Passive Solar Home Design

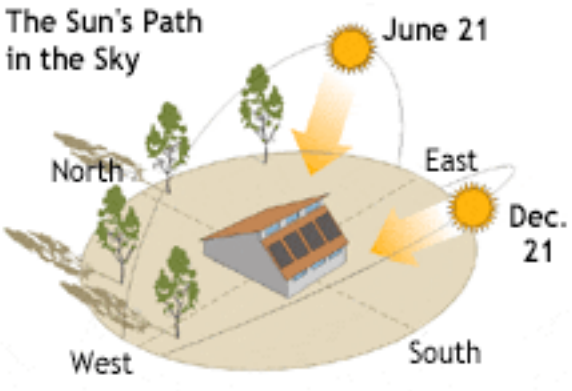
Your home's windows, walls, and floors can be designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design. Unlike active solar heating systems, passive solar design doesn't involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar heat.

Passive solar homes range from those heated almost entirely by the sun to those with south-facing windows that provide some fraction of the heating load. The difference between a passive solar home and a conventional home is design. The key is designing a passive solar home to best take advantage of your local climate.

You can apply passive solar design techniques most easily when designing a new home. However, existing buildings can be adapted or "retrofitted" to passively collect and store solar heat.

The Five Elements of Passive Solar Design

When incorporating these design elements and techniques, you want to design for summer comfort, not just for winter heating.
Your home's landscaping can also be incorporated into your passive solar design.



How a Passive Solar Home Design Works

To understand how a passive solar home design works, you need to understand how heat moves and how it can be stored.

As a fundamental law, heat moves from warmer materials to cooler ones until there is no longer a temperature difference between the two. To distribute heat throughout the living space, a passive solar home design makes use of this law through the following heat-movement and heat-storage mechanisms:

Conduction

Conduction is the way heat moves through materials, traveling from molecule to molecule. Heat causes molecules close to the heat source to vibrate vigorously, and these vibrations spread to neighboring molecules, thus transferring heat energy. For example, a spoon placed into a hot cup of coffee conducts heat through its handle and into the hand that grasps it.

Convection

Convection is the way heat circulates through liquids and gases. Lighter, warmer fluid rises, and cooler, denser fluid sinks. For instance, warm air rises because it is lighter than cold air, which sinks. This is why warmer air accumulates on the second floor of a house, while the basement stays cool. Some passive solar homes use air convection to carry solar heat from a south wall into the building's interior.

Radiation

Radiant heat moves through the air from warmer objects to cooler ones. There are two types of radiation important to passive solar design: solar radiation and infrared radiation. When radiation strikes an object, it is absorbed, reflected, or transmitted, depending on certain properties of that object.

Opaque objects absorb 40%–95% of incoming solar radiation from the sun, depending on their color—darker colors typically absorb a greater percentage than lighter colors. This is why solar-absorber surfaces tend to be dark colored. Bright-white materials or objects reflect 80%–98% of incoming solar energy.

Inside a home, infrared radiation occurs when warmed surfaces radiate heat towards cooler surfaces. For example, your body can radiate infrared heat to a cold surface, possibly causing you discomfort. These surfaces can include walls, windows, or ceilings in the home.

Clear glass transmits 80%–90% of solar radiation, absorbing or reflecting only 10%–20%. After solar radiation is transmitted through the glass and absorbed by the home, it is radiated again from the interior surfaces as infrared radiation. Although glass allows solar radiation to pass through, it absorbs the infrared radiation. The glass then radiates part of that heat back to the home's interior. In this way, glass traps solar heat entering the home.

Heat storage (thermal capacitance)

Thermal capacitance refers to the ability of materials to store heat. Thermal mass refers to the materials that store heat. Thermal mass stores heat by changing its temperature, which can be done by storing heat from a warm room or by converting direct solar radiation into heat. The more thermal mass, the more heat can be stored for each degree rise in temperature. Masonry materials, like concrete, stones, brick, and tile, are commonly used as thermal mass in passive solar homes. Water also has been successfully used.

Five Elements of Passive Solar Home Design

The following five elements constitute a complete passive solar home design. Each performs a separate function, but all five must work together for the design to be successful.

Aperture (Collector)

The large glass (window) area through which sunlight enters the building. Typically, the aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9 a.m. to 3 p.m. each day during the heating season.

Absorber

The hard, darkened surface of the storage element. This surface—which could be that of a masonry wall, floor, or partition (phase change material), or that of a water container—sits in the direct path of sunlight. Sunlight hits the surface and is absorbed as heat.

Thermal mass

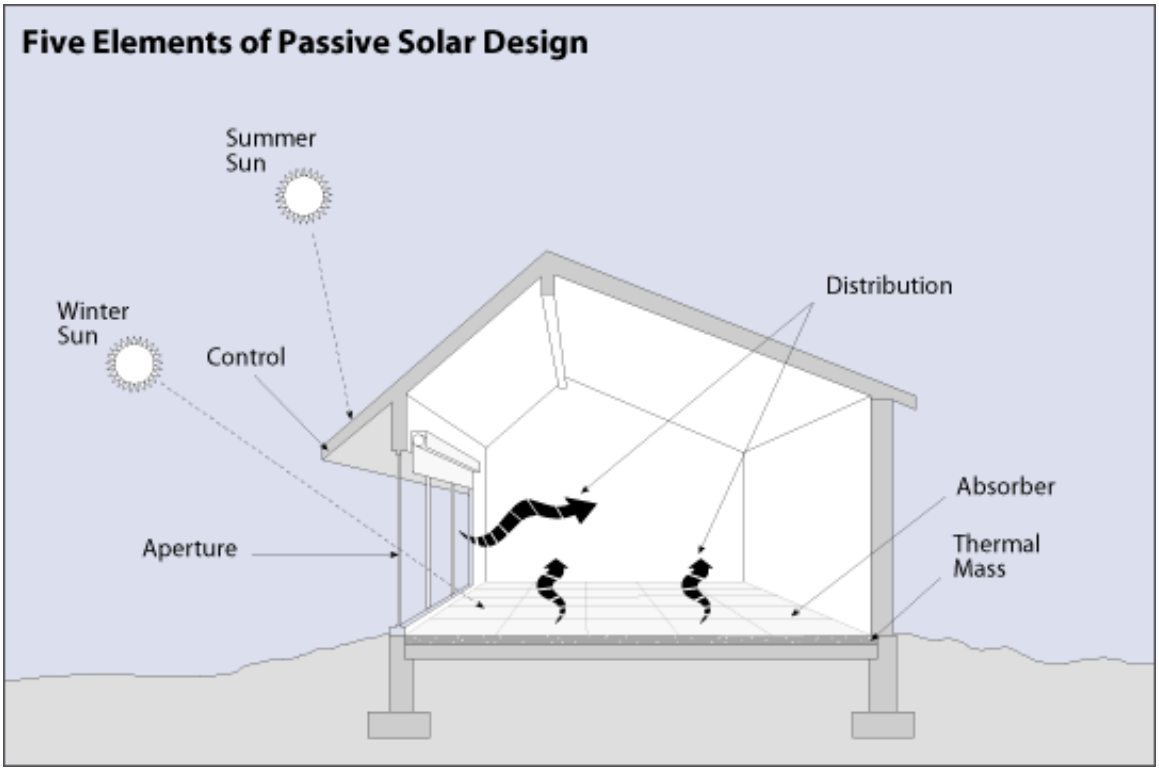
The materials that retain or store the heat produced by sunlight. The difference between the absorber and thermal mass, although they often form the same wall or floor, is that the absorber is an exposed surface whereas thermal mass is the material below or behind that surface.

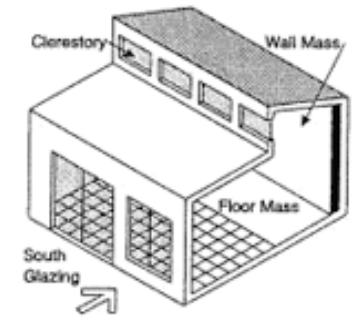
Distribution

The method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes—conduction, convection, and radiation—exclusively. In some applications, however, fans, ducts, and blowers may help with the distribution of heat through the house.

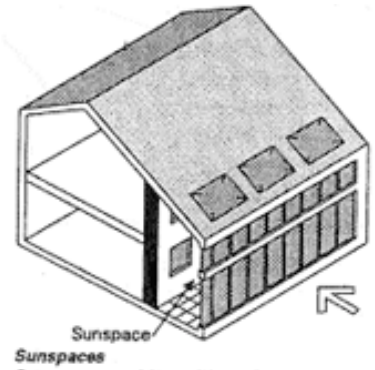
Control

Roof overhangs can be used to shade the aperture area during summer months. Other elements that control under- and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

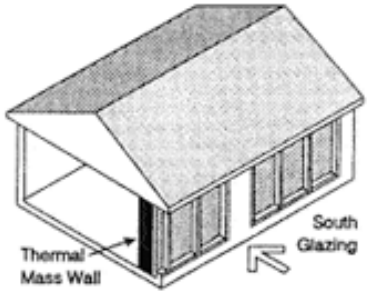




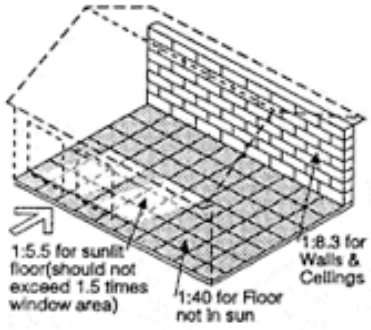
Direct Gain
Direct gain is the most common passive solar system in residential applications

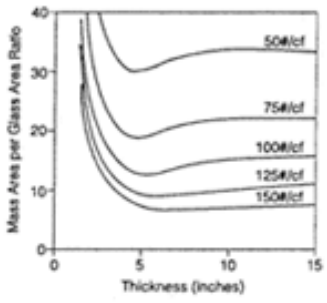


Sunspaces
Sunspaces provide useful passive solar heating and also provide a valuable amenity to homes.

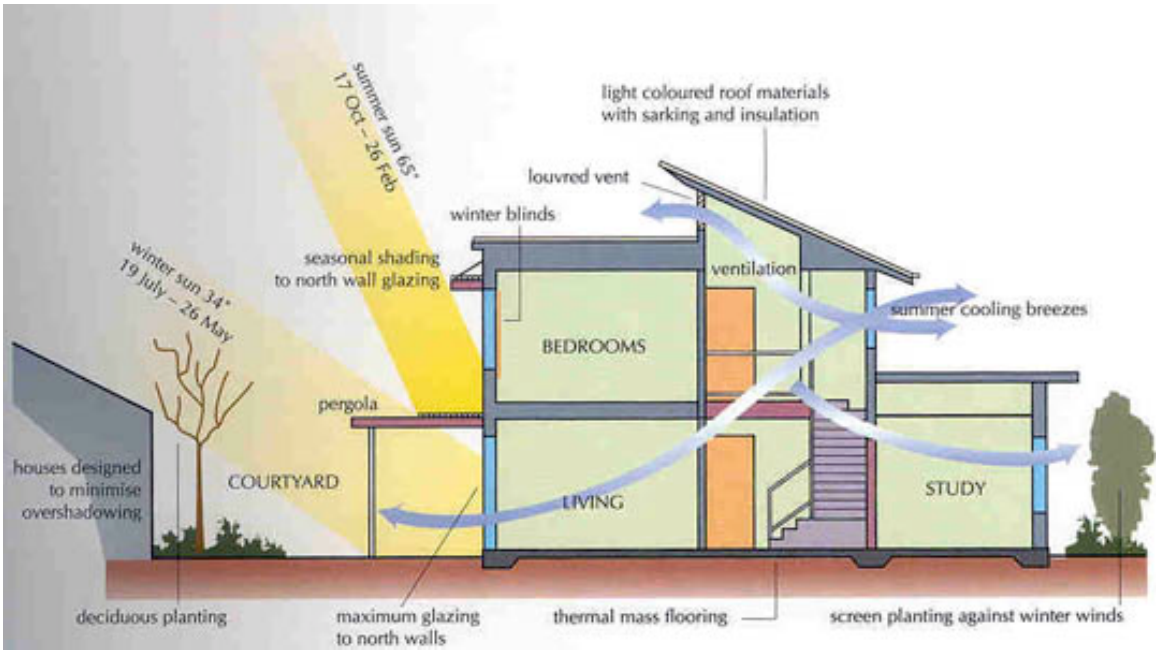


Thermal Storage Wall
A thermal storage wall is an effective passive solar system, especially to provide nighttime heating.





Some Strategies for incorporating Passive Solar Design



A Complete System integrating Landscaping