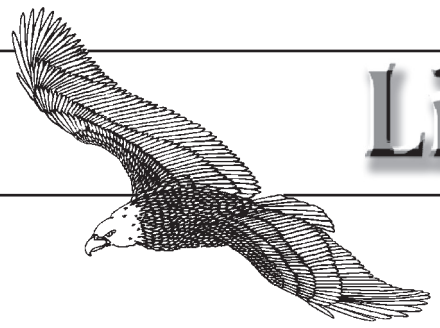


Living on the Earth

Passive solar design skills

Direct-gain type of passive solar system enhanced by imaginative art & architectural shapes by Jeff Ellis in Boulder, Colorado. *photo by Paul Shippee*

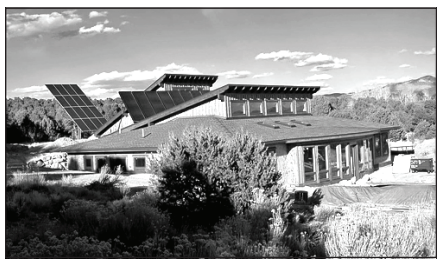
by Paul Shippee

Passive solar is an attractive, smooth and sexy word phrase. No moving parts. Just align the house so it faces the abundant winter sunshine and let the sun's rays shine in those large windows. Free heating and winter warmth and daytime comfort at almost no cost—and the plants love it!

However, effective passive solar design may not be so simple when you get right down to it and consider the overall picture and then move into the nitty-gritty details. The best results are deceptively simple yet somehow quite sophisticated. The design of passive solar buildings is an imaginative art because the spatial forms are virtually unlimited. Some stunning shapes and forms may result when integrated with balanced solar collection and thermal mass storage options.

The first principle of passive solar design is the use of the whole house as a solar collector. This introduces an opportunity for new and specially adapted architectural forms, materials and functionality. Well-designed passive solar homes—along with tight, well-insulated construction practices—are attractive because they look great, work well and because it may be the cheapest heating system in the long run. Any extra costs to produce a high-functioning solar home may be viewed as an investment, not an expense. This common sense view becomes clear when you consider displaced conventional fossil fuel heating costs as dollar savings that add up over the life of the home. This is the life-cycle economics viewpoint.

An early decision to be considered by the owner in the design process is the desired Solar Heating Fraction. This design parameter is an important choice as it affects the building cost, shape, materials and ultimate performance. The SHF is the selected target for how much the sun's heat will contribute to the annual heating requirement of the home. For example, the desired SHF may be 30%, 50%, 80% or even 100% solar heated. As expected, extra costs are naturally incurred for higher performance, ie, larger windows, interior thermal mass heat storage materials, and increased insulation levels all around. Optimizing these three factors will determine the comfort and overall passive solar contribution to the home's heating performance, warmth and satisfaction.



Passive solar Sunspace and clerestory, in Salida, with solar thermal collectors for radiant floor charging and heat distribution. Large, attractive adobe wall between Sunspace and house interiors distributes low temperature daily solar gains at night via large radiant wall areas. This results in hi-performance solar heating approaching 100%. Passive solar design & radiant floor installation by Paul Shippee.
photo by Paul Shippee

Both comfort and performance levels may be controlled and predicted in the design of the passive home. Balancing the three factors stated above according to scientifically researched and proven design principles will eliminate some common design flaws such as overheating on winter sunny days that must be relieved by opening windows, under-heating by placing windows outside the optimal orientation to the noonday winter sun, and not understanding the importance of what's called the aspect ratio, which is the proportion of the long south side of the house to the short side, optimally a ratio of two to one.

In addition to these design considerations and choice points there are other decisions to be made that will create a living space that is comfortable, attractive to the eye, and genuinely responsive to climate while eliminating most of the need for heating fuel.

The basic operation of all passive solar buildings is:

• Collect solar heat during the day.

• Store the heat in the living space.

• Use some of it during the day.

• Passively (or naturally) discharge heat from the store at night or on cloudy days, as needed.

• Recharge the store when the sun comes out.

Obviously, a perfect match cannot be made between the availability of sunshine and the demands of indoor temperature. But it is interesting to find out just how close you can come; just what kind of building construction can be placed between these two climatic supply and demand forces to achieve the right kind of balance for an indoor human environment.

Hybrid passive solar direct-gain home with interior thermal mass walls of rammed earth. Solar thermal panels supply warm water under radiant adobe floor all day for night use. Design/build by Paul Shippee. *photo by Paul Shippee*

There are a few different architectural configurations that are commonly used to make a home that can perform the basic functions of collect and store solar heat. They are:

• Direct gain systems (including clerestory windows) allow the sun to shine directly into the living space. It's a popular approach because it is simple and low cost. Problems when overdone are lack of control resulting in overheating during the day, glare, destruction of fabrics and lack of privacy.

• Mass walls are a way of blocking most of the sun from the living space. They are located directly behind south-facing glass and may be of heavy masonry (Trombe wall) or of containers full of water. Water stores 2.5 times more heat than earth materials for a given volume. The main idea is that the wall (with openings to admit some sunshine) stores heat without overheating and releases it to the house slowly after sundown. There are many creative variations on mass wall design.

• Sunspace south wall configurations may be the most attractive, utilitarian and practical. They are a kind of hybrid combination of the first two where the mass wall is moved back from the south glass several feet to create a greenhouse room that can tolerate wider temperature swings between winter days and nights, at the same time preventing too much sun from blasting into the house interiors. Again, solar heat maybe stored in the greenhouse mass wall and released slowly during winter nights into the house.

• Another hybrid configuration is achieved by using direct gain windows and deploying large amounts of thermal mass in the interior walls. These can be lining the north wall with four inches of brick or adobe blocks, building interior walls with adobe or rammed earth, and tall columns of water strategically placed to absorb daily sunshine thereby reducing temperature swings in the house.

• Roof Pond and Free Convection Loops have also demonstrated passive solar options. Roof ponds with insulated moveable doors on top can be used in extreme desert environments, and free convection loops may be deployed whenever solar thermal collectors utilizing

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Passive solar

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utilizing air or water transfer fluids can be placed below the storage.

To summarize, the basic elements of natural or passive heat transfer, from collection to storage and later release from storage will include:

• Transparent building surfaces facing south.

• Interior heat storage materials.

• Moveable window insulation (cold climate).

• Control of temperature swings.

The last one is of major importance and involves proper arrangement of indoor spaces, color choices, and interior building materials of sufficient area and mass to achieve the desired effect. Keep in mind that we are dealing with a low-temperature heating application. Passive solar temperature differentials rarely exceed 10° or 20° for driving the heat distribution flow from storage. In best-case scenarios, superior designs with large thermal mass can achieve smaller temperature swings between 3-5°s from day to night.

Heat distribution is all-natural and therefore depends on differentials to drive it from warm storage mass into the living space as it cools down during the night. Therefore, passive solar homes will experience temperature swings. This is different from mechanical systems consuming fossil fuels where temperatures are kept at a constant 68-70°. A mitigating factor regarding comfort in passive solar environments is the fact that interior surfaces emitting stored heat into a room allow comfort to be experienced in cooler air temperatures because the body is radiating to warmer thermal mass surfaces than in conventional homes.

Of course, backup heating sources can also mitigate and control temperature swings by utilizing active solar panels that store daily solar heat in radiant mass floors, or wood burning stoves, or fossil fuel appliances, or worst-choice power plant electrical resistance heating devices. There is at least one house in the Baca that I know of where backup heating uses less than three wheelbarrows of wood over the winter. This house is on land with an ongoing source of wood from dead or dying trees that are replenished in the forest every 30 years or so. Since this process utilizes recent sunshine, rather than ancient sunshine that created the stored ancient sunlight we know as fossil fuels—such as propane, oil and coal—then this fortunate home may be said to be 100% solar heated. Renewable. Sustainable. Resilient.

May all beings be happy and enjoy passive solar energy.

For more information please visit my website www.crestonesolarschool.com

Passive solar heat storage in water drums.

Passive solar Trombe Wall system with clerestory windows to bring light & warmth to north interior spaces in Snowmass, Colorado. Reflections of sunlight off the snow enhance heat gain by up to 50%. *photo by Paul Shippee*