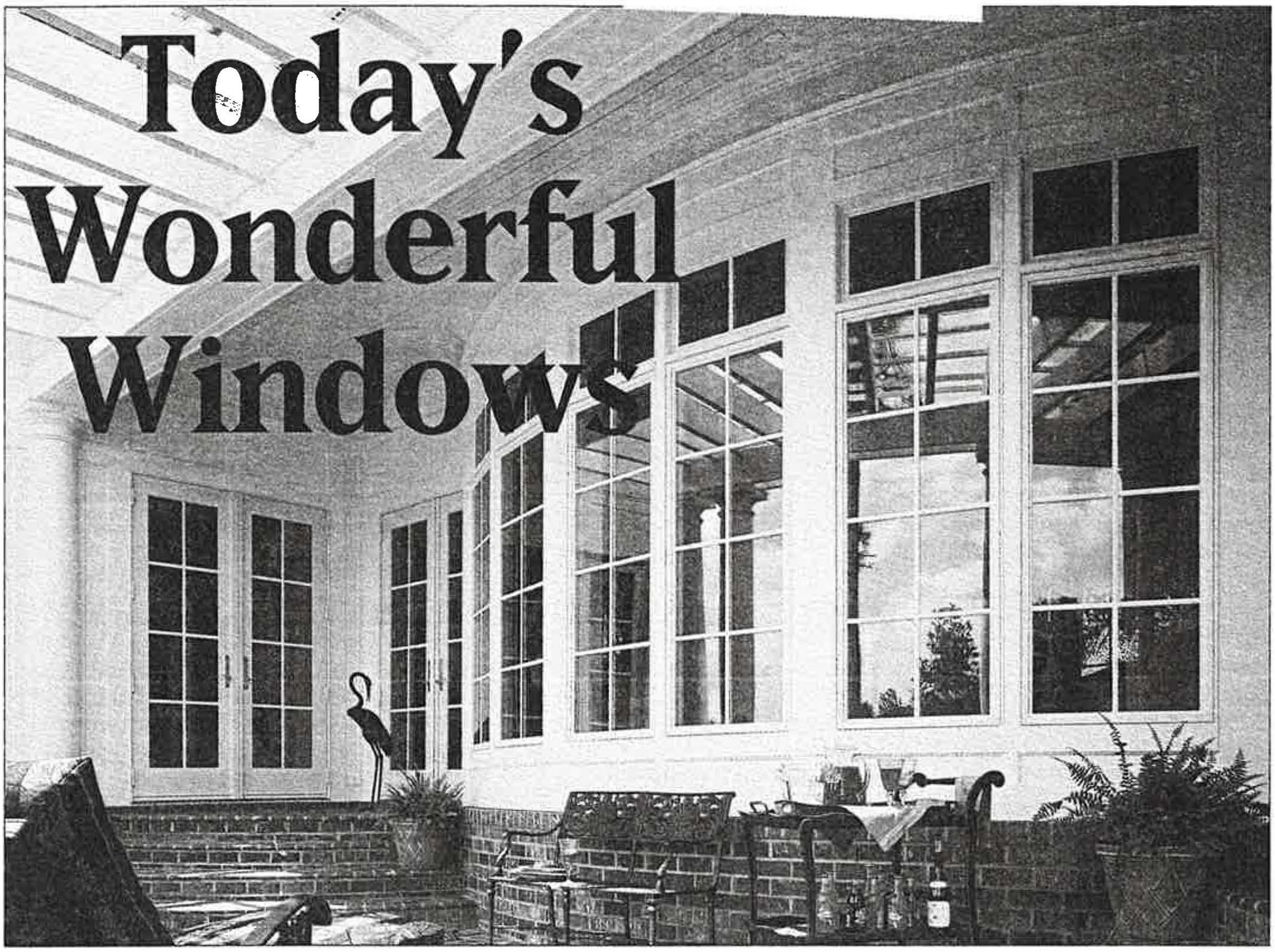
Today's Wonderful Windows



ANDERSON WINDOWS INC.

by Cindy Wills

The main barriers to choosing high-efficiency windows are lack of product awareness and cost considerations. As a result, residential construction professionals play a key role in promoting wise window choices to their clients.

While replacing windows is not always the most cost-effective improvement, changing from single-pane windows or damaged sashes to double-glazed, low-e windows with insulating sashes will improve comfort substantially. In addition, energy-efficient windows save heat when it is cold, reduce solar gain when it is hot, protect furnishings from fading, reduce infiltration of outside air, keep out unwanted noise, allow in fresh air, and prevent glare. Current technologies allow these qualities to be combined in one window. In the past ten years, new glazing and frame technologies have substantially improved the energy performance of windows. Figures 1 and 2 demonstrate the effects of windows on annual cooling and heating costs. If all residential windows in the United States were replaced with Energy Star models, Americans could save $7 billion in energy costs over the next 15 years.

Efficiency Is Cost-Effective

High-efficiency windows were initially much more expensive than the market standard, but the cost difference is decreasing as options expand. Multiple glazings, low-e coatings, warm-edge spacers, insulating sashes, and inert gas fills have all come down in price in recent years. Today, it is cost-effective to choose energy-efficient windows. While some energy-efficient measures can be postponed when first costs are an issue, those embedded in the infrastructure of a house (such as windows) must be included from the start. However, unless buyers understand the technology and the long-term benefits, they may not approve the higher costs. Recent work in Florida has shown that sellers and builders too often fail to understand the new technologies and don't or won't stock them, citing low demand.

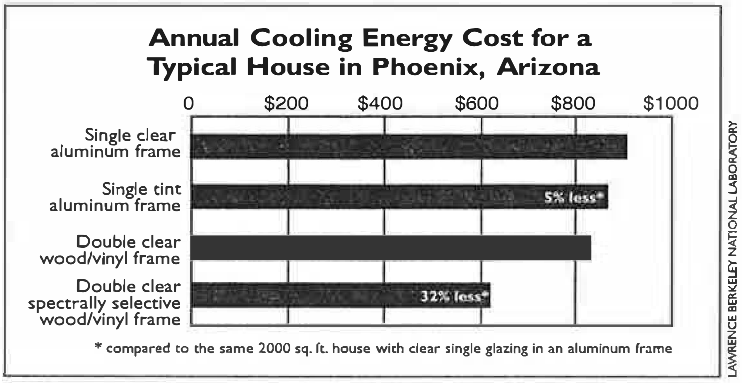


Figure 1. In Phoenix homes, the most efficient window type can save almost $300 in annual cooling costs.

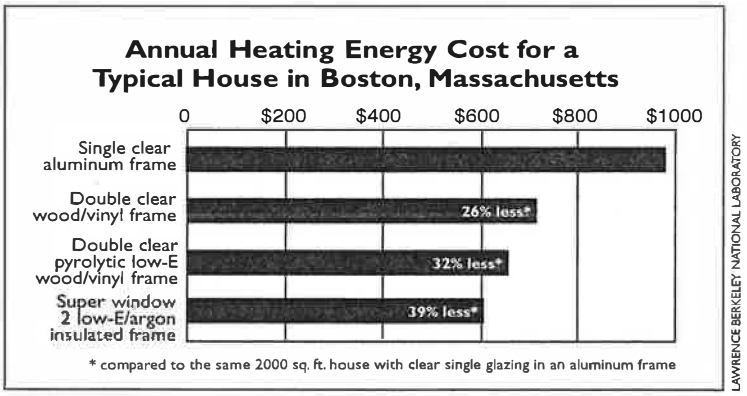


Figure 2. In Boston, very efficient windows can shave heating energy costs by 39%.

Using high-efficiency windows often allows installation of smaller heating or cooling systems, reducing the size and cost of mechanical components and the duct system. The Consortium for Advanced Residential Buildings (CARB) and others working in the Department of Energy's Building America program have found that in cooling climates, reducing the size of air conditioning equipment, regardless of the size of the home, comes very close to balancing the cost of improved windows. William Zoeller, of Steven Winter Associates, the architecture firm for CARB, says builders have expressed concern about using the better windows-smaller A/C combination because they fear that their competition may market against them. If two homes have similar features and price, prospective buyers may assume that they get more for their money with the bigger A/C unit, falling back on the belief that bigger is better.

Zoeller says that it can also be hard to sell the better windows-smaller cooling system to the HVAC contractor. Traditionally, the contractor makes the sizing calculations and adds a .25 safety factor, resulting in an oversized system. If the house is now tightened up, the resulting system may be greatly oversized, reducing both efficiency and comfort. In addition to making more profit by selling larger systems, HVAC contractors worry that they, rather than the builder, will be called back if cooling is inadequate. Zoeller came to this conclusion after surveying builders and marketing and production personnel involved with CARB.

Current Market Conditions

A recent study done for the Northwest Energy Efficiency Alliance (NEEA) revealed that the most important factors home buyers consider are the overall price of the home, the size of the home, the floor plan, and the home's energy savings. The study found that custom home builders, users of electrically heated homes, and builders already familiar with efficient windows are most likely to value efficiency products. Occupants of electrically heated homes, because they tend to pay more for heating than owners of gas-heated homes, are also more likely to value the home's energy-saving features.

However, builders of spec homes, houses built on speculation that there will be a buyer, typically choose windows with curb appeal—those that look good at low cost. The NEEA study concluded that builders of spec homes play a significant role in slowing the adoption of more efficient windows, and that they are not likely to change until they are convinced that energy efficiency helps sell their product. In the study, when buyers of new homes were asked if they were willing to pay more for energy-efficient features (in this case $\$2.15/ft^2$ more for low-e, argon-filled windows), more than half said yes, and only 19% said they would not pay for anything beyond code.

For remodels or retrofits, window changes are usually costly; yet in the NEEA study, 47% of homeowners who had installed new windows in the previous two years reported that they chose to do so because the old ones were inefficient (see "Energy-Efficient Retrofits: Install with Care," *HE* Jan/Feb '97, p. 23).

Wise Window Decisions

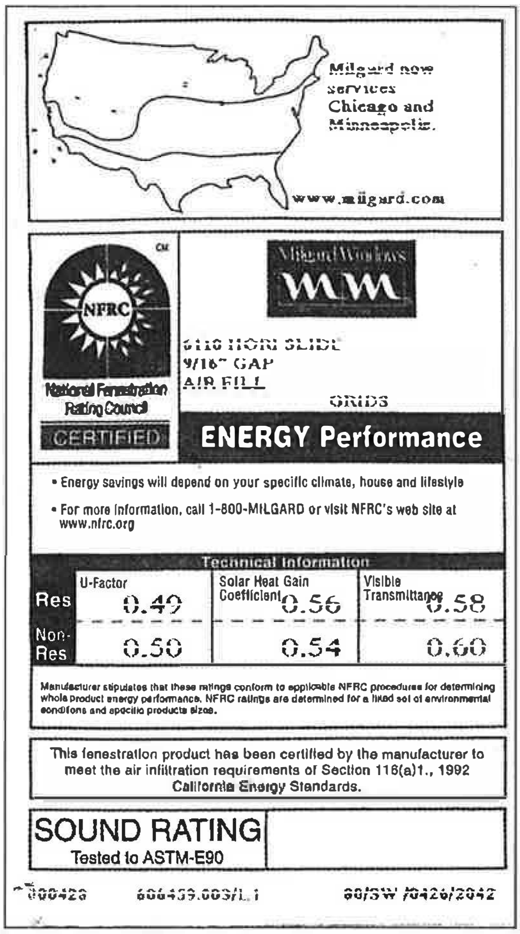
The more information and knowledge a marketer has, the more likely he or she will sell a higher-quality product that will bring both long-term customer satisfaction and higher profits to your business. Window labels are an important information source. However, since windows are made up of a variety of materials—framing, glazing, and insulating layers of air or inert gases—a rating of the entire window gives a better indication of actual performance than a rating of the glass area only. If you are checking specifications, be sure you know whether they apply to the whole unit or just the glazing. The National Fenestration Rating Council (NFRC) label (See Figure 3) makes it easier to compare the performance of windows as a whole system, including the frame (see "Window Rating Lessons from Around the Globe," *HE* Sept/Oct '98, p. 35). It is a voluntary label, so it does not appear on all window products. NFRC certification, however, is required in many states. A reasonable selection criterion should be that the product have an NFRC and Energy Star label.

Builders and consumers should understand that building codes specify minimum levels of energy-efficiency. It often makes sense to exceed the code in order to reduce long-term energy costs and increase occupant comfort. Building codes can also be market drivers. Where codes mandate high efficiency (as in Oregon, which requires a U-factor of 0.40 or less), the code drives the market. Oregon and Washington are leaders in statewide energy code adoption and enforcement. In 1998, Energy Star windows (See "Energy Star Windows," below) made up 41%–44% of the Northwest residential market. In 1995, Cardinal, a major supplier of window glass, built a glass coating plant in Tumwater, Washington, specifically to produce code-approved windows for the Oregon and Washington markets and for export to Japan. They also just opened a plant in Sacramento, California, to satisfy California Title 24 standards.

Window Basics

During the heating season, there is a large temperature difference between the inside air and the outside air. Cool air descends and hot air rises. If a window is cold while the interior air is warm, there is a tendency for the window glass to cool the air adjacent to it. As warm air hits a window surface that is cool relative to the adjacent wall, the warm air is cooled and drops toward the floor, causing drafts. During the cooling season, although the outside air temperature feels hot at 90˚F and above, the differences between outside air temperature, inside air temperature, and body temperature are much smaller. This slows air movement, so drafts are much less noticable. Windows with a higher U-factor reduce these temperature differences, slowing the heat transfer process and improving occupant comfort. (U-factor indicates the flow of nonsolar heat through windows, expressed in Btu/per hour/ft^2/˚F. U-factor is the inverse of R-value. The greater the heat loss, the higher the U-factor.) What many people perceive as a draft is a combination of the cool air falling—as noted—and the heat loss by thermal radiation from their warm skin to the cold glass surface. (Remember that for single-pane windows, the inside surface of the glass is closer to the outdoor temperature than to the indoor temperature.)

Windows that face the sun heat the house with direct gain. Older windows, though they let in solar heat, also lose a lot of heat through air leaks and poor insulation. Today, windows sold for cold climates let in solar heat yet are well insulated and airtight.



NFRC

Figure 3. This NFRC label allows consumers to compare the performance of windows as a whole system.

Condensation can also be a problem on single-pane windows when the outside air temperature is low and indoor temperature and humidity are high. Windows with a lower U-factor allow the inside pane of glass to remain warmer, and the probability for condensation goes down. Condensation appearing between the panes of insulated glass indicates a failed seal and requires replacement of the insulated glazing, or the whole window, depending on the window design.

Insulation reduces heat transfer by creating dead air space. Still air is a poor conductor of temperature, so the more still air that is trapped, the slower the transfer. While a thin layer of still air on the surface of a single-pane window provides insulating value, multiple-pane windows trap relitively large volumes of still air, significantly increasing the insulating value.

The solar heat gain coefficient (SHGC) is a fraction of incident solar radiant energy that enters through the glass as interior heat gain. The higher

Energy Star Windows

Energy Star is a joint program of the U.S. Department of Energy and the Environmental Protection Agency. It labels products that are more efficient than equivalent, standard efficiency products. Windows, appliances, heating and cooling products, compact fluorescent light bulbs, and even whole houses are labeled with the Energy Star logo.

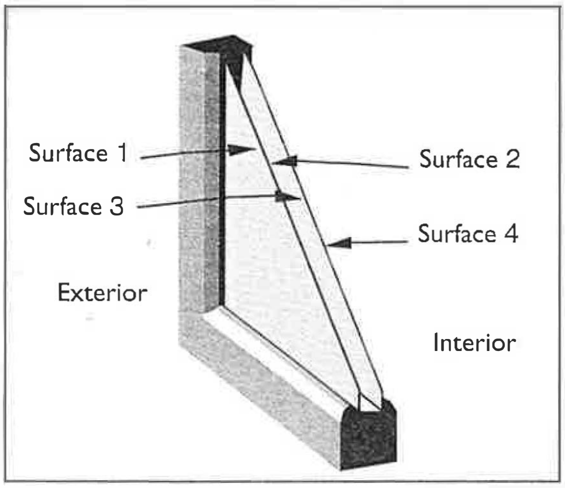
All Energy Star windows have NFRC labels. Programs like Energy Star are market drivers, encouraging consumers to choose energy efficient products and inducing manufacturers to respond competitively. High-performance windows may also help a home to qualify for programs that use home energy ratings to obtain energy-efficient mortgages or for builder marketing programs like Energy Star Homes (see "Selecting Windows for Energy Efficiency," *HE* July/Aug '95, p.11).

The Energy Star Windows program is designed to help consumers identify efficient windows, doors, and skylights for their climates. The program partners with manufacturers, utilities, retailers, and other organizations to leverage market incentives. For example, the Northwest Energy Efficiency Alliance has an Energy Star High-Efficiency Residential Windows Program aimed at boosting consumer demand and market share for high-efficiency windows in the Northwest; visit www.nwalliance.org/projects/current/ windows.html, for more details on this program.

Energy Star offers a Web site full of useful information, product lists, dealer locations and utility partners at www.energystar.gov.

the SHGC, the greater the heat gain. SHGC includes both frame and glass elements. SHGC is composed of two parts. The first part is the directly transmitted solar radiation, and the second part is the fraction of the absorbed radiation that enters as additional heat. If direct solar transmittance is low, but the inward flowing portion of the absorbed radiation is high, SHGC will be fairly high while the visible transmittance is low—just the opposite of what is generally desired in hot climates.

The shading coefficient (SC) is an older indicator of solar impact on glazing. "Shading coefficient" is a bit of a misnomer, since the higher the value, the more heat is transferred, *not* shaded. It's a measure of the ability of a window or skylight to transmit solar heat, relative to that ability for 1/8" double- strength, single glass. It is equal to the SHGC multiplied by 1.15 and is expressed as a number without units between 0 and 1.



RESIDENTIAL WINDOW COMODY - SKLEKOWITZ AND HESCHONG

Figure 4. Low-e coatings are placed on different surfaces to achieve different effects.

High-Tech Options

Energy-efficient windows use a variety of technologies to reduce conduction, convection, and radiation, and to absorb or reflect the sunlight—which is part of the radiation. The most effective technologies available for residential windows include multiple glazings, insulated frame materials and designs, spacer technology, low-e and solar-control coatings, insulating spaces filled with inert gases, and reduced air leakage.

Multiple Glazing, Frame Design, and Spacers

Compared to single panes, the first double-pane windows in aluminum frames saved around 25% of the energy used to heat a home. Because the indoor glass temperature itself was warmer and convection currents were reduced, the probability of discomfort near the windows dropped from slightly more than 60% to less than 40%. Further improvements have brought even more savings. Unfortunately, aluminum frames are also excellent conductors of heat. The edge-effect of the conductivity of the frame contributes to increased heat loss around the window perimeter in a band about 2 1/2 inches wide; hence the smaller the window, the larger the relative problem.

In early versions of thermal-pane (or double-pane) windows, the temperature difference often resulted in condensation. Moisture collected where the frame met the wallboard, and it stained and deteriorated the drywall and surrounding areas, or worse. A substantial amount of infiltration still entered the home through and around the window framing and closures. The simple double-pane, aluminum-framed windows sold today typically have a thermal break to reduce condensation woes. Moving away from metal frames— to wood, vinyl, fiberglass, and

What's Coming?

New products continue to be developed that will offer efficiency gains for both new construction and retrofit/remodel projects. Many improvements to existing technology will result in incremental efficiency and performance gains, while more exotic technologies are also being researched.

Hard Coat Solar-E

A hard solar-E coating, being developed by Pilkington LOF, offers improvement for single-glazing applications, as well as adding efficiency to insulated glass. Hard coatings are pyrolytically applied, a process with less precision in application than the sputter process used to make spectrally selective low-E glass, but that does not require additional protection like standard low-E coatings. The pyrolytic process can often produce a somewhat hazy appearance according to one manufacturer, so improvements are being researched. Single glazed windows with this hard coating have an SHGC of 0.35, which does not meet Energy Star performance levels for cooling climates. However, these coated windows would certainly improve comfort. In southern cooling climates, Energy Star standards require a U-factor of 0.75 or less and an SHGC of 0.40 or less.

Integrated Window Panels

An integrated window panel that includes moveable insulation is being developed for use in homes built with Structural Integrated Panels or standard framing.

Smart Windows

The term "smart windows" usually applies to very high technology windows that are still under development. Chromogenics is the term given to windows that respond dynamically to the environment and factors such as temperature (thermotropics), light (photochromics), or electrical input (electrochromics). A liquid crystal display that used electricity and changed from transparent to diffused white has been taken off the market. But new electrochromic glazings are being developed that show great promise.

Most of the "smart windows" technology will find a place in commercial applications long before residential use, although skylights, with their high exposure, may be early candidates for smart technology adoption. Costs of these technologies are likely to keep them out of the general residential market for years. Expect further improvements in low-E and solar control filters. Visit the Lawrence Berkeley National Laboratory Web site for more details on these developing technologies at http://windows.lbl.gov/materials/default.htm.

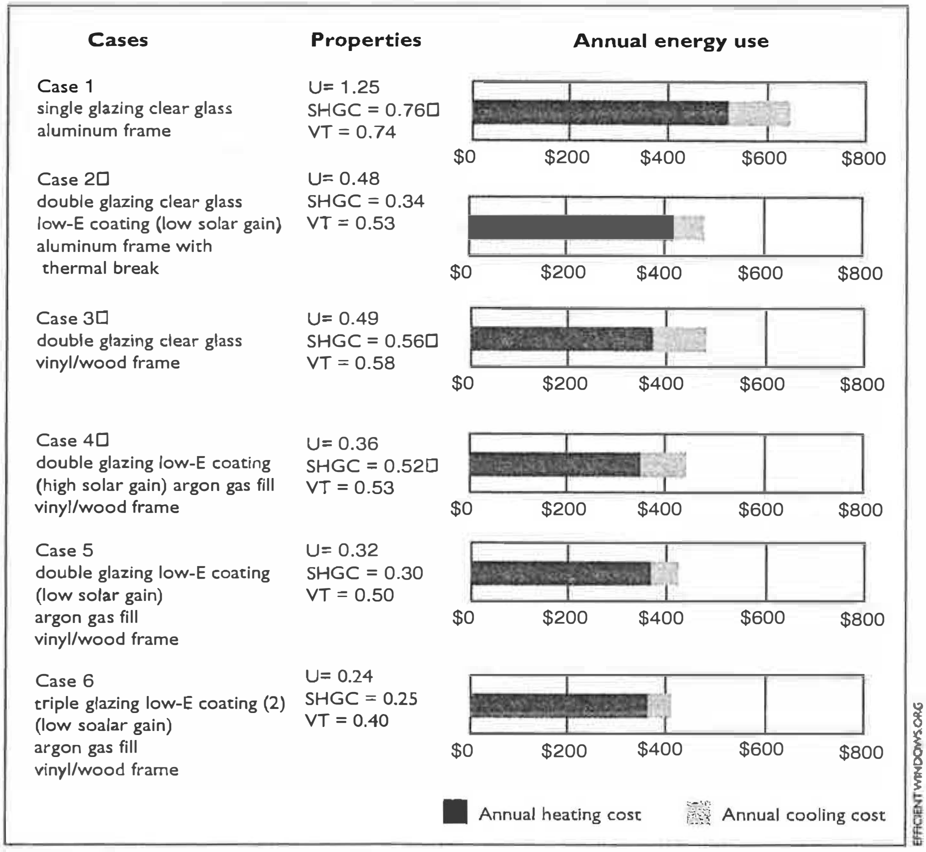


Figure 5. This graph shows energy use, U-factor, visible transmittance, and solar heat gain coefficient in Chicago with various window technologies.

composites—and adding insulation has greatly reduced the heat transfer through the frame, as well as improving the windows' appearance.

The spacer is the small piece of material separating the panes of glass. It affects how much heat is transmitted between the panes. Improved spacer technology and better construction and sealing methods are also factors in the higher performance of modern windows. These are also areas where there is still room for improvement.

Triple-pane windows create two layers of air, but as the number of panes increases, either the total thickness must also increase or the amount of dead air space is decreased. Triple-pane windows were developed before low-e coatings came out, and performance of the two is often very similar. Increasing the amount of materials in window units increases the cost, and in the case of triple-pane windows, the increase is substantial. In extremely cold climates, however, the extra cost may be justified.

Low-e Technology and Insulating Gases

Low-e technology is a big improvement over single-pane, double-pane, or conventionally tinted windows, and the extra cost is now minimal. Low-e glass contains a microscopically thin, transparent layer of metal or metallic oxide applied to the interior face of a multiglazed window, or a thin plastic film placed between the panes. The best of these coatings consist of a soft layer that must be protected from handling and abrasion.

These coatings act as radiant barriers. As illustrated in Figure 4, the coating is placed on the #3 surface in heating climates to maximize passive solar gain, reflecting the heat energy back into the home. In cooling climates it is placed on the #2 surface to reduce solar heat gain by reflecting it out. A noble gas (typically argon, krypton, or xenon) is often used instead of air between the panes to further improve the insulating value. Argon is relatively cheap and plentiful, and is less conductive than air. Krypton is more effective than argon, but significantly more expensive. Xenon would be better still, but it's even rarer and dearer.

Engineering allows low-e windows to be spectrally selective—cold-climate (high solar heat gain) systems or hot-climate (low solar heat gain) systems—in order to control the amount of short-wave infrared radiation from the sun that passes through the glass. This means that not only is the U-factor improved, but the spectrum of light is also slowed. Some light frequencies are blocked with different technologies, and the SHGC is controlled. Windows are available with high, medium, and low SHGC. Windows with the lowest heat gain (because of reflective gas) also have the lowest visible transmittance (VT)—the percentage or fraction of visible light transmitted by a window or skylight—and have a more colored outdoor reflection.

Rare is the house that fits neatly into only one category—heating or cooling. A mixed climate requires consideration of both heat loss control and solar heat gain protection. Figure 5 shows graphs for energy use in Chicago, a mixed zone, with various technologies. The climate map used by Energy Star shows three distinct zones in the United States, while the Efficient Windows Collaborative (EWC) Web site at www.efficientwindows.org includes a map with more specific zones relating to U.S. cities. Neither accounts for the wide variability in microclimates.

Microclimates may be created by a highly reflective surface that is close to the house, such as water, snow or sand, by an adjacent structure, by tree canopies, or by localized weather conditions, and can be very small. Indeed, the orientation of houses in the same neighborhood can greatly impact the comfort and economy of a home.

Many people in heating or mixed climates find that reducing the solar gain year round makes the house more comfortable. Choosing an SHGC lower than that suggested by Energy Star may help to achieve this. Unless a heating system is zoned or controlled room by room, a bright sunny day could overheat some spaces without significantly reducing the heating load on the central system; and in areas where air con-

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These energy-efficient windows provide style, light, and comfort.

ditioning is not typically used, overheating is quite likely in the summer months. Spectrally selective sealed windows with low-e coatings have become common in new construction where heating degree-days exceed 5,500.

Air Leakage

Operable windows are popular for ventilation, but unintentional air leaks may account for up to 10% of the energy use in a home. For example, wind pressure can flex the window unit and increase air flow, and sliding windows with weather stripping do not provide as tight a closure as windows with compressing seals.

The industry standard for air flow leakage is 0.30 CFM/ft^2. In areas of harsh weather, or on the stormy side of the house, a window with an even lower value can reduce infiltration and noise. Check the rating on the NFRC label. Installation instructions should be followed carefully for good performance.

Controlling the "Bad" Light

Spectrally selective low-e glass insulated panels reduce the light coming through with a fairly color-neutral effect on the view, but placed next to uncoated glass, they appear darker. The VT rating may seem low when it is close to 0.6, but keep in mind that like SHGC, this rating includes both frame and glazing. The higher the VT rating, the more light comes through. Where glare is a problem, a lower VT rating may be preferable. Figure 5 gives the VT ratings of various window options. In warm climates, where single-pane windows are still common, tinted glass or add-on films and other shading options may offer the best solar control available (see "Snapshots of Shading Options," p. 20).

Ultraviolet light from the sun is an important cause of sun-damage and fading to interior furnishings and finishes. Glass alone absorbs a large amount of the UV, and low-e glass further reduces it. While windows do not eliminate sun damage, high-tech windows can slow it considerably, extending the life of furnishings and floor, and wall coverings.

Educate Your Clients

Consumers expect windows to provide style, light, and comfort to their homes. They trust building professionals to choose quality window products and are generally unaware of the most efficient window technologies or of information resources. If building professionals can explain which high-performance windows will work best in the home's specific microclimate, the consumer may come to find that energy-efficient windows are a wise investment—one that will be repaid in performance, comfort, cost, and environmental benefits.

At a minimum, builders, designers, remodelers, and others in the building industry should follow the Energy Star guidelines or use the checklist on the Efficient Windows Collaborative Web site. For increased performance and comfort, an analysis that takes into account the home's microclimate and orientation is recommended.

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