PILKINGTON

Determining Energy Efficiency in Windows

An overview of how windows are rated in Canada

The use of energy efficient products, such as automobiles, appliances and windows, contributes to a cleaner environment, saves valuable natural resources and, ultimately, saves consumers money.

Natural Resources Canada has taken an active role in educating the public on energy efficiency and promoting the use of energy efficient products. In support of that effort and in conjunction with Natural Resources Canada, industry and trade groups have developed energy efficiency standards for their respective products.

These combined efforts have resulted in increased awareness and knowledge by the Canadian consumer for energy efficient products, and this has been reflected in a shift in their buying patterns toward such products.

However, because of the unique nature of window glass, performance numbers are often subject to misinterpretation that, whether inadvertently or intentionally, can lead to false and misleading conclusions.

The purpose of this paper is to provide a straight-forward, clear overview of window performance and comparisons for the Canadian climate in general, the CSA-A440.2 window performance rating system in particular, and how both window manufacturers and consumers can confidently – and correctly – use this guideline to select glass and windows that best meets their needs.

Energy Codes, Rating Systems and the Unique Properties of Windows

For most materials used in the building envelope, like walls and roofs, determining energy performance is a relatively simple process.

In the case of a wall, for example, heat moves from the warmer surface to the cooler surface by *conductivity* – the ability of the material to transfer heat.

Heat can also be lost through *air infiltration* – the physical passing of cold air into the home and warm air out of the home in winter, through small cracks, leaks, or openings.

By measuring the ability of a material to conduct heat by its U-Value (or, conversely, by measuring its ability to *resist* heat transfer, which is the R-Value), and factoring in the air infiltration of a particular structural component, the relative energy efficiency can be measured.

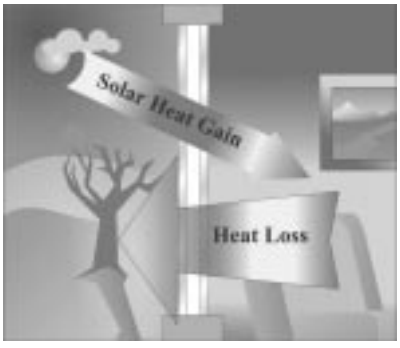
Windows, however, pose a particular challenge in developing an energy rating system because of the unique nature of glass.

Like other materials, windows transfer heat by conductivity and air infiltration. For example, a window with an insulated glass unit (I.G.) – two panes of glass with an insulating space between them – has a lower U-Value than a comparable window with a single pane of glass, and therefore provides better thermal performance.

But unlike opaque building materials, glass can also allow ***radiant*** heat – energy in the visible portion of the spectrum and beyond – to pass through.

This is particularly important because, even on a cloudy winter day, the sun is an important source of free radiant energy that heats the home.

However, since all clear float glass allows similar amounts of radiant energy to enter the home, it wasn't considered necessary to quantify this factor to compare them.



Unlike walls or roofs, glass allows solar energy to enter the home, providing a source of free energy in the winter that offsets some of the heat that is lost through the window.

All you needed to do to compare window glass was to compare the U-Value.

Beyond U-Values: Why Low-E Glass Required a New Way of Measuring Performance

With the advent of Low-E glass (which has a special coating on one of the panes of glass that provides lower U-Values than a comparable I.G. unit with clear float glass), however, a new way of measuring glass performance was required.

That's because the coating that gives Low-E glass its lower U-Value also blocks some of the sun's radiant energy from entering the home.

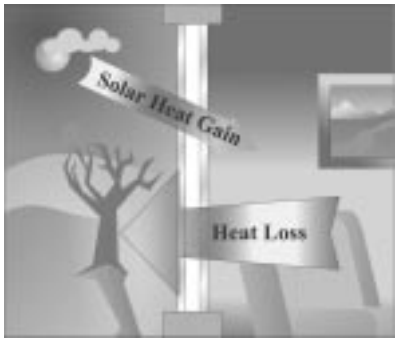
Further complicating this is the fact that different brands of Low-E glass, made by different processes and with different coatings, not only differ in their U-Value but also in the degree to which they allow the sun's radiant energy to enter the home.

The ability of a glass to allow solar heat through it is measured by a numerical value known as the **Solar Heat Gain Coefficient**.

In order to accurately determine the true thermal performance of glass (and therefore the impact that it will have on the homeowners heating bills), it is necessary to consider not only the U-Value of the glass (measuring how well it insulates), but also how the Solar Heat Gain Coefficient effects a home's total energy requirements.

How important is the Solar Heat Gain Coefficient?

It's so important that, as we'll see shortly, some popular types of Low-E glass can actually be less energy efficient than clear float glass, by blocking more passive solar heat than their lower U-Values save!



Because the same coating that gives Low-E glass its lower U-Value also blocks some of the heat gained from solar radiation, a way of measuring the combined impact of both was needed to compare the different kinds of Low-E glass.

The Energy Rating System

This problem – comparing the relative merits of different kinds of glass with different strengths and advantages to determine which performs best in terms of the energy efficiency of a home – was precisely the issue addressed by the **Canadian Standards Association (CSA)** when they developed the **Energy Rating** (or "E.R."), in CSA-A440.2, the portion of the ***Model National Energy Code for Houses*** that relates to window performance.

E.R. is a measurement that is specific to the heating-dominated climate of Canada.

E.R. is a single number (positive or negative) for a specified window size in seven window categories (fixed, casement, sliders, etc.).

In determining a window's E.R., three measurements are used:

1) how much of the beneficial solar heat is transmitted from the outside to the inside of a house through the window (using the *Solar Heat Gain Coefficient*),
2) how much valuable interior heat is lost through the window (using the *U-value*), and
3) how much useful heat is lost through the window by *air leakage*.

Those three measurements are put into an equation that determines a window's Overall Energy Rating.

- A window with a positive E.R. adds more beneficial heat to a home than it loses during the heating season; thus decreasing the home's heating costs.
- A window with a zero E.R. loses as much heat as it gains during the heating season. Therefore, it has no impact on a home's annual fuel consumption.
- A window with a negative E.R. loses more heat than it gains, making the home's heating system work harder. Since these numbers are negative, the smaller the absolute number (the number if it were not negative), the better. For example, a window with an E.R. of -9 is better than a window with an E.R. of -12.

To select a window based on its energy efficiency, consumers need simply choose the window with the best Energy Rating.

Evaluating Low-E Glass

Although the E.R. rating of any window will, of course, depend on the air leakage, we can determine the relative merits of different glass types by comparing them in identical windows (with equal air leakage).

When we calculate the Energy Rating for a typical window with a clear float inboard lite, as well as with three common Low-E glass types – Cardinal LoE²-72 (the most commonly-used Low-E glass in the U.S.), AFG Titanium PS (specifically designed for passive solar heat gain), and Pilkington Energy Advantage Low-E Glass (the leading Low-E in the Canadian market) we find some surprising facts.

The window with Cardinal LoE²-72 glass, although it has the lowest U-Value of all, is the worst performer in terms of the Energy Rating, with a -19. *In fact, even ordinary clear float glass units, with an E.R. of -16, outperform it under the Canadian standards.*

How can this be?

Simply because the additional energy saved by the lower U-Value is *more than offset* by the amount of solar heat gain that is blocked by its Low-E coating.

The AFG Titanium PS unit, on the other hand, has an identical U-Value as the Cardinal LoE²-72 but, because of its higher Solar Heat Gain Coefficient, significantly outperforms both the Cardinal LoE²-72 and clear float, with an E.R. of -9.

The best performing window, however, is the one with Pilkington Energy Advantage™ Low-E Glass, with an E.R. of -6.

Even though it has the highest U-Value of the three Low-E glass types compared, its high Solar Heat Gain Coefficient means that it allows more passive solar heat than the other two, and offers the best overall performance.

As this example demonstrates, consumers making a decision based on the U-Value of the glass alone could easily be misled into purchasing a window that either didn't give them the performance they expected or, in the extreme case, would actually require more energy to heat their homes than a comparable window with an inboard lite of ordinary float glass!

Comparative Window Performance Data[1]

I.G. Unit Type	Clear Float Glass	Cardinal LoE²-72™ Glass	AFG Comfort Titanium PS™ Glass	Pilkington Energy Advantage™ Low-E Glass
Visible Light Transmission (Center of Glass)	81%	72%	77%	75%
Window U-Value ($W/m^2 °C$)	2.50	1.82	1.82	1.93
Window Solar Heat Gain Coefficient	0.54	0.29	0.42	0.50
Canadian Standard Energy Rating (E.R.)	**-16**	**-19**	**-9**	**-6**

[1] Note: Window/I.G. unit data based on 3/4″ thick window with 1/8″ Low-E glass inside, with 1/2″ air space, and 1/8″ clear glass outside. (Low-E coating is on #3 surface except for Cardinal LoE²-72 which is on #2 surface.) Overall U-Value and Energy Rating assumes 24″ x 48″ casement style vinyl window with butyl-metal spacer and zero air infiltration. Performance data calculated by LBL Window 4.1 software.

Toward a National Rating System

In November 1997, Natural Resources Canada (NRCan) published the latest version of the *Model National Energy Code for Houses*, incorporating the E.R. Rating methodology of CSA-A440.2.

The goal of the Model NEC for Houses is to increase the energy efficiency in new homes by setting minimum levels of thermal performance and helping provinces and other governmental agencies incorporate the codes into their building regulations. Houses that comply with the national energy code use less space-heating energy than similar houses that do not comply.

Although, as of early 1999, the Model NEC has not been formally adopted by any province, there is movement in that direction, and the rating system itself provides guidelines for both window manufacturers and consumers in selecting window glass.

In the meantime, the Canadian Window and Door Manufacturers Association (CWDMA) – with financial and marketing support from NRCan – has developed a voluntary certification program for windows, doors and patio doors.

To participate in the program, manufacturers must apply to CWDMA to have their products certified. As part of the certification process, an auditor will visit the manufacturing facility and witness the production of the test sample. The sample will be labeled and forwarded to a test laboratory of the manufacturer's choice. The lab will perform the necessary tests and evaluations to determine if the window or door complies with industry standards.

Following initial certification, the manufacturer will be audited twice a year (without advanced notice) to ensure the window is being built to the same standards as the one originally tested.

If approved, the manufacturer uses the CWDMA certification label, which, for windows, includes the product's Energy Rating.

In addition, all manufacturers who are certified under the CWDMA program are included in the Catalogue Program. The Catalogue Program is a database of windows and doors and their performance characteristics. Developed by NRCan and Enermodal Engineering of Kitchener, Ont., the Catalogue is designed to assist building designers to select the optimum windows and doors for a project based on product characteristics set by the user.

Because this certification uses the E.R. rating, which includes both U-Value and Solar Heat Gain Coefficient in determining window performance, it represents a positive step forward in assuring consumers that they will get the window performance they are paying for, and which is a potentially valuable marketing tool for quality-conscious window manufacturers dedicated to providing their customers optimum value for the money they spend.

ENERGY EFFICIENCY MILESTONES: CANADIAN WINDOW INDUSTRY

1950's	Pilkington/Libbey-Owens-Ford successfully develops and markets Thermopane™ insulating glass, incorporating two panes of glass hermetically sealed together at the edge to create a dead space between the glass. Commonly referred to today as an insulating glass (or I.G.) unit, the Thermopane concept improved the thermal performance in a window by over 50%.
1989	Pilkington/Libbey-Owens-Ford develops Energy Advantage Low-E Glass. Made by a patented pyrolytic process, Energy Advantage Low-E Glass is the first high-performance, color-neutral Low-E in the market.
1989	Enermodal Engineering, Waterloo, Ontario, an energy consultant under contract to NRCan develops a simple and effective means to evaluate the thermal performance of windows, utilizing an energy rating equation (E.R.) that allows windows to be compared under heating conditions in residential applications.
1990	Pilkington/Libbey-Owens-Ford conducts independent, third-party testing that confirms the performance of Energy Advantage Low-E compared to the leading sputter-coated product.
1991-93	Ontario Hydro provides incentives to customers to upgrade their windows based on the E.R. performance requirement.
1993	Canadian Standards Association establishes the CSA-A440 as the standard for windows, establishing performance ratings that include air tightness, water tightness, and wind load resistance and establishing the method for evaluating and comparing thermal energy performance by the use of the Energy Rating (E.R.) equation.
1994	Pilkington/Libbey-Owens-Ford advances the pyrolytic Low-E technology by reducing the emissivity of Energy Advantage Low-E Glass to .15. Energy Advantage remains the best-performing pyrolytic Low-E on the market.
1995	Natural Resources Canada (NRCan) incorporates E.R. in Canada's Model National Building Code.
1995	Enermodal Engineering releases Catalogue software program for use in sourcing and evaluating CWDMA window products.
1996	Canadian Window and Door Manufacturers Association introduces voluntary labeling program which incorporates the E.R. standard.
1999	Enermodal Engineering introduces the RETScreen software program for evaluating the energy performance (based on the E.R. rating) of window products in specific residential applications.

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