Designing Your Place in the Sun

Take advantage of the sun to maximize your home's comfort, and reduce your heating & cooling bills.

Debra Rucker Coleman

Passive solar design can make a home more comfortable in every season. The winter sun can warm a home's interior, while simple shading and thermal mass strategies can prevent summer overheating.

The home designs on the following pages balance four primary building elements—orientation, windows, overhangs, and thermal mass—to optimize use of the sun's energy. While these elements are found in most conventional homes, the designs included here put the right amount in the right places for maximal efficiency and performance. Most of them also provide ample south-facing roof space to accommodate the addition of solar hot water collectors and solar-electric arrays—part of a whole-house plan for energy efficiency and independence.

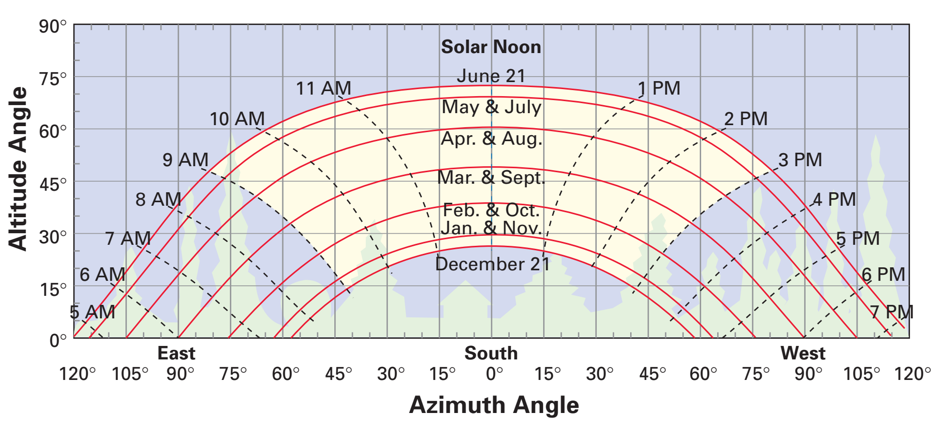
Whether you're having a builder construct your own home from these plans or building for a client, consider these best design bets.

Site Right

In the winter, the sun rises in the southeast, is low in the south sky at midday, and sets in the southwest in the middle latitudes in North America. In the summer, the sun rises in the northeast, is high in the south sky at midday, and sets in the northwest.

In all areas except the southern tip of Florida, choose a home site that receives full southern sun in winter and is unobstructed by trees, other buildings, or hillsides. Besides your own observations about shading during the seasons, site analysis tools can provide a quick, accurate assessment of your proposed building site (see Access). You can also use a compass to help find true north and south, but keep in mind that a compass points to magnetic north, which can vary by as much as 25 degrees from *true* north. This difference is called magnetic declination. You can find the declination of your location by visiting www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp.

Sun Path for 40° North Latitude



To maximize winter sun and summer shade, orient the home's south face to within 10 degrees of true south. Even though orienting the house 30 degrees from true south reduces winter solar gain by only 13 percent, the cooling penalty can be greater. Homes facing from 30 to 45 degrees east or west of south may need longer overhangs. This is especially true if the home's orientation favors the west, because overhangs quickly become much less effective as the hot western sun, low in the sky, strikes the house. In most locations, a slight orientation to the east is desirable to increase winter morning sun and decrease summer afternoon sun.

Proper Window Placement

Heat from the sun entering south-facing windows and doors with glass can provide between 20 and 80 percent of the heat required to keep a house warm in winter. The highest percentages are possible in homes in mild climates and those that are well insulated.

South-facing glass should be at least 5 percent and usually no greater than 12 percent of the conditioned square footage of the house. (For example, a 1,000-square-foot house would have between 50 and 120 square feet of south-facing glazing.) Ideally this should apply separately to each floor of the house. Include only the *glazing* square footage—do not include window or door frames. For instance, a 30- by 60-inch window (12.5 square feet) might only have 10 square feet of glazing.

Homes with south glass area between 5 and 7 percent are commonly referred to as sun-tempered, and are appropriate for very hot climates such as the southernmost areas of the United States (as a rule, below 35 degrees north latitude, although there are many exceptions based on local climate conditions). If south glass exceeds 7 percent of the floor area, install materials with high thermal mass inside the house, such as concrete or masonry, to moderate interior temperature swings.

Place just enough windows on the north, east, and west walls to balance interior light levels, capture any views, create an attractive house, and allow for natural cooling. But be sparing, because windows placed in these orientations are energy drains in cold months and, in the summer, eastern and western windows let in unwanted hot morning or afternoon sun, unless they are shaded. For balanced lighting and ventilation, place windows on opposite or at least two sides of each room. Limit the use of skylights, which admit too much sun in the summer and are difficult to shade. Instead, install sun tubes (also known as tubular skylights) in interior rooms without windows, which let in some light, but less heat.

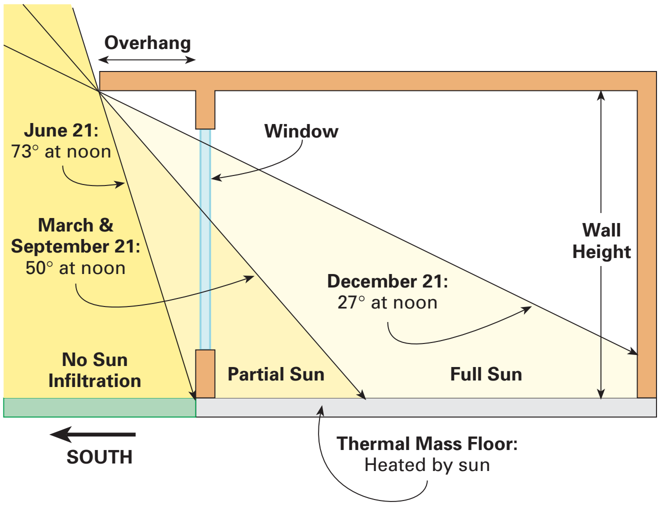
Window manufacturers often use "solar" to describe glazing, but usually this is an indication that the glass *blocks* the sun (has a low solar heat gain coefficient; SHGC) and can be very misleading. For passive solar space heating, south-facing windows should have a high SHGC (at least 0.52) to maximize the amount of the sun's heat that passes through the glass. A window with a SHGC of 0.33 lets in only 33 percent of the sun's heat energy. If you can't find high SHGC windows, a reasonable option is to install clear (uncoated) double-paned glass and use insulated blinds or shutters at night to minimize heat loss. Alternatively, triple-paned clear glass will let in a large amount of sun while limiting heat loss. Some building codes stipulate a maximum SHGC of 0.4, but then allow you to average all of the SHGCs so that windows with higher SHGCs can be used on the home's south face.

The right amount of glazing, facing the right direction, is only one element of a successful passive solar home design.

Seek Summertime Shade

Overhangs, awnings, and porches can shade windows in certain seasons and prevent the home from overheating. For cold climates, design overhangs for a long season of full sun striking the south glass. Overhangs should fully shade south-facing windows during the summer months, and allow full sun on windows during the wintertime. For hot climates, design overhangs for a long season of full shade on the south glass. It is fairly simple to achieve full shade on June 21, the summer solstice, when the sun is high. Shading in August becomes more difficult, since increasing the overhang depth will also shade the window in April, when more solar gain may be desirable for heating. This is where a slight easterly rotation of the house can help.

Roof Overhang for 40° North Latitude



South window overhangs should be sized for the height of the windows, wall height, and the construction detail of where the roof meets the wall. West and east windows require much longer overhangs, and these windows are best shaded by other methods, such as porches or trees. Computer simulation software, such as the shareware at Sustainable by Design (www.susdesign.com), and especially the online Overhang Design Tool, can make sizing overhangs a snap if you, your builder, or design professional understand roof/wall construction details.

During the late summer and early fall months, it may be necessary to close blinds or curtains, and pay more attention to passive cooling strategies like opening windows when the temperature drops below 70°F, and closing up the house in the morning, before the day begins to warm. Likewise, in late spring, there may be a few cool days where more heat is desired than is entering the partially shaded south windows. Conserving the heat that does enter by using insulated curtains on the windows can be highly effective.

Make It Massive

Materials with high thermal mass, such as brick, stone, ceramic tile, and concrete, absorb direct solar gain in the winter and indirect heat during the summer. Although it is best to locate thermal mass in the path of direct sunlight, other mass in contact with the material that receives direct solar gain can serve the same function. Including thermal mass is especially important for homes with glass above 7 percent of the home's square footage. Locate the mass as close to south-facing windows as possible. For each square foot of glass above 7 percent, add:

- 5.5 sq. ft. of mass in floors that receive direct sunlight
- 8.3 sq. ft. of mass in walls and ceilings in the same room
- 40 sq. ft. of mass in floors that don't receive direct solar gain

Strive for a minimum of 2 inches (and a maximum of 4 inches) of thermal mass. Less than 2 inches does not store sufficient heat and more than 4 inches (unless it is an 8-inch wall with both sides exposed) can absorb so much heat that it will be too slowly released. The maximum amount of floor mass area that should be used is 1.5 times the south-facing window area, since the sun cannot hit large areas all at once.

Courtesy Gordon Plumblee

Thermal mass, like this brick wall and floor, stores solar heat and releases it slowly.

Passive Solar House Plans

Although the house plans on following pages were originally designed for clients in specific climates, they are adaptable to other situations. In hot climates, the south glass can be reduced to 7 percent. Occasionally south overhang lengths may need to be slightly shortened or lengthened. Specifications that accompany the blueprint and CAD drawings recommend appropriate insulation values for the slab, basement, walls, roof, and windows, as well as the SHGC for south windows for the climate in which the house is to be constructed.

For cost effectiveness, use concrete, concrete masonry, and earthen plasters as thermal mass. Slab-on-grade construction, where a concrete floor is poured over insulation, can economically combine the foundation with a heat-absorbing floor. ICF (insulating concrete form) foundations, which sandwich concrete between expanded polystyrene foam panels, are very compatible with cold climate slabs, even when the upper part of the house is framed with studs. ICFs are an excellent option for the main house walls also. Studies have shown that their combination of mass and insulation helps temper interior temperature swings, even though the foam somewhat isolates the concrete (mass) from the living areas.

Interior heat-absorbing walls, made of concrete block, stone, or brick, can also serve to absorb solar heat. Masonry walls are commonly incorporated into fireplace or wood heater surrounds. With the creative use of decorative concrete block, or coverings (veneers) of stone, brick, stucco, plaster, or tile, heat-storing walls can become effective passive heating elements, as well as beautiful accent walls and focal points in a home.

Going Solar

Saving up to 80 percent on heating and cooling costs is possible when passive solar design techniques are combined with careful attention to insulation, caulking, and efficient supplemental heating and cooling equipment. The initial downside is that passive solar and energy-efficient design elements typically increase the cost of building a home by 10 to 15 percent over average construction costs. Alternative construction methods, green building materials, and active solar (solar hot water and solar-electric systems) will also add to these initial costs.

But the payback—reduced energy bills, better energy efficiency, and improved home comfort—are all part of the benefits of a well-designed home. Typically, energy savings will be greater than the increase in any mortgage payment—which makes the improvements pay for themselves from the start. Some lenders now offer energy efficiency and Energy Star mortgages, which allow increased loan amounts by factoring in a home's estimated monthly utility savings (see Access).

Katrina Cottage

Size: 1,236 square feet
South-Facing Glazing: 10 percent
Number of Bedrooms: 3
Number of Bathrooms: 1.5
Plan Complexity: Simple

Floor Plan

South (Back) Elevation

This three-bedroom home has a lot to offer in a modest foundation footprint. The southeast porch is a gathering area and is shaded from the hot western sun. It welcomes the morning rays and wraps around to the south patio for cookouts and winter lounging. The vaulted ceilings and unique walls add openness and character with little wasted square footage. The dining area will feel like a sunroom with its wraparound corner windows. The kitchen will be cool but sunny in the morning with the east-facing window box. The wood heater, surrounding hearth, and adjacent entertainment center are the focal point of the home. The stone, brick, or tile adds visual warmth to the interior while simultaneously providing thermal mass to absorb the heater and sun's heat in winter. A proper south orientation and overhang prevents the space from receiving too much sun in summer.

Sunshine 4

Size: 1,486 square feet
South-facing Glazing: 11 percent
Number of Bedrooms: 2
Number of Bathrooms: 1.5
Plan Complexity: Simple

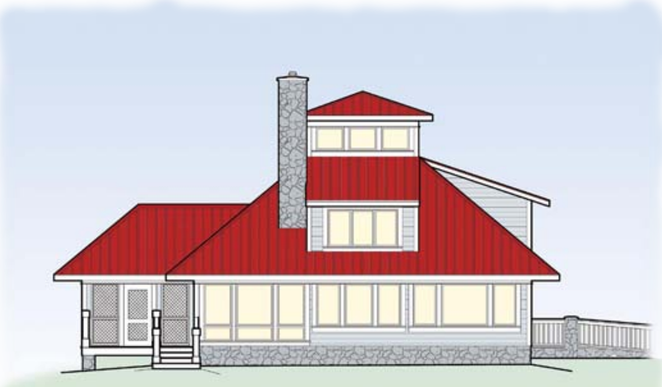
Floor Plan

South (Back) Elevation

The Sunshine 4's relatively small building footprint lends to this home's potential for having a lower environmental impact than most conventional homes of its size. The side porch faces east for sunny mornings, and provides a cool place to relax on hot afternoons. The light in the great room and passive cooling of the entire house is aided with the daylight cooling chimney. With the addition of PV modules and a solar hot water system, efficient appliances and lighting, and a tendency toward thoughtful resource consumption, it would be easy to make this house a zero energy home.

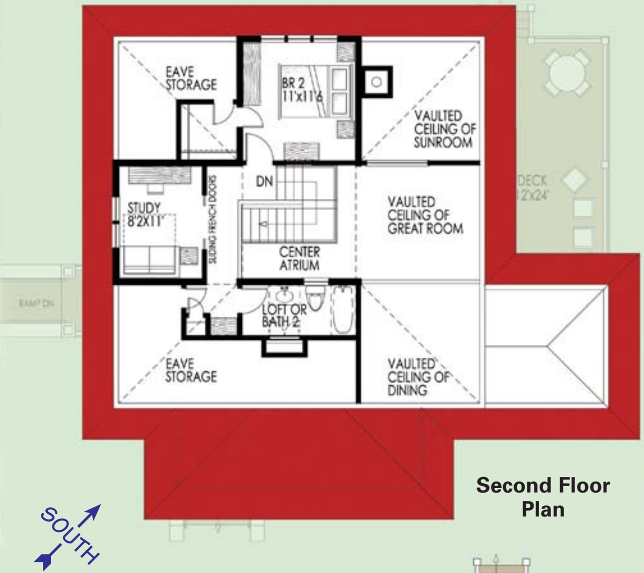
Cottage Atrium

Size: 1,741 square feet (1.5 stories)
South-Facing Glazing: 10 percent
Number of Bedrooms: 2
Number of Bathrooms: 1.5–2.5
Plan Complexity: Complex



Southeast (Back) Elevation

The Cottage Atrium offers the benefit of a modest foundation footprint, but with the grandeur of a large central atrium. The central staircase is full of light, and also aids in natural cooling. A small second-floor loft accommodates additional family members in this two-bedroom home. The house is full of Sarah Susanka's *Not-So-Big-House* concepts: A corner of the house faces south, which maximizes the number of rooms that receive sun. The back corner sunroom is designed to face due south with the front of the house facing northwest.



Second Floor Plan

Main Floor Plan

Sunset Bungalow

Size: 2,481 square feet
South-Facing Glazing: 10 percent
Number of Bedrooms: 3
Number of Bathrooms: 2
Plan Complexity: Simple

West (Front) Elevation

South (Side) Elevation

Fernwood

Size: 2,093 square feet (including 609 sq. ft. basement)
South-Facing Glazing: 9 percent
Number of Bedrooms: 4
Number of Bathrooms: 3
Plan Complexity: Simple

South (Side) Elevation

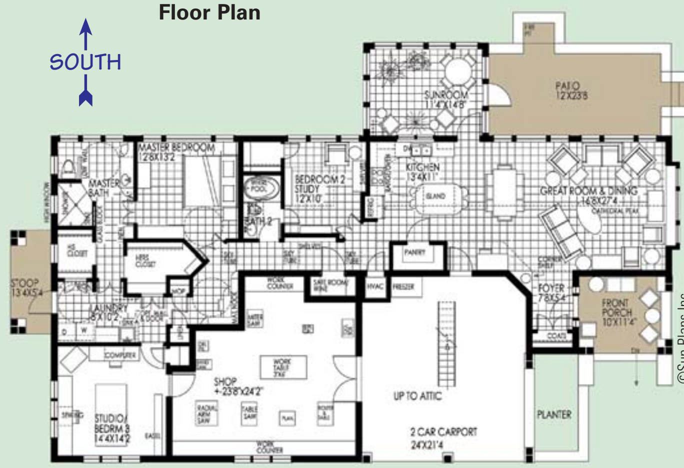
Main Floor Plan

Daylight Basement Floor Plan

The Fernwood is designed to be constructed with a trussed roof, 6-inch-thick exterior walls, and an ICF foundation. The main floor has 8-foot-tall ceilings with the south rooms vaulted to the center. The north rooms could be vaulted too, but the flat ceiling allows for some attic storage above the north rooms. Thermal mass walls around the kitchen temper the strong winter heat gain if finished in tile, stone, or stucco. The daylight basement is designed with flexibility for one or two sunny bedrooms, as well as a sunroom or greenhouse. Root storage and mechanical rooms are on the cool, bermed north and west ends. A one-vehicle garage has been tucked into the east end of the basement, taking advantage of the excavated area and keeping the building footprint smaller.

The Sunset Bungalow can make its home in a traditional neighborhood with narrow lots or in the middle of the woods. Several sun tubes (aka tubular skylights) throughout bring light into the middle of the house. The long south wall allows for an abundance of solar gain in winter, yet the overhang will keep out the direct sun in summer. The slab-on-grade construction, resulting in a concrete floor that can be covered with tile, offers an economical way to add thermal mass to the structure. Since the sunroom is not tucked within the main house, its temperatures will swing a little more in the seasonal extremes, but the glass on east and west will allow for great views year-round and cross-ventilation in summer, just like a screened porch.

Floor Plan



Midnight Sun

Size: 2,742 square feet (two-story, plus daylight basement)
South-Facing Glazing: 10 percent
Number of Bedrooms: 5
Number of Bathrooms: 3.75
Plan Complexity: Simple

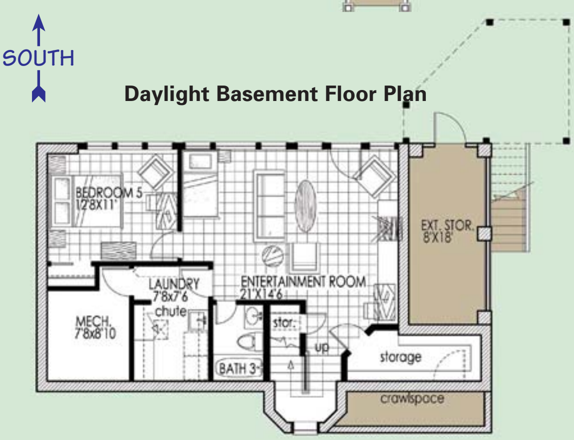
South Elevation

Second Floor Plan

Main Floor Plan

SOUTH

Daylight Basement Floor Plan



The Midnight Sun's design—building up rather than out—offers lots of living space, with a building footprint that is ideal for small lots. The first floor and basement have 8-foot-tall walls, but since there is plenty of south glass, the rooms will not feel small. The second floor ceilings are sloped with no attic space. High shelves and exposed rafter ties add character. The foundation is ICF, upper floors use 2 by 6 construction, and rafter sizes vary with insulation requirements. Customized energy recommendations that accompany the blueprints contain other energy-related suggestions, such as how much rigid insulation to use in addition to the stud wall, and the type of glass that's best suited for your climate. The thermal mass is in the basement floor, stone-covered hearth, and tile floors over gypsum cement in the upper levels.

Access

Debra Rucker Coleman, Architect, AIA, Sun Plans Inc., PO Box 85, Citronelle, AL 36522 • info@sunplans.com • www.sunplans.com

Information and plans adapted from sunplans.com and *The Sun-Inspired House: House Designs Warmed & Brightened by the Sun*, by Debra Rucker Coleman, 2005, Paperback, 248 pages, ISBN 0976731800, $29.95, distributed by Chelsea Green Publishing • 800-639-4099 • www.chelseagreen.com or online from Sun Plans Inc. • www.sunplans.com

Energy Star mortgages • www.hud.gov/energystar/lendersbrokers.cfm

Solar Site Analysis Tools:

Solar Pathfinder • 317-501-2529 • www.solarpathfinder.com

Solmetric SunEye • 877-263-5026 • www.solmetric.com

Wiley Electronics Acme Solar Site Evaluation Tool • 845-247-2875 • www.we-llc.com/ASSET.html