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Industry Guide to Selecting the Best Residential Window Options for the Florida Climate

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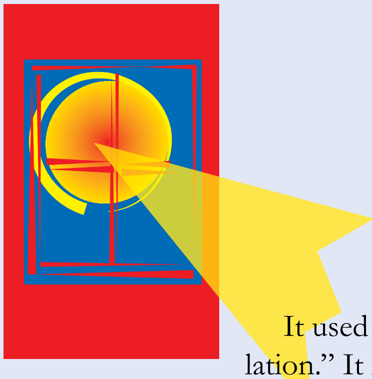
This document has been prepared to help retailers, builders, distributors, and other window industry professionals in Florida assist homeowners and other residential window purchasers in choosing the best window options for Florida homes. Consumers may find it useful in obtaining detailed information concerning proper window placement and selection for Florida's generally hot, humid climate. A companion publication, "Homeowners' guide to selecting the best residential window options for the Florida climate" is also available from the Florida Solar Energy Center®.



Introduction

It used to be said that “windows are little more than holes in the insulation.” It is true to some extent that poorly insulated and drafty windows in certain climates defeat the purpose of wall insulation. However, modern high performance windows are almost as good as opaque insulated wall sections, at least in terms of *total* energy savings over long periods of time. In some cases, they can be shown to actually *out-perform* insulated walls. Of course, they have the priceless additional benefits of providing views to the outdoors and natural daylight illumination indoors — important issues of quality and comfort.

The main purpose of a building and its windows is to provide comfort to the occupants — as the sun moves through the sky, as the outdoor air temperature and humidity vary, and as the wind and rain come and go. If comfort can be achieved while reducing the building’s energy use and lowering monthly utility bills, so much the better.

This Energy Guide focuses on choosing window options for *residential* buildings in hot climates. Many of the principles offered here apply as well to non-residential buildings. However, there are major differences in the types of windows available for these two building classes, and there are normally major differences in their building occupancy schedules. This is important because unoccupied buildings don’t need illumination. Non-residential buildings are most generally occupied during daylight hours. This provides a greater opportunity for the use of daylighting in these buildings to displace electric lighting, saving energy in the process.

Residential buildings are usually less occupied during daylight hours, so there is less chance to save energy by using daylight to displace daytime electric lighting. With its relatively higher fraction of retirees, however, Florida offers numerous exceptions to this general rule. Proper use of windows for daytime lighting of residential building interiors *can* displace the electric lighting that might otherwise be needed.

How Do Windows Affect Energy Use in the Home?

Windows are not directly energy-consuming devices. Sometimes they cause the building to use *more* energy than would be the case without them, and at other times they actually *reduce* the building's need for energy. When windows let heat escape on cold winter nights (causing the heating system to use more energy) and when they admit solar radiant heat on hot summer afternoons (causing the air cooling system to use more energy) they *increase* the building's energy costs.

How can they reduce energy use? One way is to admit solar radiant heat into the building on a cold winter day. The solar radiation directly heats the building's interior, and this heat is used to displace energy that would otherwise be purchased for heating the house. When daylight illumination enters through a window, it directly illuminates the interior of the building. If this daylight displaces electric lighting which would otherwise be on, there are energy savings from not having to turn on the lights.

Windows are seldom selected by consumers on the basis of their energy performance alone. Instead, appearance, the operating mechanism, color, and price dominate selection features. Energy impacts have been less important, due primarily to a lack of objective information on the window itself, or available at the sale site, about energy performance. Furthermore, it is not as easy to compare windows on the basis of energy efficiency, as with refrigerators, microwave ovens, and automobiles. To partially alleviate this difficulty, the National Fenestration Rating Council (NFRC) has developed a system for the certification, rating, and labeling of windows for energy performance. This system is slowly entering use by code bodies in the U.S. The NFRC label is intended to help the purchaser and code officials determine the energy performance of windows for which labels are issued.

Even when using the NFRC labeling program, reducing the energy costs associated with windows while increasing their human comfort without excessive price increases, is a real challenge to the building designer. Achieving an acceptable design depends upon many factors.

- ★ Which way the window faces relative to the direction of the sun
- ★ How much outside shading is planned or is present for the window
- ★ How bright the exterior scene is (*the brighter the scene, the greater the potential for glare*)
- ★ How dark the interior is (*the brighter the interior surfaces, the less the window glare*)
- ★ The homeowner's willingness to operate shading devices to achieve their best performance
- ★ The homeowner's desire (or code-requirement) for impact resistance *(the impact can come from storm-blown objects or intruders*)
- ★ How critical it is to maintain an unobstructed view to the outside (*gorgeous vistas shouldn't be permanently blocked by window shades or other add-ons, although temporary blocking for privacy or solar heat rejection may be desired at times*)
- ★ The homeowner's desire for acoustic isolation in noisy environments
- ★ Whether the window can meet aesthetic desires for appearance and quality

Selecting Windows

There are some basic principles to keep in mind when selecting windows for Florida residences. The winter space-heating season is short and not severe. Thus, there is not a strong need to insulate a window, at least in comparison with the much greater need to protect it from direct solar radiant heat gain. It is true that insulating the window with multiple panes, insulating gases, and a special coating can reduce the size of the air conditioner needed to meet *peak* loads and that this smaller size will reduce both heating and cooling costs as well. Reduced heating and cooling equipment size could save enough construction dollars to pay for the extra cost of the window insulation, but this should be proven by calculations before it is accepted as truth. (Computer tools are available, such as the program RESFEN, for making these calculations. See the web sites mentioned at the end of this publication for more information about such programs.)

For retrofit applications — replacing windows in an existing building — there is seldom the chance to save dollars on the air conditioner, unless it happens that the homeowner needs to replace the air conditioner at the same time that the windows are replaced.

If the homeowner decides to install insulated windows — for whatever dominant reason — a few extra comfort benefits can be expected too. There will be less transfer of sound through the window, an advantage in urban settings with frequent road or aircraft noise, but a possible disadvantage for rural sites where the occupant might enjoy hearing better the sound of the wind or the chirping of birds. Insulated windows have less tendency toward condensation and the resultant growth of mold and mildew. On the infrequent cold Florida winter nights and excessively hot summer afternoons, an insulated window will be more comfortable to sit near.

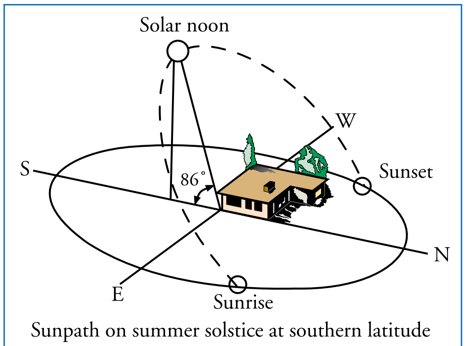


Figure 1. Summer solstice sunpath.

In trying to prevent unwanted solar radiant heat gain during summer months, it is important to realize that the sun rises north of east and sets north of west during these months *(as shown in Fig. 1)*. It rises due east and sets due west only on the equinoxes, near the 21st of March and September. Thus, whenever possible, it is best to minimize window exposures toward the east and northeast and toward the west and northwest. This can be accomplished by the design and orientation of the building and by shading the window, as discussed below.

Shading Strategies

It is far better, for heat gain prevention, to block the sunlight *before* it reaches the window, thereby dissipating the absorbed heat outside where it can be carried away by air currents. This means that simple shade trees and other exterior shading methods can be very effective, both in saving air cooling energy and in blocking the strong glare which direct sunlight can produce if allowed inside.

If the owner and building designer cannot avoid windows facing east or west, then the use of *exterior* operable shading devices should be considered to protect the windows from the sun. In this case, shades can be pulled down to reduce solar radiant heat gain along with its glare and higher energy costs. They can be opened when the sun is not shining directly on the window, to provide both good exterior views and interior daylight illumination. A variety of exterior shading devices is illustrated in *Fig. 3 (page 4)*.

Note that in winter, the sun rises south of due east and sets south of due west *(Fig. 2)*. Advantage can be taken of this fact by putting exterior *vertical* shades on east- and west-facing windows *(Fig. 4, page 4)*. Properly designed, vertical protruding shades on one side of the window can allow sunlight to enter from the southeast to east through east-facing windows in winter, and from the southwest to west through west-facing ones, while blocking the sun at other seasons of the year. With this strategy of putting a "wing wall" on the window (along with a properly sized roof overhang), the worst of the solar gain conditions could be avoided, while still providing a view and daylight illumination without the need to operate exterior shades. With Florida's warm winter climate, admission of any direct solar gain, even in winter, may not be desirable for everyone, so other shading strategies should also be considered.

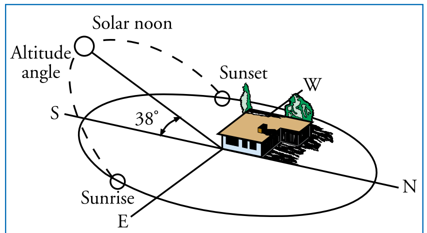


Figure 2. Winter solstice sunpath.

If exterior shades are not wanted, consider the use of white or otherwise highly reflecting *interior* shades. For best performance, they should be operable. When they are closed, they can reflect solar radiation back through the window to the outside. They can be drawn closed when the sun is strong and not wanted, and then opened when the sun is not shining on the glass or when access to a good view and daylight is desired.

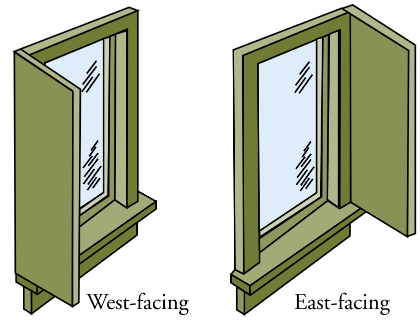


Figure 4. Exterior vertical shades in The form of "wing walls."

Exterior window shading strategies

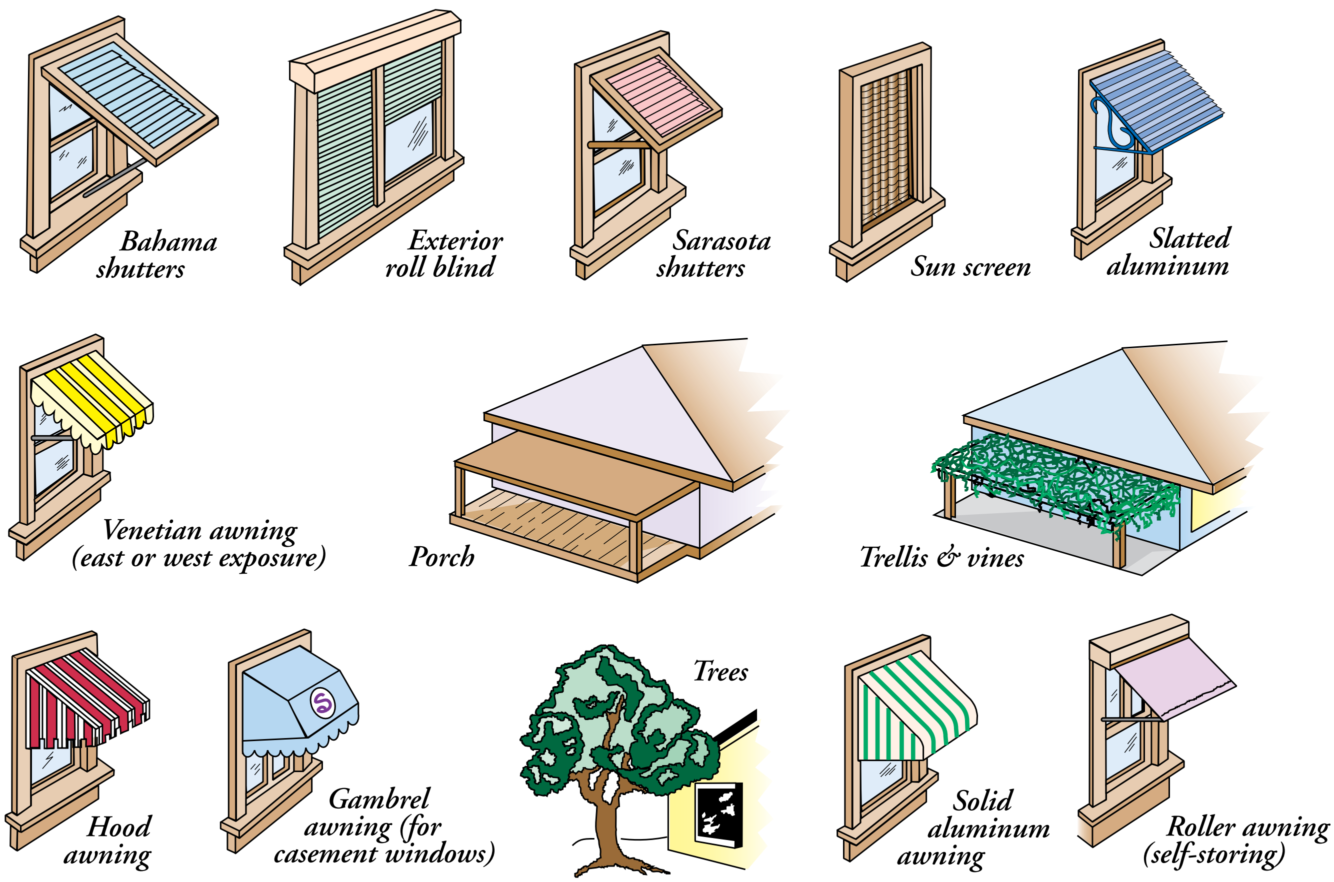


Figure 3. A variety of exterior shading devices is available to block the sun before it reaches the glass.

Specialized Window Options

If the use of exterior and interior shades is unacceptable, there are other options that can be selected in the window *itself* to reduce (though not necessarily eliminate) solar gain effects. These options can be effective even if interior shades are installed too.

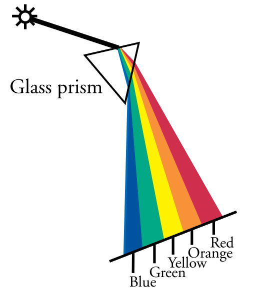


Figure 5. Colors of the visible spectrum.

One way is to choose a "spectrally selective" glazing system for the window, using specially tinted glass or coated glass that blocks much of the solar gain without adversely affecting the view through the window. To understand this option requires some knowledge of the solar spectrum.

An early experiment in optics (Sir Isaac Newton, about 1723), diagramed in *Fig. 5* revealed that white light is composed of a rainbow of colors, spanning what is called the "visible portion of the solar spectrum." The complete solar spectrum is plotted in *Fig. 6*, showing that the visible portion contains less than half the energy of the total solar spectrum. All of the solar spectrum produces heat when absorbed by interior surfaces, but only the fairly narrow visible portion produces the sensation of vision. The rest is *invisible* radiation. This includes what are called *infrared* and *ultraviolet* radiation. Neither of these wavelength bands contribute to vision and cannot be called light.

The visible transmittance of glass is simply the fraction of incident light transmitted by the glass to the interior. It has the symbol *VT* (or *T*) in window product literature and is a number ranging from 0% to 100% (or 0 to 1.0 in fractional terms). "Spectral selectivity" denotes the ability of glass (or its coating) to transmit radiation in a tailored way over the spectrum. In this document, the principal applications of spectral selectivity are two: the transmittance might be high over the whole solar spectrum but low outside this region, or it might be high over just the visible spectrum and low everywhere else.

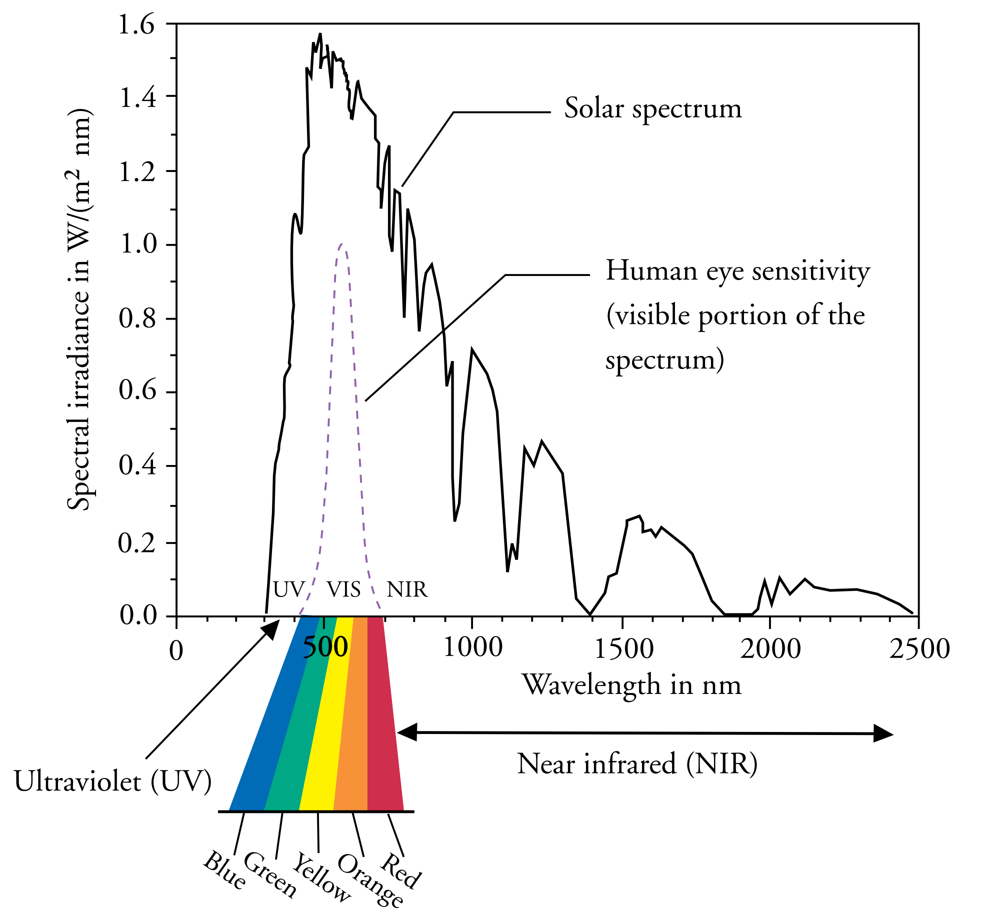


Figure 6. Comparison of the solar spectrum to the human eye color sensitivity.

The total energy spectrum extends well beyond the solar spectrum limits, and all warm objects radiate some energy outside the solar spectrum. A special kind of glass coating called *low-emittance* or "low-e" was developed for cold climates, to exploit the difference between the wavelengths of incident solar radiation and those much longer wavelengths of radiation emitted by warm interior objects, as shown by the blue boundary in *Fig. 7*.

Cold-Climate Window Coatings

Historically, cold climate glazings evolved into their warm climate counterparts. The transmittance of low-e coated glass is high over the solar spectrum to capture the maximum solar heat possible, but low (with high reflectance) "beyond the upper limit" of the solar spectrum, shown in *Fig. 6 (page 5)*. In a cold climate, radiation from the warm inner pane of a two-pane

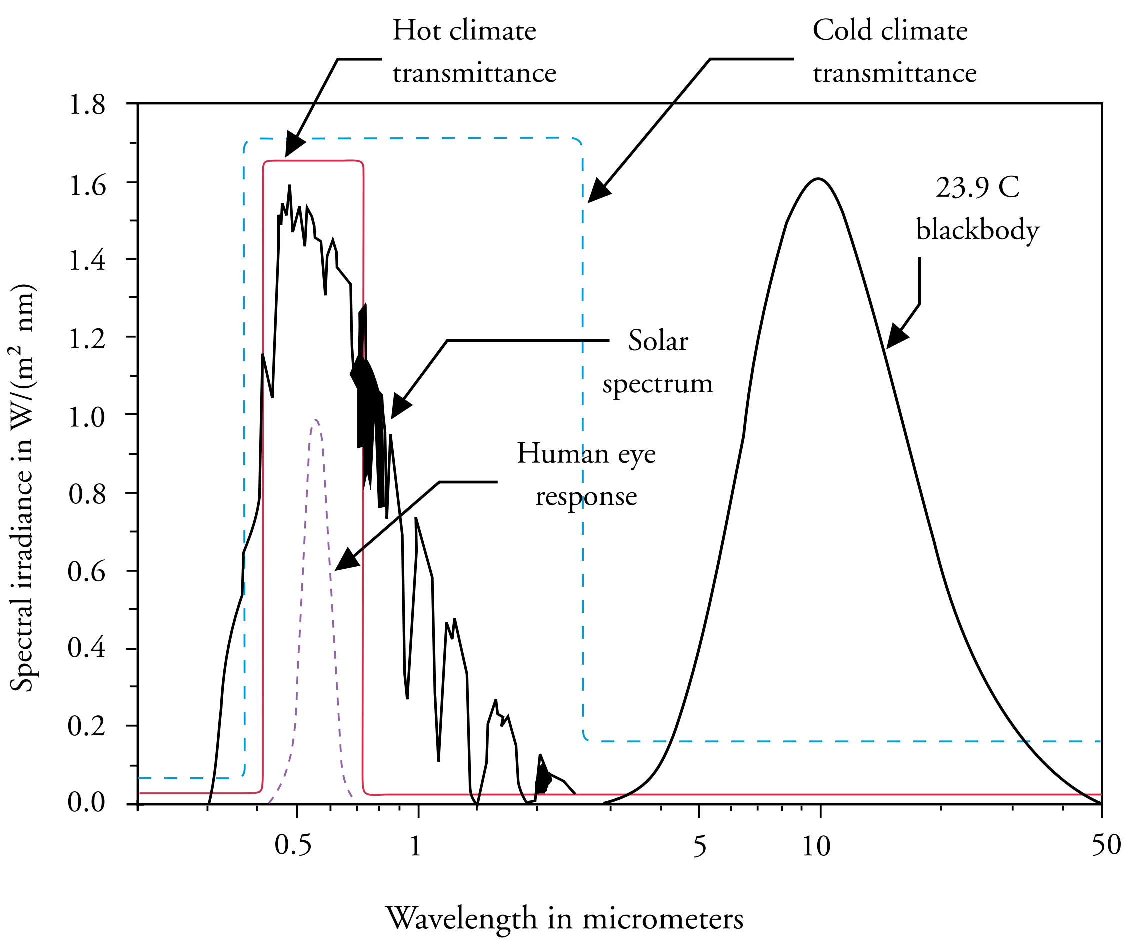


Figure 7. Solar spectrum at a window, blackbody radiation spectrum from the interior, and two idealized window transmittance spectra.

window to the colder outer pane has wavelengths much greater than those of the solar spectrum. The laws of physics tell us that this long-wavelength infrared radiation propagates between the glazings in both directions, but that the net energy flow is from the warm inner glazing across the gas space to the cold outer pane, where it is absorbed by the bare glass and then *re-emitted* to the outdoors, causing a loss of the building's interior heat.

The low-e coating was originally developed to stop this wintertime heat loss. The coating's physical properties allow this in either of two different configurations, emissive or reflective (see *Fig. 8, a* and *b*). A warm inner pane with a low-e coating (*8a*) is a poor emitter of longwave radiation to the cold outer pane, and thence to the cold outside air, thus trapping this radiant heat indoors.

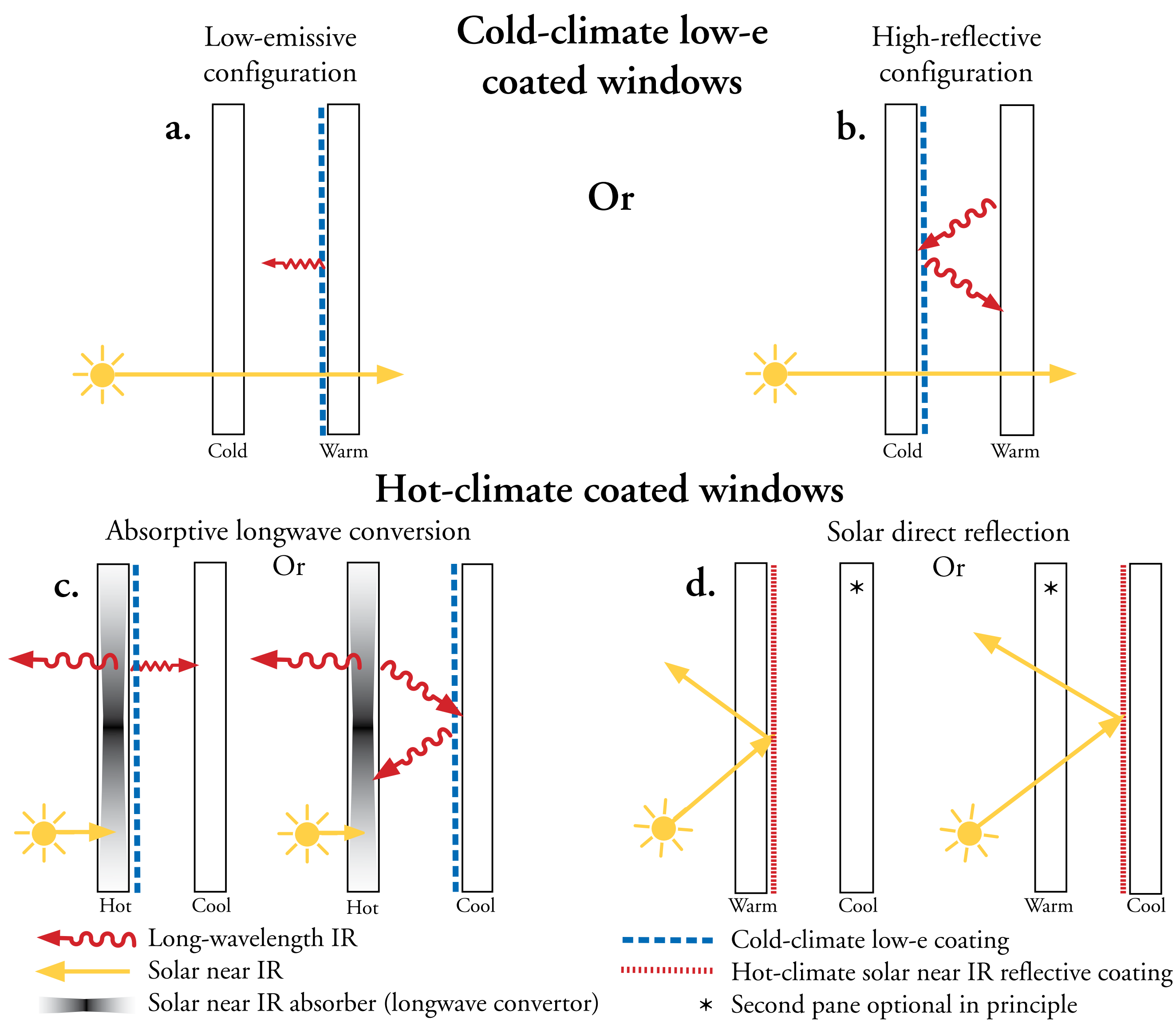


Figure 8. Low emittance coatings for radiative energy trapping or rejection.

This same energy trapping function is retained if the manufacturer places the low-e coating on the *outer* pane, facing inward (*8b*), even though that glass is colder than the inner one. The explanation here depends on the high longwave *reflectance* associated with a typical low-e coating. The longwave radiation reflects back toward the warmer glass. A common name for this longwave radiation is "far infrared" (FIR) radiation, because its wavelengths are far from the visible spectral region, farther than the "neaR infrared" (NIR) radiation that extends from the edge of the visible portion of the spectrum to the end of the solar spectrum.

Windows with conventional, cold-climate low-e coatings effectively trap radiant heat inside the building, making it warmer than it otherwise would be without the coating, and reducing the need for supplemental heating. This works great for cold northern climates, but not in sunny Florida! We might call the conventional low-e coating a "northern low-e" one, or more accurately a "cold-climate low-e coating" (to include our southern hemisphere neighbors in this discussion, where southern latitudes are the colder ones). Another name for this coating is "high solar gain low-e."

In summary, typical cold-climate low-e coatings emit poorly and reflect well in the far infrared region of the spectrum; their reflectance is made to change from high to low between the solar spectrum and the FIR, admitting solar radiation to warm the interior while trapping radiant heat inside.

Hot Climate Glazing Systems

The low-emittance principle can also be applied to a "hot-climate glazing system." (The "system" in this case combines a specific glass, plus coatings.) The newer glazing system has been developed to meet the needs of Floridians and others living in hot climates (who, on an annualized basis, want to *exclude* solar energy, not trap it inside).

Ideal hot - and cold - climate spectral transmittances are contrasted in *Fig. 7 (page 6)*. Crucial to the difference between them is the choice of the exact wavelength at which the transmittance departs from its "low" value at longer wavelengths (to "high" at shorter ones). This illustrates an application of the general spectral selectivity principle. The end effect is to reduce the transmittance of near infrared radiation, lowering solar gain, but without a loss of visible transmittance.

The hot-climate transmittance is high *only* over the visible portion of the solar spectrum. The remaining infrared radiation, which makes up over half the total solar radiation, is blocked from entering the building.

The terminology in this case is "hot climate glazing system with low-e coating(s)." Another generic term used for this class of glazing system is "low solar gain low-e," but this terminology can be misleading because the "low-e" quality extends over different spectral regions in the two different low-e coating types, as described in the following two sections.

Spectral Selection by Absorption

One way of achieving hot-climate solar NIR rejection is by spectrally selective *absorption*, as illustrated in *Fig. 8c*.
An uncoated sheet of glass is selected that has high absorptance over the near infrared portion of the solar spectrum but good transmittance over the visible portion. As a result, such glass will absorb much of the solar NIR radiation and heat up. But being spectrally selective, much more solar energy is absorbed outside the visible spectrum than inside it.

In order to protect the interior of the building from the heat conducted and convected away from this hot glass, a second pane must be added on the interior side, with an insulating gap in between. The result is a double- pane insulated glazing unit (IGU) with a spectrally selective absorber for the outer pane. It helps if a cold-climate low-e coating is added to the outer pane's inner surface. The reason for this apparent paradox of mixing cold- and hot-climate techniques is to reduce the infrared re-radiation from the hot outer glass to the cooler inner one. The result of this combination (*Fig. 8c*) is *just the opposite* of that for the cold-climate low-e coating; it is not to *trap* heat inside the building but to protect the inner pane of glass from the heat of the outer one, thus keeping solar heat out of the building. If an insulating gas is also used between the panes, the system works even better. This arrangement offers a good way of achieving a high overall spectral selectivity for hot climates.

In two-pane glazing systems, the four glass surfaces are conventionally numbered from the outside in. Thus, the coating can be placed on either surface 2 or surface 3 as shown in *Fig. 8c*. Note that if this absorbing type of hot-climate glazing system is flipped over, with the inside now facing the outside, the result is a good window for a cold climate. For more information about this clever window design, see the sidebar on flip windows page 12.

Spectral Selection by Direct Solar Reflection

There is a second basic way of rejecting the solar NIR radiation — by working directly on this radiation without converting it to heat first. In this approach, the rejection is achieved by a new type of coating rather than by absorption in the glass. This coating is made to have a high reflectance over the solar near IR. The transmittance of this coating is high over the visible portion of the spectrum for good view and daylight admission, but low over the NIR to reduce solar heating of the interior. See *Fig. 9*.

Window for hot climates

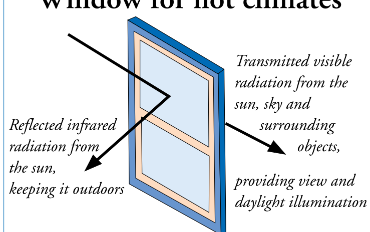


Figure 9. A window with Spectrally selective optical properties for hot climates reflects the NIR coponents of incident solar radiation while admitting visible radiation.

Soft Coatings

The best-performing of the hot-climate coatings is made with a process that results in the coatings being relatively soft. In consequence, they cannot be placed on the outside of the window glass — exposed to rain and weather — nor on the inside of the uncovered glass, since washing the windows could damage them. As a result, these highly spectrally selective soft coatings are put inside a two-pane sealed glazing unit, to protect them from damage. The added insulation of the permanently trapped gas in the gap has other benefits as well. These benefits are described subsequently, as are the liabilities.

Manufacturers place coatings on the surface anticipated to have the least thermal stress for the application.

Hard Coatings

Some manufacturers sell tougher coatings (now typically manufactured by a lower-cost *pyrolytic* process), but their spectral performance is generally not quite as good as that of the softer coatings. With just a little sacrifice on the energy performance, however, choosing a single-pane window with a hard coating is a good option in the Florida climate. Single pane windows are not as costly as double pane ones. As the technology of making these coatings advances, so too will their energy performance, causing them in many ways to approach the ideal.

If one of these hard coatings is used, then the second pane becomes functionally optional — it is not required for this principle to work. But because present-day hard coatings have far from ideal NIR reflection characteristics, the glass under them gets somewhat hot and a second clear pane is still added to isolate this heat from the interior and its occupants.

Coating Terminology

The term "low-e" clearly needs qualification, especially when its hot-climate applications are added. For the cold-climate version, it is only required that the coating's emittance be low (*Fig. 8a*), or equivalently, its

Terminology - *continued on page 15*

Cost Incentives

One can expect to pay more for an energy efficient window or shading system. The extra initial cost will be offset by savings on the monthly energy bill. After-the-fact window upgrades always entail a price premium. The payback time is the time it takes for these savings to equal or exceed the extra cost of the better windows. (Dividing the initial cost by the annual dollar savings yields the simple, as opposed to discounted, payback time in years.) Payback times of only a few years can be very compelling to a homeowner, especially when it is pointed out that the window lasts, and continues to save money, for many more years into the future. One can even get special mortgages for energy-efficient homes and special home improvement loans for energy efficient replacement windows.

Other incentives are available from time to time. Sometimes electric utility companies offer financial or other incentives for selecting energy-efficient windows. Whatever discounts, subsidies, or rebates are available, the total net cost to the homeowner, including installation costs, should be divided by the anticipated monthly energy savings when computing payback time. More sophisticated measures of life-cycle costs are available, but a good simple payback time is likely to be reflected as also favorable when other, more accurate, life-cycle costs are calculated.

As mentioned, better windows and shades can make it possible to install a smaller air conditioner (A/C). In this case, some or all of the extra cost of the better window can be offset by the reduced air conditioner cost. There are cases where the reduced A/C cost more than pays for the extra window costs, making the payback time zero. The window has paid for itself the instant it is installed in such cases, and all future energy savings are completely free of cost.

The homeowner pays energy bills monthly. During times of peak electrical demand, such as during a nighttime winter cold front or on a very hot summer afternoon, the homeowner pays the same rate per kilowatt hour of electricity as at other times. It costs the electric utility more, however, to produce peak load power. Some utilities provide incentives to homeowners for installing devices or using strategies that reduce their peak electrical demand. For windows, this usually means insulated windows that also limit solar gain. The energy economics of windows, therefore, is not easily determined by the homeowner alone. Some assistance in determining window costs and savings is provided on the Efficient Windows Collaborative web site listed at the end of this publication. After-the-fact window upgrades always entail a price premium.

Peak load is a relative term. It does not occur uniformly for all members within a power sharing community. Your domestic peak load may not coincide with your community's peak load, especially in mixed residential/commercial regions. Air conditioner sizing is relative too. It need not amount to the same heat pumping requirement from identically built houses. Air conditioner sizing depends on your lifestyle.

Only the utility itself experiences the aggregate peak demand of the local area. (Minor peaks may appear in addition to the major one.) During Florida's relatively few winter cold snaps, efficient hot climate windows slightly worsen the daytime peak load to the utility by admitting less radiant solar heat to warm the interior.

Other Selection Factors

Energy costs are not the whole story, since a window provides far more than just energy control. The valuable assets of better visual and thermal comfort, aesthetic design, natural daylight, and acoustic isolation are often more important to the homeowner than just a window's energy costs. These features, not easily given dollar values, are difficult to combine with a window's cost accounting in the decision-making process. The homeowner knows their value, however, and may even be able to assign a personal monetary value to them. Though most Florida homeowners are very conscious of initial price, they can often be persuaded to pay the extra cost of a better window when it combines lowered energy bills along with the other less tangible assets.

Fortunately, most comfort and aesthetic features of a window are compatible with good energy conservation as well.

It is important to realize that a window can be expected to last many years. Future energy prices cannot be predicted with clarity, though few believe they will drop. An investment today in energy efficient windows can be a valuable hedge against energy price inflation, sheltering the homeowner against future price increases. Installing better windows can be thought of as a form of insurance. They protect us from future economic fluctuations that might make a home much more expensive to operate.

Providing the homeowner with an energy-efficient window that also lowers the electric load of the home during peak hours benefits everyone. The window seller benefits through the higher profits generated by selling more expensive windows. The homeowner benefits through lowered electric bills. The utility benefits through lowered peak loads. Society benefits through reduced air pollution emissions at the power plant and from the resulting cleaner air for all of us.

Window Performance Indices

The solar heat transmittance of a window is measured by the *solar heat gain coefficient*, or *SHGC*. This is the fraction of incident solar radiation that enters the building as heat gain by all mechanisms. Also, the fraction of sunlight, skylight, and reflected daylight incident on a window that enters as light is measured by the *visible transmittance*. Hot-climate glazing systems are normally intended to make the window pane high in *VT* while low in *SHGC*. The ratio of these two performance indicators is called the *light-to-solar-gain* ratio, or *LSG*

$$\mathrm{LSG} \quad \frac{\mathrm{VT}}{\mathrm{SHGC}} .$$

In general, the higher the *LSG,* the better the hot-climate performance, with the emphasis being on lowering the SHGC value. *LSG* numbers greater than 1.0 should be chosen, and those exceeding 1.5 offer the best protection from the heating rays of the sun while still providing good views of the outdoors and letting in plenty of daylight.

The *LSG* value is seldom published by manufacturers, nor does it appear directly on window energy labels. To calculate it, divide the visible transmittance of the glazing plus frame by its solar heat gain coefficient — two characteristics specified by the NFRC that *are* published by reputable window manufacturers.

If a window manufacturer does not publish *SHGC* values, but instead the older *shading coefficient*, *SC*, the results usually will be little different if *SHGC* is replaced by *SC* in the above formula. There is a *caution* in this, however. The NFRC values for both the *VT* and the *SHGC* apply to the whole window, including opaque framing elements. It is an area-weighted sum of the transmittances of all parts of the window, including glass, opaque frame, and semi-opaque parts. Thus, the visible transmittance value used in calculating the *LSG* above should be the NFRC standard one (for the whole window). When using *SC* in the denominator of the *LSG* equation, however, the numerator should contain the visible transmittance of the glass only.

High-*LSG* glass provides the best energy and comfort performance in Florida buildings. The extra cost for such glass can often be offset by smaller air conditioners (reduced peak load) and lower monthly electric bills (reduced average energy use). Since high-*LSG* glass is most often offered only in double pane models, the extra benefits of double pane windows are a bonus.

The solar gain could always be reduced still further by lowering *VT*, while keeping *LSG* the same. This should not be overdone. A *VT* below about 0.3 to 0.35 would look somewhat extreme.

Flip Windows for Improved Winter Performance

The double pane absorptive glazing system for hot climates has a useful feature for regions with pronounced seasonal swings in climate: if the positions of the two glass panes are flipped over from their summertime positions during the cold winter, the system converts to a solar radiant heater. In the cold-day position, solar radiation passes through the clear outer pane and is absorbed by the inner one, which heats up and dumps most of its heat to the interior, warming the building. The low-e coating on the inner pane now reduces the radiation of heat from this hot inner pane to the cold outer one, trapping the heat inside. Flipping it back over makes it a hot-climate glazing system since the solar heat is now absorbed in the outer pane of glass which is insulated from the interior of the building. (The glazing serves as either a hot- or a cold-climate system depending on its orientation.) A measure of performance for a flip window is the *asymmetry index,* the ratio of the winter and summer SHGC's

$$J = \frac{SHGC_w}{SHGC_s}.$$

"Flip windows" are manufactured and sold in several areas, including Europe, mainly to aid in cleaning the outside of a window from the inside, especially useful in high-rise apartments. Such a flippable window, equipped with a hot-climate glazing system based on spectrally selective absorption in one of the two panes, can save energy in both hot or cold seasons. The sub-tropical Florida peninsula does not experience true extremes in summer/winter climates, but the worldwide application for flip windows is substantial. *J*-values of 2.3 have been achieved.

Weather Damage Protection

Damage from hurricanes and other severe weather has led some Florida counties to require impact-resistant windows. The new Florida unified statewide building code requires impact resistant fenestrations in counties having highest susceptibility to damage.

One way of achieving this goal is to use laminated glass panes. Such panes consist of two sheets of glass stuck together with a layer of polyvinyl butyral. At least one manufacturer offers such a glazing system with a spectrally selective (not a conventional low-e) hot-climate coating sandwiched in the middle of the laminated glass. Other manufacturers are expected to follow with similar or alternate means of reducing the SHGC (without overly reducing the VT). In addition to the damage protection provided, this is an excellent way to achieve some of the benefits of a spectrally selective coating without having to resort to full double-pane windows just for solar gain control.

The other accepted way to meet the damage protection requirements of the building code is with exterior shades and shutters that can be drawn or rolled tightly over the window, protecting it in times of severe weather. This option has the benefits for energy conservation detailed previously for shading devices.

Since *some* form of damage protection is required in much of Florida, alert homeowners will compare the relative costs of damage-resistant glazing versus attached exterior shades or shutters. This comparison, to be complete, should include the price of reduced air conditioner installation and the annual saved energy costs for the two as well.

More on Shades

No matter how good the window, if it faces east or west and is not adequately shaded, it can produce serious glare, peak A/C loads, and localized over-heating problems inside the building. The localized over-heating can make the areas affected very uncomfortable for residents. These are the reasons that the use of shading devices was discussed so extensively at the beginning of this Energy Guide.

As described previously, exterior shades are more effective than interior ones. Shades located on the room side of the window heat up when the sun shines on them, even if they reflect *some* of the incident sunshine back out through the window. In consequence, they can still admit a lot of heat into the building, making the room less comfortable and causing the air conditioner to work harder. Shades located outside, however, release nearly all of the solar heat absorbed by them to the surrounding air and outside objects. For this reason, it is much more effective to block incident solar heat *before* it reaches the window.

Interior shades are most effective if they have high reflectivity over the whole solar spectrum on the outward-facing side. This means that the outside appearance of such shades will be either bright white or shiny. The inward side can be just about any color, texture, and pattern wanted. If the outside appearance of the shade is mirror-like or excessively shiny, this can be an aesthetic problem to some people, so it is probably best to have a "duller," diffusely reflecting white shade.

Some shades offer a partially or fully trapped air space between the outward- and inward-facing sides, and should better keep the heat that is absorbed by the shade's outer surface away from the interior air. This reduces the load on the air conditioner and makes the shade more comfortable to sit near. (For best results with such shades, the edges should feather seal to the edges of the window, trapping the warm air between the shade and the window. In this case, the heat so trapped has a better chance of being conducted through the window to the outside.)

Window Orientation and Shading

The windows chosen for a house should reflect the *individual* outdoor conditions in the directions they face. An exterior that is generally dark, for example, with reduced views of the sky and the sun, probably requires high visible transmittance glass to provide good view and to admit reflected daylight. Although a low SHGC is generally desirable, it is less important in this case due to the lesser solar radiation incident on the window.

If, on the other hand, the window looks out onto clear open sky and brightly reflecting surrounding objects, it is best to have a lower visible transmittance, and as low a *SHGC* as possible. (High-LSG glass is *not* the primary goal here.) Again, adding shades to the window can moderate this sky brightness, reducing the need for the low transmittance and low *SHGC* glass. Well-shaded windows probably do not benefit greatly from high-LSG glass, so the extra cost of this glazing feature can be avoided with such windows. When choosing *operable* shades, however, it is best to select high-*LSG* glass for protection during the times when occupants forget to, or choose not to, close the shades.

Green Windows

Many consumers seem willing to pay more for a product labeled "green." The achievement of a claim to environmental friendliness, as judged by an independent agency, can do wonders in the marketing of energy-efficient windows.

The "green buildings" movement is based on a presumption that energy efficient buildings are good for the environment. Of course if the number of buildings increases more than their efficiency, the net impact on the environment is negative. On an hypothetical basis at least, it is clear that by saving energy, a building would be responsible for less air and water pollution at the power plant, less depletion of fossil fuels and its attendant consequences (or reduced adverse consequences of nuclear power production), and reduced emissions of certain gases. The latter means smaller contributions to the inadvertent climate modification that has been linked to global warming. These benefits, therefore, would also accrue from any energy efficient windows present in a building.

Against these benefits must be balanced the extra energy and materials costs required to manufacture high performance windows. One way of viewing this environmental impact would be to claim that the extra environmental costs attributable to the manufacturing of energy-efficient windows are more than balanced by their environmental life-cycle savings.

Such arguments are prone to errors and misrepresentations, but are currently popular in today's culture. If you desire to market or promote energy-efficient windows as "green," at least be mindful of the words of Chris Hayhurst, writing in "Look for the Label" in the May/June 2000 issue of *E MAGAZINE*.

> "Still, don't just dash into the store and fall for every 'environmentally friendly' label you see. Not all claims of environmental or social good are legitimate. A general rule: If the label comes directly from the manufacturer or from a private trade association, proceed with caution. It may be a 'greenwashing,' unjustified environmental claims. On the other hand, if the label has been awarded by an independent, third-party program with no vested interest in the product itself, it's probably for real."

Summary Recommendations

In selecting windows for the Florida home, the first thing to consider is their orientation relative to the points of the compass. In new construction, this leads to a few simple recommendations.

- ★ Minimize east - and west - exposures, which are difficult to shade early or late in the day.
- ★ Don't worry too much about north - facing windows (the glazing recommendations below should be sufficient).
- ★ Use a reasonably-sized roof overhang to protect south - facing windows and a modest one on the north side.
- ★ Keep natural shading. Don't cut down shade trees prior to construction. Locate the residence to take free advantage of tree shading, especially from their upper canopies.

Experience has shown that the best exterior shade for east - or west - facing windows is a tall tree full with leaves. If it is some distance from the building, it will provide a nice scene to view when the sun is on the other side of the house. It will also block low sun early in the morning or late in the afternoon. Blocking the sun's rays before they reach the window is the most effective preventive strategy that can be used. Nature is the best landscape architect. (Deciduous trees are an effective shading device for south-facing windows in climatic zones with substantial winter/summer temperature differences. They provide good shade in summer but drop their leaves in winter to admit solar radiation into the dwelling. Deciduous trees are of less pronounced benefit for Florida, however, due to our mild winters and high summer sun angles: for south - facing windows, direct summer sun is easily blocked by roof overhangs.) For guidance on roof overhangs, see FSEC publication "Roof Overhangs and Solar Time," R. McCluney, FSEC-RM-5-80, (Supplement to "Sun Position in Florida," FSEC-DN-4-83, Rev. March, 1985.

If east - or west - facing windows cannot be avoided, either because the building already exists or because the best views are in those directions, then follow our graduated recommendations for protecting them, and the occupants, from the heat and glare effects of direct sun entry into the house. In these recommendations, tall exterior trees, separated from the house, were emphasized first; the remaining recommendations follow.

- ★ The next best outdoor shade for east - or west - facing windows is a tall existing building, opaque fence, tall and densely foliated hedge row, or possibly an overhead trellis filled with green vines. Then comes the large variety of awnings and other exterior shades attached to the window, as shown in

Fig. 2. If effective shading already exists for the windows, uninsulated windows with single pane clear glass can be purchased. Exterior shades have the value that heat absorbed by them is carried away by the winds and radiation, and doesn't heat up the house as much as an interior one might do.

- ★ The next best shade is a brightly-reflecting operable interior shade that can be closed to reflect unwanted solar heat and glare, and opened for good views and daylight access.
- ★ The final choice to be made is the kind of glazing for the window. If moderate amounts of direct-beam sunlight can reach this glass during the hottest parts of the day, then high-LSG glass should be used in this window, preferably single pane, if such a product is available. If the high-LSG value chosen is only available in a soft-coat IGU, the homeowner will have no choice but to use an IGU. These double-pane insulated windows may be desired for other reasons, such as improved comfort on cold nights or hot days, to reduce the size and cost of the air conditioning system, for acoustic isolation, or to protect against possible future added costs from the utility company if clear, single-pane glass were used. (If the building was built before the new costs or other penalties for using uninsulated windows are imposed, the building may be "grand-fathered" in — exempted from the new requirements.)
- ★ Finally, note that although plastic, applied window films are a common retrofit choice for moderating glare and overheating problems on east - and west - facing windows, they are less effective than the previous recommendations. In order for them to block sufficient solar heat, they generally are quite dark, and have low visible transmittances. If they are dark enough to provide effective shielding from the glare and heat of direct sunlight, they may be so dark when the sun is on the other side of the house that they badly degrade the view. Of course, window film manufacturers are continuously improving the films' spectrally selective performance, and window films applied to single pane clear glass can have LSG ratios a little greater than 1.0, but these latest products may not be widely promoted by retailers — possibly for reasons of cost.

If the homeowner is considering window film, it is important to realize that some window manufacturers void their warranties if window films are applied to their products. The main reason is that most window films accomplish their solar glare reduction by absorbing solar radiation inside the film, causing it to heat up. Some of the heat in the film will conduct to the glass on which it is applied, causing this glass to expand. If it expands enough, stresses can build up in the window and cause it to fail, most often through a shattering of the glass.

To see comparisons of some energy-savings for different window types in Miami, Tampa, and Jacksonville, visit the web site of the Efficient Windows Collaborative at http://www.efficientwindows.org. This site also offers a special fact sheet, "Selecting Efficient Windows for Homes in Florida," that can be downloaded and printed. Computer software for making such calculations is described at http://www.efficientwindows.org/software.html.

Terminology - *continued from page 9*

reflectance high *(Fig. 8b)*, over the far infrared portion of the spectrum. The emittance can vary outside that particular range. Indiscriminate use of the term "low-e" can lead to misunderstanding because the exact lower wavelength at which the emittance departs from its "low" value, as the wavelength decreases, is crucial to the different cold/hot applications of the low-e principle. (Equivalently, in terms of the reflectance, for the hot-climate version the reflectance must be high over both the NIR and FIR regions.)

For More Information

"Choosing the Best Residential Window Options for the Florida Climate — Guide for Florida Homeowners," R. McCluney and P. Jindra, FSEC Energy Note: FSEC-PF-359-00 (to be published). Contact the Efficient Windows Collaborative, Alliance to Save Energy, 1200 18th St., N.W., Suite 900, Washington, DC 20036 (Phone: 202-857-0666) and visit the fenestrations web site of the Florida Solar Energy Center at http://www.fsec.ucf.edu/~fen/. This publication and others can be found there as well. The following somewhat more technical publications are available from the Florida Solar Energy Center Publications Office.

"Low-E and Other Coatings and Glass Tints for Window Glass," R. McCluney and P. Jindra, Florida Solar Energy Center Technical Note: (FSEC-PF-359-00) (to be published).

"Rebuilding for Efficiency: Improving the Energy Use of Reconstructed Residences in South Florida," co-authors D. Parker, P. Fairey, C. Gueymard, R. McCluney, J. McIlvaine, and T. Stedman, December 1992, prepared for U. S. Department of Energy, Florida Energy Office, and Florida Power & Light. (FSEC-CR-562-92).

"Selecting Windows for South Florida Residences," R. McCluney and C. Gueymard, prepared for Florida Energy Office, 2740 Centerview Dr., Tallahassee, FL 32399, 15 January 1993, (FSEC-CR-577-93).

"Fenestration Solar Gain Analysis," Florida Solar Energy Center, 1 November 1996. (FSEC-GP-65-96).

"Let There Be Daylight," *Window Rehabilitation Guide for Historic Buildings*, The Window Conference and Exposition for Historic Buildings II, National Park Service, Washington, DC, 19-21 February 1997, pp. IV-45-54.

Residential Windows: A Guide to New Technologies and Energy Performance, co-authors Carmody, John; Selkowitz, Stephen; Heschong, Lisa. W. W. Norton & Company, Inc., 550 Fifth Ave., NY, NY 10110 (1996). 214 pp.

"The benefits of using window shades," R. McCluney and L. Mills, *ASHRAE Journal*, November 1993, Vol. 35, No. 11, pp. 20-26. (FSEC-PF-263-93).

"Choosing the Best Windows for Hot Climates," Ross McCluney, *Proc. Innovative Housing '93 Conference*, Vancouver, BC, Canada, 21-25 June 1993, pp. 366-375. (FSEC-PF-253-93)

"Daylighting in America. Some Practical Suggestions for Proper Usage," Ross McCluney, *Lighting Design & Application*, Vol. 15, No. 7, July 1985, pp. 36-38. (FSEC-PF-88-85).

"A Daylighting Checklist," Ross McCluney, *Solar Age Magazine,* April 1985, p. 84.

Some of these papers, and additional information including this Energy Note, are available on the FSEC Fenestration Web site: http://www.fsec.ucf.edu/~fen/

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