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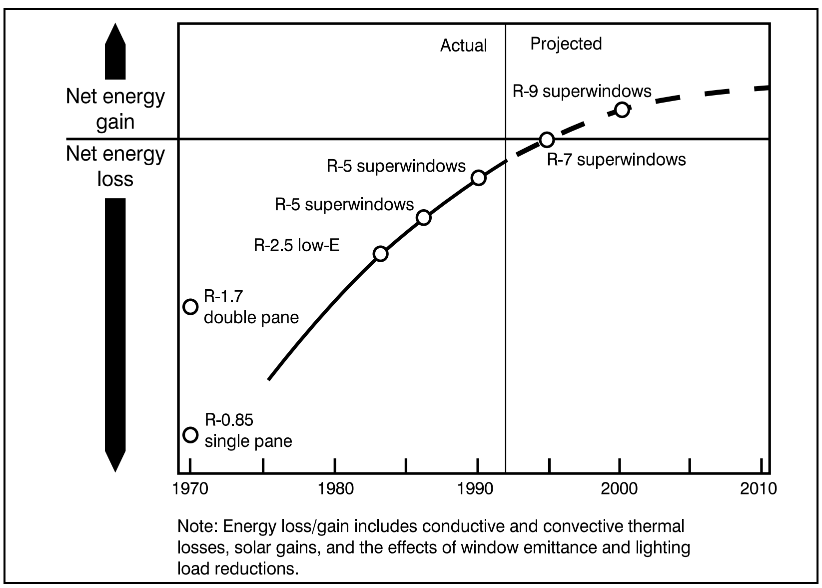
Advances in Glazing Materials for Windows

Until recently, clear glass was the primary glazing material used in windows. Although glass is durable and allows a high percentage of sunlight to enter buildings, it has very little resistance to heat flow. During the past two decades, though, glazing technology has changed greatly.

Research and development into types of glazing have created a new generation of materials that offer improved window efficiency and performance for consumers. While this new generation of glazing materials quickly gains acceptance in the marketplace, the research and development of even more efficient technologies continues.



Advanced glazings have increased windows' resistance to heat flow, or R-value. vc-cd16-a1515-06

Current Options that Increase a Window's Energy Efficiency

Manufacturers usually represent the energy efficiency of windows in terms of their U-values (conductance of heat) or their R-values (resistance to heat flow). If a window's R-value is high, it will lose less heat than one with a lower R-value. Conversely, if a window's U-value is low, it will lose less heat than one with a higher U-value. In other words, U-values are the reciprocals of R-values (U-value = 1/R-value).

Usually, window R-values range from 0.9 to 3.0 (and U-values range from 1.1 to 0.3), but some highly energy-efficient exceptions also exist. When comparing different windows, you should ensure that all U- or R-values listed by manufacturers: (1) are based on current standards set by the American Society of Heating, Refrigerating,

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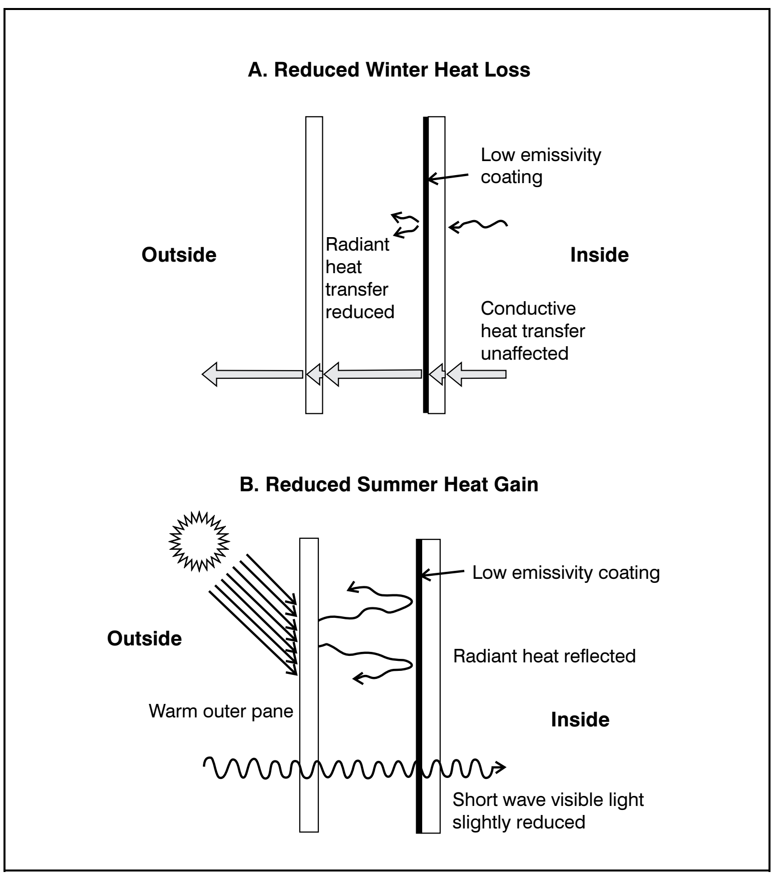
If a window's resistance to heat flow, or R-value, is high, it will lose less heat than one with a lower R-value.

and Air-Conditioning Engineers (ASHRAE), (2) are calculated for the entire window, including the frame, and not just for the center of the glass, and (3) represent the same size and style of window.

Today, several types of advanced glazing systems are available to help control heat loss or gain. The advanced glazings include double- and triple-pane windows with such coatings as low-emissivity (low-e), spectrally selective, heat-absorbing (tinted), or reflective; gas-filled windows; and windows incorporating combinations of these options.

Low-e Glazings

Low-e glazings have special coatings that reduce heat transfer through windows. The coatings are thin, almost invisible metal oxide or semiconductor films that are placed directly on one or more surfaces of glass or on plastic films between two or more panes. The coatings typically face air spaces within windows and reduce heat flow between the panes of glass.



Low-e glazings reduce radiant heat transfer. vc-cd16-a1515-01

When applied inside a double-pane window, the low-e coating is placed on the outer surface of the inner pane of glass to reflect heat back into the living space during the heating season. This same coating will slightly reduce heat gain during the cooling season.

Low-e films are applied in either soft or hard coats. Soft-coat low-e films degrade when exposed to air and moisture, are easily damaged, and have a limited shelf life, so they are carefully applied by manufacturers in insulated multiple-pane windows. Hard low-e coatings, on the other hand, are more durable and can be used in add-on (retrofit) applications. But the energy performance of hard-coat low-e films is slightly poorer than that of soft-coat films. Windows manufactured with low-e films typically cost about 10% to 15% more than regular windows, but they reduce energy loss by as much as 30% to 50%.

Although low-e films are usually applied during manufacturing, retrofit low-e window films are also widely available for do-it-yourselfers. These films are inexpensive compared to total window replacements, last 10 to 15 years without peeling, save energy, reduce fabric fading, and increase comfort.

Spectrally Selective Coatings

Spectrally selective (optical) coatings are considered to be the next generation of low-e technologies. These coatings filter out from 40% to 70% of the heat normally transmitted through clear glass, while allowing the full amount of light to be transmitted. Spectrally selective coatings can be applied on various types of tinted glass to produce "customized" glazing systems capable of either increasing or decreasing solar gains according to the aesthetic and climatic effects desired.

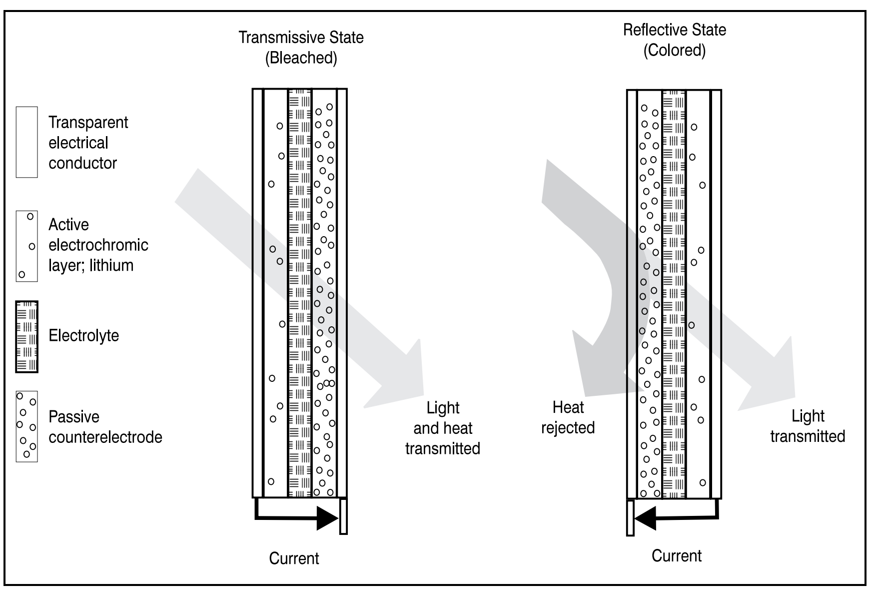
Optical properties such as solar transmittance can be customized for specific climate zones.

Computer simulations have shown that advanced glazings with spectrally selective coatings can reduce the electric space cooling requirements of new homes in hot climates by more than 40%. Because of the energy-saving potential of spectrally selective glass, some utilities now offer rebates to encourage its use.

Heat-Absorbing Glazings

Another technology uses heat-absorbing glazings with tinted coatings to absorb solar heat gain. Some heat, however, continues to pass through tinted windows by conduction and reradiation. But inner layers of clear glass or spectrally selective coatings can be applied with tinted glass to further reduce this heat transfer. Heat-absorbing glass reflects only a small percentage of light and therefore does not have the mirror-like appearance of reflective glass.

Gray- and bronze-tinted windows reduce the penetration of both light and heat into buildings in equal amounts (i.e., not spectrally selective) and are the most common tint colors used. On the other hand, blue- and green-tinted windows offer greater penetration of visible light and slightly reduced heat transfer compared with other colors of tinted glass. When windows transmit less than 70% of visible light, plants inside could die or grow more slowly. In hot climates black-tinted glass should be avoided because it absorbs more light than heat.



"Smart windows" use electricity to vary sunlight and heat transmission. vc-cd16-a1515-02

Reflective Coatings

Like black-tinted coatings, reflective coatings greatly reduce the transmission of daylight through clear glass. Although they typically block more light than heat, reflective coatings, when applied to tinted or clear glass, can also slow the transmission of heat. Reflective glazings are commonly applied in hot climates in which solar control is critical; however, the reduced cooling energy demands they achieve can be offset by the resulting need for additional electrical lighting.

Tomorrow's Options for More Efficient Windows

"Superwindows" now coming on the market can attain high thermal resistance by combining multiple low-e coatings; low-conductance gas fills; barriers between panes, which reduce convective circulation of the gas fill; and insulating frames and edge spacers.

Also, optical properties such as solar transmittance can be customized for specific climate zones. The heat from even a small amount of diffuse winter sunlight will convert these superwindows into net suppliers of energy. This first generation of superwindows now available have a center-of-glass R-value of 8 or 9, but have an overall window R-value of only about 4 or 5 because of edge and frame losses.

Also under development are chromogenic (optical switching) glazings that will adapt to the frequent changes in the lighting and heating or cooling requirements of buildings. These "smart windows" will be separated into either passive or active glazing categories.

Passive glazings will be capable of varying their light transmission characteristics according to changes in sunlight (photochromic) and their heat transmittance characteristics according to ambient temperature swings (thermochromic). Active (electrochromic) windows will use a small electric current to alter their transmission properties. Both types should be on the market within 2 to 5 years.

Consumers may discover that they need two types of glazing for a home because of the directions that the windows face and the local climate.

Conclusion

No one type of glazing is suitable for every application. Many materials are available that serve different purposes. Moreover, consumers may discover that they need two types of glazing for a home because of the directions that the windows face and the local climate. To make wise purchases, consumers should first examine their heating and cooling needs and prioritize desired features such as daylighting, solar heating, shading, ventilation, and aesthetic value.

Source List

The following organizations and publications provide more information on advances in glazing technology.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329
(404) 636-8400

ASHRAE's *Handbook of Fundamentals* contains tables citing heat transfer, light transmittance, and shading properties for various window types and materials.

National Fenestration Rating Council (NFRC)
1300 Spring Street, Suite 120
Silver Spring, MD 20910
(301) 589-6372

NFRC developed procedures now being used in window certification and efficiency labeling programs.

Lawrence Berkeley Laboratory
90-311
Berkeley, CA 94720
(510) 486-4040

Distributes the WINDOW computer program, which was developed by the U.S. Department of Energy to help window manufacturers and building designers optimize the thermal and daylighting performance of windows.

Reading List

"Low-E Glass—Why the Coating Is Where It Is," *Energy Design Update*, pp. 5–7, March 1990.

"No Pane, No Gain (Window Technology: Part One)," *Popular Science*, pp. 92–98, June 1993.

"The Elusive Benefits of Low-E and Gas-Filled Windows," *Energy Design Update*, pp. 7–9, June 1990.

"Through the Glass Darkly," *Popular Science*, pp. 80–87, July 1993.