

Using the sun to beat the heat:

June 21st may be the longest day of the year, but, in Alabama, the hottest day usually comes in August.

I used to live and work as a civil engineer on Kwajalein Island in the Republic of the Marshall Islands located only 700 miles north of the equator; the hottest day of the year there could come on any date. We enjoyed beautiful sunrises and even more spectacular sunsets, like the one above below. Between the two, however, our only thoughts of the sun were how to eliminate the heat and humidity the sun brought us.



All our electricity was generated from oil brought from Hawaii. Since Hawaii has no wells, the oil was brought from at least 4,000 miles away. Still, nobody thought about using the sun instead of fuel oil to beat the heat or the humidity. It was the early 1990's, and oil was still cheap and plentiful.

So how can we use heat to cool things off? The easiest way is to keep the sun off the building to start with. "Natural light control and shading is the most often overlooked solar asset," claims ASA member, author, and Auburn professor Norbert Lechner.

ASA Solarite and Mobile architect Debra Coleman (<http://www.sunplans.com/>) designs passive solar homes all over the US. She calls her "sun-inspired designs" the "gold lining of a green building." Custom energy specs that are a part of each sun-inspired home design include recommending an orientation. In conjunction with the latitude, climate, details of each plan, and the customer's preferences, Debra's plans recommend orienting the home a little to the southeast so that the south wall of home is in the shade by mid-afternoon in summer. This is a common recommendation that results in little winter heating penalty for the benefits gained.

The house to the right shows the entire south wall of the home in shade late in the afternoon as would be the case with a slight easterly orientation. Photo courtesy of SunPlans.



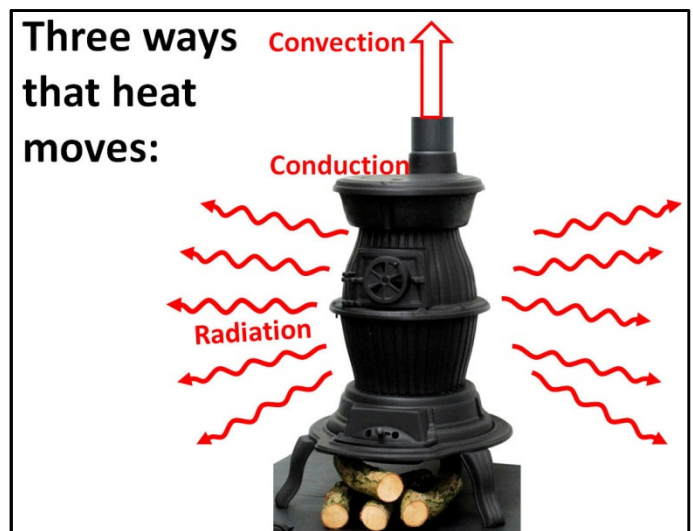
Ideally, a south-face overhang should allow for full sun in the winter from 9 AM to 3 PM on the Winter Solstice and full shade on the Summer Solstice during the same time period. This criteria varies based on latitude, climate, the particular roof-to-wall overhang detail, and wall and window heights of each design. Porches and trees placed on the east and west sides of homes keep the intensive morning and afternoon sun off of both the glass and the house!

Where the night temperatures drop below 68°F, some home owners find passive cooling desirable in summer, or at least during late spring and early fall with some of the following window strategies:

- ✓ Windows and doors on opposite sides of rooms increase cross breezes
- ✓ Casement windows have a greater operable area when open **and** scoop air with windows that swing out thus increasing air flow.
- ✓ Opening windows on both upper and lower floors (including daylight basements) increases the stack effect of passive cooling which again increases air flow.

To understand how orientation and shading work with other passive solar techniques, let's look at how heat moves. This Alabama pioneer's pot-belly stove shows all three ways. You can get warm by heat radiating out from the stove, but it only warms the side facing the stove. Conduction heats a cooking pot on top of the stove. Convection (hot air rises) pulls smoke up the stovepipe. If you've never experienced an old pot-belly stove, think of a campfire.

In the movie *Karate Kid*, Mr. Miyagi advises "Best way to avoid punch is not be there." Best way to avoid solar radiation gain is block it out. Craig McManus of Affordable Solar in Dothan advises using a radiant barrier stapled to the rafters to keep sun from radiating through the roof structure. It's very similar to the space-age foil we use behind our windshield to keep the sun from turning the vehicle into a solar oven. The shiny foil radiant barrier surface reflects heat trying to enter or leave the building. Thermal insulation reduces conduction losses through the walls, floor, and ceiling. Well-placed vents can allow heat to rise through convection and bring in cooler air behind it. For more info, see <http://www.asolarpro.com/Home.html>.

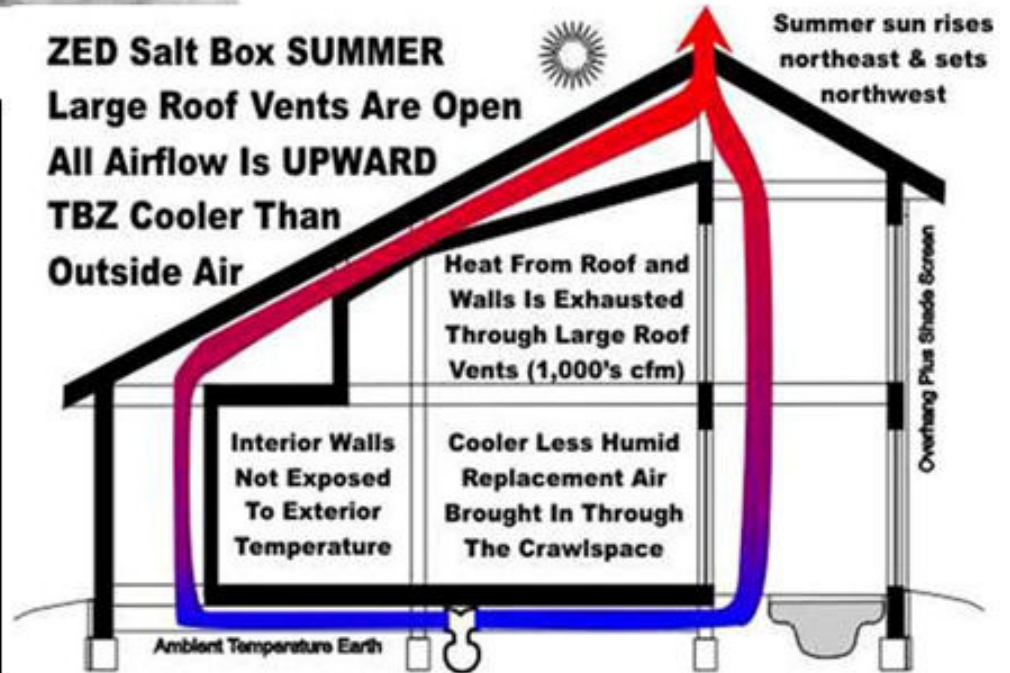


Now let's look more at the movement of heat by convection. Back in the 1700's, the closest thing we had to a power grid was Ben Franklin's kite string. There was certainly no air conditioning, but early New Englanders developed an architecture that captured the sun's heat in winter and shed it in summer. They used a combination of geothermal heat transfer from beneath the home and convection to let heat from the house escape in summer and stay inside in the winter. These principles can be used today with better technology, a little electricity, and lot better results.



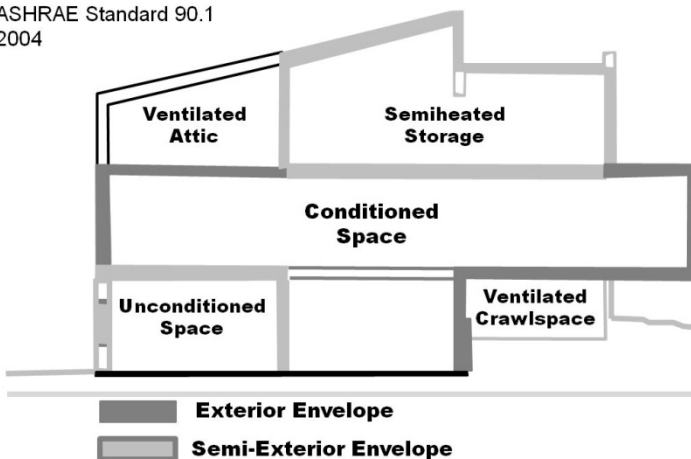
1700's ZED (no utility company)

The south side was often two stories high with a lot of glass to let in the low winter sun. Overhangs and trellises blocked the high summer sun. The west side had little glass and shade trees. Attic vents opened to exhaust summer heat and draw in cooler air through the first floor windows by convection. Southern breezes prevail



The building envelope

ASHRAE Standard 90.1
2004



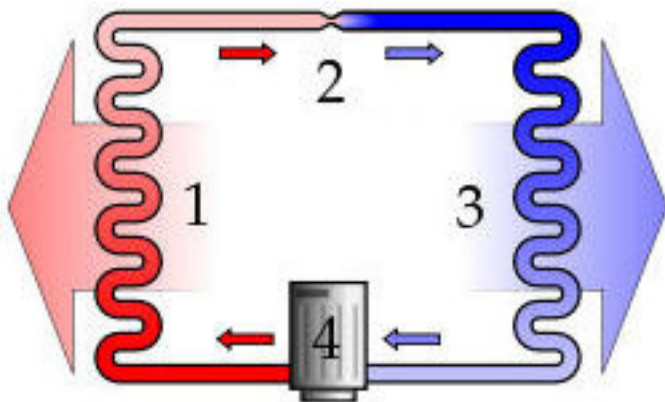
Clearly, sealing your building envelope is a first step to keeping cool under the summer sun. By today's standards, there are actually several building envelopes, as the above diagram shows.

The power of sealing the building envelope is clearly evident in the Warren House in Hoover, Alabama. The homeowner wanted to convert his 1962 tri-level home into a zero-energy building. Daryl Bergquist, Earth Steward Solar Consulting, recommended first sealing the leaks in the old



house. Warner installed an Energy Star metal roof, dense packed the exterior walls, sprayed foam to seal behind switch and outlet boxes, and added under-floor insulation. He converted appliances to Energy Star models and all lighting to fluorescents—LEDs were not yet available at a reasonable cost. These efficiency steps allowed him to replace the four-ton conventional HVAC unit with a three-ton geo-exchange heat pump. Central Alabama geo-exchange heat pumps need one 180-foot deep well for each ton of cooling required. See pictures and more info at <http://www.al-solar.org/photos/#Warren>. By sealing the building envelope first, the owner saved drilling one well, and then he saved the cost of operating the fourth underground loop. Better than looking at pictures, see the house itself on October 1st or 2nd on the National Solar Tour (<http://nationalsolartour.org/>).

A heat pump moves heat from one place to another. In summer, it moves heat out of the building. In winter, it reverses and moves heat from outside to inside. Even if the outside air is 32° F., you can still get enough heat from it to warm a room to 80° F.

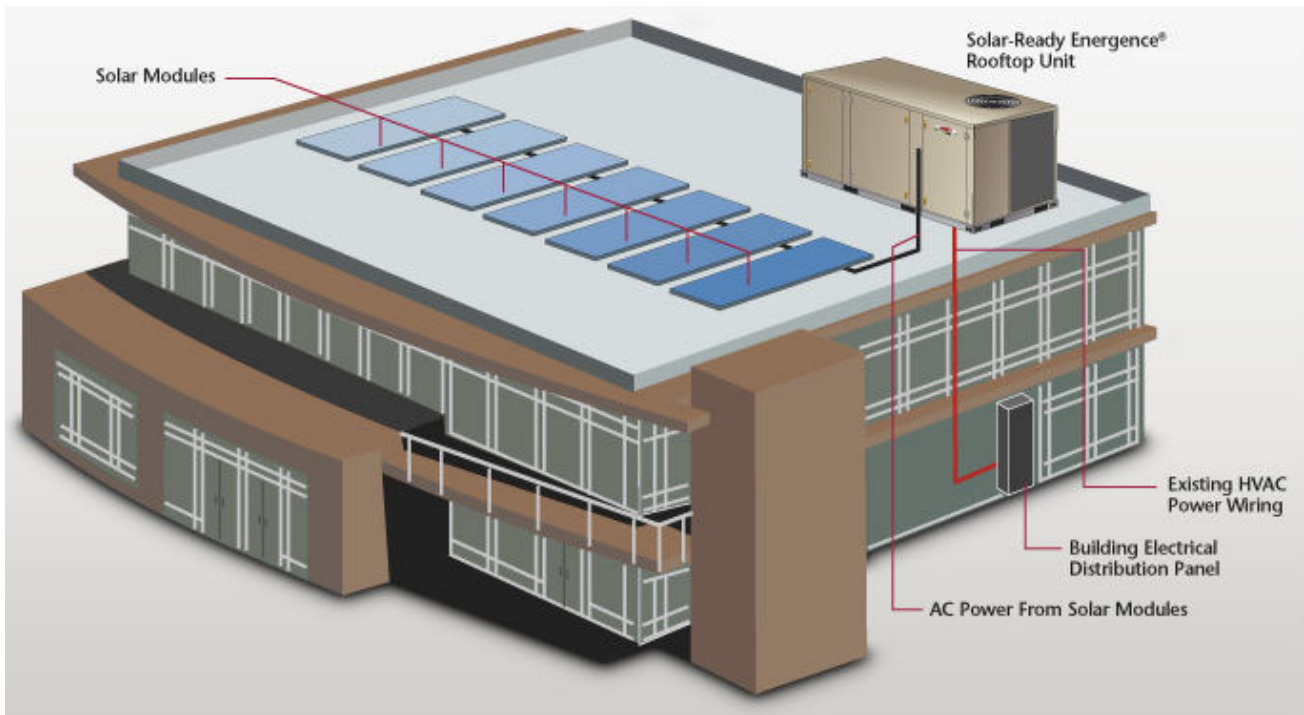


The heat pump works on the principle that when a gas expands, it cools; when a gas compresses, it gets hot. The process begins in the evaporator (item 2 left). Spray anything out of an aerosol can, and the can immediately feels cold. In fact it can cool well below the 32° F. freezing mark. Had we been at the factory when the can was first filled, it would have been too hot to hold in our bare hands.

The evaporator (3) passes air over the chilled refrigerant lines. This cools the air and allows the refrigerant to warm back up to ambient temperature. In summer, the cold air is blown into the building; in winter, the cold air is expelled outside. The compressor (4) squeezes the refrigerant making it hot again, much like the factory packing a product and a propellant into a new aerosol can. The condenser (1) cools the refrigerant back to ambient temperature by blowing air across it. In winter, this air is blown into the building to warm it; in summer, the warm air is expelled outside.

The US Government established the Season Energy Efficiency Ratio (SEER) rating system to establish the efficiency level of cooling equipment. The higher the SEER rating, the less electricity the equipment uses and the more efficient it is. SEER is determined by dividing the cooling capacity, measured in BTUh, of a continuously operating air conditioner by the electric power input, measured in WATTS of power consumed. The current standard for equipment in the United States is that they must function at a minimum of 10 SEER, but many new units have a much higher rating. If you have an older unit, even if it is still functioning well, it may pay you to replace it with one of a higher SEER.

Some super-efficient heat pumps, such as the Lennox SunSource® (picture, next page), with a SEER of up to 34, (<http://commercial.poweractive.com/news/2011/sunsource-dealer-design-2011>) use rooftop solar panels to generate part of the electricity needed to operate the system. The roof of a typical building will usually not have room for enough solar panels to generate enough electricity to operate a heat pump year round. Such systems can still be effective by generating the most electricity when heat is at its worst and sending any excess generated back to the grid.



Super efficient heat pumps work just as well as geo-exchange or geothermal heat pumps for two months out of each year. During the other ten months, the geo units perform like it was springtime all year long. If you have ever visited a cave in Alabama, you know that deep inside, the temperature is a chilly-but-livable 60° F. year round. The geo-exchange heat pump takes advantage of this principle.

The system works just like the regular heat pump above, but you use the near-constant temperature of the ground rather than that of the highly-variable ambient air as a heat reservoir. Generally geo-exchange heat pumps get four kilowatts of free energy from the earth for every kilowatt of electricity input into the system. It is relatively easy to generate enough PV electricity on a rooftop to run a geo-exchange or geothermal heat pump year round in Alabama. This way, all the operating energy is free.

Suppose you want to cool a big building or a campus of many structures. An adsorption chiller can convert waste heat or solar hot water into cooling. This device uses heat to cause chemical changes in a material thus causing the refrigerant in it to evaporate. This chills water similar to the way a heat pump evaporator cools air. Chilled water can then be circulated through one building or many buildings to cool the air inside. Chilled water is much easier to control and regulate than is flowing cool air.

Heat



Waste heat



Combined Heat & Power



Solar Hot Water



Adsorption Chiller



Cooling

Power Partners, Inc., of Athens, Georgia (www.powerpartners-usa.com), has collaborated with Department of Energy's Pacific Northwest National Laboratory to \$2.54 million research program to test new sorbents (a material used to absorb liquids or gases) and refrigerants in a type of air conditioning unit that runs on waste heat or heat from solar thermal collectors. Power Partners has already built a small chiller to test the new metal organic adsorbers. This system is expected to be as much as five times more efficient than the traditional silica-gel materials now being used. The new chillers should be small enough for residential use.

Using sunshine and heat to make things cool is not magic. Sunshine provides light, heat, and electricity. Heat causes evaporation which in turn causes cooling. By carefully controlling the chemistry and physical state (solid, liquid, or gas) of a substance, engineers can magnify the effects of evaporation, condensation, and freezing. By moving heat, you can make some spaces cooler and some warmer. Electricity, either from rooftop panels or from the power grid, keeps things moving.

Take some old ideas, add some space-age technology, mix in some foresight to look ahead to the future, and you have a sustainable, money-saving design.