IEA-SHC Task 27: Setting Window Energy Efficiency Levels in Canada

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Introduction

Over the last two decades, the energy efficiency of new low-rise residential buildings and the new commercial buildings have increased significantly in Canada. Energy efficiency gains are mainly attributed to better insulation levels of walls, windows, roof and below-grade components, airtightness of the building envelope as well as availability of efficient space heating, space cooling and ventilation systems.

Over these years, the thermal performance of windows has also improved significantly – ranging from 40% to 150% improvement in the thermal insulation levels. There have been significant changes in the window market over the years and now energy efficient windows are commercially available at marginally low incremental costs. Commercially available energy efficient windows can reduce the annual space heating requirement of a house by about 13% or more – ranging from 0.7 to 1.2 GJ per square meter of window area. This translates in savings of about Can$125/year for gas heated and about Can$220 for electrically heated houses in Toronto area (based on May 2002 cost data). Figure 1 shows typical energy analysis of a newly constructed house in Toronto.

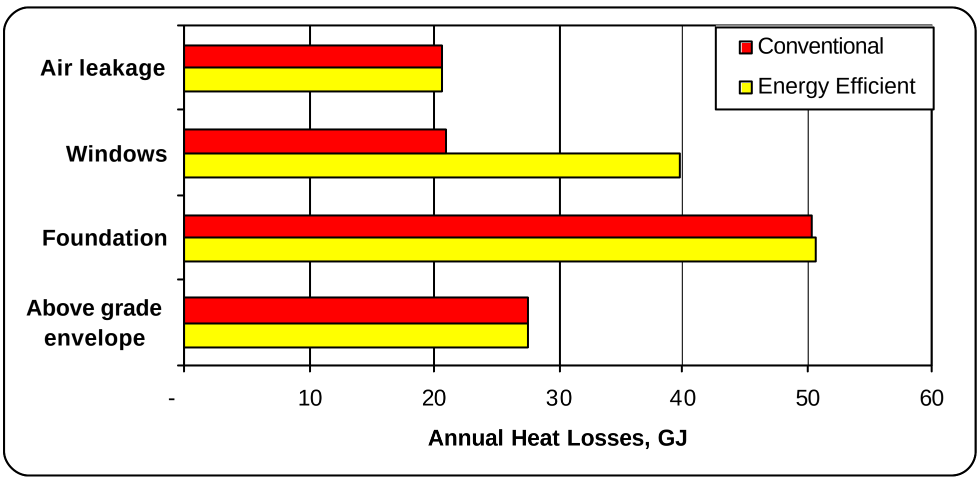


Figure 1. Comparison of annual heat losses of a typical 178 sqm (1900 sqft) floor area house located in Toronto (about 3,900 deg C-days) with conventional double-glazed (U-

value of 2.90 and solar heat gain coefficient of 0.65) and energy efficient double-glazed (U-value of 1.63 and SHGC of 0.42) windows.

Over the years, Natural Resources Canada (NRCan) and National Research Council of Canada have contributed a multitude of resources for the advancement of the research and deployment of energy efficient windows. These efforts have resulted successfully in the commercial availability of energy efficient windows now at marginally low incremental costs. These federal government agencies also helped the development of the national standard, CSA A440.2, for determining the thermal and energy performance of windows. Even with these efforts, the uptake of energy efficient windows is still limited to about 25% of the total window market in the new construction and about 45% in the retrofit market. Conventional windows (double-glazed, 12 mm thickness and wood/vinyl frame) are still much in demand, especially in the new construction and the replacement markets.

Currently, Natural Resources Canada is proposing ways to reduce the greenhouse gas emissions through the promotion of innovative labelling/marketing efforts and are also exploring ways to regulate factory-built fenestration products. This paper provides background research on various options and rationale for pursuing labelling/marketing efforts and also criteria for minimum performance requirements for windows for the labeling purposes.

Context

Goals of setting energy efficiency levels of acceptable energy descriptors for labelling and regulation purpose are as follows:

- to increase the energy efficiency of fenestration products available in Canada;
- to reduce the amount of energy used in housing and buildings;
- to reduce the amount of greenhouse gas emissions from energy generation; and
- to implement an industry acceptable fenestration labelling system for Canada.

The main issue: what is the primary purpose of the labelling? Or regulation? Labelling is generally to *provide information* on thermal performance of windows. The purpose of regulation is to *prescribe minimum* level of performance.

Energy efficiency levels must provide clear measure of:

- *Level 1: Descriptors* – U-value, Solar Heat Gain Coefficient (SHGC), visible transmittance, condensation resistance. These descriptors are dependent only on geometry and properties of glazing and frame. Measurement methodologies are well proven for most descriptors and are harmonized in a North American context.

- *Level 2: Annual energy demand and use (Energy Rating System).* Dependent on climate, type of dwelling (building) and energy descriptors defined in Level 1. Various methods do exist: equation based, simulation based. There is no standard by which the annual energy demand and use is established. This also does not provide perfect information for every situation, but the rating system must provide enough information to improve product selection on average in each region.

The window energy efficiency levels must be based on the following norms:

1. Efficiency levels set for the labelling or marketing efforts must reward better performing windows. These efforts should be able to differentiate conventional and energy efficient windows clearly.
2. Energy efficiency levels should be no worse (lower) than the 1997 Model National Energy Code for Houses (MNECH) for any location and probably should exceed it for the majority of the coverage area.
3. As per above (2), being voluntary measure, the efficiency level doesn't necessarily have to be optimum for "all" situations and locations, as this would likely add too much complexity.
4. Recommendations should take into account the issues of manufacturers shipping and distribution patterns and minimize confusion when promoting to consumers.
5. Efficiency levels set for labelling or marketing efforts must result in at least a 5 to 10 percent more energy efficient window based on the annual energy use compared to conventional double-glazed, clear glass, window.
6. Energy efficient windows must contribute in the net greenhouse gas reductions based on the stock analysis in all situations.
7. Energy descriptors must be defined as per the CSA A440.2 (revised to be published in 2002) and should also conform to the National Fenestration Rating Council (NFRC based in the US) requirements.
8. The minimum entry-point energy efficiency level set for the regulatory purpose should be able to satisfy more than 80% of current windows so that the economic impact is minimized.
9. Energy efficiency levels should be able to eliminate poor performing windows.

Energy Descriptors

The following descriptors define thermal and optical performance of fenestration products:

- *U-value* – defines heat loss coefficient of windows. The lower the value, the better is the energy efficiency.
- *Solar heat gain coefficient (SHGC)* – defines solar-optical performance of window assembly. The higher the SHGC value, the

better the amount of usable solar gains. In heating dominated climates, a high value of SHGC is preferred. In a cooling dominated climate, lower SHGC is preferred to reduce air-conditioning loads.

- *Energy Rating (ER)* – combining U-value and SHGC. Energy Rating combines the effects of heat losses associated with thermal conductance and convection, represented by U-value, air leakage losses and the solar gains through the windows. The higher the ER value, the better the energy performance of windows during the heating season.
- *Energy Levels (based on ER and U-value)* – defines equivalent energy performance targets for different applications of similar products.

Canadian Market for Residential Windows

First, let us look at the current window market in Canada. Ducker Research data on the Canadian window market available for the year 1999 stated that the residential window market was about 5.14 million window units[1]. Residential-type windows accounted for 4.98 million units – 2.28 million used in new construction and 2.7 million in the retrofit / replacement market as shown in Table 1. The residential-type windows are often defined as factory-glazed windows that are designed for low-rise residential applications. Often these units are also employed in mid-rise multi-residential buildings. [This is the most recent data available on the window market in Canada. Ducker Research is in the process of compiling data for year 2001.]

Highlights are as follows:

- Residential-type windows are mainly wood and vinyl windows. Aluminum framing material dominates the non-residential market. Wood-frame (clad or non-clad) units have traditionally represented the largest share of the residential-type windows. Vinyl window units have penetrated the market significantly over the last fifteen years, and have captured a large portion of the new construction market in Canada.

Table 1. Residential window market (1999).

	Million Units		Million Units
Residential	4.98	New Construction	2.28
		Retrofit / Replacement	2.7
Non residential	0.16		
Total	**5.14**		

- Wood windows currently represent about 39% of the total residential-type window market as shown in Table 2. The market survey showed that over last ten years vinyl has displaced

[1] Ducker Research Corporation, "Study of the U.S. and Canadian Market for Windows and Doors," April 2000.

aluminium framing. Other framing materials include fibreglass and composites.

- The Ducker report also indicated that about 69% of total window sales account for operable units while 31% of windows are fixed. This data is quite different for United States where only 15% of windows are fixed.
- Insulating glazing units (IGUs) represent the dominant type of glazing configuration in residential windows. About 91% of windows are made with IGUs.

Table 2. Framing material used in residential products.

Framing Material	Units, millions	
Wood and clad wood	1.94	39.0%
Aluminum	0.3	6.0%
Vinyl	2.69	54.0%
Other	0.05	1.0%
Total	**4.98**	

- The warm-edge technology has continued to penetrate the market. Warm-edge usage surpassed the use of an aluminum spacer in 1995, and in 1999 it represented 82% of all residential windows. Rigid warm edge (shaped steel spacers, butyl-metal spacers) accounted for 54% of the market while the non-rigid warm edge (butyl, silicon foam, plastic and non-metal) accounted for 28% of the market share. Aluminum spacers were found only in 18% of new windows.
- Of those IG units containing sealed backing, dual sealed units were predominantly found in the Canadian market. A dual sealed unit contains both a primary and secondary sealant.
- About 36% of IG units manufactured in Canada contained at least one low-emissivity coating. Based on this data, it is assumed that 36% windows sold in Canada contained a low-emissivity coating. It is also assumed that about half of these windows contained inert gas (mainly argon-filled).
- Glass that is visually clear dominates the new construction residential market.

Canadian Energy Rating System

Canadian Energy Rating System was designed to show the average heating season thermal performance of windows. The Energy Rating procedure is incorporated in the Canadian Standard A-440.2-98, "Energy Performance of Windows and Other Fenestration Systems." The Energy Rating (ER) combines the effects of U-value, SHGC and air leakage characteristics of windows.

ER = solar heat gains – conductive heat losses – air leakage heat losses

$$ER = 0.8 * 72.2 * SHGC_w – 21.9 * U_w – 0.54 * (L_{75} / A_w)$$

Where,

ER is Energy Rating, W

$SHGC_w$ – Solar heat gain coefficient of a window

U_w – Overall heat loss coefficient, $W/(m^2\ {}^oC)$

72.2 represent the average solar radiation on a vertical window during the heating season, (W/m^2).

0.8 factor is to account for exterior shadings on windows.

21.9 represents average temperature difference over the heating season.

Canada has a variety of weather patterns – ranging from mild climate in southern BC to very cold northern regions. Therefore, there have been a number of situations arising in certain mild regions as well as with window designs in which the ER values do not seem to reflect the use of better fenestration technologies (such as low-E, argon-filled, insulated spacer and so on). This has been identified as a major obstacle in acceptance of the Energy Rating system. Again, the issue is *not* the technical soundness of the ER equation but the proportional contribution of the solar effects and insulating effects. Manufacturers can voluntarily rate energy performance of windows using the services of Canadian Standards Association.

Analyses of Thermal and Solar Properties of Windows

To be able to set the appropriate energy efficiency levels for windows, thermal and optical properties were obtained for a variety of fenestration products. The database included about 3,695 fenestration products. These products are manufactured or distributed in Canada. Data included the following parameters:

- *Product specifics:* source, origin of manufacture, product type, primary operative type, and secondary operative type.
- *Performance data:* ER, Uw, SHGCw, air leakage rating, air leakage rate $(m^3/h)m^{-1}$, B rating (wind pressure), C rating (water penetration), U_{cg}, $SHGC_{cg}$.
- *Sizing and Material data:* frame material, sash material, number of glazing, low-e characteristics, type of gas-fill, type of spacer, tint classification, rated width, rated height, and various other parameters.
- *Testing laboratory:* name of the testing laboratory.

Data analyses showed the following trends in relation to determination of energy efficiency levels:

- About 72% of products have an overall U-value of 2.5 W/m^2-C or less. Windows with higher U-values tend to contain metal frames and metal spacers. Figure 2 shows the U-value profiles of windows.
- About 1/3rd of products have an U-value of 1.8 W/m^{2}C or lower. These windows generally assemble insulated spacers, better frames and argon-filled, low-e insulated glazing unit.
- Low-e glass is becoming a more common option for Canadian window manufacturers. About 55% of products have at least one low-e coating.

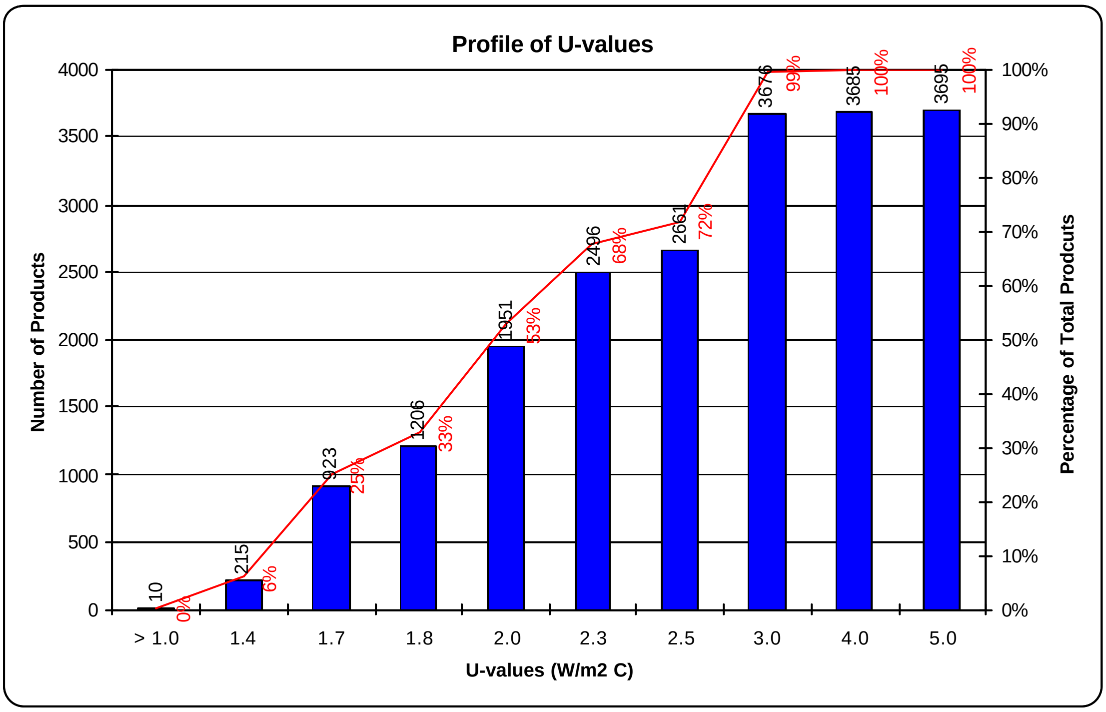


Figure 2. Profile of heat loss coefficient of windows (U-Value).

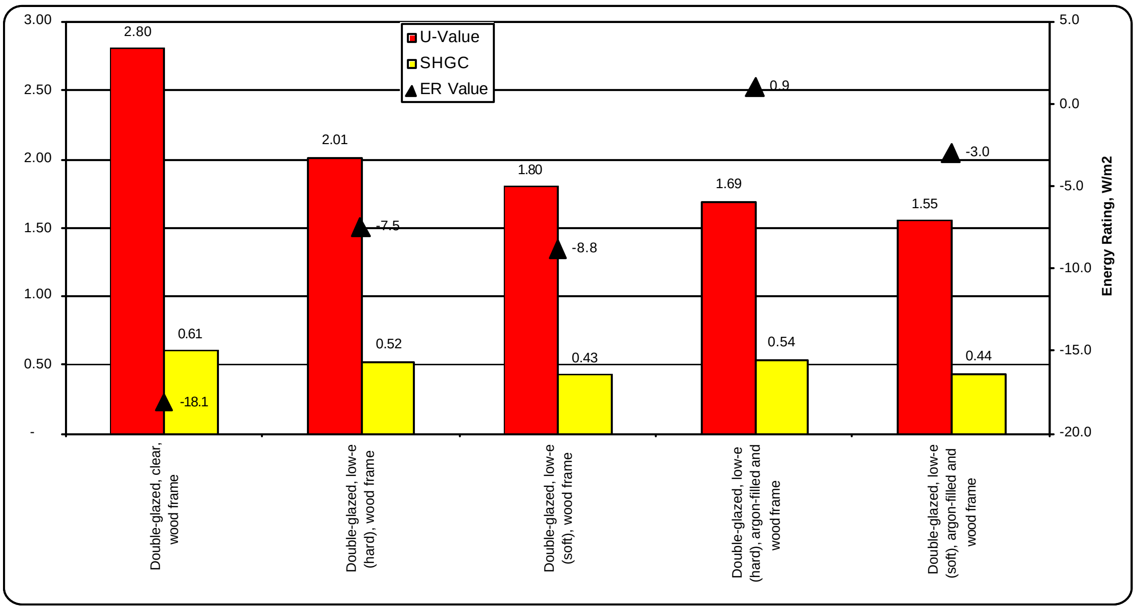


Figure 3. Typical average thermal performance data for double-glazed windows.

Table 3. Thermal and solar heat gain factor for typical double-glazed windows.

	Type of Windows	Heat Loss Factor U-value (m2.C/W) Range	Average	Solar Heat Gain Coefficient Range	Average	Energy Rating High	Low	Spread
1	Double-glazed, clear, vinyl frame	2.40 to 3.00	2.70	0.57 to 0.63	0.60	-20.1	-29.8	9.7
2	Double-glazed, clear, wood frame	2.50 to 3.10	2.80	0.53 to 0.68	0.61	-24.6	-29.1	4.5
3	Double-glazed, low-e (hard) and vinyl frame	1.85 to 2.30	1.99	0.45 to 0.66	0.56	-15.0	-12.7	2.3
4	Double-glazed, low-e (hard), wood frame	1.87 to 2.20	2.01	0.45 to 0.59	0.52	-15.4	-14.6	0.9
5	Double-glazed, low-e (soft) and vinyl frame	1.67 to 2.00	1.76	0.35 to 0.52	0.44	-16.8	-14.2	2.6
6	Double-glazed, low-e (soft), wood frame	1.70 to 1.90	1.80	0.37 to 0.49	0.43	-16.3	-13.8	2.6
7	Double-glazed, low-e (hard), argon-filled, vinyl frame	1.60 to 1.90	1.71	0.45 to 0.62	0.54	-9.5	-6.2	3.2
8	Double-glazed, low-e (hard), argon-filled and wood frame	1.60 to 1.80	1.69	0.45 to 0.62	0.54	-9.5	-4.1	5.4
9	Double-glazed, low-e (soft), argon-filled and vinyl frame	1.40 to 1.70	1.51	0.32 to 0.52	0.42	-12.6	-7.6	5.0
10	Double-glazed, low-e (soft), argon-filled and wood frame	1.40 to 1.70	1.55	0.32 to 0.55	0.44	-12.6	-5.9	6.7

Table 4. Energy levels for labelling options.

	Zone A	Zone B	Zone C	Zone D	Energy Savings PJ	GHG Reductions kilotonnes
Option 1: 4-zone model						
HDD	< 3500	3500-5500	5500-8000	> 8000	2.76	130.9
U-Value	2.0 (0.35)	2.0 (0.35)	1.7 (0.30)	1.4 (0.25)		
SHGC	min 0.30	min 0.35	min 0.40	Any		
Option 2: 3-zone model						
HDD	< 5000	5000-7000	> 7000		2.94	139.6
U-Value	2.0 (0.35)	1.7 (0.30)	1.4 (0.25)			
SHGC	min 0.35	min 0.35	Any			
Option 3: 2-zones - division in southwestern B.C.						
HDD	< 3500	> 3500			3.25	153.6
U-Value	2.0 (0.35)	1.7 (0.30)				
SHGC	min 0.35	min 0.35				
Option 4: 2-zones - division at the 60th degree parallel						
HDD	Below North 60deg	Above North 60deg			3.37	154.9
U-Value	1.7 (0.30)	1.4 (0.25)				
SHGC	min 0.35	min 0.35				
Option 5: 3-zones model						
HDD	< 3500	>3500 to <6000	>6000		3.21	147.4
U-Value	2.0 (0.35)	1.7 (0.30)	1.4 (0.25)			
Energy Rating (ER	-18 (O) and -8 (F)	-13 (O) and -3 (F)	-9 (O) and +1 (F)			

- Table 3 and Figure 3 show the U-value, solar heat gain and energy ratings of properties of typical double-glazed windows. They indicate that the higher the solar heat gain and lower the U-value, better the energy rating.

Detailed Energy Analyses to Establish Benefits

For the labelling program, five different options were defined based on heating degree-days criteria. These options are shown in Table 4. For each option, a detailed energy analysis was conducted using representative weather locations (based on building stock population) and regionally representative housing and small commercial building characteristics.

Option 1 to 4 included the energy efficiency levels defined by meeting a maximum U-value requirement and a minimum solar heat gain coefficient. Option 5 included meeting a maximum U-value requirement or meeting the Energy Rating target.

Figure 4 and Figure 5 shows the energy analysis results of a typical small commercial building located in a relatively mild climate of Windsor, Ontario. As shown, higher the solar heat gain coefficient, lower the space heating energy requirement in winter months and higher the cooling energy requirement in summer months. The utility cost analysis for this building showed that the SHGC of 0.25 to 0.35 offered an optimum balance for the space heating and space cooling costs. These trends were observed in all other locations with a similar range of SHGC values.

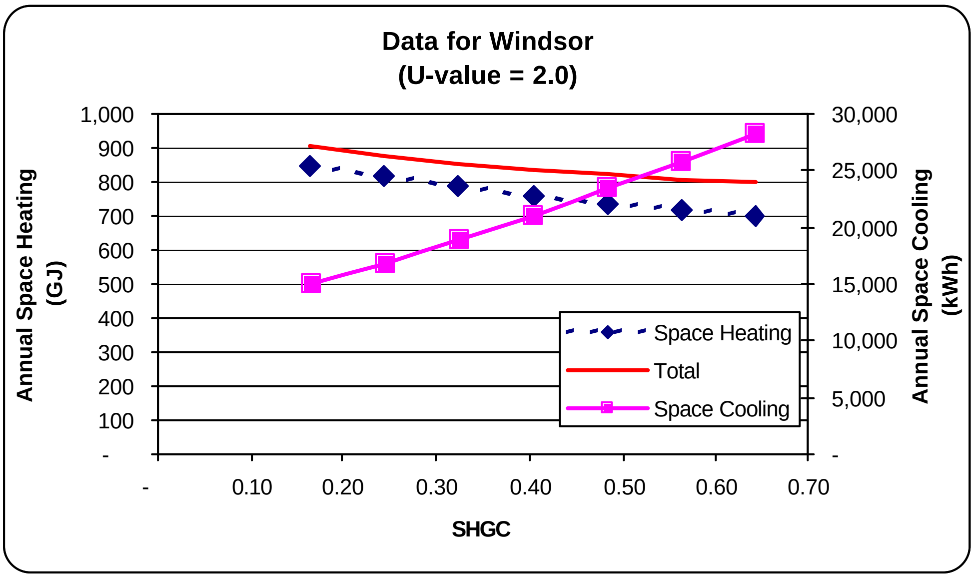


Figure 4. Energy needs for a typical 1400-m2 small commercial building located in Windsor, Ontario.

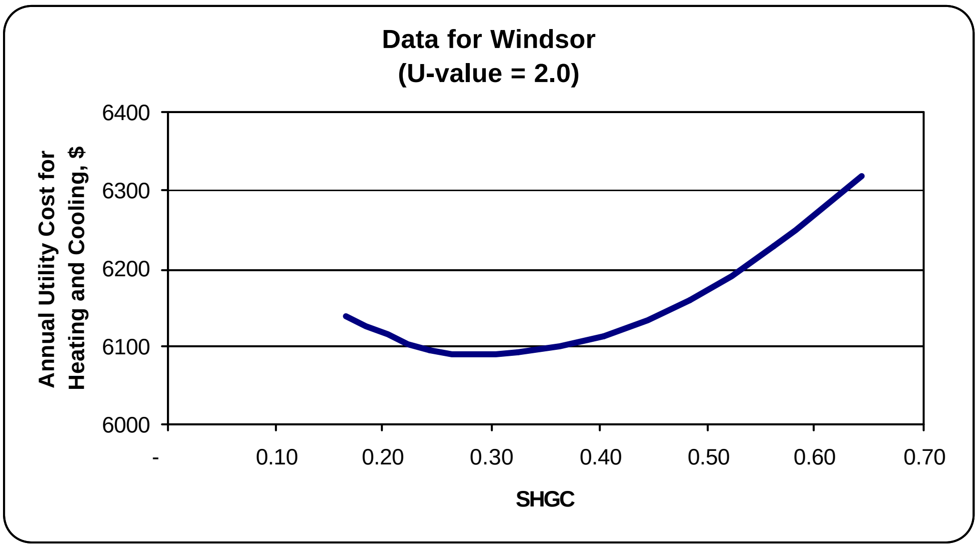


Figure 5. Annual space heating and cooling costs for the above example small commercial building located in Windsor, Ontario.

Table 5. Criteria for setting energy efficiency levels for the labelling program (3-Zone model, imperial equivalent in brackets).

Zones		**U-value (maximum)**	**Energy Rating, ER**		**Energy Level**
			Operable	Fixed	
A	=3500 (6300)	2.0 (0.35)	-18	-8	3
B	>3500 (6300) to =6000 (10800)	1.7 (0.30)	-13	-3	4
C	>6000 (10800)	1.4 (0.25)	-9	+1	5

Energy Efficiency Levels for the Labelling Program

Based on detailed energy analysis of various options described in the previous section, Option 5 was selected as most appropriate. Table 5 defines the criteria. The rationale for choosing the Energy Star criteria is based on the following considerations:

- B.C. lower mainland has unique weather and market conditions that require this region to be a special zone.
- The maximum U-value specifications and ER levels are based on the existing requirements set by B.C. Hydro's existing Power Smart Program as well as requirements set in the Model National Energy Code for Housing (MNECH).
- The Energy Level criteria will provide flexibilities for window manufacturer to produce windows that optimizes solar heat gains and the thermal resistance.

For Option 1, the Zone A includes about 10% of the building stock population. A double-glazed, low-e (hard or soft) with wood/vinyl/ fibreglass/composite frame can meet this requirement. The Zone B includes about 80% of the building stock. A double-glazed, low-e (hard or soft), argon-filled with wood/vinyl/fibreglass/composite frame can meet this requirement. Zone C represents less than 10% of the building stock. A double-glazed and triple-glazed with one or two low-e, argon-filled windows can meet this requirement.

This Option also takes into account current requirements set by B.C. Hydro as well as Manitoba Hydro (except for Zone B definition by B.C. Hydro which includes 3500 to 5800 ^{O}C-days). This Option also confirms that the labellling criteria is better than or equal to the requirements specified in the Model National Energy code for Houses (1997 MNECH).

There is technical potential for saving the annual energy consumption by about 3.2 PJ per year. The reductions in greenhouse gas emissions would be about 147 kilotonnes as shown in Table 6.

Canadian Window Database was further used to determine availability of qualifying products for specific set of U-values and the Energy Levels. Figure 6 shows the number of qualifying products for specific zones. A large number of products can meet the U-value criteria. The Energy Level criteria can expand the available product range for each zone.

Issues Considered for Setting Energy Efficiency Levels

Impact of Solar Heat Gain Coefficient

Primarily, issue centered on at what level do we define minimum SHGC requirement. In order to evaluate what impact this has, several energy and operating cost analyses were performed for housing and small commercial buildings. Also performed was the evaluation of available windows from the Window Database. Relative energy consumption for a new and existing home using windows with a U-value of 2.00 and SHGC of 0.2, 0.3, 0.4, 0.5, 0.6 was evaluated eight different locations. The energy analysis results showed that the SHGC of 0.3 to 0.4 provided optimum energy savings as well as energy costs savings in all regions below 6500 degree-days (which incidentally, covers more than 85% Canadian building stock).

Cooling and Heating Loads in Critical Areas

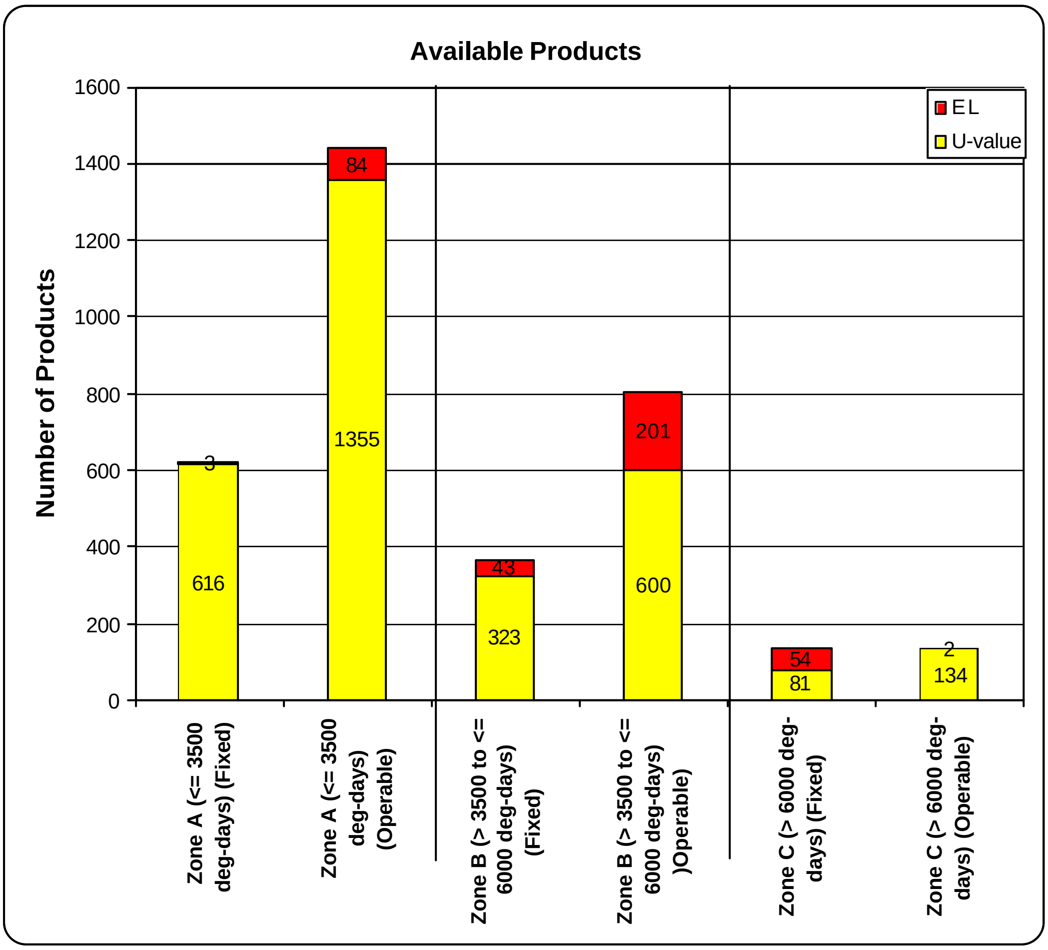
Canada has a heating-dominated climate. A weather data survey showed that the maximum heating degree-days of 13,700 ^{o}C-days occurs in Eureka, NU. The minimum number of HDD of 2720 ^{o}C-days recorded in Merry Island, lower mainland of B.C. Cooling degree-days are prominent in Windsor and some parts of southern Ontario and lower mainland BC with a maximum of about 422 ^{o}C-days.

Residential Buildings: Energy analyses results showed that the cooling energy requirements in “mild” climates accounted for about 7 to 12% of the total annual space conditioning energy requirements (space heating plus space cooling only). A recent Statistic Canada survey showed that about 29% housing stock contained cooling equipment. The survey also showed that, on an average, homeowner operated cooling system for a period of 8 to 30 days during the summer months.

Table 6. Annual technical potential for energy savings and GHG reductions associated with the adoption of Option 5 criteria.

Regions	Window Market, units		Energy Savings, GJ		GHG Emissions, killotonnes	
	Retrofits / Replacement	New Construction	Retrofits / Replacement	New Construction	Retrofits / Replacement	New Construction
Atlantic	210,932	177,653	140,486	117,786	8.3	7.0
Quebec	680,679	573,286	456,400	382,652	0.4	0.4
Ontario	1,004,035	845,625	611,908	513,033	12.6	10.5
Prairies	429,826	362,011	326,483	273,728	55.4	46.5
BC	362,273	305,116	178,801	196,245	2.3	2.5
North	7,065	5,950	6,201	4,193	0.9	0.6
Canada - Total	2,694,810	2,269,640	1,720,279	1,487,638	80.0	67.5
		4,964,450		3,207,917		147.4

Figure 6. Number of qualifying products which can meet labelling criteria based on window types.



There is also rise in the inclusion of central cooling systems in the new construction of homes. As per Heating Refrigeration and Air-conditioning Institute (HRAI) survey, about 50% of new homes come with the installed cooling equipment.

In sunny and warm climates of lower mainland BC and southern Ontario, solar gains through windows can over heat the house. However, houses with proper window overhangs and window coverings can overcome the over heating problem effectively. Also, it should be noted that the low-e windows (either hard or soft coat) would reduce the solar gains compared to conventional clear double-glazed windows.

Small Commercial Buildings: Energy analyses results showed that the cooling energy requirements in “mild” climates accounted for about 10 to 23% of the total annual space conditioning energy requirements (space heating plus space cooling only). Figure 4 and Figure 5 showed a typical profile of space heating cooling loads for a small commercial building in Windsor. Analysis results showed that windows with lower SHGC reduced dependency on cooling loads thereby reducing the electricity usage in summer months. The results also showed that the heating requirements still dominated over the year. In mild Canadian climates, windows with a minimum SHGC of 0.35 will still be optimally cost effective.

New construction and existing buildings

As shown in previous section, the market for window sales is almost evenly split between new construction and retrofit / replacement applications. There are a couple of differences in the estimates for new and retrofit, due to differences in each of these markets. These differences are:

- Air conditioning represents a greater percentage of total energy use in the new construction market due to increased use of insulation. The increased insulation reduces the heating load more than it reduces the cooling load. Also, new homes are far more likely to have air conditioning.
- Energy efficient windows are already popular in the retrofit / replacement market.

Impact on Manufacturing and Distribution of Windows

Window manufacturers and consumers would likely value an approved label for identifying efficiency and comfort. Thus, the label's requirement affect window manufacturers' decisions about window components and consumers' decisions about which products to purchase. The impacts of program requirements on participants in the window market should therefore be well-understood and included as part of the final decision-making process regarding setting energy efficiency levels.

We reviewed the available window performance data to ensure that commercially available products were available for the criteria levels included in the various options. The products were chosen to represent the more common residential window types. In terms of number of products available, it would appear product availability is not an issue.

Even though product availability does not appear to be an issue, there are some manufacturing sectors within the window industry where industry has made significant investments and where there may be significant impacts caused by proposed specifications for Canadian energy efficiency levels. These sectors are:

- Wood frames
- Aluminium frames in Québec region
- Types of low-emissivity (low-e) coatings

<u>Wood frames</u>

Wood frames are very popular in Canada. Wood frames or wood clad windows consist of about 39% of the total window market. There are some issues with regard to thermal and solar performance associated thicker window frames. Generally, wood frames thickness range from 76 mm to 90 mm or more. Thicker frames provide consumers with a sense of confidence for sturdier frames. The thicker frames greatly affect the solar heat gain coefficient of the whole window. Due to the lower SHGC values associated with wood frames, window manufacturers have raised issues with regard to the Energy Rating System.

The issue of thicker frames need further investigations. Low-profile wood frames are being introduced in the marketplace. The database showed that there are a number of double-glazed and triple-glazed wood windows which can meet aggressive energy efficiency levels set for labelling or marketing efforts.

Aluminums Frames

Thermally-broken aluminium-framed residential windows once represented a significant portion of the market (30 percent or more during the 1970s but now it is less than 6 percent in low-rise buildings). Because of the relative lower energy efficiency and lower condensation resistance of these windows, consumers have moved away from these products. The lower market share of thermally-broken aluminium frames has been hastened by the emergence of vinyl as a cost-effective and thermally efficient replacement. The decreased market share of aluminium windows has hurt aluminium extruders more than window manufacturers; manufacturers switched to vinyl extrusions and continued to sell windows while aluminium extruders have been left without a market.

However, in Québec market aluminium frames are quite popular. In this region, heating energy issues are predominant compared to cooling loads. The energy efficiency levels for labelling should attempt to take into account the prevalence and benefits of aluminium frames in Québec and other markets associated with traditionally lower cost.

Low-e coatings

Low-emissivity or low-e coatings are the key components used to create an efficient. Low-e coatings are invisible, microscopically thin, metal or metallic oxide layers deposited on glass during manufacturing or soon after manufacturing. Emissivity relates to the rate of long-wave radiative heat transfer between glazing layers in a double glazed window (the lower the emissivity, the less heat transfer). This leads to decreased window U-values (compared to uncoated clear glass) from the use of any low-e coating. Low-e coatings are all but required for an energy efficient product, so the way in which labelling addresses the different types of low-e coatings is critical for the low-e coating industry.

There are two manufacturing processes for low-e coatings, with each process producing a different product. Both products lead to significantly lower window U-values but they differ in how they impact a window's Solar Heat Gain Coefficient (SHGC) – the fraction of incident solar radiation transmitted by the window. The products resulting from these two manufacturing processes are summarized below:

- Pyrolitic (sometimes called hard) low-e coatings are deposited on the glass while it is being manufactured. These coatings transmit a higher level of sunlight, which provides for added warmth in the winter but do not reduce summer cooling loads.

- Spectrally selective coatings (sometimes called soft) are applied to glass after it is manufactured using sputtering equipment. These coatings reflect the invisible part of sunlight (the solar-infrared) while still transmitting visible light. This results in “clear” looking glass with significantly reduced summer cooling loads. However, “free solar heating” during the winter is also reduced.

Spectrally selective products have become quite popular because they meet maximum U-value requirements (for northern climates) and also maximum SHGC requirements (for cooling dominated climates). Canadian window manufacturers find this combination appealing because they only need to stock one product that can meet or beat codes or labelling requirements. Until a few years ago, several national manufacturers offered a “northern” low-e (pyrolitic) and a “southern” low-e (spectrally selective) product; these dual products have almost all been eliminated in recent years.

In climates with the 3,000–4,000 HDD zone, both products save significant energy compared to clear uncoated double-glazing. Pyrolitic coatings save more heating energy and less cooling energy. Spectrally selective coatings save less heating but more cooling energy. The selection about which type of low-e product one can use depends primarily on local climate and specifics of the application. In general, in Canada, heating outweighs cooling energy use in the residential sector. However, in a good number of applications, air conditioning may be critical to energy use and comfort particularly in small commercial buildings.

Conclusions

The Government of Canada is committed to the mitigation of climate change through reduced energy consumption. The sale of energy-efficient products in Canada is being encouraged through various means. This article provided background research on various options and rationale for pursuing labelling efforts and also criteria for setting minimum performance requirements for windows. Energy efficiency levels for windows are established based on the overall energy efficiency improvements, potential for reductions in greenhouse gas emissions, availability of products in the marketplace, overcoming various ‘manufacturing and distribution’ barriers, and acceptance of the criteria by the window industry. The main goal is to transform and move the marketplace towards energy-efficient fenestration products in the residential and light commercial sectors. The proposed energy-efficiency levels for windows presented in this paper will encourage different segments of window industry (such as, wood and vinyl sectors) to achieve better products at reasonably low costs and will provide level playing field for innovative products.