PASSIVE COOLING OF LOUISIANA BUILDINGS

by
Jerry Heinberg, AIA, Architect

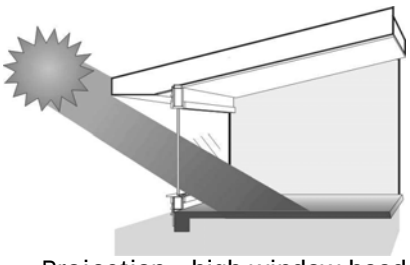
The hot-humid climate of Louisiana does not readily lend itself to natural cooling as it does in dryer states northwest of us. To compensate, we have to create designated areas of shade and configure the site plan to catch the prevailing breezes, making nature work for us in the spring and summer. During the mid-1800s, kitchens were built outside of the main house. This was not only to keep the odors out of the main house, but also especially to exclude the heat, although today, it is expensive and impractical to have only an exterior kitchen. The building "envelope" can be defined as any barrier to wind, water penetration, and thermal transmission. Inside the envelope is the useable space contained in our buildings. Outside the envelope, ambient temperature and humidity prevail.

Keeping the cooking heat out of the house is still a sound principle. Cooking outside on a Bar B-Q pit helps keep additional heat out of the envelope on a hot, muggy summer day. Excluding heat is equivalent to cooling. That big refrigerator-freezer (even the highly efficient ones in common residential use today) is removing heat seven days a week, twenty-four hours per day from its contents and dumping the heat inside the kitchen. That would be bad enough, but the occupant is also paying for the electricity that creates the additional heat, which then has to be removed by the HVAC system, which requires additional electricity use. The dishwasher also dumps heat and humidity into the envelope by doing its job, and is amplified if the "dry" cycle is used. It goes without saying that cooking adds heat and humidity, except that the exhaust fan, if used, removes a great deal of it (along with the HVAC pre-cooled air for which we pay dearly). A little planning and imagination can have the condenser section of the refrigerator-freezer transfer its heat load directly to the exterior of the envelope. Even more efficient would be accomplishing this through the use of a water-cooled refrigerator-freezer condenser connected to a heat exchanger, which preheats water in the domestic water heater storage tank. This gets the heat out of the envelope, and puts it to good use. This approach could be augmented by solar thermal production of pre-heated water to the storage tank. The dishwasher also could be vented directly to the exterior as we do with clothes dryers. The ceiling fan is an appropriate tool for active cooling as it makes us feel cooler through convective removal of heat from our bodies and by evaporation of perspiration. However, again, it is not only adding to the heat gain in the envelope through its use of electricity, but the humidity and heat, although removed from us, still remains in the envelope.

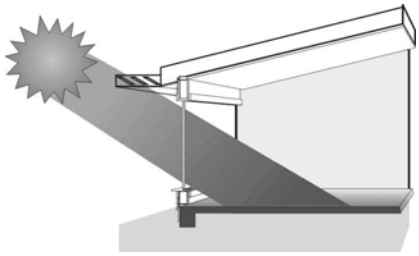
The north elevation of a building receives very little direct sunlight with enough long and short wave infrared radiation to penetrate windows and add heat to the envelope. Only very early or very late in the day in late June do the sun's rays come from the east-northeast or west-northwest. During these times, the sun is very low and its rays are almost parallel to the ground. It is not possible to block it with an overhang, but other methods may help. Landscaping, such as flowering vines on a trellis, will block much of this low sunlight. Also, avoid hard reflective ground cover, such as paving, in the path of the low east and west sunrays. The reflected sunlight bouncing off the hard surface and entering the windows creates undesired heat and glare, and is disconcerting to see sunlight entering the house from bouncing rays casting patterns of light on the ceiling.

The proper design of roof overhangs admits the low winter sun into the house, and excludes the higher summer sun. The design of the overhang is dependent on the orientation of the wall under consideration, the height of the wall, the depth of the soffit (exterior ceiling), and the vertical distance from the soffit to the sill (bottom) of the window, or glass door (collectively called

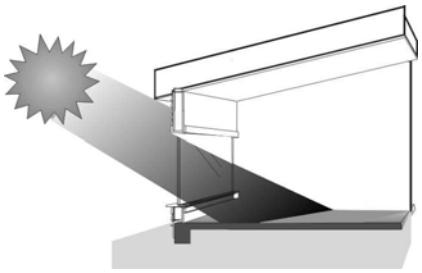
"fenestration," indicating glazed openings in an opaque wall). Our energy codes such as IRC-2006



Projection – high window head. Excludes summer sun; admits winter sun.



Louver – high window head. Excludes summer sun; admits winter sun



Low window head. Excludes summer sun; admits winter sun

(residential for 1 & 2 family dwellings), IECC-2006 (for low-rise multi-family residential), or ASHRAE 90.1-2004 (commercial) refer to this cut-off angle as Projection Factor, or PF. This is basically the ray angle of sunlight cut off by the overhang. Ideally, the overhang would be designed to totally shade a window at noon, on the Summer Equinox (around June 21) for a south-facing wall. It is clear that a uniform two-foot overhang around the whole building (which is very common) may not be appropriate to shield the windows from summer solar energy. It may work well for getting water runoff from the roof away from the wall/foundation, or may to simplify the framing design, or may be just for aesthetic reasons. Conversely, it would be useful if the same overhang was designed specifically to permit the low-angled winter sun to penetrate the window while excluding the summer sun. Because the sun's rays originate at a considerably lower angle (from horizontal) at noon on the Winter Solstice (around December 21), the same overhang provides some welcome morning heat penetrating the south fenestration.

A wind rose graphically shows the annual average wind direction and wind speed for a specific geographical location. If one were site planning a building, and was aware that the predominant summer breeze was from the southwest, there may be a dedicated design intent to capture that trend with a breezeway, or by orienting the building to take advantage of natural ventilation by location of operable windows. Wind rose tools are available online and as software. One such tool is available at http://mesonet.agron.iastate.edu/sites/locate.php?network=LA_ASOS. It is very useful in determining the predominant strength and direction of wind for the area of the site. This allows design for natural summer ventilation and shielding from cold winter winds. The web site will construct a wind rose for the most populated areas of the state. Thirty-eight stations on land are available in Louisiana, plus Vicksburg and Natchez in Mississippi. Be sure to try several years as these plots are for one year of data, and will vary somewhat, year to year. By using January 1 to March 1 and July 1 to September 1, the most significant prevailing winds can be seen for the more extreme seasons. April to June and October to December will show the temperate seasons when many people like to be out-of-doors. Be careful to avoid a date range with hurricanes, as they will distort the average results.

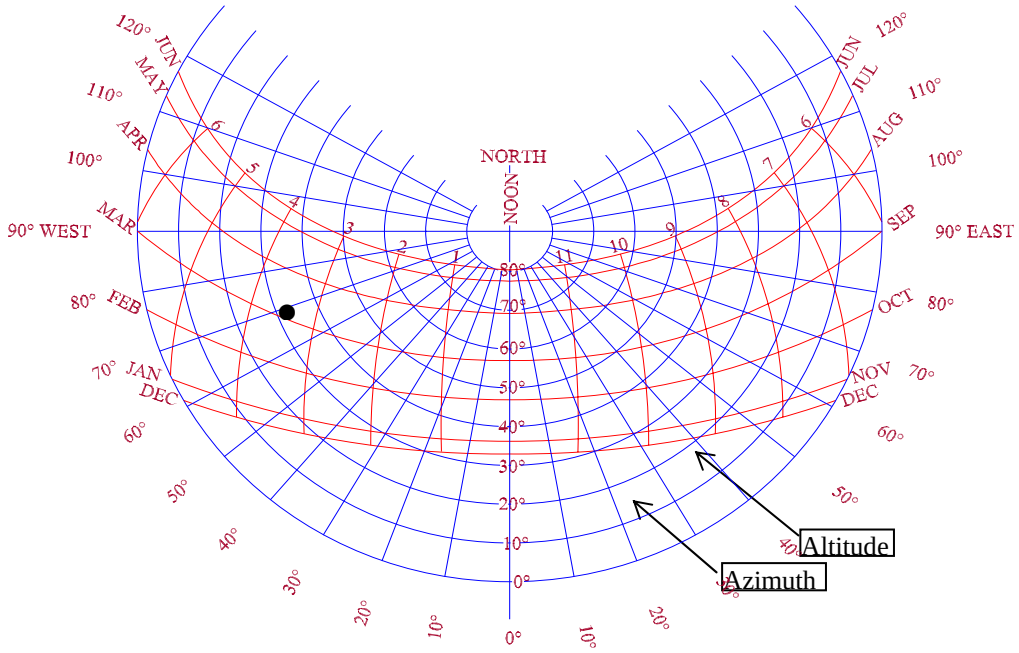
The length of the wind rose ray (vector) indicates the percent of the time that the wind blew from a particular direction while the different sized/colored sections indicate the proportion of that time within a particular speed range. The center shows the percentage of the time period that was calm and the average wind speed for the period is shown below the speed legend. The USDA also has a wind rose program that illustrates the yearly average since 1961 of wind direction and speed for four cities around the state at ftp://ftp.wcc.nrcs.usda.gov/downloads/climate/windrose/louisiana/.

Natural Ventilation

Even in the land of hot and humid, there are those times when we would prefer natural ventilation to heating or cooling. The fresh air is great for removing odors or pollutants from our environs. The savings for not using the heating and cooling is another plus. Use the wind rose information combined with site-specific information. A forest or high hill on one side of the site will change wind directions. Large man-made structures will also, but are not usually found in residential areas. Locating on the side of a hill or on the edge of a lake or other large cleared area will affect wind patterns. For example, if the site is on a man-made lake, it is probably sloping; that is, a hill on the side away from the lake. The same winds will affect similar sites on north and south shores of the lake differently. The north shore site will have some of the winter winds blocked and receive direct breezes in the summer, while the south shore site will be just the opposite. The degree of affect will depend on the magnitude of the obstacles being considered. It may be desired to present the bedroom side of the house with few windows to predominantly north winter winds. The west side may be "shaded" by a garage and storage area. But the south or southeast breezes of the spring and fall present a good time to welcome the breezes by opening various windows on opposite sides of the house. Careful planning is required to combine the many beneficial features into an efficient house.

Solar Position

Below is a solar chart used to determine the position of the sun at any time during the year. The curved horizontal arcs (months) represent the 21st day of each month. Solar altitude is shown by concentric circles in 10° increments. Curved lines indicating the time of day are labeled as 6 a.m. (east) to 6 p.m. (west). Azimuth lines are radial lines in 10° increments from south. Interpolation is permissible. In the example indicated by the "●": month/day: March 23 (or August 30), time: 3:35 p.m., azimuth: 69° west of south, altitude: 30.5° above the horizon.



The chart above is for 32 degrees north latitude. A chart can be calculated mathematically for a specific

latitude, but this one is representative of much of Louisiana. It is based on sun time, not Daylight Savings time, for the particular latitude. Using the chart as an overlay on a site plan provides insight to how the sun's path each day of the year will affect window placement, admitting daylight and heat gain when and where desired, and excluding them when they would be detrimental.

Natural Cooling

Louisiana's hot, humid summers drive most people indoors to seek air-conditioned comfort -- comfort that is paid for by high monthly cooling bills. Natural cooling design measures can further reduce the air conditioning needs of any house. Natural cooling guidelines are especially important for passive solar homes because their large expanses of south-facing glass can cause overheating if unprotected in summer. In Louisiana, summer discomfort is caused by humidity as much as by heat. Natural cooling techniques and approaches designed to reduce humidity levels can promote comfort on moderately warm days. Natural cooling techniques, proper insulation, and air sealing will continue to save money and energy. Remember that shading from trees can greatly reduce the ambient temperature, saving air conditioning. Capturing the natural breezes on the site can reduce the need for air conditioning during spring and fall.

Landscaping and Trees

According to the U.S. Department of Energy report, "Landscaping for Energy Efficiency," careful landscaping can save up to 25% of a household's energy consumption for heating and cooling. Trees and vines on trellis or arbor are very effective means of shading in the summer months. In addition to contributing shade, landscape features, combined with a lawn or other ground cover, can reduce air temperatures as much as 9^{o} F in the surrounding area when water evaporates from vegetation and cools the surrounding air. Louisiana's abundant trees are wonderful for natural shading and cooling. However, they must be located so as to provide shade in summer and permit sun light in the winter coming from the south. Even deciduous trees that lose their leaves during cold weather block some winter sunlight – bare trees can block over 50 percent of the available solar energy if they have a lot of limbs. Here are some general landscaping guidelines: 1) Ground cover reduces reflected sunlight; 2) deciduous trees shade east, west, southeast, and southwest sides in summer; 3) trellis with deciduous vine can shade east and west walls; 4) a windbreak of evergreen trees and/or shrubs to the north buffers winter winds.

Orientation of Building and Components

Major glazed areas should be oriented within 20 degrees of north and south that have overhangs for summer shading. Placing the garage on the west blocks summer sun. One should plant low-limb, deciduous trees to the east and west of living spaces. This helps to permit the passage of some sun into the space in winter, but the heavy summer foliage blocks the sunlight when the heat gain is least wanted inside the space. South-facing overhangs can be designed to permit the passage of low altitude winter sunlight into the space, while excluding the high altitude summer sun. Low shrubbery can help prevent ground bounce glare from reflecting off the ground or paved areas and penetrating the windows. Using high operable clearstory windows can create a stack effect and replace rising exiting hot air with cooler air entering through low windows due to the negative pressure created by the escape of the hot air above.