NORTH CAROLINA
SOLAR CENTER

SOLAR CENTER INFORMATION

NCSU • Box 7401 • Raleigh, NC 27695 • (919) 515-3480 • Toll Free 1-800-33-NC SUN

Passive Solar Home Design Checklist

Good passive solar homes are not difficult to design or expensive to build. However, they do require the use of basic, common-sense methods of working with the climate rather than against it. When you build a solar home that responds well to the climate in which it is built, you can count on it being:

1 **Comfortable** – warm in the winter and cool in the summer;
2 **Economical** – homeowners receive a positive cash flow or excellent return on their investment;
3 **Durable** – often built from locally available, long-lasting, low-maintenance materials;
4 **Attractive** – full of light and well connected to the outdoors; and
5 **Environmentally Responsible** – passive solar homes make efficient use of our energy resources and provide a healthy space for owners.

Passive solar concepts are not difficult to apply, but require consideration from the preliminary stages of design to be most effective. This checklist is presented as a planning tool, with references to other, more complete sources. The *Passive Solar Options for North Carolina Homes* fact sheet is another, more comprehensive fact sheet that works well in tandem with this checklist.

✓ ***The longest wall of the home should face within 15 degrees, plus or minus, of true south to receive the most winter solar heat gain and reduce summer cooling costs (Figures 1 and 4).*** At 30 degrees east or west of south, winter heat gain is reduced by 15 percent from the optimum. Minimizing east and west facing walls and windows reduces excessive summer heat gain. See fact sheet *Siting of Active Solar Collectors and Photovoltaic Modules* for more information on determining true south.

✓ ***Size south-facing windows and thermal mass appropriately.***

◆ *Suntempered* homes with no internal solar thermal mass should have south facing windows with a glass area of no more than 7 percent of the floor area .

◆ *Direct gain systems* can have south-facing window glass area which is 7-12 percent of the floor area. Every 1 square foot of south-facing glass over the 7 percent suntempering allowance must be accompanied by 5-6 square feet of 4-inch-thick masonry.

◆ *Sunspaces* should include only vertical glass. Sloped glazing can cause serious overheating. Every 1 square foot of south-facing glass must be accompanied by 3 square feet of 4-inch-thick masonry.

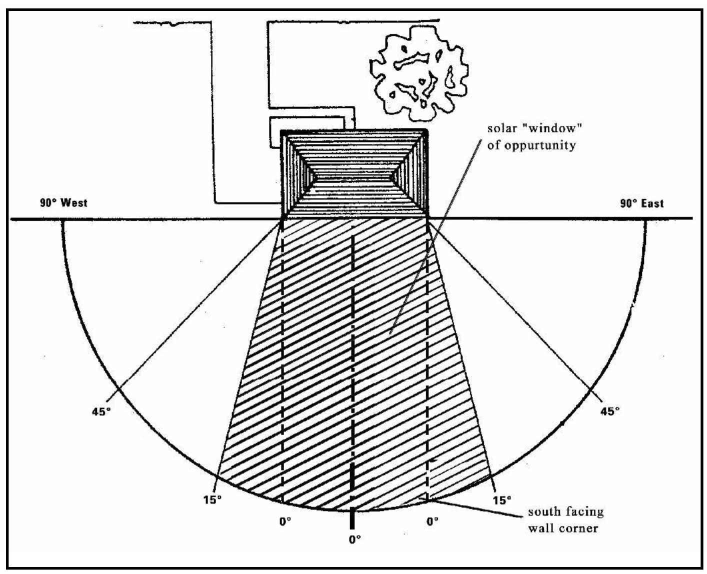

Figure 1. A house can be angled as much as 15 degrees east or west of true south and still collect useful solar heat.

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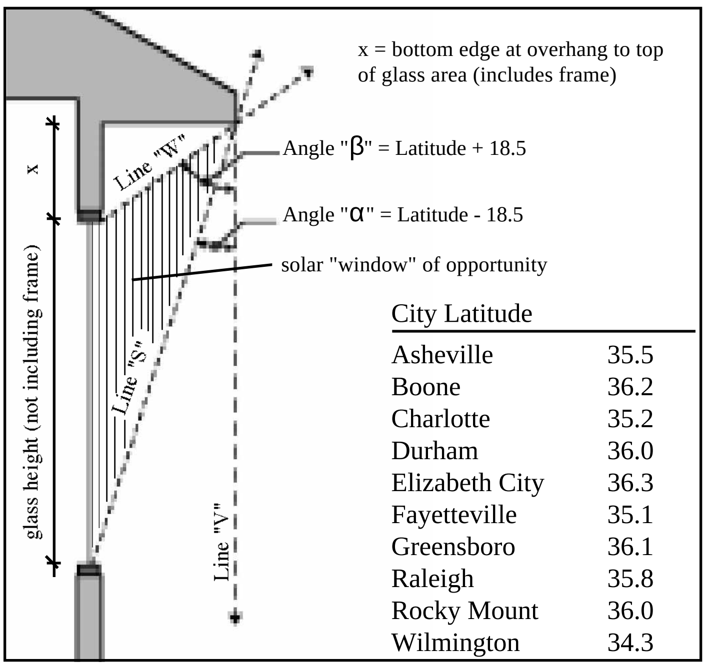
- *Thermal storage or Trombe walls* should be 8 to 12-inch-thick masonry. The outside of the masonry should be coated with a selective surface and the inside surface should be free of coverings. The outside of theglass should be covered or shaded in summer. In NC, these walls require the least operator involvement in our colder climates.

✓ ***Size overhangs properly.***
As a rule of thumb in North Carolina to prevent summer gains, the angle "α" between a line "S" from edge of the overhang to the bottom of the window and a vertical line "V" should be approximately equal to the latitude minus 18.5 degrees. To prevent winter shading, the angle "β" between a line "W" from the edge of the overhang to the top of the window and a vertical line should be approximately equal to the latitude plus 18.5 degrees. An overhang designed with this formula will provide shade all summer and full sun in the coldest part of the winter (Figures 2 and 4). For more detailed calculations, use computer simulation software or procure services of a professional solar designer.



City	Latitude
Asheville	35.5
Boone	36.2
Charlotte	35.2
Durham	36.0
Elizabeth City	36.3
Fayetteville	35.1
Greensboro	36.1
Raleigh	35.8
Rocky Mount	36.0
Wilmington	34.3

Figure 2. Diagram for sizing overhang

✓ ***Match the solar heating system to the room use.***
What are the heating, lighting and privacy needs after sunset? A Trombe wall might be a logical choice for a room requiring privacy. A living room, on the other hand, which needs daytime and early evening heat and has a higher lighting requirement, might benefit from a direct gain system or sunspace.

✓ ***Buffer the north side of the building.***
Place rooms with low heating, lighting, and use requirements, such as utility rooms, storage rooms and garages, on the north side of the building to reduce the effect of winter heat loads. This can reduce the normally higher heat loss through northern walls while not interfering with solar access. Rooms that generate their own internal heat, such as the kitchen, should also be placed on the north side (Figure 3). Landscaping elements, such as evergreen trees on the north and west sides of the house, can buffer against the cold winter winds and strong afternoon summer sun.

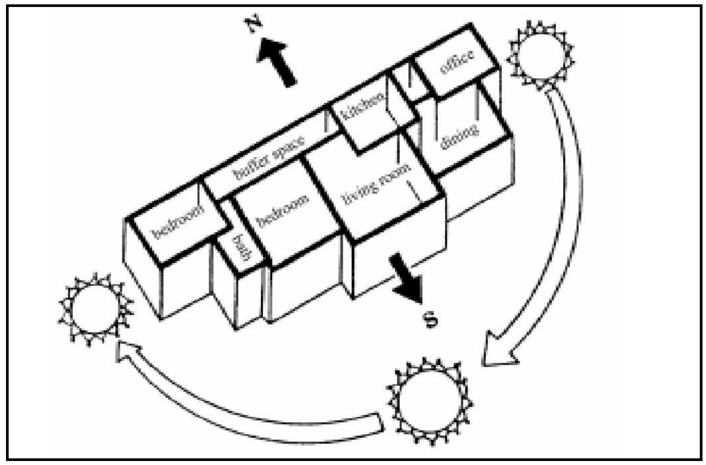


Figure 3. Place rooms where they are compatible with the sun's path. Buffer spaces should be placed to the north.

✓ ***Lightweight materials should be lighter in color.***
Lighter colors absorb less energy (sunlight) and are more reflective. When light energy is absorbed, it is transferred into heat energy. If the material does not have sufficient storage mass, the material may heat up too quickly and release the excess heat to the room air, causing overheating.

✓ ***Masonry walls can be any color in direct gain system,*** but... actually, it is best to use colors in the middle range of the absorptivity scale to diffuse the solar energy over all the storage mass in the room. (The absorptivity range of concrete masonry falls in this range without paints or special treatment being necessary). Colors for dense materials such as brick and concrete, need to be somewhat darker than lighter weight materials; however, if the storage mass is too dark, surfaces exposed to the direct rays of the sun will soon reach high temperatures. This can lead to overheating of the air, while other surfaces in the room may receive very little of the day's solar energy.

Trombe walls should always be very dark to increase solar absorption.

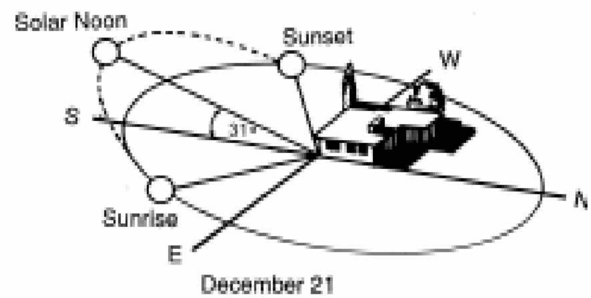
✓ ***Do not cover the storage mass with furniture.*** Rugs and wall tapestries can also reduce the effect of storage mass. It is wise to plan in advance to match the system to room use. See fact sheet *Decorating Your Passive Solar Home* for additional information.

✓ ***Distribute the mass throughout the room.*** In direct gain systems, performance is fairly insensitive to the locations of mass in the room. It is relatively the same whether the mass is located on the floor or on the east, west, or north walls. It is important to put some mass in direct sun, but rarely is it possible to expose all the required thermal mass because of furniture and floor coverings. Comfort is improved if the mass is distributed evenly in the room because the increased surface area reduces localized hot or cold spots. Light colored, lightweight materials “bounce” the sun to more massive materials as long as they are in a room with lots of sun. Also, vertical mass surfaces not in direct sunlight can reduce temperature swings by absorbing excess heat in the air.

✓ ***Consider night window insulation.*** Generally R–9 night insulation over double pane windows provides an approximate 20 to 30 percent increase in annual solar performance over systems using double pane windows without night insulation.

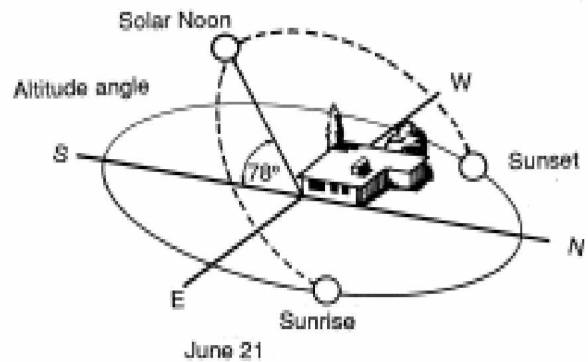
✓ ***Integrate wentilation for cooling.*** In most parts of North Carolina, just as much energy, if not more, may be used for cooling in summer. Thus, a properly designed home in North Carolina, whether it is solar or not, should require a minimum amount of energy for cooling in the summer. Ventilation, or the movement of air, is one of the most powerful means of achieving a cool home. Ventilation has two goals: to remove heat from the house and to provide air movement within the house to cool its occupants. See the fact sheet ***Passive Cooling for your North Carolina Home***, for more detailed information on ventilation and also interior and exterior shading.

Winter Sun



For 36 degrees Northern latitude, the angle of winter sun is 31 degrees from horizon at solar noon.

Summer Sun



For 36 degrees Northern latitude, the angle of summer sun is 78 degrees from horizon at solar noon.

Figure 4. Seasonal path of the sun in horizon in Raleigh, NC.

Once these preliminary design issues are addressed, it is time to consider the finer details. The NC Solar Center has several fact sheets that deal with these issues in a more detailed manner. These are available by mail, via the internet, or by visiting the NCSU Solar House in Raleigh. The Center also offers a free plan review service for people designing or retrofitting a solar home. For more information, or to set up an appointment to talk about your plans, call us at (919) 515-3480 or toll-free in North Carolina at 1-800-33 NC SUN

Other Sources of Information

Computer Simulation Software

The Sustainable Buildings Industry Council offers workshops around the country for builders and architects on guidelines for passive solar building and remodeling and the easy-to-use computer software program, ***BuilderGuide***. SBIC developed the *"Passive Solar Design Strategies: Guidelines for Home Builders"* workshops and the *BuilderGuide* software with the National Renewable Energy Laboratory and the US Department of Energy. Climate-specific guidelines are available for more than 2,000 cities and towns around the United States. SBIC also provides the building industry with practical, useful information on passive solar and sustainable technologies for commercial buildings. They distribute a Windows version of BuilderGuide and an advanced energy simulation program for commercial buildings called Energy-10.

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Email: sbic@sbicouncil.org
Web: //www.sbic.org

For additional resources, see the fact sheet *Recommended Reading List for Solar and Renewable Energy Technologies.*

This publication is available for download and printing from the list of information factsheets on the NC Solar Center's web-site at www.ncsc.ncsu.edu. To reduce paper waste, this publication was not mass reproduced in hardcopy. Printed copies can be mailed to those who do not have access to the Internet.

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Passive Cooling for Your North Carolina Home

As energy costs rise, and the public becomes more aware of the environmental damage arising from current energy use patterns, more people are looking into passive or active solar heating as a way of reducing the amount of energy used in their home. In most of North Carolina, just as much energy, if not more, may be used for cooling in summer. Thus, a properly designed home in North Carolina, whether it is solar or not, should be designed to require a minimum amount of energy for cooling in the summer.

This factsheet will discuss the major passive and low-energy cooling methods applicable to North Carolina homes. In general, the strategy for reducing cooling energy in the home is as follows:

- ***Block heat from entering***
- ***Minimize heat generated***
- ***Ventilate to remove heat and move air***
- ***Air condition only when needed as a supplement to low-energy cooling strategies.***

There are two factors which determine summertime comfort: temperature and humidity. Although passive cooling measures can be very effective in controlling temperature, they are generally incapable of removing the moisture from humid air. Therefore, it may be necessary to use an air conditioner from time to time for dehumidification. Humidity control is important not just for comfort reasons, but to prevent moisture problems such as mildew growth in closets.

Remember that the goal of air conditioning is to provide comfort for the occupants of the house, not to maintain a particular temperature setting to appease the thermostat on the wall. If a breeze is passing through the room, your perception of the temperature will be lower than that measured by the thermostat because the movement of air allows your body to lose heat more effectively. Follow the common-sense dictum of dressing appropriately for the season, too; when you're dressed in short-sleeved, loose-fitting clothing, you'll be able to feel more comfortable at a higher thermostat setting than the one you use in your office when you're dressed in a suit.

BLOCK HEAT FROM ENTERING

INSULATE, CAULK, AND WEATHER-STRIP

One of the top cooling strategies is one that you should already be using in your house to provide savings in heating energy. By making sure your home is well-insulated, you will not only lose less heat to the outdoors in winter, but also reduce unwanted heat gains in summer. Caulking and weather-stripping will reduce the infiltration of cold air in winter and the exfiltration of air-conditioned air in summer. Though ventilation is important for your home, it should come from the planned ventilation of fans, open doors and windows rather than the uncontrollable leakage of air through cracks and gaps in the house's structure.

There are several excellent free publications available which discuss the details of insulating, caulking, and weather-stripping. "Energy: Saving is Having - Do it with Insulation" and "Do it with Weatherproofing" are part of a series of pamphlets on energy saving tips offered by the Energy Division of the North Carolina Department of Commerce (1830A Tillery Place; Raleigh, NC 27604). "Fixin' a Hole Where the Wind Gets In: Practical Information on Weatherproofing Your Home" is available from the Advanced Energy Corporation (909 Capability Drive; Raleigh, NC 27606-3870). "Caulking and Weather-Stripping" (FS 203) and "Insulation" (FS 142) are factsheets available from the Energy Efficiency and Renewable Energy Clearinghouse of the US Department of Energy, (P.O. Box 3048; Merrifield, VA 22116; 1-800-523-2929, www.eren.doe.gov/consumerinfo).

Energy Division
North Carolina
Department of Commerce

Industrial Extension Service
College of Engineering
NC STATE UNIVERSITY

SHADING

One of the simplest and most effective methods of blocking heat from entering the home is shading. There are many different methods available to provide shading both inside and outside the house. Most are very simple and can easily be retrofitted to an existing structure. In general, exterior shading is more effective than interior because it blocks the heat before it enters the house. Interior shading, while effective at blocking sunlight from reaching the center of the room, still allows heat to enter the house, where it is trapped between the shade and the window. In addition, some types of exterior shading may be used to shade the walls and roof, as well as windows, thus reducing their temperature and heat transmission to the inside. Interior shading, however, has the advantages of being easily controlled by the occupants of the house while also not being exposed to wind and rain. A combination of both indoor and outdoor shading maximizes both heat reduction and controllability.

EXTERIOR SHADING

Landscaping

Landscaping is an effective and pleasant means of providing shading for your house. An effectively planned landscape will block out the hot summer sun, encourage warming sun to enter the house in winter, deflect the cold winter winds, and channel breezes for cooling in summer. In general, an “ideal” landscape plan for North Carolina would include trees to the east and west of the house to provide summer shading, with the area to the south of the house left relatively clear in order to allow solar heating in winter. Trees will be most effective if they shade east and west windows, where the most heat can enter, but shading east and west walls and the roof is also important. Even trees which do not directly shade the house, such as those planted to its north, are valuable because they reduce the temperature of the air surrounding the house. *Figure 1* shows an "ideal" site plan for most of North Carolina.

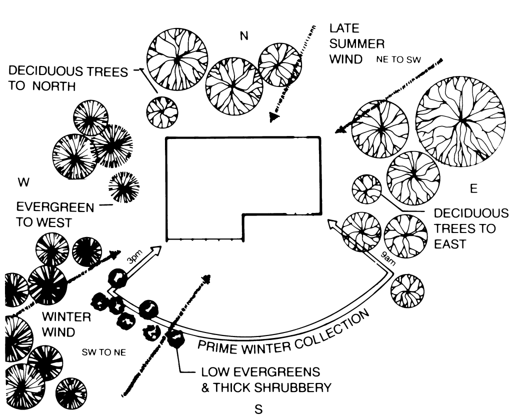


Figure 1. An Energy-saving site plan for central North Carolina.

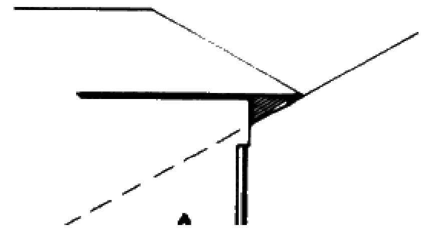


Figure 2. Overhang Shading in summer and winter

The subject of landscaping for a passive solar house is discussed in detail in *Energy-Saving Landscaping for Your Passive Solar Home (FS 109)*, a factsheet distributed by the NC Solar Center.

Roof Overhangs

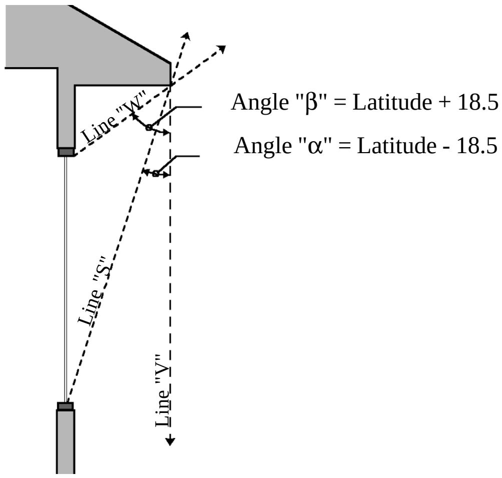
A roof overhang is a simple architectural feature which can be used on the south side of the house to block direct sunlight in summer without reducing the available sunlight in winter. *Figure 2* illustrates how this is possible: because the sun travels a higher path in the sky in the summer than in winter, the overhang blocks direct sunlight from entering in summer, while the lower winter sun passes beneath the overhang. Overhangs do not work as effectively on orientations other than due south, however, because the sun is at lower angles in the sky when it shines from the east or west, thus bypassing the overhang.

Figure 3, taken from Building with Passive Solar by the Southern Solar Energy Center, illustrates how orientation affects overhang effectiveness. The chart is designed to size overhangs to provide shading for the five most severe sun hours on August 1. For example, consider Raleigh, which sits at a latitude of 36^{0}. Find the point where 36^{0} intersects the "south-summer" curve. Then draw a line vertically downward to determine the feet of vertical wall in shade per foot of eave overhang. For Raleigh, this figure is about 3.3; that is a 1 foot overhang would shade 3.3 feet down the wall; a 2 foot overhang would shade 6.6 feet, and so on.

Following the same procedure using the "East or West" curve, however, shows that each foot of an east or west overhang will only shade about 0.8 feet down the wall. Because an east or west overhang would have to extend out several feet to provide shade, which would require extra support, a simple roof overhang is rarely used at these orientations. A covered porch or carport on the east or west side may be used, however, to produce the same effect since it would extend out by several feet.

Overhangs may be a permanent part of the building’s structure, or may be used seasonally. The sunspace of the NCSU Solar House uses overhangs as a permanent shading mechanism. The top portion of the sunspace is shaded by a permanent 3' roof overhang.

An important point to remember about overhangs is that they block direct sunlight. During the summer, only about 45 percent of the sunlight shining on a vertical



City	*Latitude*
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Durham	*36.0*
Elizabeth City	*36.3*
Fayetteville	*35.1*
Greensboro	*36.1*
Raleigh	*35.8*
Rocky Mount	*36.0*
Wilmington	*34.3*

Figure 3. Calculating overhangs for sites in North Carolina

window in North Carolina is direct sunlight. The remaining 55 percent is made up of diffuse and reflected sunlight, which will not be blocked by overhangs. This does not imply that overhangs are not useful; it just means that they should be used in conjunction with some other cooling strategies, such as interior shading, to be fully effective.

A chart which illustrates the varying sun angles throughout the year, which may be helpful in determining overhang effectiveness, is contained in "Siting of Active Solar Collectors and Flat Plate Modules," a free factsheet (# 112) distributed by the North Carolina Solar Center.

Awnings

Awnings serve the same general function as an overhang, but are more flexible in their application. Made of lightweight materials such as aluminum, canvas, acrylic, or polyvinyl laminate, it is possible for them to span distances of several feet without the need of extra support, thus making it possible for them to provide adequate shade even on the east or west. They are also frequently designed to extend below the top of the window, increasing their shading effectiveness.

Awnings can be custom-made to match the home exterior, making them an attractive design feature for many homes. They may have open or closed sides. Sideless awnings can shade east and west windows effectively, but for south windows, awnings with sides will give better protection against the early morning and late afternoon sunlight. To avoid trapping heat underneath the awning next to the window, the awning must have some means of allowing heat to escape, either through open sides or from a vent at the top. To be most effective, awnings should be light in color.

Permanent awnings may be appropriate for use on the east or west side, but awnings on the south side need to be retractable or removable in winter in order to allow in sunlight for heating.

Exterior Shade Screens

Solar shade screens are a very effective shading option. Made of a thick fiberglass mesh which absorbs the sunlight, they are effective against diffuse and reflected, as well as direct, sunlight. Consequently, they are capable of blocking up to 70 percent of all incoming sunlight before it enters the windows. Because most varieties can also serve as insect screening, they also allow the use of natural ventilation, unlike some other shading options (such as interior or exterior shades) which block air flow.

Shade screens come in a variety of colors. From the outside, most shade screens appear darker than a standard window screen, however, from the inside, most people will not notice an appreciable difference in color.

Shade screens may be ordered to size for a particular window, or the mesh may be purchased by the roll and installed by the homeowner using special hardware that snaps in the window frame. In addition to fiberglass mesh, there is another type of shade screen which uses thin louvered metal fins to reflect the sunlight. This type is more expensive, however, and is used more frequently on commercial buildings than residences.

Shade screens should be removed in winter to allow full sunlight to enter the windows.

Shutters and Shades

Exterior shutters and shades, either hinged or of the rolling blind type, are another option for shading. Although they block sunlight very effectively, they have a few disadvantages: they obscure the view from the window, block daylighting, and may be inconvenient to operate on a daily basis. They are also subject to wear and tear, and may block air flow.

Exterior shutters may be operated manually or automatically. Automatic controls are more costly and difficult to maintain, but may be more practical than manual controls when the shutters are at inconvenient locations, such as behind shrubbery or on the second floor. Proper use of the shutters is also more likely when they are automatically controlled rather than depending upon compliance by members of the household.

The lifestyle of the family needs to be considered in the decision of whether or not to use exterior shutters. If the house is unoccupied during the day, and the shutters can be easily closed by the homeowners as they leave for work and reopened on arriving home, exterior shutters can significantly reduce the amount of heat entering the house during the day. On the other hand, if some of the family is at home occupying those rooms during the day, they may be resistant to the loss of view. Similarly, there will be resistance from family members to opening and closing shutters which are inconvenient to operate.

Another variety of exterior shutter, the *Bahama shutter*, is hinged at the top and projects out from the window at an angle, held in place by a rod or wood strip. In practice, it shades more like an awning, allowing in daylight and ventilation. Unlike other exterior shutters, it may be operated from the inside.

INTERIOR SHADING

While interior shading is not as effective as exterior shading, since it is unable to block heat until it has already entered the building, it can still be a useful supplement to exterior shading. It should certainly be used where other shading options are unavailable. Interior window treatments are normally considered a necessity for privacy and as part of the house's decor. Proper selection of window treatments can make them an asset for cooling as well.

Draperies and curtains are most effective when made of tightly-woven, opaque material of a light or reflective color. The tighter the curtain fits to the window, the better its ability to trap heat and prevent it from entering the house.

Simple white roller shades shade quite effectively when fully drawn, but prevent light and air from entering. Venetian blinds, while not as effective at trapping heat, will allow air and light to pass through, while reflecting some of the sun's heat. Some newer blinds are coated with special reflective finishes.

The subject of interior and exterior window treatments is discussed in detail in "Summer Shading and Exterior Insulation for Windows," a free factsheet (# 103) distributed by the North Carolina Solar Center.

Reflective Films and Coatings

Reflective coatings which adhere to glass can block up to 85 percent of incoming sunlight. Some coatings may be applied seasonally; others are permanently affixed to the glass surface. Permanent films or coatings are not appropriate for south windows in passive solar homes, since they would block heat from entering all year round. However, they would be practical for unshaded east or west windows.

Window films are not recommended for windows which receive partial shading, because the film absorbs the sunlight and will cause the glass to heat unevenly and possibly crack. Some window manufacturers will invalidate their warranties if reflective films are used on the windows.

Radiant Barriers

For roofs which are unshaded, radiant barriers provide another way to block heat from entering your home. A radiant barrier is a layer of aluminum foil placed in an air space between a heat-radiating surface (the roof of your house) and a heat-absorbing surface (the insulation on the floor of your attic). It works to reduce the heat entering your house in two ways: its reflective surface reflects most of the radiant heat striking it, and it will itself emit very little heat.

Radiant barriers come in many different forms: single-sided or double-sided foils, foil-faced insulation, and multilayered foil systems with air spaces. Any of these products should perform equally well if properly installed, so the cost of the product and its ease of installation should guide your decision between them.

To work properly, the shiny side of the radiant barrier must face an air space. In an attic, this is done by stapling the radiant barrier, shiny side down, to the underside of the roof decking or the roof trusses. Although this may seem counter to what your intuition tells you, this is the preferred position. The orientation of the shiny surface itself does not matter; it will reflect heat equally well whether it points up or down. What is important is that the surface remain shiny. Hanging the radiant barrier with its shiny side down prevents dust from accumulating on its surface and reducing its ability to reflect heat. Some dealers recommend laying the radiant barrier on the floor of the attic for ease of installation. This is not a good idea, however, because of the dust accumulation problem, damage from possible traffic and, most important, the possibility of moisture problems being caused by water vapor trapped beneath the radiant barrier.

The Florida Solar Energy Center has prepared a factsheet on radiant barriers entitled "Radiant Barriers: A Question and Answer Primer." This factsheet is available free of charge from the North Carolina Solar Center.

MINIMIZE HEAT GENERATED

Not all of the heat in our homes in summer comes from the sun; much of it comes from the occupants of the home and the appliances they use. By carefully selecting appliances and the times when they are used, members of the household can help keep the house cooler.

SELECT ENERGY-EFFICIENT APPLIANCES

The first step in minimizing heat generated within the home is choosing energy-efficient appliances throughout the house, from the large appliances like refrigerators down to the smaller ones, like light bulbs. The less efficient an appliance is, the more waste heat it generates: thus, its inefficiency costs in two ways: the extra energy it costs to run the appliance, and the cooling penalty that comes with having to remove the extra heat it generates.

Most major appliances come with energy-guide labels that show how much energy the appliance will use, and compare its energy use to that of similar products. Use these labels to guide your purchases. Remember that you will continue paying for the appliance long after its purchase due to the energy it consumes, so that the one that appears least expensive at first may not be so in the long run.

This is especially true in lighting. Consider a 60 Watt incandescent light bulb. It will provide light for about 1000 hours before burning out. To get 10,000 hours worth of lighting, you would pay about $6.80 (for 10 bulbs, at $0.68 each) plus $45.60 for the electricity to run them (assuming electricity costs $0.076 per kWh) for a grand total of $52.40. Compare this to a single 15 Watt compact fluorescent “lamp”, or light bulb, which produces a similar amount of light and has a lifetime of 10,000 hours. Its initial purchase cost would be higher, about $15, but the cost of electricity to run it is one-quarter that of the incandescent, or $11.40, making the total cost of lighting from the compact fluorescent only $26.40. This is roughly half the cost of the incandescent, even without considering the extra costs imposed by the effect of the incandescents on the house’s cooling load.

In general, incandescent light bulbs are the least energy-efficient source of lighting for the home. Better alternatives include fluorescent lights and daylighting. If there are windows in the home, and if they have been shaded with trees, overhangs, awnings, or venetian blinds as discussed in the previous section, daylighting can be an effective source of diffuse sunlight. Diffuse light entering from the side is a pleasant and effective source of lighting for the house during the day. Direct sunlight tends to cause problems with glare and introduces too much heat along with it to be a sensible source of summer lighting. Skylights are generally not considered an energy-saving source of daylighting because of the increase in the house’s cooling load caused by the heat that they admit.

USE APPLIANCES WISELY

Kitchen and laundry appliances, by design, produce heat. By substituting less-heating alternatives or scheduling their use for the cooler morning or evening hours, however, their effect on the house’s load can be minimized.

In the kitchen, use a microwave oven or a smaller toaster oven rather than the large oven whenever possible. Serving cold dishes in summer is a good idea because lunch and dinner time occur during the hottest part of the day. Cold dishes will be refreshing and cut down on the amount of heat added to the house at mealtimes. Cooking dishes in the evening to be served later (either cold or reheated in the microwave) shifts the added heat of cooking away from the already warm dinner hour and also fits well into the schedules of many two-income families. Consider grilling foods outdoors. Although this can be a pretty hot way to cook a meal, the heat that is produced stays outside your house.

When cooking on the stovetop, be sure to cover pots and pans. Less energy will be needed to cook the foods, and less heat and humidity will be added to the house. If boiling in an open pot is necessary, be sure to turn on the kitchen exhaust fan so that it can help remove the humidity introduced by the steam.

When doing laundry, wash only full loads and use cold water whenever possible. It will save the energy needed to heat the water, and lessen the addition of warm, moist air in your laundry room. If the schedules of family members permit, consider using a “solar clothes dryer," or a clothes line, instead of an electric or gas clothes dryer since they produce large amounts of heat. Moving laundry tasks to the morning or evening hours is helpful, too.

VENTILATE TO REMOVE HEAT AND MOVE AIR

Ventilation, or the movement of air, is one of the most powerful means of achieving a cool home. Ventilation has two goals: (1) to remove heat from the house and (2) to provide air movement within the house to cool its occupants. There are several different types of ventilation, both natural and mechanical, which meet these goals in different ways. Though mechanical ventilation measures are not strictly passive, they are a much less energy-intensive method of achieving a cool home than air conditioning.

NATURAL VENTILATION

Natural ventilation, or relying upon summer breezes to generate air movement within the house, is the simplest of passive cooling strategies. Due to the variability of wind speed and direction, though, it can also be the least reliable. However, careful selection of windows and their positioning can help enhance the natural ventilation possibilities of your house.

When determining the type of windows to be used in your home, appearance should not be the only factor; the summer ventilation and winter infiltration potential of the window should also be considered. With the standard double-hung window, where the window is opened by pushing one half of the window in front of the other half, slightly less than half, or about 45 percent, of the total window area is available for ventilation purposes. The same is true of single-hung and horizontal sliding windows. With awning windows, this percentage is 75 percent; with casement windows, the percentage of free vent area is 90 percent. Casement and awning windows are also superior to the single-hung, double-hung, and sliding windows in winter, since they are better able to achieve a tight fit which reduces infiltration.

In planning the layout of windows in the house, the important point to remember is that for natural ventilation to succeed, there must be both an inlet and an exit for the air. In other words, windows on both the windward side and the leeward side of the house need to be open to promote air flow. If there is not an exit for the air, the house will become pressurized by the addition of incoming air. Once the house is pressurized, the wind will see the open windows of the house as just another obstacle to be bypassed, rather than an inviting gate to enter.

Pathways for airflow within the house also need to be left open. For example, if the door to the bedroom on the windward side of the house is normally left closed, the room will quickly become pressurized and lose its potential to help cool itself and the rest of the house.

Rooms with two exterior walls should have windows on both walls, with as much distance between the windows as possible, to maximize the potential for cross-ventilation. Of course, this guideline needs to be considered at the same time as the recommendation to minimize windows on the east and west side. If your family is unlikely to use natural ventilation, your cooling needs would be better met by minimizing the east/west window area. On the other hand, if your family rarely uses air conditioning and the east or west windows would be well shaded by trees or by other means, the windows could be a cooling asset.

WHOLE HOUSE FANS

Whole house fans allow your house to use outdoor air for cooling even when no breezes are blowing. Whole house fans remove hot room air from the ceiling and exhaust it out through the vents in the attic. At the same time, it pulls in cooler supply air through the windows.

A general rule of thumb for sizing whole house fans is that the fan should be able to provide between 0.5 and 1 air changes per minute. For example, consider a 2000 square foot house with 8 foot ceilings. The house volume equals the floor area times the ceiling height, or 16,000 cubic feet. Thus, this house would need a fan that provides between 8000 and 16,000 cubic feet per minute (CFM). You may find it worthwhile to choose a fan rated toward the upper end of this range. This way, you will frequently be able to operate the fan at low speed, where it will run more quietly. The installation of a 12-hour timer switch is also convenient, so that the fan can be set to turn off automatically during the night.

CEILING FANS

Whole house fans move large volumes of air at moderate speeds in order to exhaust heat from the house. Ceiling fans, on the other hand, don't remove heat. Instead, they provide localized breezes which blow past your body and help it lose heat more efficiently, giving you the perception that the temperature is about 4 degrees cooler than it actually is. Accordingly, in a house with strategically located fans, the air conditioner thermostat setting may be raised from 2 to 6 degrees above what would otherwise be considered comfortable.

To be most effective, fans need to be located throughout the house. If located only in the family room and master bedroom, family members in other rooms are likely to lower the thermostat setting to a point where they are comfortable, too. Portable fans are useful to have around to provide air movement in rooms that are only intermittently occupied. *Ceiling Fans for Cooling Comfort*, an article reprint, is available free of charge from the North Carolina Solar Center.

EXHAUST FANS

The kitchen and bathroom come equipped with exhaust fans designed to remove the hot, humid air produced in these areas. Their proper operation is important not just for comfort, but to help prevent the growth of mold and mildew.

Install a timer control switch on the bathroom vent fan, so that when the fan is turned on after a shower or bath, it will run only long enough to remove the excess moisture from the room, without having to depend on having someone remember to turn it off. When selecting a fan, choose a quiet fan (one with a rating of 3 sones or less), because experience has shown that people tend to avoid using noisier fans.

Exhaust fans need to vent to the outdoors, rather than into the attic, to avoid moisture damage to the insulation or mold growth.

ATTIC AND ROOF VENTILATION

Proper ventilation between the roof and the insulation is important all year round. In winter, it helps prevent moisture buildup which could damage the insulation and other building materials; in summer, it reduces roof and ceiling temperatures, thus saving on cooling costs and lengthening the life of the roof.

Figure 4 shows some of the variety of vent types to choose from are ridge, gable, soffit, static mushroom, and turbines. There are also electrically powered attic ventilators. In general, however, electric attic ventilators consume as much electricity to operate as they would save in air conditioning costs, and are recommended only in cases where the required ventilation cannot be met by passive means. (Note: this type of attic ventilation fan should not be confused with the whole house fan discussed earlier; they are different technologies).

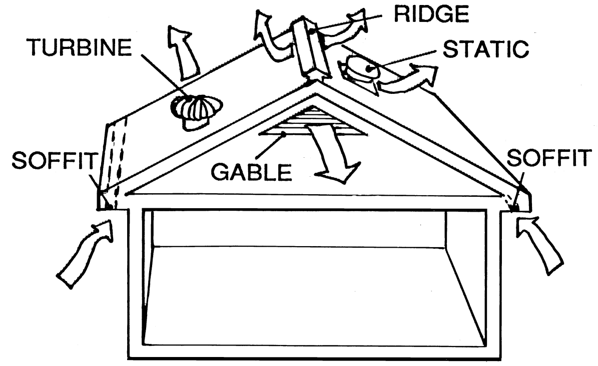

Figure 4. Types of roof vents.

To achieve proper ventilation, the vent area needs to be divided equally between low vents, at the eave or soffit, and high vents, at the roof ridge or gable. The most effective ventilation strategy is to combine continuous ridge and soffit vents. The amount of ventilation depends upon the floor area of the attic and the amount of moisture entering it. The general guideline is that there must be one square foot of attic vent for every 150 square feet of attic floor area.

AIR CONDITION ONLY IF NEEDED

In most of North Carolina, even after following all of these passive cooling guidelines, there will still be days when air conditioning is required to provide the comfort level to which most of us are accustomed. In a house designed for passive cooling, however, air conditioning will be required in lesser amounts and on fewer days.

Make sure that your central air-conditioning unit is properly sized for your house, using air conditioning industry standard "ASHRAE" or "Manual J" sizing procedures rather than a rule of thumb. Do not buy an oversized unit because it will actually be less effective in making your house comfortable. Part of your air conditioner's job is to dehumidify the air in your home. If the unit is oversized, the unit will lower the air temperature before it has a chance to dehumidify the air. To get to a comfortable humidity level, homeowners tend to lower the thermostat setting, thus consuming more energy than is necessary and sometimes ending up with a cold, clammy house.

Make sure that your ductwork has been adequately sealed and insulated. Even though it sounds as if it's the right tool for the job, duct tape does not does not do an adequate job of sealing ductwork from leaks. A sealing compound, known as *mastic*, will do a much better job of sealing the ducts.

Continue to use your ceiling fans even when the air conditioning is on. They will allow you to raise the thermostat set point and, for every one degree that the thermostat is raised, air conditioning costs will drop by 3 to 8 percent.

WHAT ABOUT....?

EARTH TUBES

The earth tube, or earth cooling tube, was a concept that gained popularity for a while in the late seventies and early eighties. It consists of pipes buried several feet below ground, where temperatures are lower. Air is drawn into the house through the underground tubes, which allow it to be cooled before entering.

Experience has shown earth tubes to be unfeasible in North Carolina for several reasons. The chief problem is the fact that the air introduced through the earth tubes is typically humid, with the result being that the occupants of the house are frequently left less comfortable than before due to the extra humidity. In some homes, they were found to be an entry way for insects, vermin, and sometimes water during heavy rain storms. Additionally, the fact that earth tubes increase the possibility of exposure to radon and other unhealthful soil gases has led to their falling into disfavor as public awareness of the dangers of these gases has grown.

SOLAR CHIMNEYS

Another concept that gained popularity during the seventies was the solar or thermal chimney. Basically, the thermal chimney is like a small, open solar collector on the roof that connects to the air inside the house through an opening in the ceiling or wall. As the air inside the chimney warms, it rises and exhausts through the top of the chimney, pulling air from inside the house to replace it, which in turn will be replaced by fresh air pulled in through the open windows of the house.

The biggest problem with the thermal chimney is that of timing. Unfortunately, the time when the solar chimney works its best is at mid-day when the sun is shining brightly, when the air temperature outside is high and outside air should not be brought indoors. In the cooler morning and evening hours, when outdoor air would be desirable, the chimney is not capable of producing a strong enough draft to effectively draw in the cooler air.

EVAPORATIVE COOLING

Evaporative cooling concepts have been known and successfully implemented for centuries. As water evaporates, it draws heat from the air passing by it, producing cool, damp air. While this is an attractive concept in arid climates, it is less appealing in areas like North Carolina which already have high humidity levels in summer.

FOR MORE INFORMATION

The North Carolina Solar Center has a reference library as well as other free fact sheets and information on solar energy, renewable energy, energy efficiency, and related subjects. For more information on these topics, or to learn more about the resources available, contact the Solar Center.

Written by:
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Take advantage of the state tax credit for solar energy!

North Carolina has revised and updated its renewable energy tax credits, effective January 1, 2000.

For residential applications, homeowners may now take a 35 percent tax credit for all renewable energy sources, with the maximum credit depending on the application. For passive and active solar space heating and cooling, the maximum credit is $3,500. For solar water heating, the maximum credit is $1,400. For photovoltaics and other renewable energy sources, the maximum credit is $10,500. For commercial and industrial renewable energy applications, the tax credit is also 35 percent, with a maximum credit of $250,000 for all sources and applications. For further information on these tax credits, contact the North Carolina Solar Center at 1-800-33-NC SUN or 919-515-3480, or visit our website at www.ncsc.ncsu.edu.

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