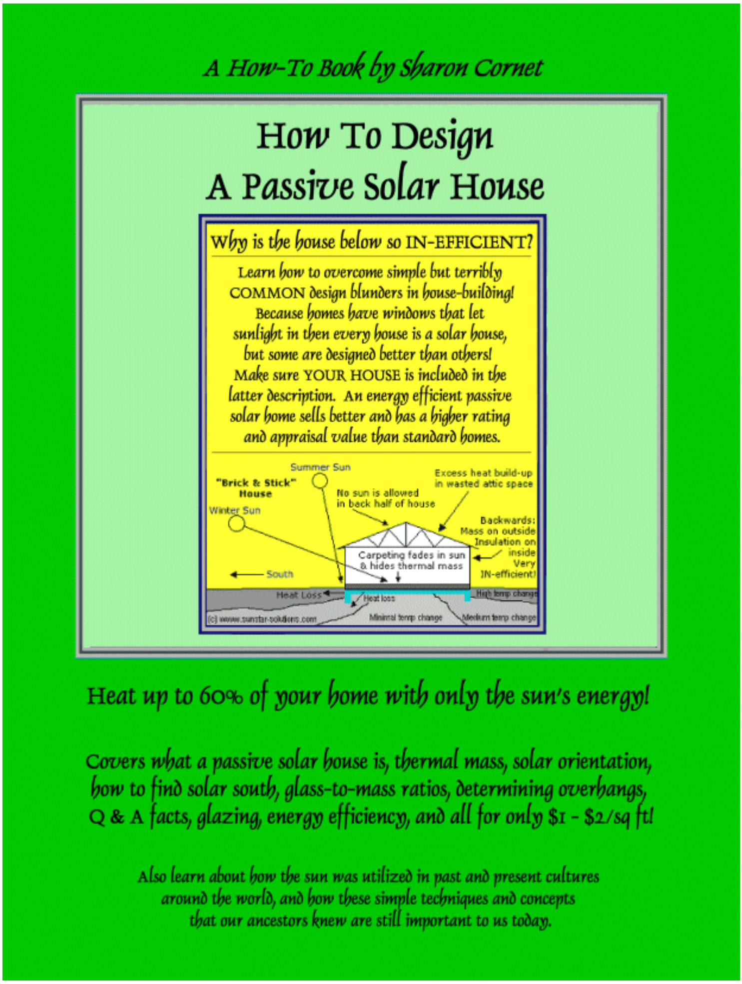
How to Design a Passive Solar House
By Sharon Buydens



Formerly Sharon Cornet

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The Sun in Past and Present Cultures

Aeschylus was an ancient Greek playwright and philosopher who lived around 525/524 BC – 456/455 BC said rather bluntly (much to the chagrin of many of today's modern home building contractors and architects):

"Only primitives & barbarians lack knowledge of houses turned to face the Winter sun."

Socrates, who lived from 469 BC – 399 BC, on a more practical note said:

"*Now, supposing a house to have a southern aspect, sunshine during winter will steal in under the verandah, but in summer, when the sun traverses a path right over our heads, the roof will afford an agreeable shade, will it not?"*

The ancient Greeks and places like Priene in Asia Minor provided a way for every home in their cities to have access to solar energy during the winters. Their streets ran north-south and east-west so all homes could face "solar south" and warm their dwellings.

Ancient Rome had south-facing rooms called a *heliocaminus*, which means "sun furnace." They trapped the heat from sunlight in these rooms by putting in windows or mica (muscovite is also a form of mica). Mica has basal cleavage, which means it is a mineral that grows in long thin sheets, one on top of another, and can be peeled into thin flexible sheets for use. This is why chunks of mica are called “books of mica.” The heat held in the room, because of this window barrier, made the heliocaminus a very warm place to stay or sleep in.

Mica

Picture Source: esrf.eu

The Greeks did not utilize these windows of mica in their southern-facing homes, so consequently they were colder (but not nearly as cold as homes that did not face the sun!). This goes to show that solar energy can be as efficient or as non-efficient as one prefers, depending on the amount of knowledge and materials at hand.

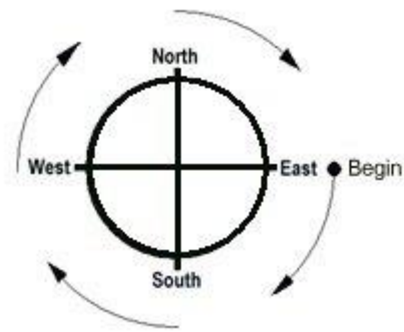
The bathhouses in Rome had large windows that faced south; however, many areas in Europe stopped utilizing solar design after the Fall of Rome. But where one culture loses its traditions in architecture and culture, others survive and thrive.

China's traditions and practices, which were guided by the cosmos, continued on for millenia the knowledge and practice of associating the southerly direction with not only summer, but good health and warmth. The Forbidden City in Beijing was aligned in 5 directions – east, south, west, north, and center (the "center" was where the Emperor was). Both astronomy and Feng Shui are associated with ancient solar and cosmological influences.

Native American Indians have utilized the sun for centuries upon centuries, and kept within their traditions sacred ceremonies that pay homage to the natural order of earth, sky, water, and the great fire in the sky… the sun. There are other items of importance, depending on the tribe, but the Lakota Sioux realize that there are not just 4 directions, but 6 of them (east, south, west, north, up, and down).

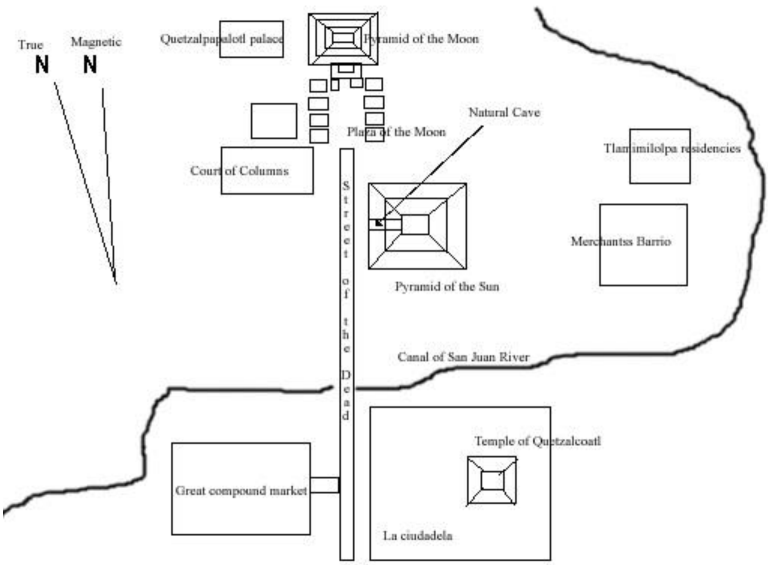
To the Apache people the number 4 is in accordance with the four directions. They begin their ceremonies from the east, and then dance "sun-wise" (clockwise), toward the south, then the west, and finally the north, before closing the circle in the east where it all began. The early morning sun shines into the east-facing opening of the ceremonial tee pee signaling for the teenage girls (in their "Coming of Age Ceremony") run out with their baskets to begin the rituals they've prepared for as they enter into young womanhood. After four days (for the 4 directions, 4 divisions of the day, 4 seasons, etc.) of the ceremony and feast the girls end the official public part of the ceremony the same way, running into the eastern sunrise with their baskets, before giving away gifts to the crowd. Always, always, the dances begin in the east and go sun-wise, as a symbol of how the sun tracks through the sky.

APACHE BASE METAPHOR



The Quartered Circle

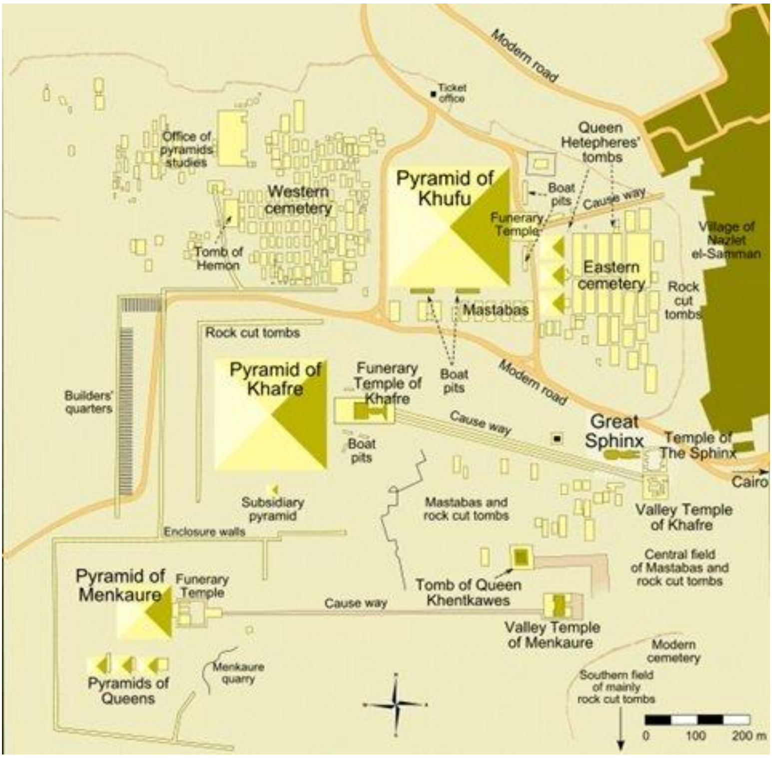
The sun is, in many cultures, associated with the endless cycles of life. It is the giver of light, and of life. The Maya in Central America were cosmological and mathematical geniuses when it came to celestial observations and how they derived their three calendars into one. They understood about the solar equinoxes, solar and lunar eclipses, and planetary alignments, and they paid special attention to the moon and Venus as well. Their large-scale architecture, like towers and temples, included construction where the sides faced the four cardinal directions. In the classification of what are called E-group structures, the stepped pyramid would always be positioned on the western side of quadrilateral platforms/plazas. North and south structures accompany the plaza on the eastern side, and an east-side stairway allows one to climb to the summit of what archaeologists now think were observatories. From the summit the sun can be seen very accurately through smaller temples during the equinoxes and winter and summer solstices. Another Mesoamerican city called Teotihuacan has a structure called the Pyramid of the Sun.



The SUN is the SOURCE of what directs human observation (not forgetting the moon and the rest of the cosmos) in and of nature to dedicate the “sunrise” to the east, and the hottest part of the day to the south, and “sunset” to the west. When the sun is not visible at night, it is on the “north” other side of the earth until seen again in the next sunrise. Many cultures, specifically Native Americans, have associated the east with birth and youth, the south with adulthood, the west with old age (and/or death and dying), and the north with the underworld or the unseen spirit world (understanding and having that faith that although it is not seen with the eyes, it still exists). Renewal comes with the next morning's sunrise. It is no surprise that the sun, namely solar energy from the sun, is called "renewable energy."

Many cultures throughout history and prehistory worship(ed) the sun, and it has been tied into many of their religious beliefs, whether they used it in their architectural designs or not. In Egypt there was Ra/Re, the sun god. Also, the 5th Dynasty Pharaohs built Sun Temples. The Sun Temple at Niuserre was excavated by Borchardt between 1898 and 1902. The Sun Temple had an obelisk symbolizing the benben (the rock, when during the creation of the world, had the sun's first rays shine on it).

The Great Pyramid at Giza (built around 4,500 years ago) is probably the most well known of all of the ancient structures in Egypt. Each of the four sides face closely to the four compass directions of east, south, west, and north. For a moment, let's focus on the north side (realizing it includes, not excludes, the three remaining sides, due to its equal 4-sided shape). The reason it doesn't point directly to magnetic north is because it is off by a little bit, which makes it face directly to what is called "truth north." You'll be learning later about what true north, and especially TRUE SOUTH mean, and how it relates to the passive solar design of houses and other buildings.



Source: Wikipedia (Great Pyramid of Giza)

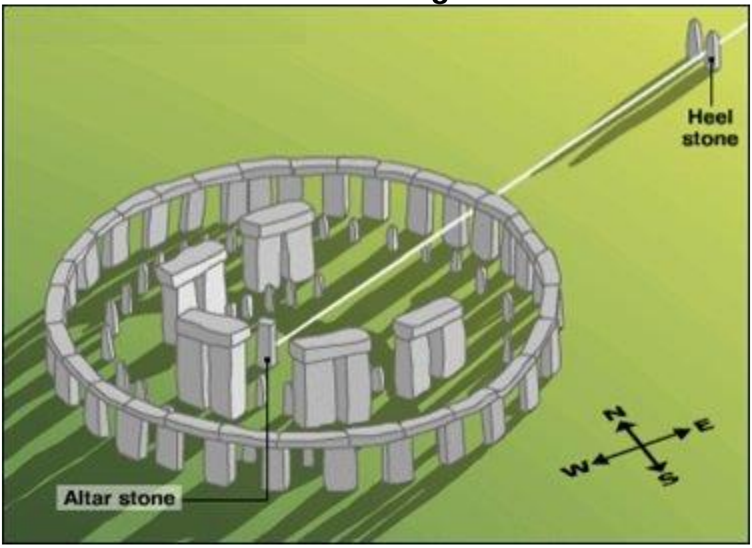
There is a 4,000 year old circle made of timbers called Seahenge, since it was found just off the Norfolk coast.

Seahenge

Source: easyweb.easynet.co.uk

Another well-known ancient structure, made up of many vertical and horizontal megalithic stones arranged in a circular pattern, which was known to be used in accordance with the cosmos. This would be Stonehenge, located in Britain. This is still a place today that is considered sacred by those who show up during the summer solstice (the longest day of the year) and the winter solstice (the shortest day of the year – with the equinoxes being exactly the same day-length during spring and fall).

Stonehenge



Source: news.bbc.co.uk

Two miles northeast from Stonehenge is a place called Woodhenge, where 6 concentric rings made up of postholes form its shape.

Woodhenge

Source: catkinlodge.fsnet.co.uk

Woodhenge Layout

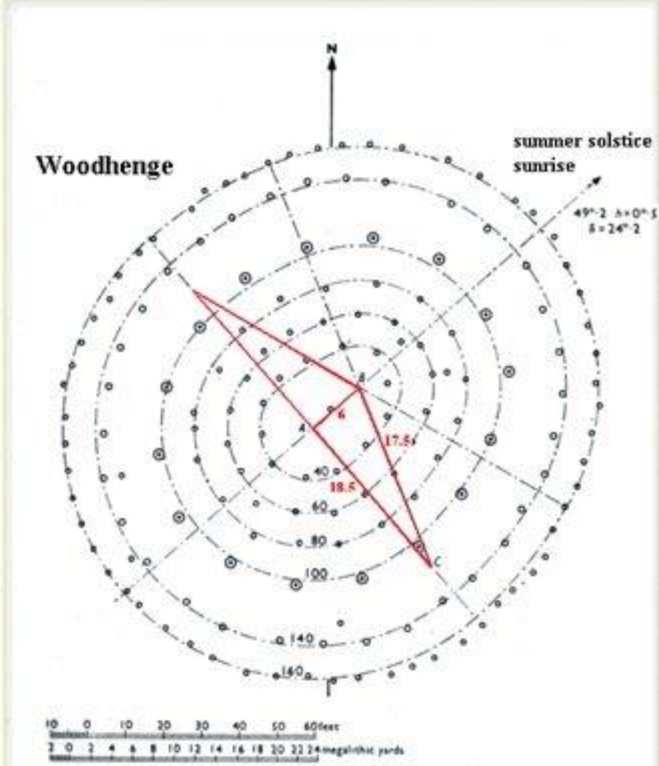
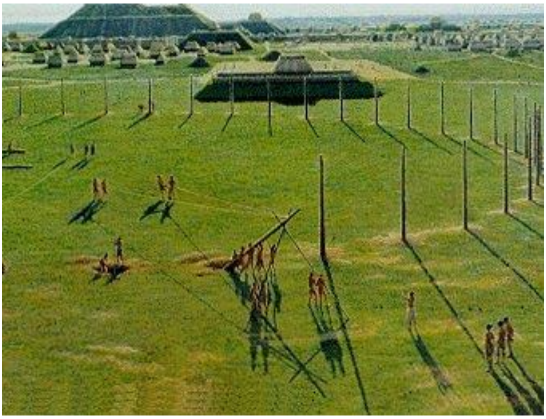


FIG. 6.16. Woodhenge, S 5/4 (51° 12', 1° 48'). Construction superimposed: $AB = 6$, $AC = 17\frac{1}{2}$, $CB = 18\frac{1}{2}$ MY; r = radii struck from $A = (P - 9{\cdot}08) \div 2\pi$; P = 40, 60, 80, 100, 140, and 160 MY (P = perimeter).

Source: www.megalithicsites.co.uk

There is also a North American Indian based “Woodhenge” at the “Cahokia” site (600 AD – 1400 AD) near Collinsville, IL, that is part of the diverse Moundbuilders cultures (3000 BC – 1500 AD). It is also based on the 4 directions and that also mark the equinoxes, solstices, and other cycles in astronomy.

Moundbuilders



Source: www.utexas.edu

A passage tomb called Newgrange, dated around 3,300 – 2,900 BC, and located in the Republic of Ireland has a strange hollow box-shaped passageway above the door. This passageway is aligned perfectly with the winter solstice sun to light up the interior of the tomb on that single day out of the year.

Newgrange in Ireland

Source: knoweth.com

These ancient civilizations and peoples and cultures exampled above are but a collective dent into the vast list of places around the world where the sun, and other astronomical bodies and cycles were important, and continue to be important today. The study of the importance of these alignments falls under anthropology, ethnoastronomy, archaeoastronomy, as well as other cultural studies and archaeology.

There are worldwide archaeoastronomy sites located in Australia, Bolivia, Brazil, Cambodia, Egypt, France, Germany, Honduras, Indonesia, India, Iran, Ireland, Israel, Mexico, Peru, Romania, Russia, Sweden, the United Kingdom, and the United States.

For more information on this you can read about it at: http://en.wikipedia.org/wiki/List_of_archaeoastronomical_sites_sorted_by_country

Or for more official information you can see *The International Society for Archaeoastronomy and Astronomy in Culture*: http://www3.archaeoastronomy.org/

As we've seen, the sun (among other things in the celestial sphere) was very important to human beings for millennia. The sun is still important to people in our present day. Solar energy and wind energy (wind being a result of solar infrared heat causing convection currents) companies abound and are flourishing as a renewable energy source, especially as pollution and climate change concerns continue to escalate. Technological knowledge is increasing daily, and the price of oil/gasoline is pushing the solar energy arena to a more equally competitive basis, at least when it comes to certain applications. Renewable energy sources are crucial to our future, and whether we use solar energy for electricity, or for hybrid or passive solar designs, including our homes, we can be rest assured that the sun is not going to disappear… it will always rise again in the morning.

Today, in our modern world, we emulate the light from the sun with electric “suns” (light bulbs) that can be turned on by the flip of a switch, and we take much for granted in doing so – that is, until a storm knocks out the electricity as a reminder that we are quite dependent upon this technology. Passive solar homes use should less electrical lighting during the day because they are naturally very bright and cheery, which saves on your electric bill. In the winter the sunlight enters directly into the house, and in the summer it is indirect lighting that brightens the room.

Be sure to tailor your home to your latitude, environment, climate, and pay attention to what indigenous peoples have done historically IN YOUR REGION. A couple of solar energy resources are below.

U.S. Department of Energy, Energy Efficiency and Renewable Energy:
http://energy.gov/eere/solarpoweringamerica/solar-powering-america

Look up your state and regional chapters of ASES (American Solar Energy Society):
http://www.ases.org/local/

What is “Passive Solar” Anyway

To find out what “passive solar” is we can compare it to “active solar” so we know the difference and have a basis for what we’re going to learn about passive solar homes. There are numerous definitions of this, but the one I like is:

ACTIVE SOLAR = MOVEMENT

Uses mechanical pumps, fans, blades (e.g., wind generator, since wind power is a derivative of solar energy), or other devices that eventually need repair from use, and which enhance solar energy conversion to electric power. Active systems typically cost more to buy or make, as well as maintain or replace.

PASSIVE SOLAR = NO MOVEMENT

Runs silently with no moving parts (e.g., energy put straight into batteries or light bulbs, etc.). Passive solar designed homes are also passive systems because the HOME itself becomes the solar collector and requires the usual “walls, roof, floor, doors & windows” but no moving parts to make it work. It just sits there passively and ‘does its thing’ with little to no input from you.

The difference between a standard constructed house and a passive solar house is that in a properly designed home, it is where you put the windows, and how much "glass to mass" there is makes all the difference. Insulating the envelope and where you place your overhangs are also important keys.

But let's start from the beginning.

You already understand the differences between PASSIVE and ACTIVE systems; now make sure you understand that **ENERGY EFFICIENCY** in a home must always be considered <u>first and foremost</u>.

With that in mind, let's continue.

Nature's Perfect Example of Passive Solar Energy

A horned lizard (a.k.a. "horny toad"... an endangered species in the southwest United States) is not unlike a vast variety of other lizards or snakes in that they are cold-blooded. This cold-blooded nature is the exact reason why you'll often find reptiles sitting on a rock in the sun in the early morning. The sunlight warms the rock and provides heat to help warm up these creatures so they can scurry around doing whatever these little creatures need to do the rest of the day. The principles behind what this horny toad knows is simple.... he's equipped with the knowledge (naturally) of passive solar design even though he doesn't know that humans call it such! If a mere lizard, or snake, or horned toad knows that a rock stores heat which he can use to warm his cold-blooded little body, then why don't people use this same technique for warming up on a cold day, or warming their house on a cold day? Of course, in a passive solar house, they do!

The technical term for the thermal storing properties of this rock (or other heat-storage material) is THERMAL MASS. Thermal mass materials are able to soak up and store heat and then later release it. Rock, or bricks, concrete, tiles, the earth, metals, or even water are all examples of thermal mass materials that can be used to your advantage in a house by storing the sunshine’s warmth in the material so you can utilize it later, much like how the lizard uses the sun-heated rock to warm up. The difference is your design will have insulation to help keep the thermal mass material warmer longer.

Horned Toad

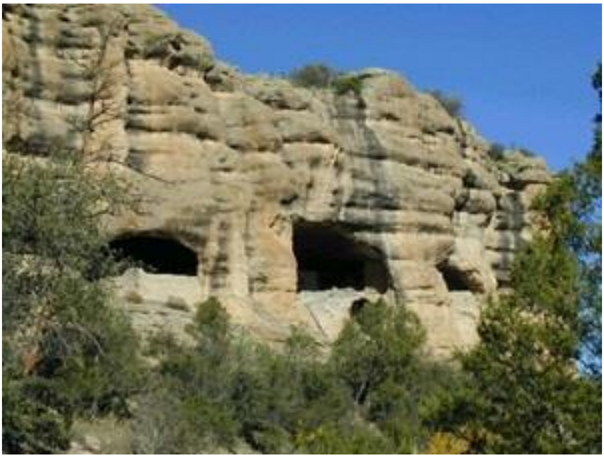
Source: animals.nationalgeographic.com

What Indian Cave Dwellers Knew

The Indian cave dwellers knew more about passive solar home design than many homebuilders do today! By harnessing the SIMPLE and EFFECTIVE aspects of sunlight, thermal mass, and insulation to create an energy efficient home, the owner-builder or the Contractor can add QUALITY to the home by providing up to 60% of the homes' heat in the winter WITHOUT A FURNACE. In even better (but far more expensive and complex) designs, such as Net Zero or Net Positive homes, that percentage can go up to as high as nearly 100%, depending on the region in which you live. This is not rocket science, however. I intend to keep it simple so you can do it in a far less expensive way than Net * homes, and far more efficient than the Indians did. However, that said, the Natives knew a secret that has been lost to most of industrialized societies today.

Native American "Cliff Dwellers" would always choose specific caves that faced south. They understood simple principles of harnessing nature, which could help them stay warmer in winter and cooler in summer. They knew which direction their caves had to face south (in the northern hemisphere—in the southern hemisphere they must face north) to take advantage of the sunlight; consequently, they would often avoid caves that did not already have this orientation. Sometimes this one important detail could mean the difference between surviving or freezing to death in winter.

One of my favorite places to visit and go camping near was the Gila Cliff Dwellings in New Mexico. I was always awed by these homes and wished I could live in one. There are cave houses around the world, but only the smartest peoples who observed nature and harnessed its natural abundant resources properly would take advantage of the sun.



Gila Cliff Dwellings, NM

In the winter the sun is lower in the sky than in the summer. At this time, during the coldest months, the sunlight streams into the cave, warming the thermal mass (rock) walls, which provides passive heat for those who lived there. Even if there is snow outside in the winter, the rocks will remain warm enough, trapped inside the cave, to be a comfortable living place all winter long, especially when supplemented by heat from their fires, which were placed at the entrance (heat in the back of the cave could smoke you out plus heat the rock in one area above the fire so much that it could cause a rock fall).

During summer the sun is very high in the sky. The large overhang of the cave's "roof" provides shelter and keeps the sunlight OUT in summertime, so the now-cool thermal mass of the cave's interior feels like air conditioning during the hot summer.

Rock walls are great "heat storage" for heat provided by sunlight. They stay warm in winter after the sun has warmed them, and release the heat at night. The rocks, alternatively, stay cool in summer since they are shaded, providing a cool-to-the-touch feeling in summer when it's scorching outside.

Spring and Fall will allow some sunlight into the cave which warms the rock during the day, for passive heating at night. In summer the sun does <u>not</u> enter most of the cave. In winter it streams fully into the cave. Any possible interior constructed rock walls were purposefully placed well under the cave's "overhang" lip above to utilize this natural principle for passive heating.

NOTE: Homes today that utilize interior thermal mass walls or floors that store heat from south-facing windows, or especially trombe wall systems, tend to overheat slightly in the spring and fall (equinoxes) since it's a transition period between the first day of both winter and spring (solstices).

Looking out from inside the Gila Cliff Dwellings

Next I will cover more specifics on passive solar home design...

What is a Passive Solar House?

Passive Solar House? People to whom the thought of "solar energy" is uncommon to immediately think of a big array of solar collectors on the roof, or stuck outside in the yard by the house. But solar collectors for producing electricity are typically a hybrid system between passive solar and active solar. You have already learned that ACTIVE solar implies using solar energy in a system with mechanical pumps and fans that will inevitably break down, and that PASSIVE solar is a system using solar energy where there are no moving parts whatsoever; in fact, you probably couldn't tell a passive solar house was even "solar" oriented unless you had a good idea of window placement and where solar south is.

Let me start by saying one thing: EVERY HOUSE IS A SOLAR HOUSE! The difference being that a properly designed house will be warmer in the winter and cooler in the summer than those built by "standard construction". Why? Does it have to do with having more insulation? It could, but no. Better, more efficient heaters and air conditioners? No. More cost into building the home than a standard house? No, not necessarily that either. Then what you say? The key is knowing how to let the sun IN to help warm the house in the wintertime and keep the sun OUT in the summer.

How is this little trick done? Well, before I tell you, let me ask you something... Do you have one of those windows in the home you live in now that faces west? Do you find that in the summer, after an already hot day, that the sun is shining straight through that window making your air conditioner work even harder because it is heating up your house even more? If so, I can almost bet that you live in a building built under "standard construction" methods. The key to letting the sun in a passive solar house is to let the house become the collector *in an efficient way*. Efficient means keeping the sun out when you don’t need it, and letting it in when you do.

The majority of the sun's energy comes from the south. Since between 60 and 80 percent of direct sunlight is available to use as solar energy, large windows facing solar south can provide up to 60 percent of a building's heating needs when the windows are insulated during the night with tight-fitting shutters, insulated curtains, or especially some other *exterior* device that closes to trap the heat in. Clerestory (highly placed thin horizontal) windows can be used for additional light to upper levels within the structure or to back rooms that would not normally receive direct sunlight.

NOTE: A passive solar house should have about 1 square foot of window area for every 3-5 square feet of floor area. Otherwise, you will be looking at either a cold house or a very overheated one.

How to Find Solar South

In order to know which way to face your windows, you must be able to find solar south, also called "true south" (not magnetic south – since the sun does not rise and set exactly due east and west).

For the purposes of this book, I have created these instructions for people who live in the northern hemisphere, specifically North America, where the sun will be in the 'solar south' direction. Please just note that for the southern hemisphere the sun will be hovering over the equator as well, but it will appear in the northerly direction rather than the south (a slight perspective difference that makes all the difference). However, that said, finding solar north is as easy as finding solar south by simply facing the opposite direction, but I will give the instructions for "solar south". Finding the sun in the sky at any given time of the year is easy.

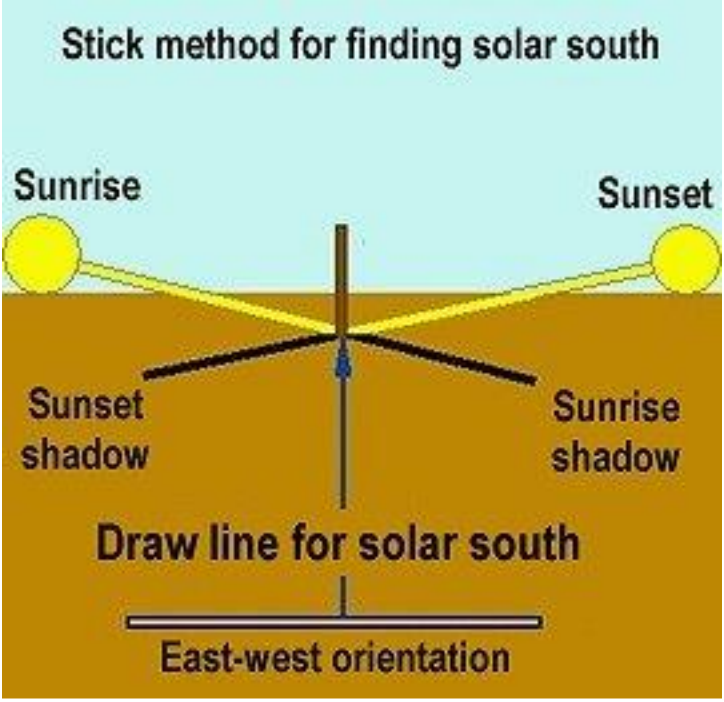
There are three different ways to find solar south:

1. The stick method
2. The sunrise-sunset method
3. The compass deviation/topo map method

I will explain each of these next…

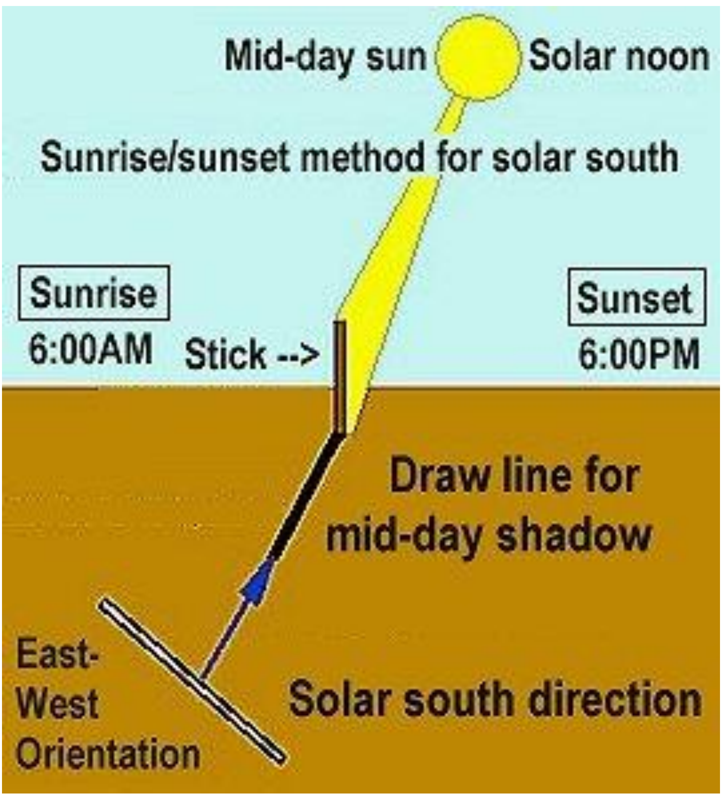
1. STICK METHOD:

Place a stick in the ground and draw a line on the shadow cast at sunrise. Then draw another line on the shadow cast at sunset. Directly in between the two shadow lines draw a third line (on the south side). This indicates the direction that the sun will be coming from exactly in the middle of the day (any time of the year), and which way your windows (double-paned) should face to receive the most ample amount of sunlight for your structure. This should be south-southeast for most areas of the U.S.



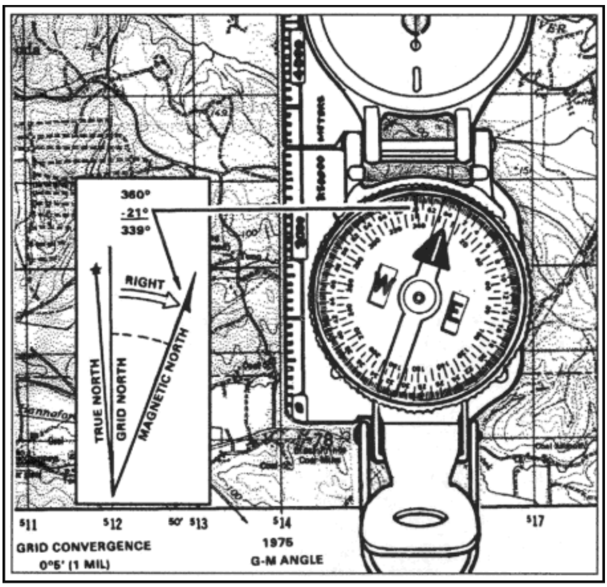
2. SUNRISE-SUNSET METHOD:

Watch the news on television, or check your Almanac, and note the times of sunrise and sunset. At exactly in between these two times, called "solar noon," place a stick in the ground and draw a line where the shadow is cast. Facing towards south (where the sun is) is where the line should point. This is solar south.



3. COMPASS DEVIATION/TOPO MAP METHOD:

Find your location and see what the compass deviation (or angle of magnetic declination) is by looking on a topographical map.



Source: http://www.globalsecurity.org/military/library/policy/army/fm/3-25-26/image139.gif

For example, in Lincoln, NE solar south is 9 degrees *east* of magnetic south according to the deviation. The main solar heating hours for the Lincoln area are between 8AM and 2PM each day. Since so many of the hours to receive direct gain are in the morning hours, many people choose to have some windows on the east side as well as on the south. ***But beware****: any windows facing more than 40 degrees off solar south (either way) start to lose efficiency at a rapid rate.*

Another example is for El Paso, TX where solar south is about 11 degrees *east* of magnetic south according to the deviation. The main solar heating hours for the El Paso area are between 9AM and 3PM each day.

I personally found this method to be more confusing than the previous two (using the stick method), and others I've spoken to say the same thing, so I've included some explanatory information here. In order to understand this you'll need to know what a few terms are, which might be new to you. Sometimes a picture better explains a concept than words, or vice versa, so when appropriate I will include those below, along with their sources.

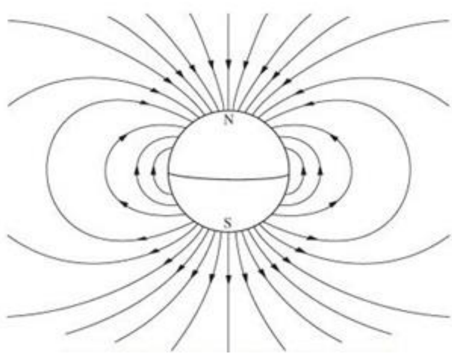
There is also a handy solar position calculation tool for major cities that is free online through NOAA's website:
http://www.esrl.noaa.gov/gmd/grad/solcalc/azel.html

Remember that 'solar south' is the same as 'true south', just as 'solar north' is the same as 'true north'; whereas, 'magnetic south' or 'magnetic north' have to do with the magnetic poles (which migrate slightly) rather than the sun's position relative to the earth (the annual/seasonal/daily paths of which are relatively fixed in the heavens, at least for our purposes here).

Here is some information on solar declination. First, a definition… “In astronomy, declination (abbrev. dec or δ) is one of the two coordinates of the equatorial coordinate system, the other being either right ascension or hour angle. Declination in astronomy is comparable to geographic latitude, but projected onto the celestial sphere.
Source: en.wikipedia.org/wiki/Solar_declination

Second, remember magnetic north/south.
Magnetic North: “The direction to which a compass points. Magnetic north differs from true north because the magnetic fields of the planet are not exactly in line…” Source: http://terrax.org/sailing/glossary/gm.aspx

Earth’s Magnetic Field (dipole)



Source: http://geomag.usgs.gov

Latitude & Longitude

Source: www.spacecom.com

Tools for finding your Latitude and Longitude location:

Latitude – Longitude Finder:
http://www.lat-long.com/

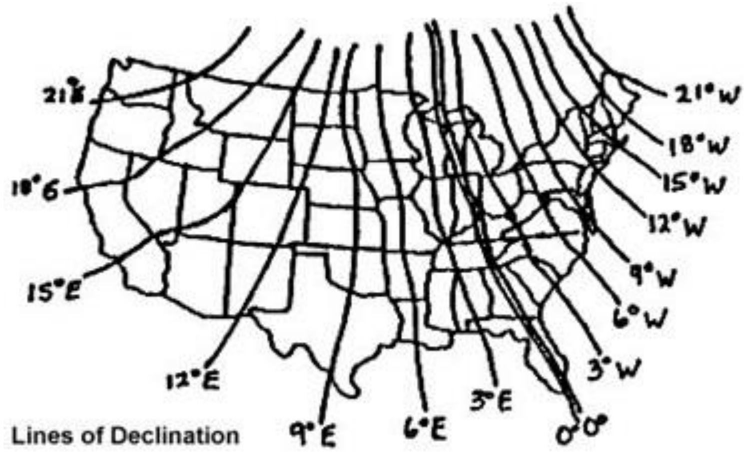
Satellite Signals, Latitude and Longitude (interactive map):
http://www.satsig.net/maps/lat-long-finder.htm

Now, more on Declination:

"At a given point, the angle between magnetic north and true north; At a given point, the angle between the line connecting this point with the geographical center of the earth and the equatorial plane…"
Source: en.wiktionary.org/wiki/declination

“The latitude that the sun is directly over at a given time. The declination is ~23°N at the summer solstice, ~23°S at the winter solstice, and 0° (over the equator) at the spring and autumn equinoxes.”

Source: www.crh.noaa.gov/glossary.php



Lines of Declination

Source: http://gorp.away.com/gorp/publishers/menasha/images/declinat.gif

Solar Declination Angle:

“The angle between the rays of the Sun and the equatorial plane of the Earth. It is zero during an equinox and 23.5° during a solstice.”

Source: www.meted.ucar.edu/tropical/textbook/ch6/moistprecip_glossary.html

Azimuth Angle:

“The azimuth angle, also known as the bearing angle, is the angle of the sun's projection onto the ground plane relative to south."

Source: http://www.wbdg.org/resources/suncontrol.php

NOTE: The Azimuth Angle can be used in place of the declination, or solar declination!

Solar Declination/Azimuth Angle:

Because of the 23.45º angle of the earth's axis, the sun appears to be higher in the sky during summer, and lower in the sky during winter.

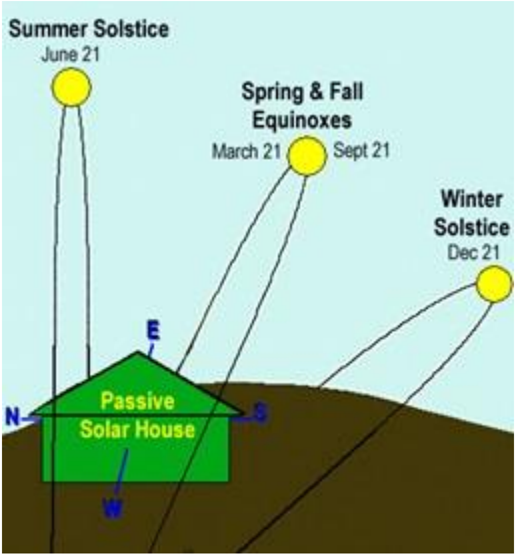
This oddity is really a great help when it comes to passive solar design since it allows roof overhangs to keep the "high" sunlight out in summer, and lets in the "low" sunlight in during winter.

I'll get into the house design, and why this is so important later, but until then take a look at the approximate (not to scale) paths the sun takes around the earth (from an earth-centric view) at different times of the year.

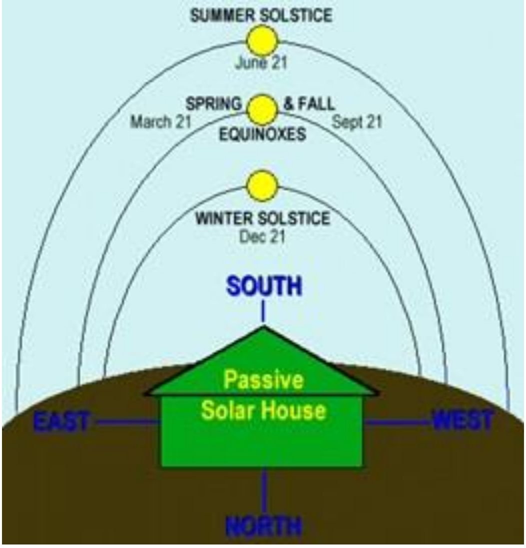
The next two pictures show:

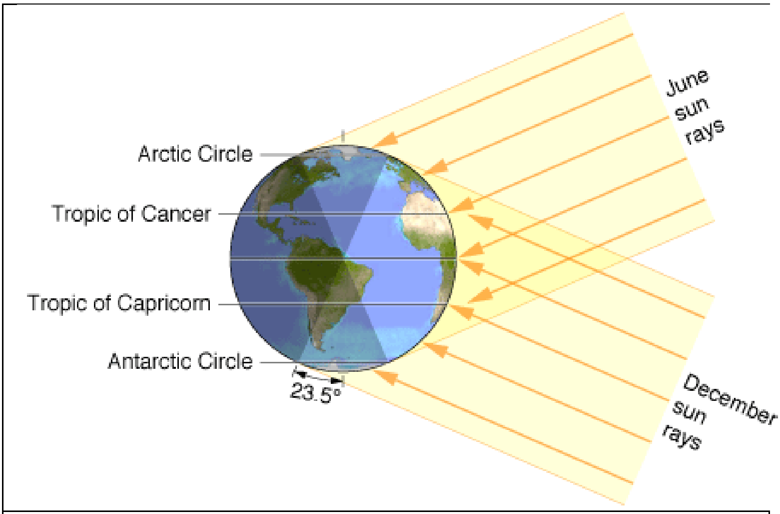
1) The side view of the sun's path
2) The sun's path if facing solar south

Side View of the Sun's Path

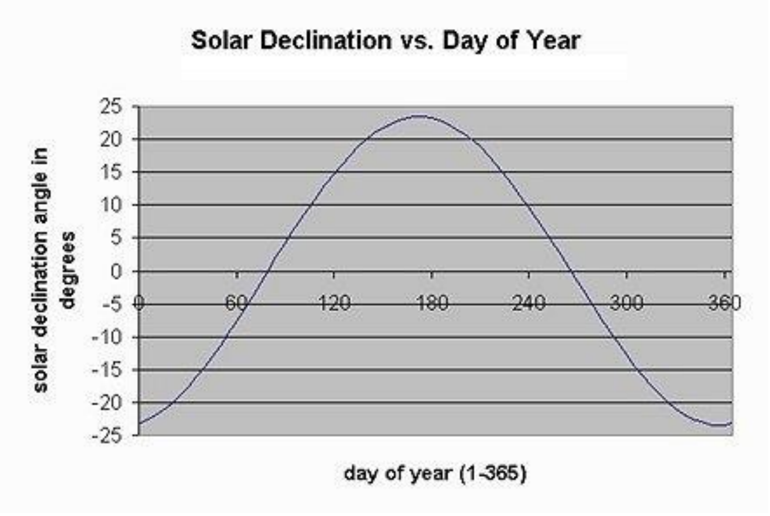


Sun's Path if Facing Solar South

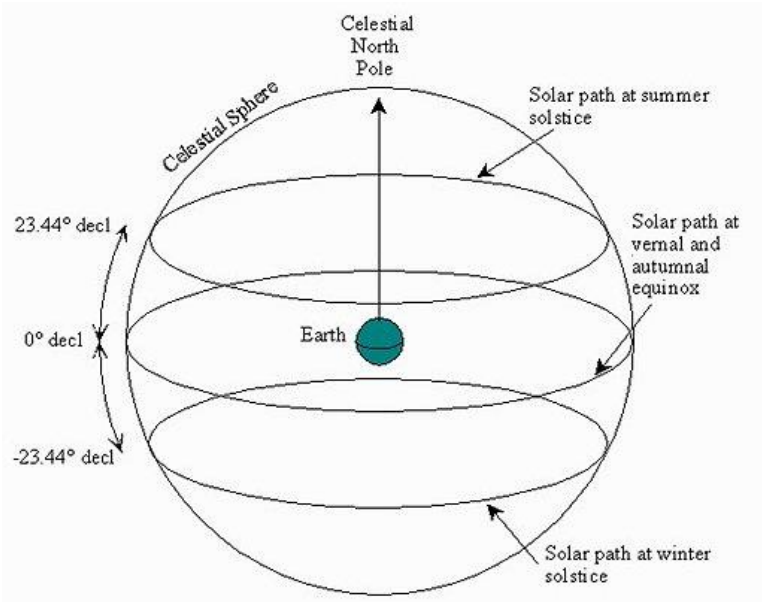




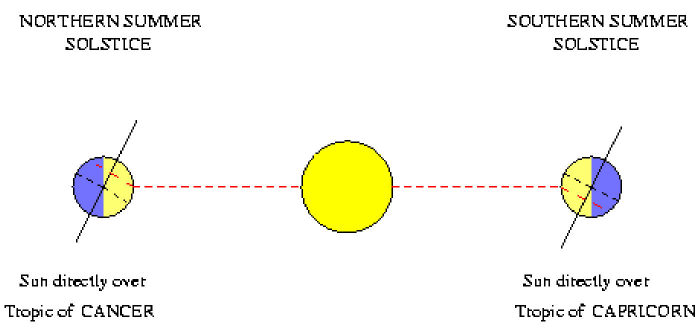
Source: http://physics.weber.edu



Source: www.srrb.noaa.gov



Source: www.srrb.noaa.gov

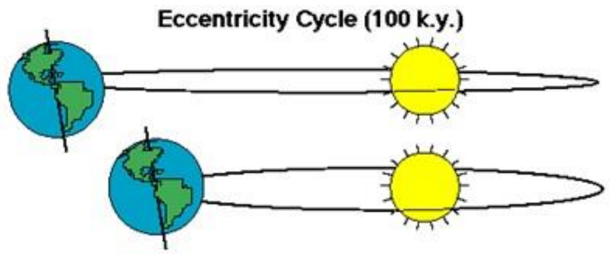


Source: http://solar.physics.montana.edu/welsch/
Phys101/tropics.gif

"Wondrous is this great, blue ship that sails around the mighty sun and joy to everyone that rides along."
~ Unknown Author

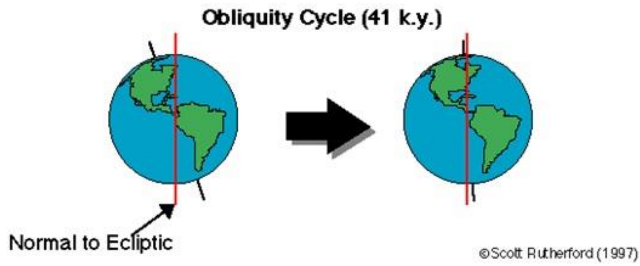
In addition to the earth's axis being 23.45º off from magnetic north, and the earth traveling around the sun, there is a much more interesting side note about the earth and the sun's "friendship" that gives a much larger picture. This is called the Milankovich Theory, also called the Precession of the Equinoxes, or the Precession Cycle. There are actually three separate cycles in the Milankovich Theory that, together, cause different amounts of sunlight to fall on the earth at any given time. Of course, these cycles are quite large, so it's not something you need worry about, but it is good to know about our world and our place in it because it affects how we think, and therefore how we do things (and why). Ultimately, it helps us understand solar energy.

1) The earth does not really go around the sun in a perfect circle; it is actually near circular and then slowly moves out into a very elongated elliptical orbit, taking about 100,000 years or so to complete the cycle. Right now our earth is moving in a low eccentricity orbit, keeping our seasons milder rather than extreme.



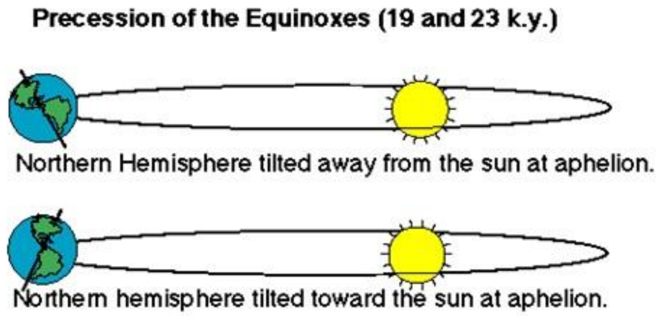
Source: www.lakepowell.net

2) The next cycle has to do with the tilt of the earth, which is presently at 23.45º but every 41,000 years the variants of the tilt falls between 22º to 24.5º, which causes warmer winters and cooler summers when there is a small tilt, and the opposite with a greater tilt.

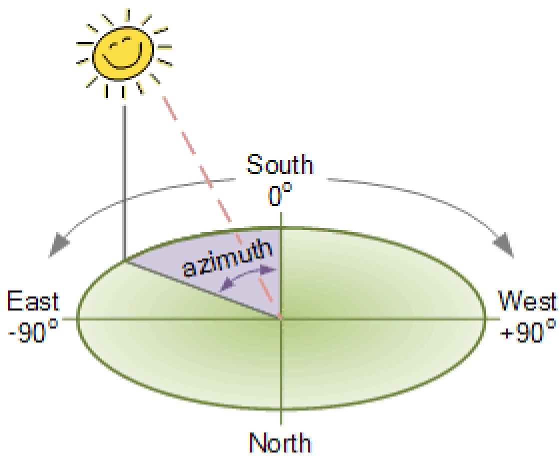


Source: www.lakepowell.net

3) The earth's axis wobbles and takes about 11,000 years (approximately) to complete a turn in addition to its eccentric orbit. Our present orbit actually causes us to have summer when the earth is farther from the sun (in January), and winter when we are closer to the sun (in July). In another 11,000 years or so this will be reversed, so every 23,000 years (give or take) there is a complete cycle. This is the precession cycle.



Source: www.lakepowell.net



Source: http://www.alternative-energy-tutorials.com/images/stories/solar/alt19.gif

Remember that solar declination is the same as the azimuth. Now that you have a better idea on the “big picture” of our earth and sun, I can move on to how this solar energy can be used, along with earth materials to help warm our house in winter, and to cool it in summer. The earth materials I speak of are items with thermal mass.

More on Thermal Mass

THERMAL MASS is any medium that has mass for storing energy. This could be rock, ceramics, tile, brick, concrete, plaster, earth, adobe, rammed-earth, or a host of other materials found naturally or that are manmade. The #1 material for absorbing heat and releasing it is water, which is 4 times more efficient than concrete at absorbing and releasing stored energy (water is used to heat and cool homes such as in solar roof ponds); however, water is not always the easiest way to store energy in a home (unless you are using a solar closet – see other books or information from the internet for this information). In most homes choosing a thermal mass product of concrete or tile (on top of concrete) is the most popular method of utilizing passive solar energy. I will focus on these rather than water.

Remember that THERMAL MASS IS ALWAYS A CONDUCTOR of energy, whereas ***its opposite is an <u>INSULATOR</u>***.

Insulation materials inhibit the transference of energy. Insulator examples include wood, cellulose, Styrofoam, Papercrete, Hempcrete, standard fiberglass batt-insulation, straw bales, blue-board (also known as pink-board, which is foundation insulation – extruded polystyrene), carpeting, gypsum board/ drywall/ sheetrock, etc.).

- Place <u>thermal mass</u> heat storage on the INSIDE of the house.

- Place <u>insulation</u> materials on the OUTSIDE of the house (the house envelope, or exterior walls).

REMEMBER! Every home is a solar home! All homes have windows that allow the sunlight in (south side is where the most gain occurs). It's just that some homes are designed poorly, while others, using the principles you're about to learn, are designed far more efficiently (like the lizard on the rock, but adding in knowledge about insulation).

- A passive solar, energy efficient home will have the majority of their glass south-facing, less on the east, little to none on the north, and none on the west. The greatest insulation will be in the roof and envelope, plus the foundation, and plenty of thermal mass will be inside the house as interior walls and flooring, or even as mantles or other features or fixtures.

- The absolute worst, or most inefficient home design will have the opposite: no south facing windows, a lot or too little on the east, the most on the west, and too much on the north side. There will be too little insulation in the envelope, and almost no thermal mass inside the house (carpeting, wood floors, or drywall are all examples of insulating materials in standard homes, which are inadequate for energy efficient or passive solar homes).

There are some specific things concerning THERMAL MASS and INSULATION which need to be understood, as well as how the sun tracks through the sky, how to properly harness this sunlight/heat in the wintertime and keep it out of your house during the hot summertime.

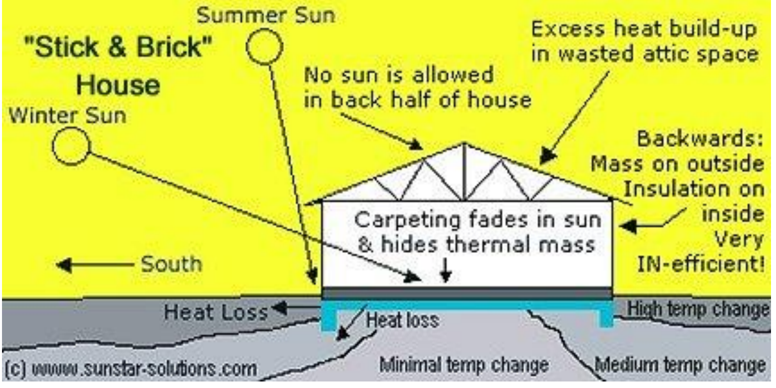
Passive Solar vs. Standard Construction Design

Below are some visuals on how solar energy enters into your home, and a comparison between a standard house and a passive solar energy efficient house... but as you study them carefully remember these two things:

Your house IS the solar collector so <u>add thermal mass</u> for heat storage!

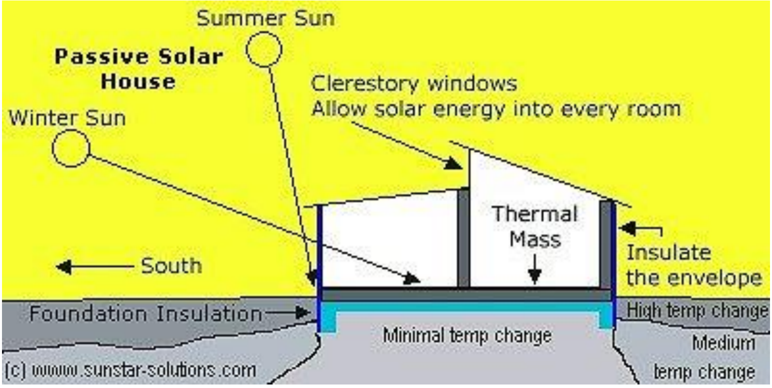
<u>Heat seeks out cold</u> so insulate the envelope of your house to keep from losing the stored energy to the outside!

STANDARD CONSTRUCTION HOUSE



Notice that the insulation is normally on the inside of the “stick and brick” house (meaning wood frame with brick exterior). The brick on the outside is great for weathering, but this house is literally built backwards. The thermal mass (brick) should be on the inside, and the insulation layer (inside the framed wall cavity) should be on the outside to hold the internal temperatures stable.

PASSIVE SOLAR HOUSE



Be sure to study the differences between these two images above. The passive solar house has thermal mass on the interior walls and floors, plus windows along the southern face (longest wall) of the house, including clerestory windows to allow extra sunlight into the back half of the house. Foundation insulation keeps heat loss from occurring through the floor and foundation as well, and is a minimal expense.

Q&A – Test Yourself!

Question: Which rock will **<u>absorb</u>** heat from sunlight faster? A black rock or a white rock?

Answer: A black rock, because it is dark colored and absorbs more of the infrared (heat) from the sun.

Common sense fact: If you want to absorb more heat from the sun, use darker colors (this could be darker colors inside your house where the sunlight touches - such as your floor.... use darker colored (thermal mass) tiles (brown or earth colored tiles are fine) or brick for your floor rather than white or light colored flooring materials... using dark colored carpet (an insulator) will **NOT** absorb the heat you are needing! Nor will wood floors (another insulating product).

Question: Which rock will **<u>reflect</u>** more heat from the sun? A black rock or a white rock?

Answer: A white rock of course! White reflects, as well as shiny metallic colors. This is why many solar collectors use metallic reflectors to gain more sunlight.

Common sense fact: Use light colors inside your house *where the sunlight does **not** touch*, to help reflect direct light, or diffuse indirect light around the room for a nice bright house instead of a dark dreary one.

Question: Which rock will **lose** heat faster after it has warmed up? A black rock or a white rock?

Answer: A black rock will lose heat faster than a white rock. Just as black and dark colors **GAIN** heat quickly, they also **LOSE** heat faster than other lighter colors.

Common sense fact: Dark floors will lose the heat it had gained throughout the day by naturally releasing it up into the room (heat tends to rise) at night.

Note: A black roof will gain more heat in summer, and will lose more heat in the night during winter—stick with white or light colored roofs!

Next, the topic of energy efficiency…

Energy Efficiency

Be sure to begin with an energy efficient house. You can either design and build it that way, or else you can make your current house more "tight" (energy efficient) by doing small things that make a BIG difference.

Heat rises naturally, so most heat is lost **FIRST** through the ceiling and then secondly through the walls in an energy **IN-efficient** house. However, in an energy efficient house, up to 30%- 40% of heat loss can occur through the foundation alone! A ***properly*** insulated house will have foundation insulation to avoid this through-the-ground heat loss. Remember that earth is a conductor, so heat will sink into your thermal mass floor (rock, cement, brick, etc.) and transfer straight into the ground and will suck the heat right out of your warm rooms, making them colder faster.

<u>Make sure that BEFORE you insulate</u> your walls/ceilings that you use caulk, expanding foam, or insulated pads (designed for this use) to close any gaps in doors, windows, electrical, and areas where plumbing enters.

Install ductwork in a heated area, NOT in the attic. Use furdowns, sealed and sheathed prior to installing ductwork. Seal or tape ductwork.

Insulate furnace closet walls.

Install ceiling fans to reduce air conditioning usage.

Be sure that your house has insulation values (called R-values) of the amounts shown below at the very least.

<u>MODERATE CLIMATE</u>

ATTIC/CEILING = R-30 insulation (blown in cellulose insulation is preferred since it fills in small gaps, although it may compact over time and need to be reapplied).

WALLS = R13 in 2x4 walls/R-20 in 2x6 walls, plus 1” expanded polystyrene R-4 rigid insulated sheathing boards.

SLAB/FOUNDATION = R-5-10 extruded polystyrene (i.e. blueboard/pinkboard).

SOLE PLATE = Exterior walls have a bottom plate (sole plate) that need to be sealed with sill sealer (top and bottom floors).

DOORS = R-5.9+ steel clad or fiberglass insulated doors. Lower R-value doors can use a storm door along with it to aid in less air (and temperature) infiltration.

COLD CLIMATE

ATTIC/CEILING = R-38 TO R-50 insulation (blown in cellulose insulation is preferred since it fills in small gaps, although it may compact over time and need to be reapplied).

WALLS = R20 in 2x6 walls, plus 1” expanded polystyrene R-4 rigid insulated sheathing boards.

SLAB/FOUNDATION = R-10 extruded polystyrene (i.e. blueboard/pinkboard).

SOLE PLATE = Exterior walls have a bottom plate (sole plate) that need to be sealed with sill sealer (top and bottom floors).

DOORS = R-5.9+ steel clad or fiberglass insulated doors. Lower R-value doors can use a storm door along with it to aid in less air (and temperature) infiltration.

As mentioned before, always have a light colored roof instead of a dark one. The last thing you need is the heat **GAIN** of a black or dark roof adding to the heat inside the house during the already-hot summertime, AND consider all that heat **LOSS** that a dark or black roof give off during wintertime! You simply cannot afford this! Why risk your COMFORT level and increase your utility bills just because of the color of your roof!

Use light/white colored (at least on the inside of) *insulated* shutters on the outside of your windows to help reflect more sunlight into your home during wintertime (angle the shutters at a diagonal to reflect the light inside the windows instead of reflecting it away from the house).

Hint: Close the insulated shutters at night to help keep the heat **IN** the house and prevent temperature loss since heat loss occurs through windows (glass only has an R-value of 1 or so). The white color will help reflect the heat back into the house while the insulation also prevents additional heat transference/loss).

What About Windows?

As in all passive solar design, one must first consider energy efficiency, however, there are some specifics about windows that everyone should become familiar with because it could "make or break" a passive solar house. Since it all hinges on the sun and allowing sunlight in to heat the thermal mass, getting the most efficient design out of the windows themselves and how many sq ft to put in, and where, etc. is most important. Improper slant of windows can create a hot-box rather than a comfortable house. Window glass is referred to as glazing.

STAY AWAY FROM HORIZONTAL GLAZING!

Glazing that is laid horizontally (such as skylights, or sunspaces) will likely overheat the house in the summer since the sun is high overhead and comes directly inside the house.

Skylights also LOSE HEAT in winter since they are located overhead, and since heat rises, the greatest loss will be there in winter. Winter is when you want to trap the most heat inside the house, not lose it!

SLANTED GLAZING ONLY IN APPROPRIATE AREAS OF THE COUNTRY!

Glazing set at a slant or diagonal should not be used unless you live up north where the winters are colder and summers are cool, and only then if the proper amount of thermal mass is adequate to absorb the heat. Slanted glass (at any angle, but the more horizontally placed, the more heat gain you have in summer, and the more heat loss you have in winter) tends to be very inefficient, but properly designed can help gain winter sun in winter in northern climates, as long as some type of exterior (exterior is superior to interior) insulated shutters are used once the sun goes down.

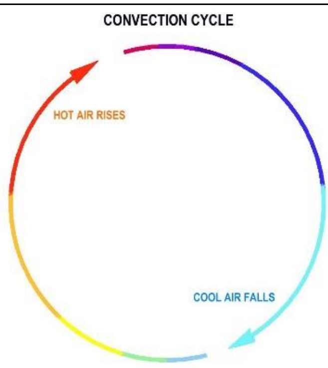
VERTICAL GLASS IS BEST!

Keeping your windows in vertical positions are usually considered the most easy and efficient way of dealing with passive solar design for the comfort and ease of year-around use of the home, which is usually what is intended since most home-owners live in the same house all year long. This makes it easy to figure out your overhang lengths and how much sq. ft. (net) of window area are needed. Also, keep in mind that vertical glass is far less likely to break during hail or other storms as compared to glass installed horizontally or at angles.

DOUBLE-PANED VS. SINGLE PANED WINDOWS

It is highly recommended to use double-pane windows rather than single-pane windows. Although each piece of glass is only about R-.5 (that's point five (.5) rather than 5... VERY LOW and almost nonexistent!) a double-pane window is only about R-1 rather than R-.5 but the extra piece of glass creates a dead-air space, which reduces the convection (causing extra heat loss) and condensation (causing interior drippage) significantly. In fact, double-pane windows can reduce heat loss by 50% compared to single pane. Most spaces between the glass are fairly thin on purpose; large air spaces greater than 1” tend to accelerate the convection cycle.

Avoid windows or between-pane spaces greater than 1”

← Heat loss in winter **Heat gain in summer →**	 1.5+ inch space <- between window panes ->	**Heat loss in winter →** **← Heat gain in summer**

Triple-pane windows do not add much more insulating value than double-paned, although they are preferred in cold climates. Triple-pane windows also cost more and weight a lot more too. Some double or triple pane windows are filled with argon (cheaper) or krypton (more expensive) gas, which helps insulate them—making them improve efficiency by up to 20-30%--but be aware that many times this gas can leak out over time, making an expensive triple-pane window worth hardly more than a double-pane in the end. If the company selling the windows has a guarantee for no leakage, or refilling them, then ensure that the testing for this is included, and realize that you just purchased a more complex and unreliable system. Increased complexity tends to increase cost and work, as well as cause waste, so you may want to consider all of these factors before deciding which windows you buy.

Also, *BE CAREFUL* with Low-E windows as they are designed to keep infrared light out. Infrared is what HEATS the mass in your home! The last thing you'll want to do is hinder that light-heat from entering your house in the winter!

For a properly designed passive solar house **<u>Low-E windows should NOT be used on the east side</u>** (to allow the light/heat inside on those early morning winter days) and ***<u>especially</u>* <u>do NOT use Low-E windows on the southern side</u>**. However, <u>you CAN use Low-E double-paned windows on the north and east sides</u> of the house (this reduces heat loss in winter, and reduces heat gain in summer).

REMEMBER ORIENTATION!!!

Remember how to find "Solar South" above? Orient your home so that the longest side, with the most amount of windows faces solar south. The longest wall, therefore, should run east to west.

SOUTH WINDOWS

"South windows should have 7% (net) of the homes' total square footage. That's not 7% NET of window - frame edge to frame edge.... the GLASS AREA itself should be 7% (do not include the frame)!

Example: 2,000 Sq. Ft. = 140 Sq. Ft. of glass

Multiply the entire window by .8 to get the net glass area.

Example: A 3'X5' window is 15 sq. ft.
15 X .8 = 12 sq. ft. net

Do not exceed this 7% net amount or overheating may occur. This 7% is the amount used for conventional home construction with wall-to-wall carpeting. If you want to increase your glass at this point, then you MUST utilize the thermal mass qualities within your house by placing mass within your house such as tile floors, concrete, brick, rock, slate, adobe, concrete block, stone fireplace & mantle, etc. <u>Remember that interior mass WALLS are 4 times better than interior mass floors (if they *do not* have direct solar gain) for heat storage</u>.

IMPORTANT TIPS!

An additional 1 sq. ft. of south glass may be added for every:

5.5 sq. ft. of sunlit thermal mass floor *

40 sq. ft. of floor not in direct sunshine

8.3 sq. ft. of thermal mass wall

*** The maximum amount of sunlit floor is 1.5 times the south window area**

The recommended maximum amount of south glass for direct gain is 12-15%"

(Source: www.epsea.org)

NORTH WINDOWS

Glass area on the north should be greatly reduced (to 4% of the homes' total square footage) as solar gain is rare to nonexistent on the north side of the house (in North America) but heat loss occurs most there. Utilizing this principle will reduce both the heating and cooling loads.

EAST WINDOWS

Glass on the east is the same as north windows (4%). Reason being is that although most solar gain doesn't occur here; however, it is the FIRST place where gain occurs. Morning hours spent by the east window drinking your coffee or hot tea while you read your paper are a nice way to begin the day, while at the same time the sun is already starting to warm up your house *(thanks to Mike Cormier for that tip!).*

WEST WINDOWS

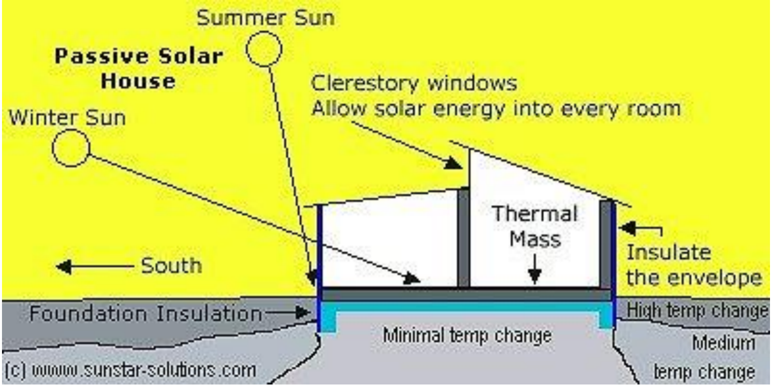
Glass area on the west should never exceed 2% of the homes' total square footage. West windows are terrible for solar gain because they don't allow sun in during the time of day when you need it, and can gain TOO MUCH in the already-hot summertime afternoons when the sun is low in the sky. West solar gain during a hot evening during summer can overheat your house and make your A/C work even harder in order to keep the house cool.

Remember those Low-E windows? Here on the west side of the house is the ONE place they might do some good! Exterior insulated shutters are even better to stop the light/heat before it ever enters your window, but if you want to see some indirect light or peek out the window then exterior louvered shutters work well, or a trellis covered in plants/vines to shade the window.

Evergreen trees planted in alternating rows starting at 25' away from the west wall also works great to shade the west wall on a late summer day, plus they double as a wind break (wind will rob heat from a house during winter VERY quickly!).

Don’t Forget the Overhangs

Roof overhangs on your house are an important part of the equation for a properly designed passive solar home. The idea is to allow the sun in during winter, and keep it out during summer. The overhang length calculation depends upon variables such as window height, wall height to top of window, and latitude.



There are formulas available on the Internet for how to calculate an overhang, but they can be quite lengthy and involved. The EASIEST way I have found to do it is by drawing a simple sketch on graph paper. Figure out if you want one square per inch (or other).

But first…

Figure in your summer and winter solstice sun angles (lowest and highest) from this website – it is absolutely the easiest and quickest way to obtain the sun's angles for your specific area at any given time!

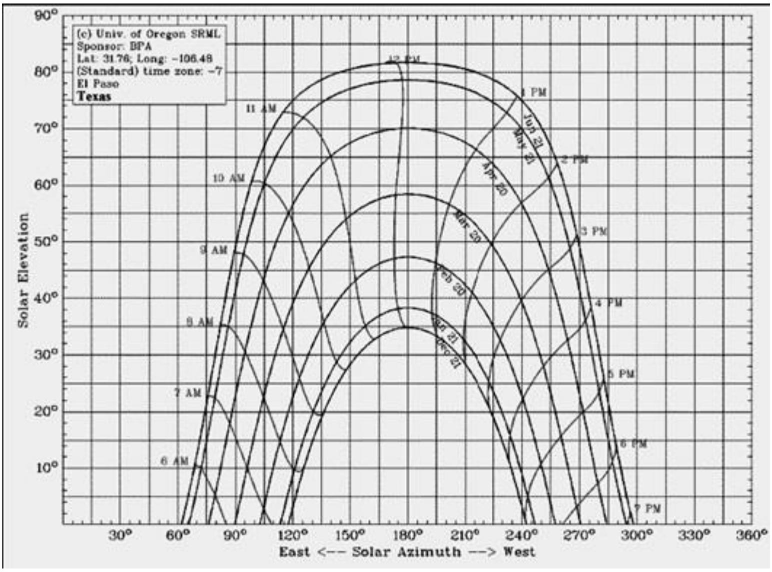
GREAT SITE BY UNIVERSITY OF OREGON FOR TAILOR-MADE SUN ANGLE CHARTS

http://solardata.uoregon.edu/SunChartProgram.html

How long your overhang is determines where your window placement should be. This chart of where the sun rises and sets, based on times of year, will help you when you begin figuring out your own overhang lengths (and don't forget that if you have troubles you can always set it to maximize the winter sun, and just use an adjustable awning that can be pulled out to shade more area in the summer).

Let's take a look at an example…

From the website named above for a sun angle chart, it gave me a .pdf version that I was able to print out. Here is what kind of chart you will wind up with – this particular chart is specifically for the El Paso, Texas area.

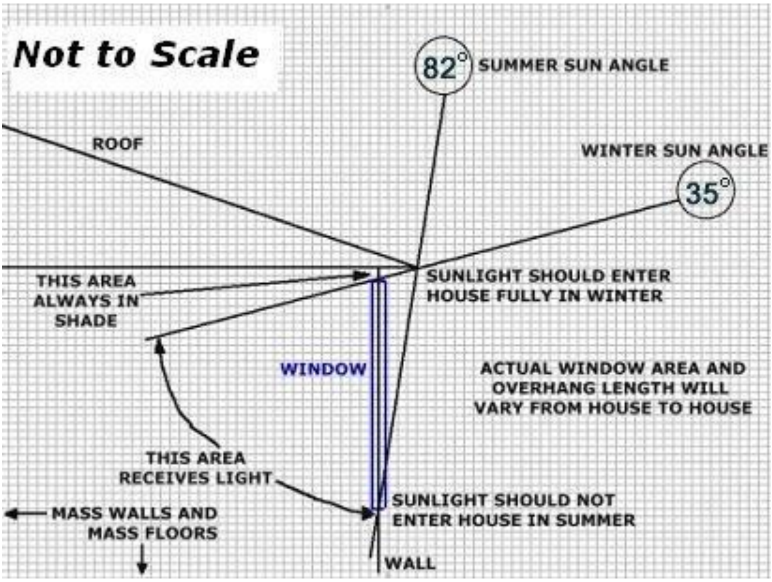


As you can see from the solar azimuth chart above, you'll know the exact placement of the sun in the sky between summer solstice (June 21) and winter solstice (Dec 21).

On the left side of the chart is the elevation of the sun in degrees. With some graph paper in hand, a pencil (with eraser, because believe me you will probably need it!), and a protractor and ruler, you'll be able to draw a southern-facing wall similar to the one below.

Note: Wall could/should be inset further (left) on this picture below. Be sure to draw yours to scale based on what should be real-life measurements.

This example:
Summer solstice sun height approx. 82 degrees.
Winter solstice sun height approx. 35 degrees.



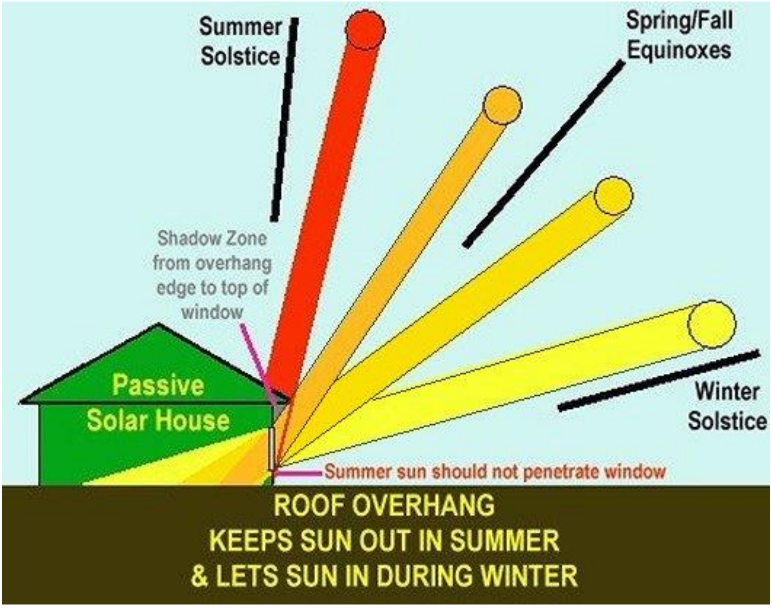
HINT: Make the overhang longer for taller windows

The area above the window, between the top of the window and the soffit on the eave, should always remain in the shade. You do not want shade on your glass during winter.

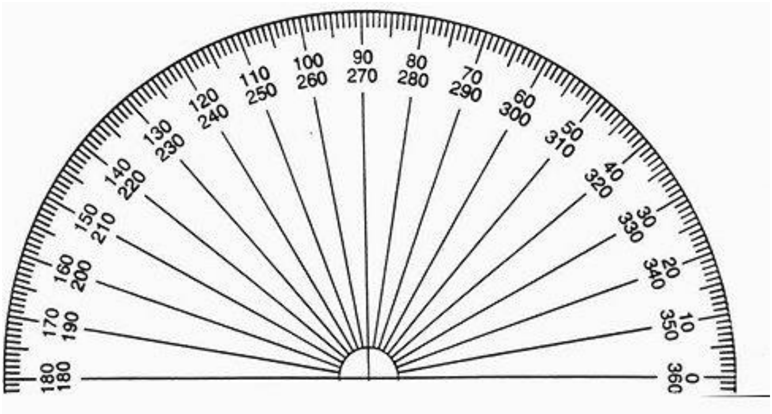
Likewise, ensure that the peak summer sun does not enter the bottom of the window.

Doing these two things will ensure that you have full sun as much as possible during winter, all the way to the shortest day of the year (winter solstice) and no sun in your windows on the longest day of the year (summer solstice).

Draw the window in to fit where the sun should shine between the solstice times, and use the measurements based on that to determine the height of the wall and roof overhang. This method is only one way to figure out your overhang, but it works well for visual people who only have graph paper and a protractor and ruler, whereas the Internet provides plenty of other tools to figure this out as well.



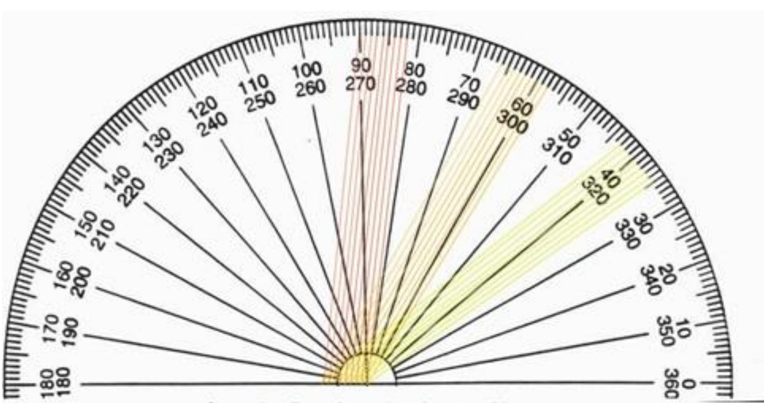
I used a protractor to determine window and overhang placement once I had my solar azimuth chart. I'll take you through some of the steps I took to figure it out. I did mine on the computer, and put thin graph paper in front of the screen so could draw the lines behind it, but this could be done using simple paper and pencil as well. First, start with the protractor.



Source: www.dynapod.com/protractor2.jpg

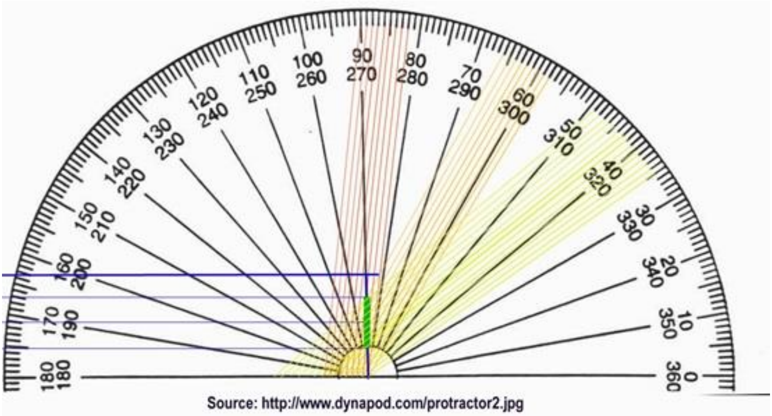
The angles of the sun according to the azimuth chart were: Winter solstice: 35º, Equinoxes: 58º, Summer solstice: 82º

The first line I drew for each went straight from the degree mark to the bottom of the 90º mark, and then I kept ALL lines parallel since the sun shines in parallel rays.



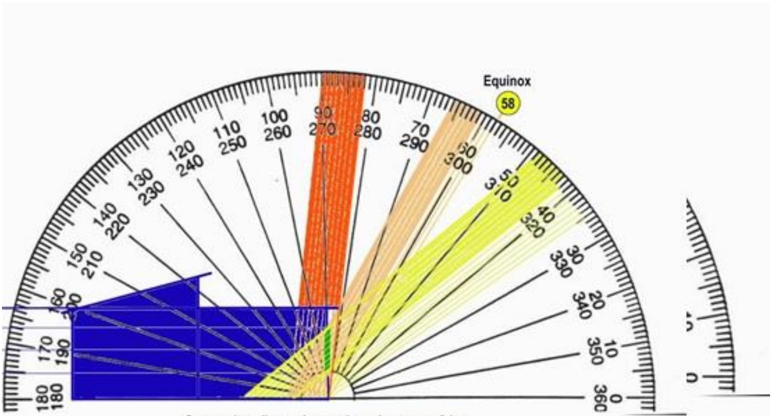
Source: http://www.dynapod.com/protractor2.jpg

Based on the red (summer solstice) line that fell to the bottom of the 90º mark I drew the edge of the overhang to the spot where it intersected the orange (equinox) line, because the idea is to ensure NO summer sunlight enters the windows, but we DO want it to enter as we approach fall/autumn. The "house" lines I drew in blue, dividing them into arbitrary 2' sections, for an 8' tall wall. The window is green. I planned to measure everything after I finished, to get the final heights and placement of the windows.



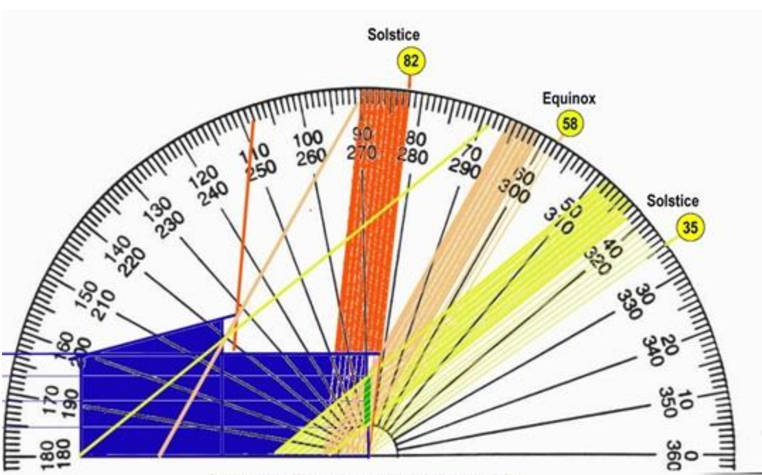
Note: The way I drew this was simply convenient at the time. You may find that another way is better.

Next I filled in the colors and added a shed-style roof on the back half of the house, with clerestory windows at the top so sunlight could enter that portion of the house. Again, the height was arbitrary, and if I had wanted I could have made the pitch of the roof higher, or lower, depending on preference.



Source: http://www.dynapod.com/protractor2.jpg

As you can see below, the overhang shuts out ALL of the summer (red) sun's rays, while letting in the peach (fall) and gold (winter) rays. I used the graph paper to align the same angled rays for the clerestory window.

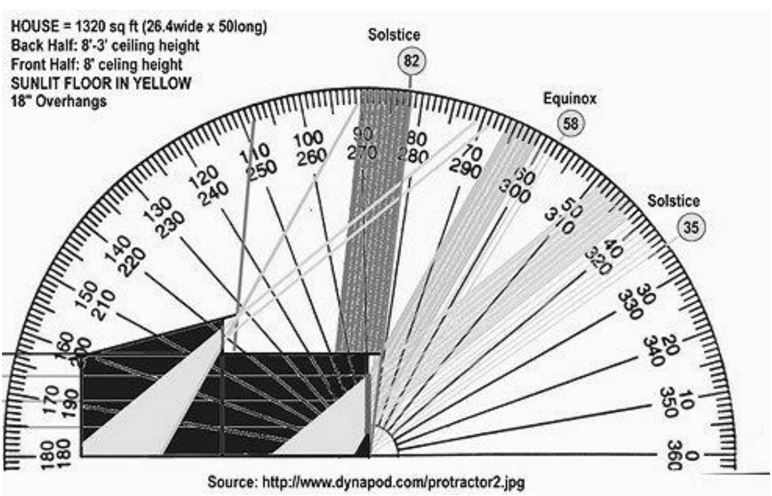


Source: http://www.dynapod.com/protractor2.jpg

Below is my final product (minus fixing the FLAT roof to have a small pitch of ½”-1’ (a half inch drop for each foot of length) minimum so rain wouldn’t puddle and cause leaks), showing exactly how much sunlight will enter the house over the period of 6 months (solstice to solstice) and back again.

You can take the square feet of sunlit area (perhaps 1’ wide strips) and work backwards to obtain the 7% NET amount of sunlight needed, or you can determine how much window area you need based on the square footage of your house, and figure out how many windows, and of what size, you will need to obtain the 7% NET.

Remember that if you want to add more windows you must also add more thermal mass or you risk overheating.



Don’t be surprised if you have to do this several times as you get better and better and seeing the “little things" that need to be changed, or that you want to add on, or take away.

Recommendations from Chuck Reel

Chuck Reel is a friend of mine and a solar energy professional whom I've known since 1989. He taught me many of the principles that I am re-teaching here in this book. He suggested some things regarding overhangs, plus his website is below. He designed and built a passive solar straw bale house that had adobe walls inside for the Alamosa, CO area that uses almost entirely passive solar energy to heat it during winter. Supplemented only by a small woodstove, the home stays warm in -40º F weather in winter.

Solar Energy and Straw Bale House Construction Expert in Alamosa, CO. Connect on Facebook: https://www.facebook.com/reelguy

Regarding Magnetic Declination and Overhangs:

"Most people think of the magnetic declination while they face north and back to true north. Solar declination to me would be while facing south going back east from magnetic south about 12.5 degrees (in the southwest) to TRUE south where all solar homes or devices should face.

"Overhangs are a challenging subject but I keep track of the latest things we have learned over the years to see what we have learned from the mistakes of the past. New Mexico seems to keep track of the latest science and the NM Solar Energy Association's website (www.nmsea.org) says that in northern NM, angles of 36 degrees to the top of the window and 73 degrees from the bottom of the window gives a shadow a full 6 weeks around the summer solstice and a full 6 weeks of sun around the winter solstice. The angles would be 30 and 77 degrees if you just wanted the full effect only on the solstices. The 6-week idea produces an overhang that is higher and longer than the other overhang design.

“Many people say that 60% of your energy can be supplied by the sun. NMSEA says 80% and I think it can be even much higher if someone was to spend the money to do it right and be willing to go a little overboard.”

A Word About Floor Plans

Sometimes you can take a pre-chosen floor plan and just flip-flop it, or turn it 90 or 180 degrees or so and find that it works fairly well for solar orientation. Sometimes you can make adjustments too. There are also a ton of passive solar floor plans online, and some are even free! Everything from contemporary to modern to round houses and even tiny house plans are available. If you are starting from scratch and want to draw up your own floor plan, however, just remember that the warmest side of the house is the south side (thanks to the sun); the coldest is the north (thanks to the shade from the house itself).

The warmest corner of the house is the SW corner, and the coolest corner is in the NE (kitchens generate their own heat due to appliances so placing kitchens here is best).

Closets and bathrooms, laundry rooms, and storage areas are excellent for the north half of the house. This is because they are “buffer areas” and do not always need to be heated, so placing them on a north or west exterior wall can be a good idea. Even bedrooms go well against north walls because people tend to sleep better in cooler rooms.

Communal living spaces, such as the living room, dining room, or family room are better for the south side. Some people also like to put their master bedroom here.

Adding in some clerestory windows to the north half of the house will also bring additional sunlight as well as natural daylighting to these areas (a real selling point!).

It's very simple really. Now when you fish through a book full of sample floor plans, or create your own floor plan, you'll be able to quickly spot which ones will work best for you, or which ones will be disastrous when it comes to your heating/cooling bills!

What Does it Cost?

$1-$3 per square foot will save you hundreds of dollars per year for the lifetime of your house!!! The total cost for all of the window orientation, overhang considerations, energy efficient additions, etc. are usually less than $3,000.... that's a mere $2-$3/sq. ft. for the average 1,000-1,500 sq. ft. house and goes down considerably with homes with more floor area. Remember that it is not the money invested (which you now see is but a fraction of the cost of the house but makes a HUGE difference overall for the LIFETIME of the home) that makes such a difference, but the DESIGN of the home. Just altering window area and placement, and some of the flooring and colors can turn what would have been a disaster into an efficient passive solar home! Passive solar design is merely a <u>trade-off</u> from things like carpet to tile (at least in sunlit areas), more area of windows in one area than another, etc. Remember to add in these energy efficient aspects (INCLUDED in the $1-$3/sq. ft. cost estimate) to ensure that you do not have unnecessary heat loss in your home. This will make your passive solar designed house runs efficiently!

One last note… if you are buying a house or land to build on, remember to check for **Solar Access:** Buildings or trees too close to your home could block the low winter sun. Know your sun angles before you go shopping!

Some pointers on vegetation around your home:

Grow **deciduous trees** (trees that lose their leaves in the fall/winter) on the south side of your home, but not too closely to the house. This provides cool shade during summer, and will allow the sunlight through to enter your southern windows in winter. Deciduous trees also do well on the east side of the house.

Grow **evergreen trees** (usually in three alternating rows) no less than 25’ from the west and north sides of your home.   This will shade that horribly hot west sun from overheating your house during summer, and will cut down the winds that will rob your house of its heat during winter. If your particular area has winds from a certain direction, then you’ll want to plant evergreens on that side of the house too, to form a wind break, but not too close or you might ruin your direct solar gain!

Now you are equipped with the basics of solar energy and passive solar home design you can get to it and enjoy your passive solar home!

The sun does not shine for a few trees and flowers, but for the wide world's joy.

~ Henry Ward Beecher

This book is the official companion book that goes with my **DIY: How To Build Your Own Energy Efficient Green Home** (available at my website or Amazon)

The much expanded step-by-step 2nd version of this book (available in hard copy) is titled:

DIY: How To Build Your Own Passive Solar House - The Frugal Living, Buy & Barter Method for Straw Bale Solar Home Design

It is available for on www.amazon.com or my website www.sunstar-solutions.com

This shorter free version (v1), including many other titles on different solar and other subjects, can also be downloaded at my website at no cost.

This is a free book by Sharon Buydens

PLEASE PASS IT ON

FREE TO OTHERS!