THE SUN AND YOUR NEW HOUSE

Are you planning a new house any time in the near future? Did you know that some detailed attention to the construction of your house and especially attention to its relationship to the sun can save you 30% or more of your total yearly heating and cooling costs? The techniques are not new, but they are poorly understood by most today, even amongst professional builders and architects.

Much experimentation has been done with solar designs including earth sheltering, storage masses, Trombe walls, water walls, roof ponds, and active systems requiring pumps and other devices. These systems are expensive to build. The active systems will require maintenance and will wear out in time. The energy saving methods I will discuss are accomplished by the design and orientation of the house and construction techniques that reduce losses. These things will add very little to the cost of your house and the benefits will be yours for as long as you own the house. There will be no maintenance or replacement costs. These techniques are sometimes called Passive Solar Techniques. The type of structure I will address uses a Direct Gain system. Direct gain implies that the structure receives some gain simply by the sun shining on it. No active components are required.

First let us consider the lot. Before you can take advantage of the sun, you must first get some sunlight onto the structure. Beware of lots that are crowded to the South, or have tall trees or buildings on the adjacent property to the South. The Ideal lot is one that is on the North side of an East West street and slopes gently toward the South. If you are fortunate enough to find such a lot, great, but if not, don't despair, as you can still realize the benefits with proper building design. The Southern exposure is especially nice in snow country as it will allow the sun to hit the steps and driveway to reduce ice problems.

Next lets talk about placement of the house and trees on the lot. It is good if you can have a wide yard on the South. This will circumvent the possibility of an adjacent landowner planting tall trees to block your sunlight. On your own lot beware of tall trees any closer than 70 feet from the house if possible. If you graph an inclined line at the lowest sun angle at noon for your latitude then you can see what size tree you may plant at any specified distance from the house without blocking the winter sun. Tall trees on the East or West sides will give you some relief from the summer sun. North side landscaping is of no consequence as far as the sun is concerned, but some trees and shrubs on the North can offer a windbreak against the Winter winds.

The path of the sun is predictable and with the help of sun charts you can tell where the sun will be at any given day or time for your latitude. In brief, the sun in summer rises slightly North of East and travels high overhead hardly hitting the South side of a structure, but bears on the East and West sides morning and evening. In winter the sun comes up in the South East and travels a low arc to go down in the South West. The southern exposure receives much sunlight in winter, and the East and West sides receive some sunlight. The amount of direct sunlight that strikes the North side of a structure that is aligned in an East West direction can be ignored for our purposes. I prefer to align a house with the long side in a true East West direction, but a deviation of 10 degrees will probably not affect the performance much. A deviation of much more than this will give you excessive heat gains in the summer. Note: These discussions assume that the proposed building is located in a Northern latitude of from approximately 35 to 50 degrees.

The most important aspects to consider are the building design, orientation, and size and placement of windows. It has been shown that a rectangular house orientated lengthwise in an East west direction can best take advantage of the sun. Sheep herders have long understood this principle. Observe that they will park their camp with the long side in an East West direction and the doorway on the East.

It can easily be seen that the South Side of a house receives the most sunlight in Winter so the more wall area you have on the South, the more solar gain you will receive. In Summer the East and West sides receive more direct sunlight than the South side so it is advantageous to have the shorter wall areas on the East and West, to reduce the solar gain.

Locate the garage on the West side if possible to block that summer afternoon sun which makes poorly designed houses unbearably hot in summer. Structures that take an L shape or various other corners and bends have more exterior wall space in proportion to the area of the building. What that means is that these cut up types will have greater heat losses than a rectangular building of the same area. Dormers, vaulted ceilings and other do-hickies common to today's modern contemporary architecture all reduce the efficiency of the house. Also bear in mind that every corner you turn drives up the cost of the structure to build. Vaulted ceilings are often not insulated or vented properly to achieve efficiency. A poorly vented roof area may have moisture condense inside which will eventually rot out the sheathing and joist. I prefer an attic above all heated spaces. The attic allows for plenty of insulation, good ventilation, and is a buffer zone against the extremes of outdoor temperature. A well-ventilated attic and plenty of insulation over all heated areas will also prevent the buildup of icicles on the roof edges. If you really want to take full advantage of passive solar principles, keep it simple.

When the sun shines on a window, some of the energy is reflected and some of the energy is transmitted through the glass to warm the contents of the room. From this we can easily deduce that it will be advantageous to have the sun strike our windows in Winter, but not in Summer.

Placement and sizing of the windows are key in achieving a solar gain in winter and limiting the heating effects of the summer sun. The recommendations are: Large South facing windows. Small or medium sized East and West windows. No North windows. Speaking strictly from the standpoint of energy savings that is how one should arrange the windows, however the aesthetics should be considered also. To some this seems to be more important than the energy savings. For instance if you had a terrific view to the East you would certainly want a fair sized window there to let you enjoy it. Reflecting shades could be used in summer to avoid a too rapid buildup of heat on summer mornings. Myself, I hate rooms with no windows, so I put small windows in the rooms on the North side. This is a small trade off and will not cause the system to fail. Remember the recommendations and use a little common sense.

South facing windows will show a substantial net heat gain in winter when you need it and a small heat gain in summer. East and West windows break even in Winter, so from the standpoint of winter heating they may be ignored, however in summer they will show a substantial heat gain, when you don't need it. North facing windows will be a heat loss all winter and show a little gain in summer.

At this point it seems appropriate to say a few words about windows. Glass manufacturers have made a big deal about their products and thermal breaks in the frames etc. to influence buyers to buy their products. Lets face the facts. Glass areas are the poorest insulated part of your house and contribute to major heat losses no matter how they are built. With the exception of South facing windows, which can give a net heat gain in Winter, glass areas are a detriment to your pocketbook. Note: In all references to glass, or windows, in this document, I mean double glazed and sealed thermal panels. If you are going all out for the solar gain, be sure to use clear glass in the South facing windows. For the other exposures follow your tastes.

What about frame materials, and thermal breaks? If you were to measure the frames and add up the square inches of frame actually exposed to the outside and compare it to the area of the rest of the house exposed to the outside, you will quickly see that the frames themselves are a very small part of the total area. So small in fact as to be almost insignificant to the overall performance of the house. The important thing to look for is good weatherstripping to keep out drafts. As far as frame materials and construction are concerned, let cost, appearance, personal preference and maintenance requirements be your guide.

In a direct gain system care should be taken in choosing the size of the South facing windows in any given room. Too much glass and the room will become too hot on sunny days. Too little glass and you won't receive the solar gain that reduces your heating bill. As a rule of thumb, find the volume of your room (length X width X height) and divide by 60 to get the area (width X height) in square feet of the South facing glass for that room. The rooms on the South side of the house are the ones that benefit most from solar gains so it is to your advantage to have the floor plan laid out with the larger rooms on the South and small rooms, closets and utility rooms, on the North.

It is poor thinking to suppose that you can place enough glass area to heat the whole house without the use of a storage mass, as the rooms would get unbearably hot when the sun shines. Our goal is to achieve a substantial boost from the sun without resorting to the high cost of the storage mass, and without getting an unacceptably high temperature fluctuation. The ratio given will provide a temperature gain of approximately 15 degrees on a sunny day in winter. Of course, depending on how open your layout is, some of this gain will move into all of the rooms of the house, and your furnace will shut off while the sun shines and for several hours after sundown. Basements can also benefit from solar gain if you design your window wells to let the sun shine on the South facing windows in winter.

Shading devices are a necessary part of the system. A shading device may be as simple as the roof overhang or may be a specially designed and built structure over the South facing windows. In either case it is necessary to get out the sun charts and calculate the angle of the shade for various days in the year. The objective here is to place the device so that you will get full shading on a certain day (of your choosing) in the Spring and from that time until late Summer there will be no sun striking the South facing glass to give you unwanted heat gains during the hot weather. The longest day of the year occurs on June 21 and you will have the same angle of incidence on a given number of days before and after that date. In other words if you calculate your shading device to give full shading on May 10 then you will have full shading until August 2. The dates given above are for full shading six weeks prior and after June 21 and are given as an example only. Depending on your local climate, you may want to choose a longer or shorter period.

There is one problem in this and that is because the temperature lags the sun by about 30 days. One could probably use a bit more sun in the Spring, but don't need it, as a rule, in mid August. Here again it is a trade off and you will have to decide for yourself which is the most important to you. While you have your sun charts out also look at the angle of incidence at noon on December 21, the shortest day of the year, to see if you will get full sun on your glass area. If not, then that part of the glass that remains shaded all year will be of no use in the calculations for window sizing given above.

Note: Use the angle of the sun at noon on the prescribed day for your calculations. An easy way to do this is by drawing a vertical cross section detail, to scale, through a window, and then draw in the sun angle from the charts. You can then measure the distances on the detailed drawing and arrive close enough for all practical purposes. This saves us from going into the geometric calculations that would be necessary otherwise. Note: Remember it is the very bottom edge of the shading structure that casts the shadow line. Don't make the mistake of thinking that it is the top edge or you will not get the results you had planned.

If you will take a careful look at the recommendations given, it will be obvious that none of these things will add any significant cost to the project. It is simply a matter of getting a good design to take advantage of a few facts of nature and physics. The resultant lower costs of yearly operation and increased comfort levels are the rewards.

Infiltration Losses

Infiltration occurs in all houses and in its worst manifestations is called drafts. Air is constantly entering and leaving your house. It comes in through minute cracks around the doors and windows, sneaks into the walls and comes out at the electrical outlets and light fixtures, comes in through the dryer vent or other equipment vents, leaks down the walls from the attic, and rushes in every time a door or window is opened. A certain amount of air actually comes through the building materials themselves. If the exchange is too rapid, the house feels drafty. We also get substantial heat losses because it is warm air that is leaking out.

If the house is super-insulated, the exchange rate may be reduced to a point that is too low and the air in the house will seem stuffy and air contaminants will not be dispersed and eliminated very soon. To get a house that tight takes a very special design and is not usually possible with conventional building techniques. My comments on the subject refer to houses of conventional design that most of us will end up living in. Unfortunately most of today's builders are under the gun to get the job finished and pay little attention to a few details that can substantially reduce infiltration. They will do whatever is necessary to satisfy the building inspector and owner and let it go at that. There is room for improvement in most of the houses being built today. Unfortunately some of the things that are required need to be done as the house is being built and cannot be retrofitted. If you are having a house custom built, you should be able to work with your builder and get these things done, but if you buy one already finished it is too late.

What can be done to minimize these drafts? The one major source of infiltration is an open doorway. If you have children running in and out constantly this can become a real problem. Consider air lock doors. Air lock doors are simply two doors separated by a space of a few feet so that you may enter an area and allow the first door to close before opening the second door. Most houses will be equipped with a storm door anyway, all that remains to be done is to provide a vestibule so that the doors may be spaced appropriately. Your architect can easily incorporate this feature into the design.

Since your door is poorly insulated compared to your walls, the vestibule will offer a buffer zone to the door so that it will not be so cold. You get two benefits from this simple design feature. A third (but unrelated to the infiltration problem) plus for a vestibule is that it provides a place for stomping off the feet or removing footwear and wet coats before tracking into the house. Mom will love this.

Equipment vents for dryers, kitchen and bath fans, and etc., should be equipped with dampers that close when the equipment is off and checked periodically to insure proper operation. Dryer vents especially can be rendered nonfunctional by accumulations of lint. The less obvious little pathways for air to leak in can be plugged with caulking or insulation if it is done as the construction proceeds.

As the wood framing is being placed on the foundation, the sill plate should be sealed against the foundation to prevent air from leaking in. This can be done by setting the plate on a bead of caulking.

Sometimes there is too much variation in the grade of the concrete to do this effectively. Some builders use a foam rope or fiberglass batting cut to the width of the sill plate. These materials will squash out and effectively seal up the crack. Any really bad voids can be filled with a concrete sand mix.

After the floor is on and before any sheathing is applied over the rim joist, take your caulking gun and caulk all joints in the rim joist and the joint between the rim joist and sill plate. Also, fill up any knot holes in the rim joist with something. Not only does this slow down infiltration, but it will prevent bugs and spiders from gaining access to your house through these little cracks.

As the exterior walls are being framed there are areas where the carpenter will place two studs for backing where there are other walls intersecting the exterior walls at 90 degrees. These voids between the backing studs need to be insulated as the walls are being constructed because they are rendered inaccessible after the intersecting wall is put in place.

When the framing is complete and the electrical wiring and plumbing are in place, but before any insulation is installed, do the following things: On all exterior walls wherever there is an electrical box for outside lights or plugs, caulk around the box on the inside (inside of the wall not the box) and also fill all of the little holes in the box with caulking compound. The idea here is to prevent air from entering the wall through or around the box where it can follow the path of the wire feeding the box and then enter the house through a light switch or plug on the inside wall. Again, it keeps out the bugs too. If there are any other breaches in the sheathing, Plug them also.

On every wall in the house, both interior and exterior, caulk around any wire or pipe leaving the wall, whether it is going up, down or out the end of the wall. It won't be necessary to caulk the wire or pipe at every stud in the wall. The idea here is to slow down the air entering or leaving the wall, and prevent the air from following the path of the wire or pipe around until it can come out into the room via an electrical box, or follow a pipe out. The outlet covers, light fixtures, and escutcheons the plumber places around pipes do not fit tight enough to stop drafts.

Wherever there is a dropped ceiling, such as in a shower or kitchen cabinet drop, place sheet rock in the drop area at the real ceiling level to prevent air from entering the drop from the attic and thence down the walls or through the void between floor joists in two level houses. I have seen water pipes, in interior walls, freeze because these pathways have not been blocked. Incidentally, if you ever have a fire in your home, the fire can and will follow these same pathways that we are trying to eliminate. Having those closed up will slow the travel of fire from area to area. You can ask any fireman about trying to fight a fire they cannot see because it is burning within the walls and between floor joists, and in other voids that are not part of a room.

The bathtub. Almost always, under the tub there will be a big hole that the plumber cut to allow installation of the drain. Take some fiberglass batting and plug this hole. While you are at it, if you want your bath water to stay hot longer, you can insulate the whole bathtub at this time.

These are the most obvious problems that you can alleviate at this time but since every house is different, and now that you have the idea of what to look for, do a little sleuthing and see what else you may find that needs plugging up. It is well worth the effort and takes only a small amount of material. Those are the things that need to be done before the insulation and wall board are installed.

Insulation is a very important part of an energy efficient house. There are many types of insulation available on the market today. Most localities have building codes that will tell you how much is required in your area. Don't skimp. More is better. In the attic I prefer to have the insulation blown in as that gives you a continuous blanket over everything and helps to reduce infiltration losses. Batts stop and start all over the place and do not give the continuity that a blown in application does.

Install adequate attic vents. Venting the attic prevents moisture condensation from rotting out the wooden members, lets hot air out in the summer, and combined with plenty of insulation will prevent icicles in winter. Building codes often specify how much venting is needed. Don't skimp.

There seems to be some differences of opinion on using vapor barriers on the exterior walls. Some builders have gone to a house wrap on the exterior of the walls instead of the vapor barrier on the inside of the exterior walls. For many years the rule was to always place a vapor barrier toward the heated side of the insulation, that is, on the inside of the exterior walls. I am going to stick to that recommendation until I see the results of a well done study that indicate the house wrap to be better. I like to put the insulation in the walls then cover the whole wall with 6 mil plastic sheathing. This makes a very tight vapor barrier and reduces infiltration.

In Utah's high and dry climate it is a definite plus to hold the moisture in winter. Otherwise the humidity may drop to a level that irritates the nasal passages, dries the skin, and causes hands to chap and cuticles and lips to crack. Drafty houses can often have a relative humidity of 25 to 30 percent which is too low for comfort. You will also feel warmer at a specified temperature if the humidity is 50% instead of 30%. In cold country, if you can reduce the infiltration of air into the house the relative humidity will remain at a higher level indoors. The reason for this is that the cold air that comes in has very little water vapor in it.

A few other things that can be done later: When the windows are installed, poke some insulation between the jamb and stud. The same goes for the door jambs. Insulate the rim joist and the concrete walls of the basement. Caulk the joint where all door and window frames meet the siding on the outside. Choose doors and windows with good weather stripping Install dampers on all equipment vents. Except furnace or other gas appliance vents where dampers are not allowed.

Adherence to these inexpensive design and construction techniques can substantially increase the comfort level and reduce the energy needs of your new house. There are many other systems and techniques that have been tried over the years, but they usually add a significant cost to the structure. The details of their operation are beyond the scope of this brief manuscript. The other systems all start out with the techniques that I have mentioned here, and add other structures and systems to further enhance the solar or earth benefits. I hope this has been adequate to urge you to think heavily about taking advantage of the sun, and perhaps to do some research to increase your knowledge on the subject.

Good luck in your venture.

James A. Lofthouse