Homeowners Guide to Choosing the Best Residential Window Options for the Florida Climate
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This document is being prepared to help Florida homeowners choose the best window options for their homes and other buildings. It provides information concerning proper window and shade selection in Florida's generally hot, humid climate. A more detailed document, "Industry Guide to Choosing the Best Residential Window Options for the Florida Climate" is available online at http://fsec.ucf.edu/download/br/fenestration/publications/industryguide.pdf.

If you are building a new home you will be investing a substantial amount in the windows for that home. Perhaps you will be installing new windows in an existing home, or are considering shading options to ameliorate problems with glare or discomfort from the sun's overheating of your existing home. With the sizeable investment you will be making, it is important to take some time to make the right choice in orienting the building (when that is an available option) and shading the windows (when this is also possible).

The variety of windows on the market is large, and prices vary considerably. There are other choices to make as well, such as which way to orient the windows if the home hasn't been built yet, and what shading options are best. The information contained in this Energy Note is intended to help you make wise choices in these areas.

Also available on the FSEC web site are additional tools which you can use to guide your specific choices. Some are under development but will be posted in draft form at this "download" site as they become available.

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 time periods. In some cases they can be shown to *out-perform* insulated walls on this basis. Of course they have the priceless additional benefits of providing views to the outdoors and natural daylight illumination of the indoors. These are strong 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, the outdoor air temperature and humidity vary, and the wind and rain come and go. If this can be achieved while reducing the building's energy use, lowering monthly utility bills, then so much the better. This publication was written to help you achieve these goals when choosing windows for your home.

Windows are not quite as simple to select on the basis of their energy performance as refrigerators, microwave ovens, and automobiles. They 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 when they admit solar radiant heat into a 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.

Reducing the energy costs associated with windows while increasing their savings is a real challenge to the building designer. Adding human comfort and aesthetic goals makes the problem even more complex. Achieving these goals depends upon many factors.

- Which way the window faces relative to where the sun comes in
- 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 relative window glare
- The homeowner's desire for acoustic isolation—in noisy environments, some isolation is desired
- The homeowner's desire and need (through building code requirements) 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 willingness to operate shading devices to achieve best performance
- Whether the window can meet aesthetic desires for appearance and quality

Basic Principles

There are some basic principles to keep in mind when selecting windows for Florida residences. Our winter space heating season is short and mild. Thus there's 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 this solar radiant heat gain that's the biggest problem in Florida, and reducing should be the primary goal for your windows.

On the other hand, there *are* a number of good reasons to select insulated windows in Florida, in addition to providing them solar gain protection too. Insulating the window with multiple panes, insulating gases, and a special coating, *can* reduce the size of the air conditioner needed to manage the building's *peak* solar heat gain (and the accompanying peak load on the electric utility).

Insulation can reduce both heating and cooling costs too. A smaller air conditioner can 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. See web site http://www.efficientwindows.org for more information on determining the energy cost consequences of various choices. Some available software is described at www.efficientwindows.org/software.html.) At some point in the future, Florida utilities may charge extra for electricity use during peak load conditions, in which case insulated and low-solar gain windows can reduce these extra costs to the homeowner.

For retrofit applications—replacing windows in an existing building—seldom is there a chance to save dollars on the air conditioner, unless you just happen to need to replace the air conditioner at the same time that you replace the windows. There are still important decisions to make. They should be grounded on a good understanding of how windows work and satisfy the building's occupants. Later sections return to the solar heat gain problem and suggest ways to avoid it.

If you decide to install insulated windows—for whatever dominant reason—you can look forward to a few extra comfort benefits 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 growth of mold and mildew. On the infrequent cold winter nights and excessively hot summer afternoons, an insulated window will be more comfortable to sit near. On the other hand, insulated windows can be subject, through seal failure, to internal fogging. The solution is expensive and inconvenient. Before purchasing a multiple pane insulated window, pay close attention to the warranty and choose a vendor expected to still be around a number of years later when the window has a problem.

Solar Dynamics and Window Shading

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, it is best to minimize window exposures toward the east and northeast and toward the west and northwest, where possible. This is accomplished by the design and orientation of the building and by shading the window, discussed subsequently. It is 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 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.

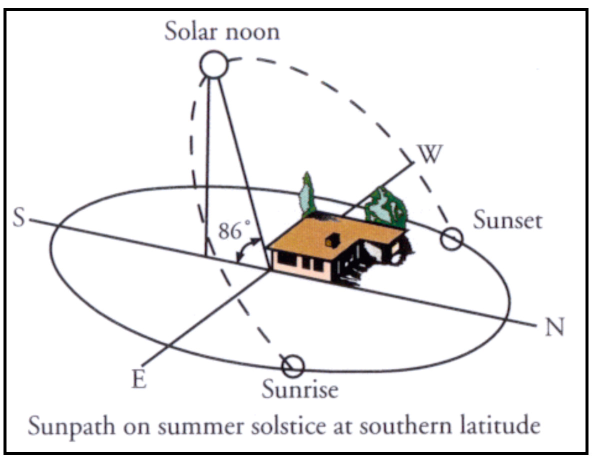


Figure 1. Solar path on summer solstice.

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 fixed exterior vertical shades on east- and west-facing windows (Fig.

3) .

Properly designed, vertical protruding shades can allow sunlight to enter from the southeast to east through east-facing windows in winter. They can admit sunlight from the southwest to west through west-facing ones. They can accomplish these desirable tasks while blocking the sun at other, hotter, seasons of the year. With this strategy of putting a “wing wall” on the window, the worst of the solar gain conditions could be avoided while

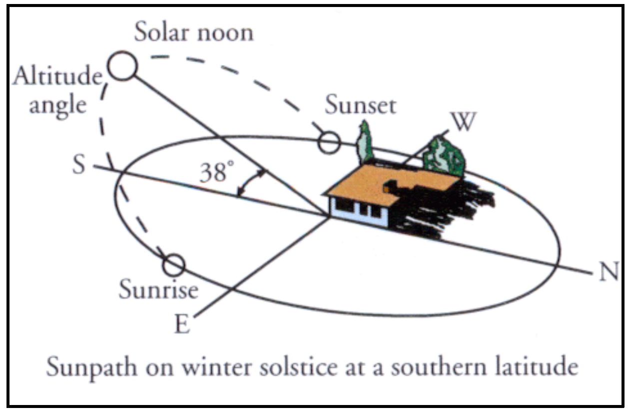


Figure 2. Solar path on winter solstice.

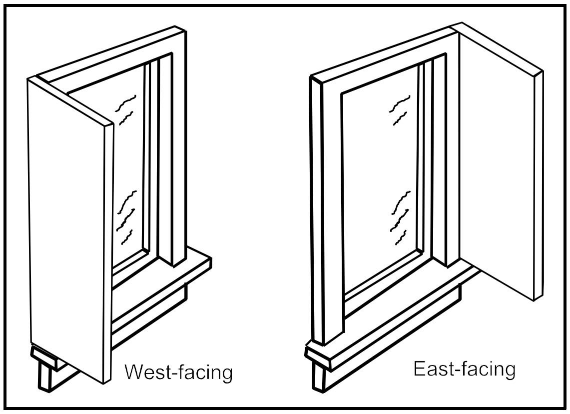


Figure 3. Wing walls for shading windows from low sun in summer, without greatly blocking the view.

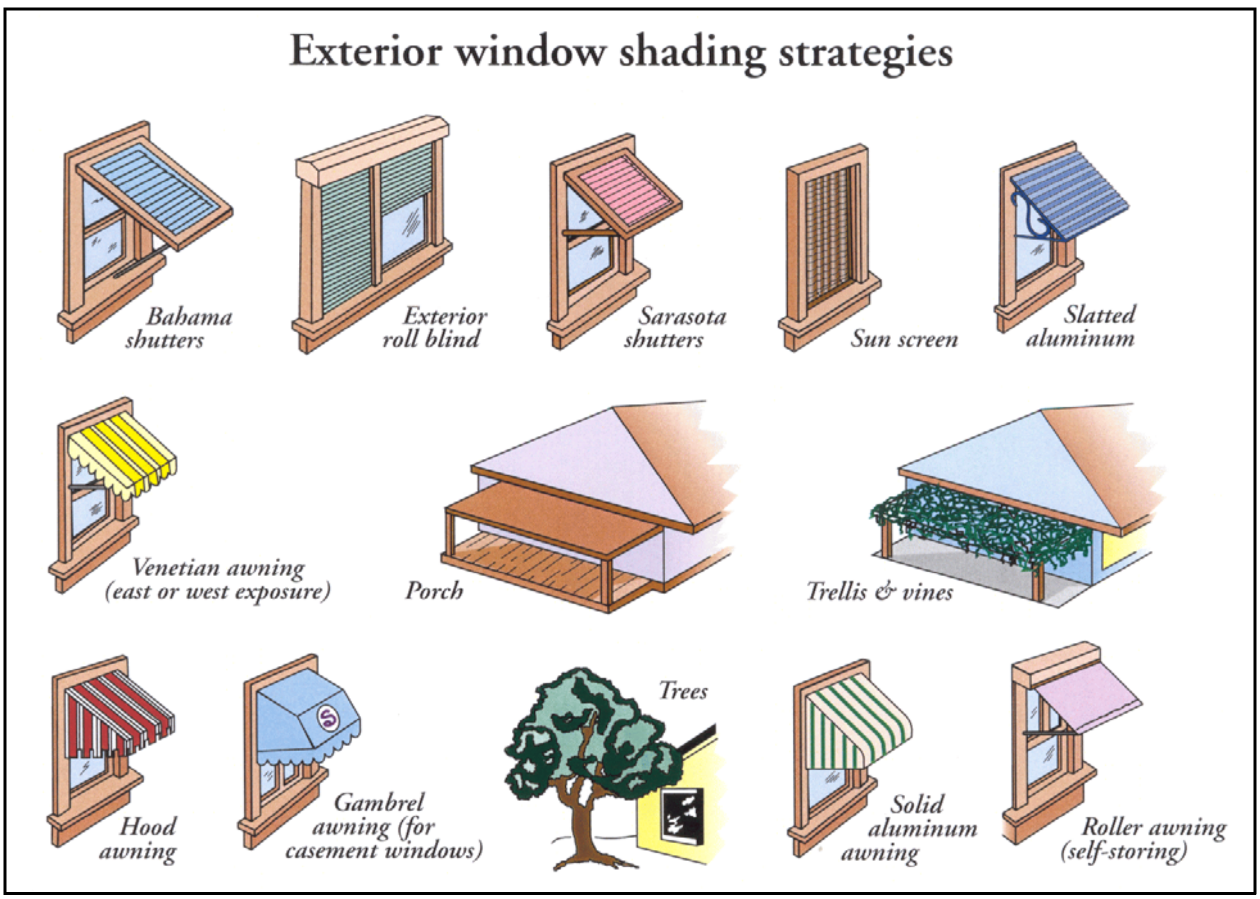


Figure 4. The variety of exterior fixed and operable shading devices is large.

still providing view and daylight illumination without the need to operate exterior shades. With Florida's warm winter climate, admission of direct solar gain, even in winter, may not be desirable for everyone, however, so other shading strategies should also be considered.

If you cannot avoid windows facing east or west, for whatever reason, then exterior operable shading devices may be the only viable way to protect them from the sun. (You might try to protect the window from the strong heat of direct sunlight low in the sky using dark window films or highly tinted glass. This might be temporarily effective, but when the sun is not shining on the glass the window may too dark to see out well and its purpose as a window will accordingly be compromised.) Exterior operable shades have the advantage that they can be pulled down to reduce solar radiant heat gain and its attendant energy costs and glare, but opened when the sun is not shining directly on the window, to provide both good exterior views and interior daylight illumination. A variety of available exterior shading devices is illustrated in Fig. 4.

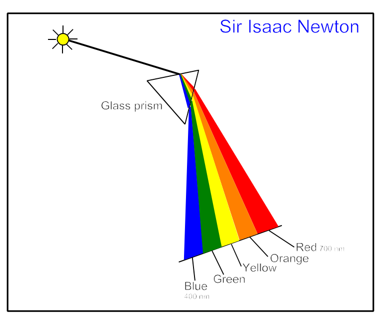
Many shade designs are available. If you cannot use *exterior* shades, consider the use of white or otherwise highly reflecting *interior* shades. For best performance they should be operable. When they are closed they can reflect a lot of solar radiation back through the window to the outside. You can draw them closed when the sun is strong and not wanted and open them when the sun is not shining on the glass and when you like access to the view and daylight.

Spectrally Selective Glazing Systems

If both exterior and interior shading are unacceptable or undesirable, there are special properties of the window itself that can be used to reduce (but not necessarily eliminate) the unwanted effects of solar overheating and glare.

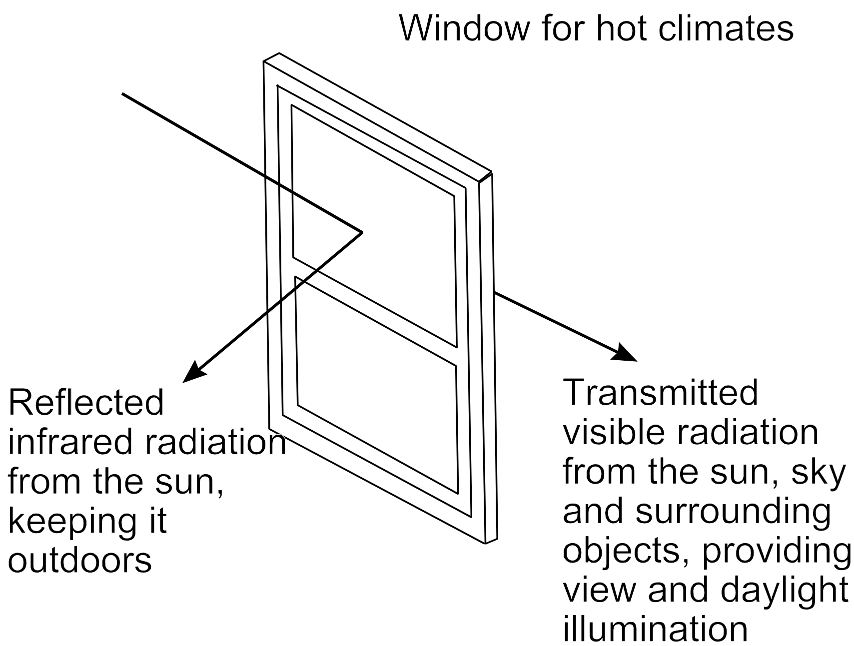
One is to choose a special "spectrally selective" glazing system for the window, using glass or a coating on it which blocks much of the solar gain, without adversely affecting your view through the window. It does this by blocking the invisible infrared portion of the solar spectrum while allowing inside the visible portion that is needed for vision and illumination. Since approximately half the total energy of the solar spectrum is in the infrared part of it, blocking this part could in principle reduce the window's solar gain by half without altering its visible transmittance, its appearance of clarity and brightness. Lowering the visible transmittance a little bit as well, reduces the solar gain still further, with little adverse effects on the visual appearance

An early experiment in optics (Sir Isaac Newton, 1723 or so) 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 of the spectrum 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 contains visible light.

of the window. This is illustrated in Fig. 5.



The visible transmittance of glass is the fraction of incident light transmitted by the glass to the interior. It has the symbol *VT* (or T_v) 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 a glass (or its coating) to transmit radiation variably over the spectrum—it might be high over the visible portion and low over the infrared portion. In this way it transmits radiation *selectively*, differently in different parts of the spectrum.

Cold-Climate Glazing Systems. A special kind of spectrally selective 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. The transparency of low-e coated glass is high over the whole solar spectrum, to capture the maximum solar heat possible, but low (with high reflectance) outside of the solar spectrum. This is illustrated by the graph in Fig. 7.

In a northern building in winter with double pane windows, radiation from the warm inner glass pane has wavelengths greater than the solar spectrum ones. This long-wavelength infrared radiation propagates from the warm inner glazing across the gas space to the cold outer pane where it normally would be absorbed and then re-emitted to the outdoors, causing a loss of the building's interior heat. The low-e coating was developed to stop this heat loss, by reflecting the long-wavelength radiation from the cold outer pane (having the low-e coating) back to the warm inner pane, preventing this heat's escape to the outside. Such a coating reflects long-wavelength radiation while still transmitting visible and solar radiation.

Windows with these conventional low-e coatings effectively trap radiant heat inside the building, making it warmer than it otherwise would be without the coating, thereby 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).

Hot-Climate Glazing Systems. An alternate and relatively new kind of "hot-climate low-e" coating was developed to meet the needs of Floridians and others living in hot climates (who, on an annualized basis, want to *exclude*, not trap, solar infrared radiation). The infrared radiation making up half the solar radiation is blocked in this case. This blocks the inflowing, heat-producing solar infrared radiation without sacrificing the admission of visible light. The result is a kind of spectrally selective "heat mirror" that reflects or otherwise blocks the heat-producing infrared radiation from the sun while admitting the visible light. This is the kind of glazing system we want for our Florida windows.

The best 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. Putting them on the *inside* of the building is not a good idea either, since washing the window can damage them. As a result, these highly spectrally-selective soft coatings are put inside a two- pane sealed glass unit, to protect them from damage. The added insulation provides the other benefits mentioned previously.

Some manufacturers are experimenting with tougher coatings, but their spectrally selective performance is generally not quite as good as for the softer coatings. If you are willing to sacrifice a little on the energy performance, however, choosing a single-pane window with a hard coating is an acceptable option.

There is another way of blocking solar infrared radiation while transmitting visible light—by spectrally selective *absorption* rather than reflection. A sheet of glass is selected which has high absorptance over the infrared portion of the solar spectrum (even without a coating applied) but good transmittance over the visible portion. As a result of this property, such glass will absorb a lot of solar's near infrared radiation and heat up. Being spectrally selective, more solar heat is absorbed outside the visible portion of the spectrum than inside it. So this glass still has good visible transmittance.

In order to protect the interior of the building from the heat emanating from this glass when the sunshine heats it, a second pane must be added on the interior side, with an (insulating) gap of air (or a better-insulating gas) in between. We end up with a double pane insulated glazing unit (IGU), with a spectrally selective absorber for the entire outer pane.

It helps if a cold-climate low-e coating is added to the hot outer pane's inner surface, to reduce the infrared heat transfer from the hot outer glass to the cooler inner one. The result of this combination is *just the opposite* that of 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, keeping the solar heat *out* of the building. This arrangement offers a second good way of achieving high spectral selectivity in a glazing system for hot climates.

The three kinds of glazing systems just described are illustrated in Fig. 6.

Glazing System Performance Measures

The solar heat transmittance of a window is measured by the *solar heat gain coefficient*, or *SHGC*. This tells the fraction of incident solar radiation that enters the window as a heat load on the air conditioner. Like the visible transmittance, *SHGC* is a number between 0 and 1. Both types of hot-climate glazing systems described in the previous section make the window glass high in *VT* while low in *SHGC.*

The ratio of these two performance indicators is called the *light-to-solar-gain* ratio, or *LSG*

$$LSG = \frac{VT}{SHGC}.$$

The higher the *LSG*, the better the hot-climate performance. *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 was seldom published by manufacturers, nor did it appear directly on window energy labels. Until its use is more widespread, you'll probably have to calculate it yourself. You divide the visible transmittance by the solar heat gain coefficient, as indicated in the above equation. *VT* and *SHGC are* published by reputable window manufacturers. (If a window manufacturer does not publish *SHGC* values, the results will not be much different if values for the older *shading coefficient*, *SC* are substituted in the above formula for the *SHGC*. However, SC applies only to the glazing, while the SHGC value is generally for the whole window. For windows with a fairly high fraction of opaque framing elements the difference can be significant. It is best, therefore, to use the SHGC value wherever possible.)

It is re-emphasized that 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 lowered monthly electric bills (reduced average energy use). Since high-*LSG* glass is most often offered only in double pane models, the added benefits of double pane windows are an added bonus.

Shades are the Best

No matter how good the window you purchase, if it faces East or West and is not adequately shaded, it can produce serious glare, peak A/C load, 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 the use of shading devices was discussed so extensively at the beginning of this brochure. As described previously, exterior shades are more effective than interior ones.

Shades located on the room side of the window heat up somewhat when the sun shines on them, even if they reflect a lot 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 should be bright white. The inward side can be just about any color, texture, and pattern you want. Some shades even offer a partially or fully trapped air space between the outward- and inward-facing sides, keeping the heat absorbed by the shade's outer surface away from the room's interior air, reducing the load on the air conditioner and making the shade more comfortable to sit near. (For maximal benefit with such shades, the edges should be sealed 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.)

Glare and Brightness Considerations for Unshaded Windows

The windows chosen for a house should be responsive to the individual outdoor conditions in the directions they face. If not otherwise shaded, windows facing an exterior that is generally dark, for example, with reduced views of the sky and all of the sun, should probably have high visible transmittance glass, to provide good view and to admit the maximum reflected daylight possible. On the other hand, if the unshaded 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* your primary goal here, however.) Of course shading can moderate this sky brightness too, reducing your need for low transmittance and low *SHGC* glass. Thus shades can minimize solar radiant heat gain and the discomfort of excessive glare or too much daylight illumination. Well shaded windows probably do not benefit greatly from high-LSG glass, so the extra cost of this glazing feature can be avoided for such windows.

Cost Considerations

Determining *the* most cost-effective option for your windows is not an easy task. The reason is that energy issues are not the only ones. If they were, things might be simpler. You would determine first the extra cost of the energy-saving features you desire for your windows. Then you would divide this by the annual dollar savings expected from lower utility bills. The result is called the "payback time." It has units of years and tells you how many years of energy savings are needed to pay off the extra cost of the energy-saving features. If this is but a few years, the choice is clear. The better windows are justified, because they pay for themselves well before they wear out, and deliver energy savings for years thereafter. It is not hard to determine the extra cost of better windows. It can be hard to determine the savings they can be expected to produce on your home in your climate. The Efficient Windows web sites cited previously can be helpful in this area.

Energy efficiency is not the only criterion you'll be using to select your fenestration options. The other benefits of your windows are likely difficult to quantify in dollars and cents. Glare avoidance, acoustic isolation, and impact resistance, for example, have important economic value. They are worth paying more for. But how much more you should pay depends upon how important they are to you. Only you can make the decision in areas such as this. With these added features, plus reduced A/C size, lowered peak electric demand, and greater thermal comfort, you are likely to be willing to pay much more for your windows and shading devices than is justified by energy savings alone. This is why it is so difficult to provide accurate and detailed advice on what you should spend for your residential fenestrations.

Summary Recommendations

In selecting windows for your Florida home, the first thing to consider is their orientation relative to the points of the compass. In new construction it is recommended that you

- minimize East- and West-exposures which are difficult to shade
- don't worry too much about north-facing windows (the glazing recommendations below should be sufficient)
- use a reasonably-sized roof overhang to protect your south-facing windows
- Nature provides good shading with trees. Don't cut down these natural shades prior to construction. Locate the residence to take free advantage of tree shading, especially from their upper canopies if not trimmed too much.

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 you with a nice scene to view when the sun is on the other side of the house. Also, the tree will block low sun otherwise directly incident on the window late in the afternoon or early in the morning. Blocking the sun's rays before they reach the window is the most effective preventive strategy you can use. Nature is the best landscape architect. (Deciduous trees are an effective shading device for south-facing windows in climatic zones with substantial winter/summer differences, appropriate for north Florida. They provide good shade in summer but drop their leaves in winter to admit solar radiation into the dwelling. Deciduous trees are of marginal benefit for the rest of Florida, however, due to its short mild winters, long hot summers, and high summer sun angles, easily blocked by roof overhangs.)

If you cannot avoid east- or west-facing windows, either because the building has already been built or because the best views are in those directions, then follow our graduated recommendations for protecting them, and you, from the heat and glare effects of direct sun entry into your house. We started with tall exterior trees, separated from the house. Now read about our remaining recommendations.

The next best outdoor shade for east- or west-facing windows is a tall existing building or opaque fence, or tall, densely foliated hedge row, or possibly an overhead trellis filled with green vines. Next comes the large variety of awnings and other exterior shades attached to the window, as shown in Fig. 3. *If you have effective shading for your windows, you can purchase uninsulated windows with single pane clear glass, unless you want insulated windows or low-solar-gain glazing for other reasons.* Heat absorbed by any exterior shade is carried away by the winds and by radiation and convection and doesn't heat up the house as much as an interior one might.

The next best shade is a brightly-reflecting operable interior shade that can be closed to reflect unwanted solar heat and glare outside, and opened for good views and daylight access. Your final choice is the kind of glazing you want in your window. If moderate amounts of direct beam sunlight (or cloud-reflected solar radiation) can reach this glass during the hottest parts of the day, then you should use high-LSG glass in this window, preferrably single pane if such a product is available. Use double pane if the high-LSG glass only comes with a soft coating that must be protected inside the sealed gas space (as described on page X), or if you desire double pane windows for other reasons, such as improved comfort on cold nights or hot days or to reduce the size, and hence cost, of your air conditioning system.

Last comes applied window films made of plastic. They are of less practical value because in order to make them block sufficient solar heat, they generally are made quite dark in appearance, with low visible transmittances. In consequence, if they are dark enough to shield you effectively from the glare and heat of direct sunlight, they may be too dark when the sun is on the other side of the house, badly degrading your view of the exterior scene. Window film manufacturers are making strides in improving their spectrally selective performance, and window films applied to single pane clear glass can have LSG ratios a bit greater than 1.0, but these latest products may not be widely promoted by retailers, possibly for reasons of cost.

Sidebar:
If you are considering window films, it is important to note that some double-pane window manufacturers void their warranties if window films are applied to their products. The 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.

If you want to see some energy-savings comparisons for different window types in Miami, Orlando, and Jacksonville and you have access to the world wide web, you can visit the Efficient Windows Collaborative. The site address is http://www.efficientwindows.org. This site also offers a special fact sheet, “Selecting Efficient Windows for Homes in Florida,” that you can download and print out. For more information on selecting windows for hot climates, contact the Efficient Windows Collaborative, Alliance to Save Energy, 1200 18th St., N.W., Suite 900, Washington, DC 20036 (Phone: 202-857-0666). A variety of publications is available from the Florida Solar Energy Center Publications Office, or accessible from the Center’s web site http://www.fsec.ucf.edu. It’s fenestration site may also be of value: http://www.fsec.ucf.edu/bldg/active/fen/index.htm.