by schools, libraries, or community organizations.

Sunbuilders 16mm, 20 minutes

Explores the progress and potential of passive design through interviews with builders and owners of passive homes throughout the country. Free loan: Regional Solar Energy Centers and Department of Energy Film Library, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. Purchase: National Audiovisual Library, General Services Administration, Washington, DC 20409 (Stock A-02139).

New Mexico Passive Solar Buildings 16mm, 13 1/2 minutes

Easy-to-understand graphics help explain direct gain, thermal storage wall, and greenhouse examples in a hot, dry climate. Five homes in the state are used as examples. Free loan: Department of Energy Film Library, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

Design With the Sun: Passive Solar Architecture 16mm, 27 minutes

Viewers are taken on a tour of passive solar homes and buildings across the country and introduced to direct gain, thermal storage wall, and greenhouse techniques. Climate and site considerations, orientation, insulation, and cooling are also covered. Rent/Purchase: Danamar Film Productions, 275 Kilby, Los Alamos, NM 87544.

The Solar Promise 16mm, 28 1/2 minutes

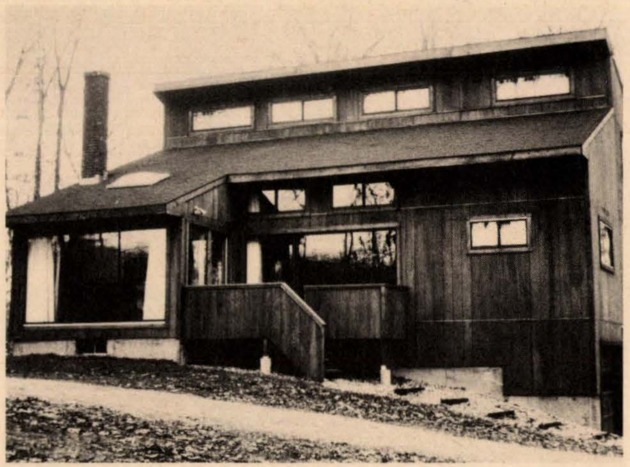
Covers passive design as well as active solar systems. Principles are presented in context of the Sundwellings project at Ghost Ranch, New Mexico, and through examples of homes in cold or cloudy climates. Rent/Purchase: Henry Mayer, M.D., 945 Middlefield Rd., Redwood City, CA 94063.

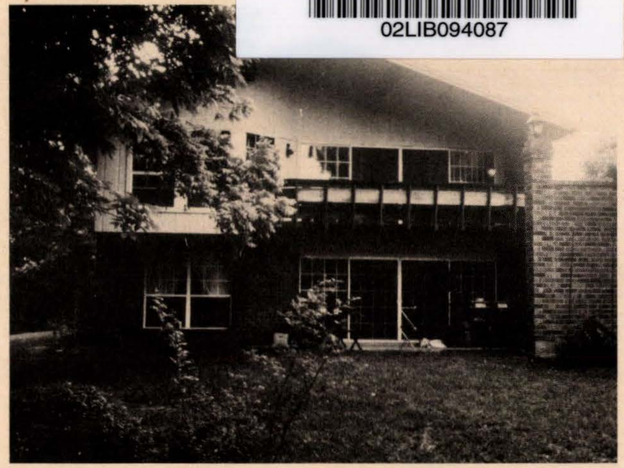
Additionally, a number of organizations and individuals have developed slide sets or slide/tape shows covering passive design. Contact state energy offices or Regional Solar Energy Centers for information, or ask NSHCIC for its brochure, "Films/Slides/Videotapes-Solar Energy for Heating & Cooling of Buildings," for a list of additional audiovisual materials.

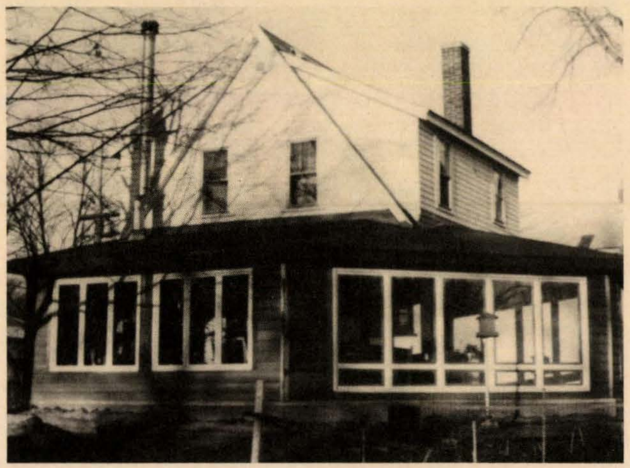
SERI/SP-432-521R

August 1980

Produced for the U.S. Department of Energy National Passive/Hybrid Heating and Cooling Program by the Passive Technology Program of the Solar Energy Research Institute. Printed and Distributed by the Solar Energy Information Data Bank.







Solar Energy Research Institute

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Operated for the

U.S. Department of Energy

under Contract No. EG-77-C-01-4042