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Sunspace Basics

Anyone who lives in a home with a sunspace will tell you that the sunspace is the most enjoyable room in the house. Many times the homeowner's only regret is that the sunspace is not larger. Although aesthetics often drive the decision to add a sunspace or include one in a new home design, sunspaces can also provide supplemental space heating and a healthy environment for plants and people. In fact, a well-designed sunspace can provide up to 60% of a home's winter heating requirements.

This publication will address basic elements of sunspace design; design considerations for supplemental space heating, growing plants, and use as a living space; design guidelines including siting, heat distribution, and glazing angles; and major sunspace components including glazing options, thermal mass, insulation, and climate controls. A list of sources for more information is also provided.


Marc Rosenbaum

This New England home uses a sunspace with overhead glazing. The sunspace can be isolated from the rest of the house to protect living spaces from temperature extremes.

Basic Elements

In a basic design, sunlight passes through glass or other "glazing" and warms the sunspace. The glazing is either vertical (as typical windows are installed) or sloped at an angle. To moderate temperature swings, massive materials (e.g., masonry or water) can be used to absorb the heat and store the sun's thermal energy. At night or during extended periods of cloudy weather, this "thermal mass" releases the heat it holds to warm the interior of the sunspace. Ceiling, wall, foundation, and window insulation in the sunspace retard heat loss at night and during cold weather. Climate-control features include operable windows, vents, and fans to keep the sunspace from overheating and to circulate the warm air to other parts of the house.

Design Considerations for Different Functions

Sunspaces serve three main functions: they are a source of auxiliary heat, they provide space to grow plants, and they are enjoyable living areas. The design considerations for these functions are very different, and although it is possible to build a sunspace that will serve all three functions, some compromises will be necessary.

If the primary function of the room is only to provide heat, you can maximize heat gain by using sloped glazing, few plants, little thermal mass, and insulated, unglazed end walls. If the winters are sunny in your area, carefully sized thermal mass will prevent extreme overheating during the day. In practice, sunspaces are rarely built to serve only as heaters, because there are less expensive ways to provide solar heat.

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Energy Efficiency Comes First

Before you add a sunspace, it makes economic sense to improve the energy efficiency of your home. Caulking, weatherstripping, insulating, and other energy-efficiency improvements will pay for themselves quickly through lower heating and cooling bills.

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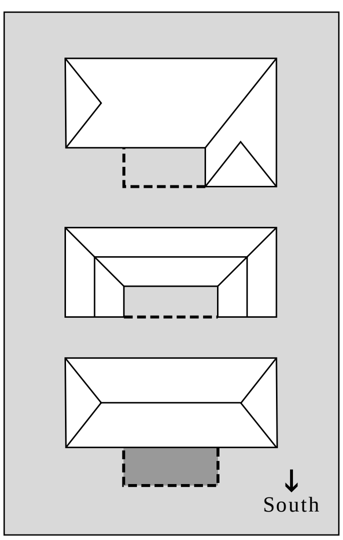


These drawings illustrate a few of the ways to attach a sunspace to a house.

If the space will mainly be used as a greenhouse, remember that plants need fresh air, water, lots of light, and protection from extreme temperatures. Greenhouses consume energy through the growth processes of plants and the evaporation of water: one pound of evaporating water uses about 1000 Btu that would otherwise be available as heat. Plants require overhead glazing (i.e., glazing in the roof), which complicates construction and maintenance, and glazed end walls, which are net heat losers. The bottom line is that a sunspace designed as an ideal horticultural environment is unlikely to have much energy left over for supplementary space heating.

Most people want to use their sunspaces as year-round living areas, so sunspaces should have minimum glare and only moderate humidity. Carefully sized thermal mass will greatly improve comfort levels by stabilizing temperature extremes. Thermal mass materials should be placed in direct sunlight and should not be covered with rugs, furniture, or plants. Movable window insulation or advanced glazings minimize nighttime heat losses and greatly improve comfort.

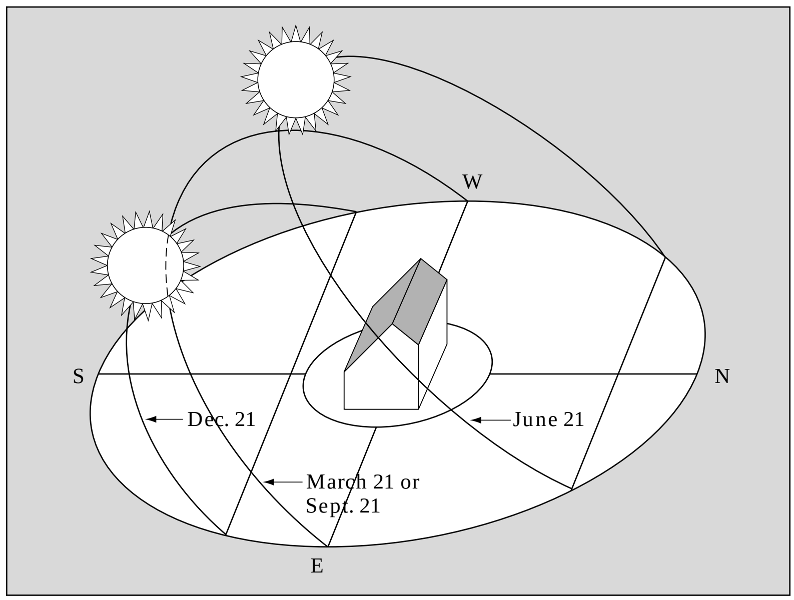
Sunspace Design Guidelines

Passive solar structures are conceptually simple, but sunspace designers and builders must pay close attention to detail to ensure maximum performance and reliability of the structures.

Computer software is now available to help establish design and performance criteria for specific passive solar projects like sunspaces. This software makes it relatively easy to avoid making uninformed, potentially costly, and disappointing decisions about a sunspace addition. Some sources for software are identified at the end of this publication.

Siting

A sunspace must face south. Due south is ideal, but 30° east or west of due south is acceptable. If your project is a retrofit, consider how the new addition will look on the south side of your house. If the south side faces the street, the design must be well integrated into the home to avoid a "tacked-on" look. And, you will need to protect your family's privacy. If the south side of your house faces the backyard, privacy may be less of an issue.



In northern latitudes, the sun is much lower in the sky in the winter than in the summer. For this reason, vertical glazing receives much more solar gain in the coldest part of the year. Sloped glazing takes in the most solar radiation in the summer.

Because the sun is low in the sky in the winter, any obstacle over 10 feet (3 meters) tall within 15 feet (4.6 meters) of the south glazing is likely to block solar gain. If the sunspace will be shaded only in the early morning or late afternoon, there is no major cause for concern. It is important, however, that the space receive direct sunlight between 10:00 a.m. and 3:00 p.m. Do not plant trees near the south glazing, and seriously consider removing existing trees from the area. Contrary to prior opinion, even deciduous trees that lose their leaves in the winter are capable of blocking the sun. In fact, a mature, well-formed deciduous tree will screen more than 40% of the winter sunlight passing through its branch structure.

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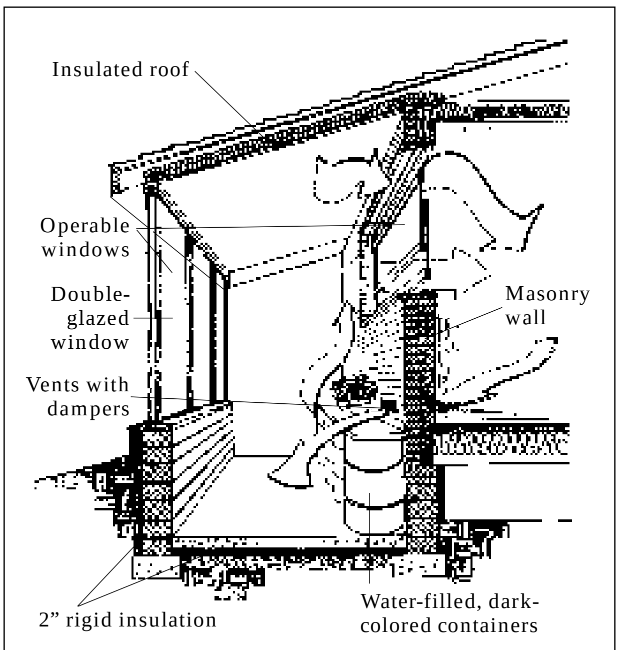
If you have a choice, locate the sunspace so that the walls of the house serve as one or both end walls of the sunspace (to reduce heat loss) and the addition is adjacent to kitchens, dining areas, children's playrooms, and family living areas occupied during the day and early evening.

Heat Distribution

Warm air can be blown through ductwork to other living areas. It can also move passively from the sunspace into the house through doors, vents, or open windows between the sunspace and the interior living space. Strategically placed openings in the common wall can distribute the warmed air from the sunspace to the house by the "thermosiphoning" circulation of the air. In a thermosiphon, warm air rises in the sunspace and passes into the adjoining space through an opening, and cool air from the adjoining space is drawn into the sunspace to be heated.



Sunspaces incorporate thermal mass to absorb solar heat. Solar-heated air can then be used to heat the house, either passively through openings in the common wall or by blowing through ductwork into other parts of the house.

The minimum opening in the common wall should be about 8 square feet (0.7 square meters) per 100 square feet (9.3 square meters) of glazing area. If the design calls for two openings—one high in the sunspace and one low—the minimum area for each opening is approximately 2.5 square feet (0.2 square meters) per 100 square feet (9.3 square meters) of glazing, with 8 vertical feet (2.4 meters) of separation between openings. Again, these are rules of thumb that should be refined through computer modeling or confirmed with local experts. An uninsulated masonry wall between the house and the sunspace will also transfer some heat into the living space by conduction.

Glazing: Sloped or Vertical?

Although sloped glazing collects more heat in the winter, many designers prefer vertical glazing or a combination of vertical and sloped glazing. Sloped glazing loses more heat at night, can be covered with snow in the winter, and can cause overheating in warmer weather. Vertical glazing can maximize gain in winter, when the angle of the sun is low, and yield less heat gain as the sun rises toward its summer zenith. A well-designed overhang may be all that is necessary to shade the glazing in the summer.

Pamm McFadden

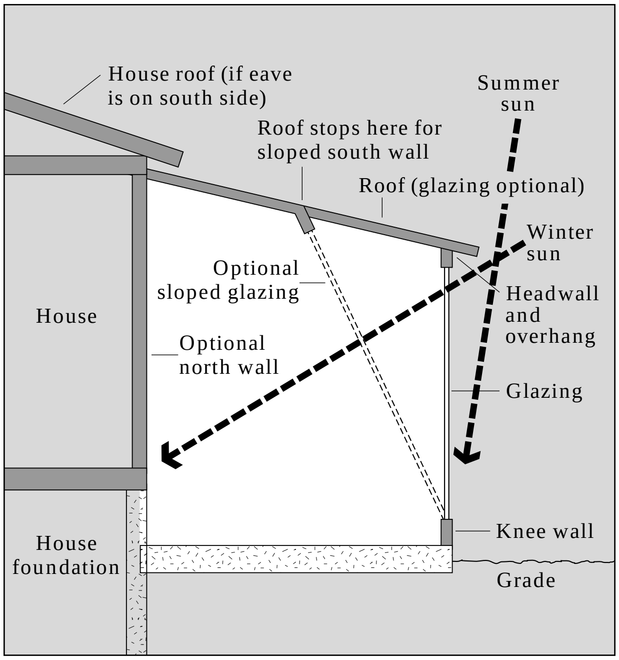
This passive solar mountain home uses vertical glazing to collect the sun's energy.

Compared with sloped glazing, vertical glazing is less expensive, easier to install and insulate, and not as prone to leaking, fogging, breaking, and other glazing failures. Vertical glazing is often more aesthetically compatible with the design of existing homes.

Sunspace Components

Glazing

Glazing is the clear or translucent material that allows sunlight to enter and warm the space. Glass is the most common glazing material, and many sunspace builders choose glass for its durability, clarity, and appearance. However, plastic glazings can be cheaper, stronger, lighter, and easier to work with—making them popular choices with the 20% of homeowners who build their own sunspaces. Some plastics even transmit solar energy more effectively than glass. On the down side, plastics



A well-designed overhang may be all that is necessary to shade a vertically sloped interior sunspace wall.

scratch more easily, expand and contract more in response to temperature extremes (making them harder to seal), and generally are less durable than glass.

Deciding on which glazing to use is only the first step in the decision-making process, however. Advances in glazing technology make it possible for designers to fine-tune performance by choosing glazings that meet the specific needs of their projects.

Historically, manufacturers have used multiple layers of glass to improve the insulating value of a window. In addition to making the unit more energy efficient, extra layers of glass also increased the weight and bulk—as well as the price—of the unit. However, today's low-emissivity (low-e) coatings—thin, nearly invisible metal or metallic oxide films—have revolutionized the glazing industry.

Vertical glazing is less expensive and easier to install and insulate, and it is not as prone to the leaking, fogging, breakage, and other glazing failures often associated with sloped glazing.

Low-e coatings are applied to the surface of glazings or to films suspended in the airspaces between the panes of glass. They reduce radiant heat loss and gain and dramatically improve a window's insulating value. For example, double-glazed, low-e windows are about as energy efficient as triple-glazed windows using regular glass, but they cost and weigh less. Note that there have been reports that windows with less than 70% visible light transmittance might not support plant growth.

When argon, sulphur hexafluoride, carbon dioxide, or other gas fills with higher insulating values than air are included between glazings, the energy efficiency of windows is further improved. Although the extra layers of glazing and low-e coatings decrease the amount of light coming into the room, the reduction is more than offset by the increased amount of heat retained in the room.

Other new window technologies include spectrally selective coatings (the next generation of low-e films) that reject heat while admitting light, electrochromic glazings that lighten and darken as small electric currents are applied and removed, and "superwindows" that combine a number of features (e.g., low-e coatings, gas fills, and insulating frames and spacers) into one unit.

If you decide to use overhead glazing in the roof of your sunspace, invest in one of the glazing systems developed specifically for this purpose. Overhead glazing has a reputation for leaking, but excellent sealing systems are now on the market. Invest in a good system—this is not a place to cut corners. In some areas, building codes require that you use plastic glazing or tempered or laminated glass in overhead and sloped glazing sections for safety reasons.

Which glazing system is most appropriate for your project depends on your budget and the climatic conditions at your site. For more detailed information on current and future glazing options, contact the Energy Efficiency and Renewable Energy Clearinghouse (see Source List).

Thermal Mass Considerations

Water is the most efficient thermal mass, because it holds the most heat per unit of volume. Anything that will not leak will work to hold the water, and designers and homeowners have used everything from plastic jugs to 55-gallon (208-liter) drums to specially designed (and often very attractive) containers.

Photo Unavailable
Please contact the Energy Efficiency and Renewable Energy Clearinghouse at (800) DOE-EREC to receive a printed copy of this publication

This well-designed passive solar home uses a sunspace to collect solar energy, and a tile floor and a masonry half-wall to store the heat. This leaves the space open to the rest of the house.

Few home improvements offer the aesthetic appeal and practical paybacks that a carefully designed and constructed sunspace can.

Masonry materials (brick, concrete, or stone) are also good choices for thermal mass. Although they store only about half as much heat as an equal volume of water, they can also support the structure, form the floor of the space, and serve as the wall between the house and the sunspace. Masonry is most effective in 4- to 6-inch (10- to 15-centimeter) thicknesses. If walls are built with concrete blocks, the holes in the blocks must be filled with concrete.

The surfaces of thermal mass materials should be dark colors of at least 70% "absorptance." Absorptance is the amount of solar radiation absorbed by a surface material. Black has about a 95% absorptance rate, deep blue has about 90%, and deep red approximately 86%. Nonstorage materials should be lighter colors so they will reflect light to the thermal mass not located in the sun. Thermal storage materials can be located in the floor and in the north, east, and west walls of the sunspace.

Pamm McFadden

Tile floors and masonry walls provide thermal mass to store solar heat. Doors between sunspaces and other living areas can be opened to allow warm air to circulate.

When masonry floors and walls are the only thermal storage materials in the space, 3 square feet (0.3 square meters) of 4-inch-thick (10-centimeter-thick) masonry surface per square foot (0.09 square meter) of south glazing is probably adequate. When water in containers is the only heat storage medium used, the recommended ratio is 3 gallons (11.3 liters) per square foot (0.09 square meter) of glazing. These are only rules of thumb and should be confirmed by modeling your project on a computer or checking with a design or building professional in your area who is familiar with local design practices.

Insulation

To maximize comfort and efficiency, it is important that your sunspace be well insulated. The perimeter of the sunspace's foundation wall or slab should be insulated down to the frost line (i.e., the depth at which frost penetrates the soil) and underneath the slab if it is appropriate in your area. If you live in a very cold climate, insulate the east and west walls of the sunspace rather than glazing them. Always insulate the sections of exterior walls that are not glazed. Check with solar specialists in your area or the resources cited in this publication's Source List for guidance on your particular project.

Although overhead glazing can be beautiful, an insulated roof provides better thermal performance. When the highest part of the structure is well insulated, heat loss in winter is reduced, and the summer sun will not cause overheating. Instead, skylights can be used to provide some overhead light for plants. And, if they are the type that open, skylights offer a way to vent excess heat. Skylights are available with advanced glazings that reduce radiant heat loss to the night sky.

Window coverings, shades, and other forms of movable insulation help trap the warm air in the sunspace both after the sun has set and during cloudy weather. When closed during extremely hot days, window coverings can help keep the sunspace from overheating.

Thermally isolating the sunspace from the house at night is important. Large glass panels, French doors, or sliding glass doors between the house and the sunspace will maintain an open feeling without the heat loss associated with an open space.

Climate Controls

Overheating can kill plants and make the sunspace unlivable. To control overheating, some designers place operable vents

WINDOW Software

With the U.S. Department of Energy, Lawrence Berkeley Laboratory developed WINDOW software to help manufacturers and building professionals optimize the thermal and daylighting performance of window systems.

For more information, contact:
Elizabeth Finlayson
MS 90-3111
Lawrence Berkeley Laboratory
Berkeley, CA 94720
(510) 486-7179 (technical questions)
FAX (510) 486-4089 (software orders)

at the top of the sunspace where temperatures are the highest and at the bottom where temperatures are the lowest. For times when you are not home to open vents manually, thermostatically controlled motors can be installed to automatically open them.

If passive (i.e., nonmechanical) circulation is not possible or practical, fans with thermostatic controls can be used to circulate air to the rest of the house. Other types of climate controls include shades or movable window insulation that can be operated with electric timers or sensors.

An Investment in Future Enjoyment

Few home improvements offer the aesthetic appeal and practical paybacks that a carefully designed and constructed sunspace can. Although you may be tempted to tackle the endeavor on your own, it is money well spent to consult with a solar engineer, architect, or contractor. They will provide feedback, as well as a computer analysis of your design. Remember, it is much less expensive to make changes on paper than to alter a sunspace once it is built. And after your sunspace is finished, you can enjoy it for years to come.

Source List

There are many groups that can provide you with more information on sunspaces. The following organizations can answer the more technical questions you or your builder may have.

Organizations

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329
(404) 636-8400

ASHRAE publishes the *Handbook of Fundamentals* that details heat transfer, light transmittance, and shading properties of different window types and materials.

American Solar Energy Society (ASES)
2400 Central Avenue, Unit G-1
Boulder, CO 80301
(303) 443-3130
FAX (303) 443-3212

ASES is a nonprofit educational organization founded in 1954 to encourage the use of solar energy technologies. ASES publishes a bimonthly magazine *(Solar Today),* sponsors the annual National Solar Energy Conference, has regional chapters throughout the United States, and offers a variety of solar publications through its catalogue.

National Center for Appropriate Technology (NCAT)
3040 Continental Drive
Butte, MT 59701
(406) 494-4572

NCAT's publication *Solar Greenhouses and Sunspaces—Lessons Learned* describes the experiences of sunspace owners and builders during the Department of Energy's Appropriate Technology Small Grants Program.

The Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
(800) 363-3732

EREC provides free general technical information to the public on the many topics and technologies pertaining to energy efficiency and renewable energy.

Software

BuilderGuide
Passive Solar Industries Council (PSIC)
1511 K Street, NW, Suite 600
Washington, DC 20005
(202) 628-7400

PSIC offers workshops around the country on the BuilderGuide computer program and guidelines for passive solar building and remodeling projects. Climate-specific guidelines are available for more than 2000 cities and towns around the United States. PSIC also provides the building industry with practical, useful information on the use of passive solar technologies in buildings. PSIC developed the "Passive Solar Design Strategies: Guidelines for Home Builders" workshops and the BuilderGuide software.

Reading List

The Passive Solar Energy Book, E. Mazria, Rodale Press, 1979.

Sunspaces: New Vistas for Living and Growing, P. Clegg and D. Watkins, Garden Way Publishing, Storey Communications, 1987.

The Sunspace Primer: A Guide to Passive Solar Heating, R. W. Jones and R. D. McFarland, Van Nostrand Reinhold Company, 1984.