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The Solar Component of Sustainable Design

In last weeks article I gave readers an overview of what it's been like to live in a sustainable home. This week we'll cover the basic elements of solar in sustainable design.

Sustainable design is a broad topic involving the selection of "green" building materials as well as the incorporation of efficiency and solar design features. Design features that reduce energy use are especially important because they can provide more energy, economic and environmental benefits per dollar than "green" building materials. Passive solar design features, in conjunction with energy efficiency features such as high insulation levels and an air-tight building shell, are the foundation of sustainable energy design. Let's take a look at the significant impact solar energy can have on a home in our area.

Using a 2000 vintage, 3,000 square foot home in Nevada City as an example, passive solar design can reduce the annual heating costs by $690 (propane). These savings were estimated using a building energy simulation model called "Energy10", developed by the U.S. Department of Energy's National Renewable Energy Lab. The model has been tested and calibrated for accuracy against other computer models as well as actual buildings. Let's take a quick look at the design changes we made to this home to get these savings.

To change the standard home into a passive solar home I made the building rectangular instead of square, oriented the long side of the building so it faced south, and put most of the glass on the south facing wall. I made sure the south glass had an overhang designed to fully block the windows from the high summer sun while fully allowing the low winter sun to enter the home. I also made sure the east and west facing glass, which I reduced in area relative to the "standard home," were properly shaded in the summer by using an exterior shade screen (deciduous trees would offer similar but more permanent shading). To hold onto the solar energy captured by the south facing glass during the day I added thermal mass to the inside walls using hard-wall plaster, and insulated the slab floor.

Using this example, let's review the basic elements of a passive solar design. They are:

1) Aperture (windows)
2) Absorber (the surface of the thermal mass)
3) Thermal mass (the material used to store energy)
4) Distribution (the way the energy is moved through the home)
5) Control (of the natural forces to optimize heating and cooling savings)

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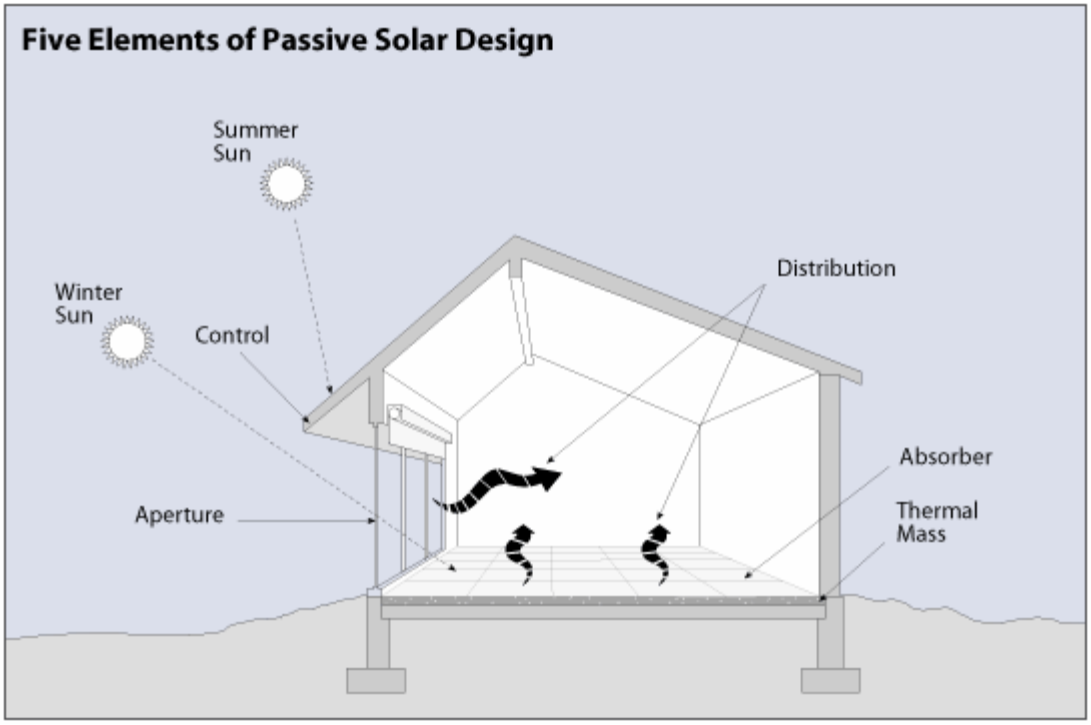

Aperture
The aperture in our example is the south facing windows. They collect more energy in winter than summer because of the path the sun follows through the sky in winter. As a general rule, windows are effective as solar aperture as long as they face within 30 degrees of true south and are un-shaded between 9 a.m. and 3 p.m. during the heating season.

On the east and west side of our example home are windows that collect very little energy in winter but can turn a room into an oven in the summertime. For this reason we want to minimize the east/west glass and shade it from the early morning and afternoon sun. North-facing glass is useful for natural day-lighting but should be minimized.

Absorber
The absorber is the surface of the thermal mass where energy is absorbed. In our example the slab floor and plaster walls act as thermal mass, absorbing solar heat from the south glass during a sunny winter day, and releasing it at night when the indoor temperature starts to fall.

In a climate like ours we need to consider natural summer cooling too. The large area of plaster and slab floor in our example absorb heat from the air during the day. The heat is drawn back out of the mass at night by ventilating the house with cool outside air.

Thermal mass
Thermal mass is where the energy is stored in a passive solar home. It can be a masonry wall, concrete floor, or a limitless combination of these and other building materials with a capacity for storing heat.

In our climate, it's best to keep the surface area large and the thickness of the thermal mass thin so the mass can save us energy in both the heating and cooling season. This is called "distributed mass" – in contrast, a small area of thick thermal mass is called "concentrated mass." Distributed mass is best when the absorber surface is not in direct sun (which is difficult in practice anyway) and the greater surface area allows it to store and release energy more quickly.

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Distribution
Distribution is the method through which energy is transferred through the home. By definition, a passive design transfers energy through one of three natural means -conduction, convection, and radiation. A slab floor in direct sun is a good example because it uses all three modes – radiant energy from the sun is absorbed by the surface and the energy is conducted down into the concrete. When the floor surface becomes warmer than the inside air, the stored energy is convected away from the slab surface to the inside air.

Control
Controlling the energy flows in a passive solar home helps maximize savings and comfort. The overhangs that shade our windows in the summer are a control feature, as are the solar screens we put up on the east and west windows in summer. Opening windows at night in the summer to allow the cool air to scrub away heat accumulated during the daytime hours is another example of control.

Putting It All Together
Keep in mind this is just one example of a passive solar design and, as such, it's not representative of every application. The features incorporated, the materials used and the savings associated with passive solar design will vary with every application – some might have lower and some might have higher savings (and likewise with installation costs).

A building energy simulation model in the hands of an experienced energy professional can be used to "fine tune" these five elements of a passive solar design. The same tool is also useful for comparing a wide variety of efficiency alternatives. That said, effective passive designs do not *require* a high-tech computer approach. Keep in mind that passive design has been around and practiced by civilizations for hundreds of years, long before computers were available!

The biggest challenge is finding the optimum site for a passive solar home (or an existing home with solar potential as was the situation in my case). Not every property is fortunate enough to have solar access to the south. And for many of those, their south-facing "view" might be a parking lot or the ugliest back yard in the neighborhood! Given the direction energy prices are headed it won't be long before properties with solar access *and* a nice view to the south will command a real price premium over the rest. I hear now is a good time to shop for real estate so, good luck, and shop south!

Ray Darby is President of Sustainable Energy Group Inc., a Grass Valley company offering energy efficiency and solar services for residential and commercial buildings, from comparing the alternatives through installation and servicing of energy systems of all types. You can reach him at 530-273-4422, via email RayDarby@SustainableEnergyGroup.com, or visit their web site at www.SustainableEnergyGroup.com.

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