ENERGY-SAVING WINDOWS

High Performance windows admit the sun's warmth while significantly reducing both house heat loss and air leakage.

Houses built to recent code requirements have generally been constructed with conventional sealed double-glazed windows. With an R-value generally equal to only one-tenth of the house walls, these windows account for 20 to 25% of total house heat loss. But today's high-performance windows capture more heat from the sun than they allow to escape to the outside. The new technologies which make this possible include:

- low-emissivity (low-E) coating on the inside glazing surface to reduce radiant heat loss;
- new glazing materials;
- an insulating, inert gas between panes to reduce convection heat loss;
- insulating spacers separating panes, to reduce conduction heat loss and condensation along edges;
- better sealing in the frame components to prevent air leakage;
- frames that lose less heat and are narrower to admit more solar energy;
- greater durability through design and careful use of materials; and
- improved installation practices to minimize air leakage around the window.

This fact sheet describes the new technologies and standards for high-performance windows. It explains:

- the energy efficiency of the various window types and designs,
- the criteria for performance, window standards, certification and warranties.

Technologies in high-performance windows

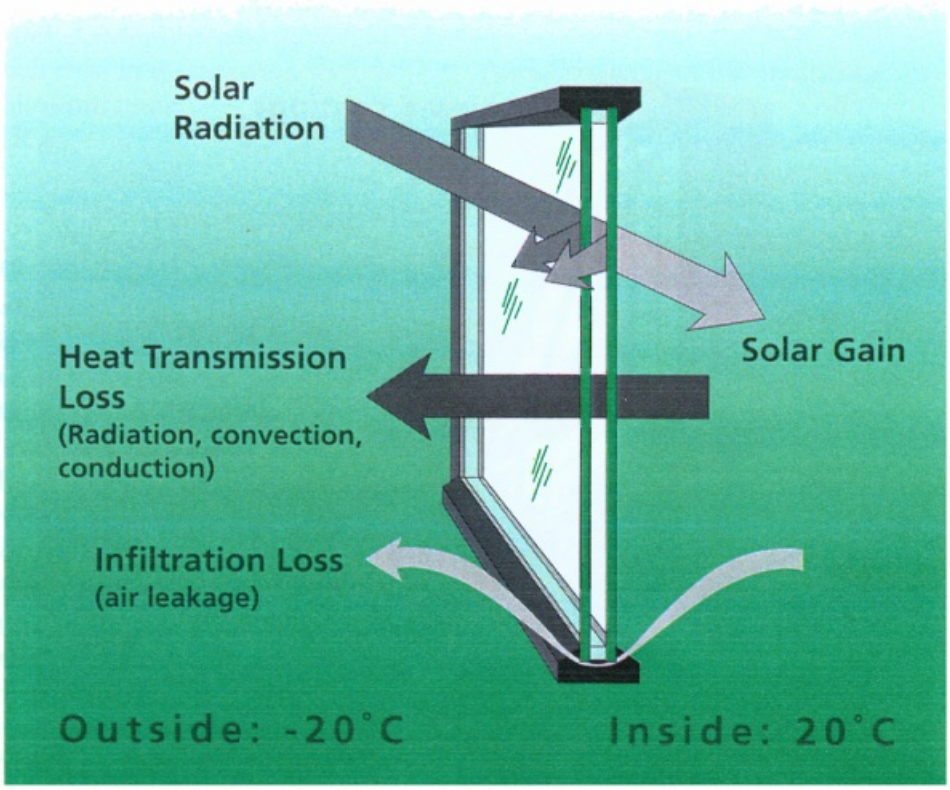
Glazing

The goal of any high performance window is to admit maximum light—and solar gain in winter months—with minimum loss of heat.

Standard double glazing has an insulation value of about R-2, so it loses about 10 times as much heat as the same area of wall with six inches of insulation. High-performance windows not only reduce heat loss but, through solar gains, can be net contributors to home heating. They also make houses feel more comfortable by reducing drafts, by reducing radiation to cold interior window surfaces and by permitting higher interior humidity levels without condensation forming on the window. (Higher humidity provides greater warmth at the same temperature.)

Multiple glazings—three or more—are often used to reduce heat loss. Some manufacturers use thin plastic membranes rather than glass as dividers in the glazing unit.

Window in Winter



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Coatings

Radiation of heat accounts for fully two-thirds of the heat loss from a standard double-glazed window. This heat loss can be reduced by applying an almost invisible (just a few atoms thick) low-E coating on the interior glazing surface.

Furnishings are faded by both visible light and invisible ultra-violet (UV) light. While normal glass stops some UV, low-E coatings and plastic inner glazing reduce it further.

Pyrolytic, or hard, coatings are applied by fusing tin oxide to the surface of molten glass. They are not easily damaged and tend to allow full solar heat gain.

Sputtered, or soft, coatings are produced by coating a glazing surface with silver or zinc atoms in a vacuum. They are easily damaged and must be protected during window manufacture. Generally, they have lower emissivities and thus higher insulation values, but do not admit as much solar heat.

Some manufacturers place thin polyester membranes with a low-E coating in the spaces between inner and outer panes to achieve light-weight triple or quadruple glazing.

Tinted glass and some low-E coatings may reduce solar transmission by up to 50%. For Canada, a window with high solar heat gain and a narrow frame profile that minimizes blocking of the sun is a desirable residential combination.

Gas fills

Low-E coatings can reduce radiation heat transfer to the point that transfer owing to natural convection becomes dominant. However, this convection loss can also be reduced substantially by filling the air spaces between panes with an inert, high-molecular-weight gas like argon or krypton.

Research indicates that careful sealing limits gas loss to less than 2% annually. A window's gas fill could therefore remain effective over its expected 20-year life.

Spacers

Spacers around the perimeter of glazing separate panes. A one-half inch space is optimum and this is filled with air or argon. Conventional sealed units use hollow metal spacers which conduct a great deal of heat to the outdoors.

Once the thermal resistance of a unit has been improved with a low-E coating and an inert gas, newly developed low-conductivity spacers can reduce heat loss by a further 20%. The spacers keep the outer perimeter of the glass warmer, reduce thermal stresses and decrease the incidence of condensation on the perimeter of the inside pane in cold weather. Dessicants are incorporated in the spacer to absorb moisture present at the time of manufacture of the window.

Good sealing of the spacers is important. Failure of the elastomeric edge sealant permits outside air to get between the panes. This introduces more moisture than the desiccant in the spacer can accommodate and results in condensation inside the unit.

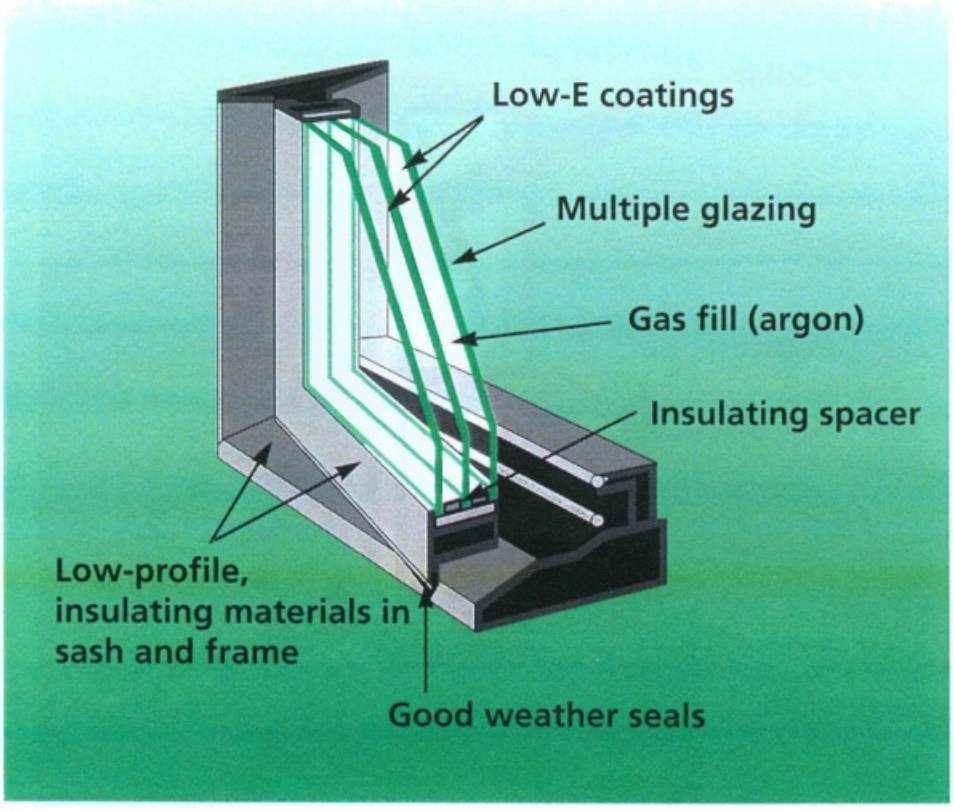
Frames

Wood, PVC, aluminum, fibreglass and composite frames are available and each type varies in strength, longevity, air leakage and insulation value.

In a conventional double-glazed window, the insulation value of a solid wood frame or good quality vinyl frame is about the same as the glazing—R-2. Aluminum frames, even those with thermal breaks, are often less efficient.

Generally, a well-designed PVC or fibreglass frame has slightly greater

High-Performance Window



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Typical ER Numbers

Frame	Spacer	Glazing	Fixed	Operable
Common (poor frame)	Aluminum	Double	-35	-50
Common (good quality)	Aluminum	Double	-15	-30
"High-performance" threshold			+2	-11
Moderate-cost high performance	Insulated	Double, Low E, argon	+5	-8
Best commercially available	Insulated	Triple, two Low E, argon	+15	+8

insulation value than wood, particularly if hollows in the frame are filled with insulation. However, a poorly designed, metal-reinforced PVC frame may not perform as well as wood owing to thermal bridges or greater air leakage at low temperatures.

A frame can occupy up to 30 percent of a window's area, reducing the window's potential for solar heat gain. Narrower frames with higher insulation values are therefore desirable. Fibreglass frames offer insulation and strength in a low profile frame contributing to some of the highest energy ratings.

Performance rating

Manufacturers have traditonally used R-value to express the energy performance rating of their windows. But there are two problems with this. First, R-value was usually quoted for the "center-of-glass", not the whole window, and therefore did not account for spacers and frames. Second, R-value is related only to heat loss and does not measure a window's ability to capture solar energy.

In 1988 CANMET initiated a program to develop a national consensus standard for window performance, rating and labelling. The standard describes a single number performance rating which indicates: a window's capability to admit solar heat, its insulating capability (R-value) and its ability to resist air leakage. The energy performance rating is derived from the following formula:

ER (energy rating) =
+ solar gains,
- transmission loss,
- infiltration loss.

This energy rating has been evaluated for a reference standard house, heated only with equal window areas in each of four cardinal directions, and for a climate average based on several Canadian cities. Appropriate factors weight each term in the equation with the following result:

ER =
72.2 SHGC
- 21.9 U_w
- 0.54(L_{75}/A_w)

where:
SHGC is the overall window solar heat gain coefficient
U_w is the overall window u-value (inverse of R-value)
L_{75} is the window air leakage rate
AW is the total window area.

The ER system for windows provides a simple procedure for calculating a single ER number for a standard size of each window type, and is being used in a voluntary certification and labelling program by members of the Canadian Window and Door Manufacturers Association (CWDMA). The ER system has the same intent as the EnerGuide rating system for household appliances—to indicate the relative energy efficiency of various products.

The higher the ER number, the greater the capability to admit solar gain and prevent heat escaping from the house.

Typical ER numbers are presented above for standard-sized fixed and operable windows. ER numbers should be compared within each window type—fixed, casement, sliders, etc.

A window with an ER number of zero is neutral in energy consumption—it contributes as much solar heat to the house over a heating season as it loses. Any window with a plus number actually contributes more heating energy to a house than it loses. In contrast, a standard, double-glazed window with an ER number of about -30 is a substantial energy loser.

Good passive solar design requires window placement which will obtain maximum solar gain during the heating season. The user's guide for the new standard describes calculation of a specific energy rating (ERS) for window size and compass exposure in a given house in a specific geographic location.

Where overheating may be a problem, judicious landscaping and overhangs above windows are the best method of avoiding summertime heat while permitting winter solar gain. The WIN-2000 computer program, being developed by CANMET, will provide an easy interactive approach to window selection for a specific home in which size and location fine-tunings are desired.

The HOT-2000 computer program, distributed by the Canadian Home Builders' Association (CHBA) for CANMET, further allows home builders to accurately simulate energy performance of windows at the design stage, and develop prototypes to meet specific energy performance targets (a requirement of the R-2000 energy-efficient house design and construction program).

In co-operation with government agencies, Canadian standards bodies have devised methods to measure and express window quality and performance.

Performance standards

Sealed glazing unit (IGU) standard

The CAN/CGSB 12.8 Insulating Glass Unit (IGU) Standard describes an accelerated aging test in which a glazing unit is exposed to extremes of temperature and moisture to test durability of the edge seal. Research work, supported in part by CANMET, is currently under way that may lead to revising this standard to include tests for gas fill retention, coating durability and film layers.

Complete-window standards

The CAN/CSA A440.M.90 Standard describes ways of testing windows and categorizing results for air tightness, resistance to water penetration and wind load, material quality, and other requirements. Air tightness, for example, is rated A-3 (best), A-2, and A-1. Also within the Standard are optional ratings for such factors as resistance to condensation and forced entry.

The CAN/CSA A440.2M 1991 Standard describes how a window's thermal performance characteristics can be obtained and its energy performance expressed as an ER rating.

The thermal performance characteristics (U-value, SHGC and infiltration) are obtained by laboratory measurement or, optionally, the first two may be obtained using a computerized mathematical model. CANMET's window modelling programs VISION and FRAME were selected for the calculation option.
If a window meets the CSA standards, an accompanying label describes how the product has met CSA requirements and passed tests at certain levels.

The energy rating does not presently apply to skylights, greenhouse spaces or doors (other than sliding glass doors). However, current research should eventually lead to a revised standard which will include these products.

Certification, warranties, and performance ratings

IGMAC certification

The Insulating Glass Manufacturers Association of Canada (IGMAC) certifies manufacturers after sample glazing units have been tested. Certified products bear a label on the spacer between panes indicating: IGMAC, a date, a company name and a place of manufacture. If the spacer is the insulating type, the label is etched in a corner of the glazing.

Canadian Window and Door Manufacturers Association (CWDMA) certification

A certification label indicates the entire window unit has earned a specific ER rating, has passed all requirements of the Canadian Standards Association with respect to air and water leakage (achieving certain levels) and may also indicate the window has passed certain optional standards.

Warranties

Manufacturers offer a range of warranties on the glazing unit (up to 10 years) and the entire window.

Installation

Manufacturers stress that their window products must be installed "square, plumb and level" in order to assure long life and continuing high performance. Correct installation can be verified through close supervision. It is also necessary to fill openings around locating shims with insulating foam, to fill larger spaces with insulation, and to seal the home's vapour barrier to the edges of the window unit.

The bottom line

By investing in high-performance windows, home owners reap a number of benefits including higher levels of comfort and increased resistance to condensation in addition to lower energy costs.

The higher the energy cost and the more northerly the location, the shorter the pay-back period will be. Some electrical utilities have programs to encourage home owners to purchase windows that meet Canadian standards and certain energy efficiency levels.

For renovation or replacement, the key to window selection is to obtain maximum energy efficiency at reasonable cost and to meet specific needs. Some moderately priced

windows perform as well as higher-priced models, so the ER ratings should be used when comparing differences.

Many quality high-performance windows are being marketed for little more than traditional windows. Studies have shown that their modest premium will be paid back many times over the life of the windows. In addition, high-performance windows add comfort, require less maintenance, provide immediate reduction of energy costs and add to the desirability and value of any home.

Through the Buildings Energy Technology Advancement (BETA) Plan CANMET is striving to advance the commercialization of energy efficient and passive solar technologies for residential and commercial buildings in Canada. As part of BETA, the Passive Solar Program focuses on the development and adoption of high-performance windows, advanced window research and development, daylighting, and integration of systems to optimize solar energy gains. Specific activities include advanced window research and industry support through the development of computer design tools, window durability test methods and energy performance rating standards.

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