Passive Solar Design, Part 2

Introduction

Passive solar design is the process of creating a home that provides both shelter and comfort year-round while responding to regional climate conditions and minimizing dependence on energy-consuming mechanical systems. The goal is to build and occupy a home that a) utilizes solar heat gain in the winter to warm the interior of a home, b) controls solar heat gain in the summer, and c) facilitates daylighting, natural ventilation, and nighttime cooling to keep a home comfortably cool in the summer.

The overall shape, orientation, and roof design of the home, as well as the location of major rooms and their solar aperture, have been determined using the Passive Solar Design 1 fact sheet. Moving to the interior of the home, surfaces and building materials must be carefully chosen and strategically placed to perform as absorbers and thermal mass storage of solar heat gain in winter and convective cooling breezes in summer. In addition, window coverings for preventing heat loss in winter and heat gain in summer are recommended. Finally, fans and controls for air distribution from one room to another can provide supplemental heating and cooling to the entire home. This fact sheet describes the ABCDs of passive solar design for the interior of a home:

Absorber
Building materials
Coverings
Distribution

Green Building Benefits

Passive solar design saves energy by maximizing the home's natural heating, cooling, ventilation, and lighting. Reduced energy consumption reduces utility bills for the owner or occupant and reduces air pollution from power plants. Homes featuring good passive solar design are typically healthier and more comfortable.

Absorber

A is for Absorber: Use dark surfaces in direct sunlight to absorb solar heat.

Once it strikes a surface, solar radiation is converted from light to heat. Building materials inside a home must be able to absorb and store this heat (see building materials below). Otherwise, the air temperature in the home will rise quickly, often to uncomfortable levels even on clear winter days.

The ability of a material to absorb solar heat depends to a great extent on its finish color and texture. The definition of the term "absorber" when used in discussions of passive solar heating refers to the dark surface of the heat storage or thermal mass material exposed to direct sunlight. This can be a dark masonry wall or the dark-colored surface of a concrete floor. The darker the surface, the more solar heat the material will absorb. However, although a black finish may be the most efficient color for absorbing solar heat, it is rarely acceptable as an interior finish for aesthetic reasons. Many other colors, such as dark shades of brown, blue, or even green, will perform almost as well.

Building Materials

B is for Building Materials: Use thermal mass materials in living spaces to store solar heat.

The ability of a material to store heat or coolness is called its thermal mass. Building materials with high thermal mass have greater heat storage capacity than building materials with low thermal mass. The simplest way to store solar heat in a home is to place materials with high thermal mass in direct sunlight. High thermal mass is a property of dense building materials such as concrete, masonry, and stone. Placing these materials in direct sunlight by using them for floors and interior walls near south-facing windows can provide enough heat storage in the home to last overnight.

The amount of thermal mass required for each square foot of solar aperture could be determined using methods described in the references below. In general, the more mass the better. For example, when the floor is in direct sunlight during the heating season, consider using concrete and masonry floors that are 5-6" thick rather than the more typical 3-4" thickness.

For the interior space to be kept comfortably warm all night long in the winter from heat stored in thermal mass building materials, the solar aperture must be covered or insulated in some way. Otherwise, convection and conduction heat losses through the solar aperture will occur. Heat loss through the solar aperture can be greatly reduced by using window coverings at night. They can also help keep a home cooler in summer when used to block solar gain from entering the living space during the day.

Coverings

C is for Coverings: Cover or insulate south windows on winter nights and summer days.

At night and during cloudy days of the heating season, even the most efficient window loses heat to the outside at a much faster rate than an insulated wall or roof. This heat loss can be significantly reduced by the use of blinds, shades, or window coverings that provide insulation over the glazing surface and window frame. In general, the thicker the material is the better insulation it provides. For example, filled fabric shades or quilts will provide more insulation than a single layer wood or metal shade or blind.

In addition, the same insulating devices may help to block solar transmission during the cooling season. Window coverings on the outside, such as solar screens, help block solar gain before it is transmitted through the glass into the living space. Reflective blinds on the interior, such as white metal mini-blinds, also greatly reduce unwanted summer solar heat gain.

Distribution

D is for Distribution: Distribute warm and cool air throughout the home.

In practice, it is quite difficult to design a home that has all major living spaces ideally located and oriented to take full advantage of passive heating and cooling options, especially on small building sites or lots. In order to maintain comfort throughout a home, during some portion of the year moving warm air or cool air is required. Simple devices can be used, such as timers, occupancy sensors, or thermostats, to control air-circulating fans. Three different kinds of fans can be used: ceiling fans, wall- or ceiling-mounted exhaust fans, and whole house fans.

Ceiling fans provide convective air currents only within localized areas or parts of a room. They are not used to circulate air between rooms. Comfort can be facilitated in winter by circulating warm air downward toward the occupied level of a room. In summer, comfort can be facilitated by circulating air over people resulting in evaporative cooling of the skin. Ceiling fans should be operated only when the room is occupied since the benefits of circulating warm or cool air are felt only by people and will not significantly alter the temperature of building surfaces and materials.

Wall- or ceiling-mounted exhaust fans, both through-the-wall units (without ducts) and with ducts to distribute air, can circulate warm or cool air from one room to another. They typically circulate very low volumes of air compared to whole house fans. They can be operated by thermostatic controls when excess heat is built-up in one room to circulate warm air to another room even when the rooms are not occupied.

Whole house fans usually circulate much larger volumes of air than ceiling fans or exhaust fans. They can exhaust warm air quickly from the entire house during the summer. They can be used to supplement natural ventilation, especially at night when wind speeds are lower and the air temperature cooler than during the day. This greatly increases the times when passive cooling can be effective and reduces the operating time of mechanical systems. Whole house fans also offer better security control and privacy than open windows.

For more information

- *Energy Savers: Five Elements of Passive Solar Design*; U.S. DOE, Energy Efficiency and Renewable Energy Program, www.eere.energy.gov/consumer/your_home/designing_remodeling/index.cfm/mytopic=10270
- *Man, Climate, and Architecture*; Baruch Givoni, Van Nostrand Reinhold Co., 1981.

- *Passive Solar Design*; Consumer Energy Center, California Energy Commission, www.consumerenergycenter.org/home/construction/solardesign/index.html
- *Passive Solar House, The*; James Kachadorian, Chelsea Green Publishing, 1997.
- *Sun, Wind, and Light*; G. Z. Brown and M. DeKay, John Wiley & Sons, Inc., 2001
- For more information about Build It Green, visit our web site at www.BuildItGreen.org or call us at 510-845-0472.

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