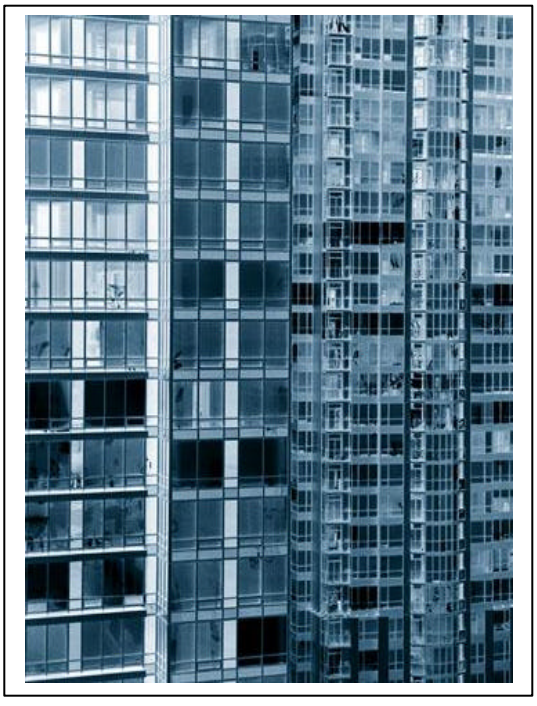
Commercial Window Market Assessment

Final Report



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January 2007

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Glossary

ASHRAE	American Society for Heating Refrigeration and Air Conditioning Engineers
Low-e glass	Thin layers of pure metals or semi conductors installed on glass to enhance the thermal performance
Solar Heat Gain Co-efficient	SHGC is the portion of solar heat that passes through a window
Thermal Transmittance	The rate of heat loss through a window is known as the thermal transmittance (U-value) and is measured in units of W/sq m*K.
Window / wall Ratio	Portion of the vertical surface of a building clad with fenestration

Summary

This report characterises the market for energy efficient glazing in the commercial building sector in British Columbia. Commercial glazing systems (fenestration) represent a significant opportunity to reduce mechanical heating load in winter, cooling load in summer and electric lighting load during typical work schedules. This report also summarises the current status of the residential Energy Star windows program in British Columbia, including an estimate of the current market share of Energy Star certified products.

The analysis focuses on energy savings opportunities and does not include air leakage through windows, or at the window to wall interface.

Significant analysis has been completed to characterise the commercial glazing market with an effort to improve the energy performance of the commercial sector. These previous efforts provide a point of departure for the current study. They highlight that the commercial glazing market is distinct and more complex than the residential glazing market. Internal heat gains, day lighting, variations in the uses of and number of occupants, and several other environmental and human factors result in the increased complexity of commercial windows. This in turn results in the need to specify additional factors such as shading coefficient, orientation and building use in order to delineate energy efficient commercial glazing.

There are three major commercial glazing archetypes: storefront, punched windows and window wall/curtain wall. These archetypes represent functional rather than energy performance characteristics, as the materials used throughout the commercial glazing sector are similar (aluminium frames and insulated glazing units[1]). The opportunities to improve the thermal performance are common to all the archetypes. Thermal archetype characteristics include:

- Operation (fixed versus operable),
- Location (climate zone, orientation),
- Building Type (internal versus external load), and
- Amount (window / wall ratio).

A range of energy efficient components exist to enhance the performance of commercial glazing, including:

- Low-e films on the glass
- Improved thermal breaks in the frames
- Insulating spacers to separate the glass sheets in the insulted glazing units, and
- Inert gas fill

All of these components are widely available.

[1] Monolithic glass is also used to lesser degree.

The commercial glazing market is estimated at 600,000 m^2 per year. The split between new and retrofit activity is estimated at 70% new and 30% retrofit. Eighty-five percent of the commercial glazing market in British Columbia is located in the Lower Mainland and Vancouver Island, and approximately 70% of the market includes high-rise residential and small commercial buildings. Finally, it is estimated that 50 % of the commercial glazing market currently uses low-e glass.

The relatively high penetration rate of low-e glass is driven largely by the ASHRAE 90.1 energy utilisation requirements in the City of Vancouver. While low-e glass has historically been a benchmark to delineate an energy efficient product, many respondents surveyed for this study indicated that there is no single threshold for an energy efficient commercial glazing product. Survey respondents identified the need to move beyond low-e, and to address issues related to orientation, window wall ratio and other factors to encourage improved efficiency. In short, respondents felt the need to move to systems based optimisation where the glazing performance is adjusted to optimise building (not window) energy performance. Those respondents familiar with ASHRAE 90.1 promoted its use.

The costs for energy efficient glazing components are summarised in Table 1.

Table 1: Incremental Cost of Energy Efficiency Improvements

Feature	Survey Response	Enermodal [2]
Low-e coating	$10/Sq m	$18/Sq m
Argon gas fill	$10/Sq m	$8/Sq m
Improved spacers	$4/m	$3/m
Thermal break	$4/m	$7/m

The current PST exemption for glazing products results in $25 million lost revenue for the Province. If the Province were to provide a PST exemption on only that portion of glazing that is low-e, the provincial revenue potential is estimated at $13 million per year.

An assessment of the market barriers to increased adoption of energy efficient glazing products reveals that price and limited understanding of the benefits of improved glazing performance hinder greater adoption of energy efficient products.

An analysis of the proposed Energy Star thresholds for commercial glazing was completed. It was estimated that implementation of the Commercial Window Energy Star threshold would reduce energy use in the commercial buildings by 8%, on average. Implementation of an Energy Star rating has a positive life cycle cost for all building types in retrofit construction. The life cycle cost is positive in new construction for all segments, except for medium sized schools and warehouses, due to their lower glazing areas. The payback period ranges from one to fifteen years in the retrofit market and is immediate to up to eight years in new construction. Electricity savings are estimated at

[2] Enermodal Engineering, Energy Star for Commercial Windows – Feasibility Study, 2005.

18 GWh/yr and natural gas savings are estimated at 100,000 GJ/yr. Should the ASHRAE 90.1 standard be chosen, it is estimated to result in a 4 GWh/yr savings in electricity and a 30,000 GJ/yr savings in natural gas.

It is recommended that British Columbia continue to work with the Federal Government to develop an Energy Star rating for commercial glazing products to offer a voluntary labelling program to promote innovation and recognise "best in class" products. However, to protect the market transformation to low-e products that has occurred throughout the province and to stop back slippage, it is also recommended that the prescriptive performance requirements defined in ASHRAE 90.1 be considered for implementation by the Province of British Columbia. The implementation could occur through amendment of the Energy Efficiency Act Standard for Manufactured Fenestration Products currently proposed to commence January 1, 2009. In cases where the glazing amount of a building exceeds 50% (the maximum allowable glazing under the prescriptive compliance path for ASHRAE), the prescriptive requirements for 50% are recommended.

ASHRAE 90.1 offer multiple benefits compared to the current Energy Star threshold:

- The standards are sensitive to the window wall ratio, orientation and occupancy.
- The standard will have the largest impact on buildings with significant portions of glass (such as high-rise apartments and office towers) yet require minimal change from current practice in buildings with low window wall ratios.
- The standard includes thresholds for U-value and solar heat gain.
- The standard requires product certification (NFRC).
- The ASHRAE standard forms a part of the building code in the City of Vancouver, and adoption by the province results in a "level playing field" throughout BC.
- ASHRAE 90.1 is consistent with "good engineering practice", and the performance levels are based on life-cycle costing to ensure cost effectiveness.

Residential Window Survey

Analysis was conducted to assess the penetration of Energy Star certified residential windows in BC. It is estimated that Energy Star rated residential windows have 20% to 30% market penetration of the residential glazing market.

1. Introduction

The Province of BC has committed, through the *Energy Efficient Buildings: A Plan for BC*, to improve energy efficiency in homes and buildings. This includes "working with the building industry, governments and others to improve energy efficiency in new and existing buildings". As part of this mandate, the Province is exploring options to improve the energy efficiency of windows installed into commercial and institutional buildings.

1.1. Objectives

This market assessment will assist policy makers to develop and design programs to achieve the Provincial government's voluntary energy performance target of 25% below the Model National Energy Code for Buildings (MNECB) by 2010. The commercial building sector is characterised by significant diversity across building segments, construction practices and window types. Developing an understanding of this market will ensure emerging energy policy works with industry in a way that is efficient and effective.

1.2. Rationale

Window systems represent a significant opportunity to reduce mechanical heating load in winter, cooling load in summer and electric lighting load during typical work schedules. While it is difficult to generalize across the commercial sector, it is clear that windows represent one of the largest sources of heat loss during winter, and heat gain during summer. For example, as shown in Figure 1, windows are the most significant source of heat loss in a typical multi-unit residential building.

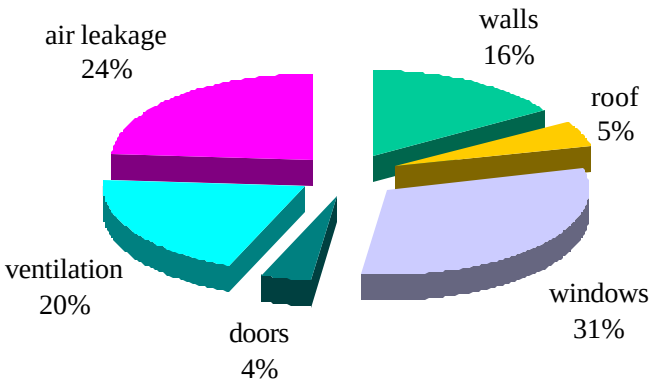


Figure 1: Component Heat Loss in MURBs[3]

[3] The Sheltair Group, 2005. Air Leakage Control Manual, Canada Mortgage and Housing Corporation.

Furthermore, as shown in the parametric analysis in Figure 2, incremental improvements in window thermal resistance and window wall ratio are significant, compared to improvements to the mechanical system or other envelope components. [4]

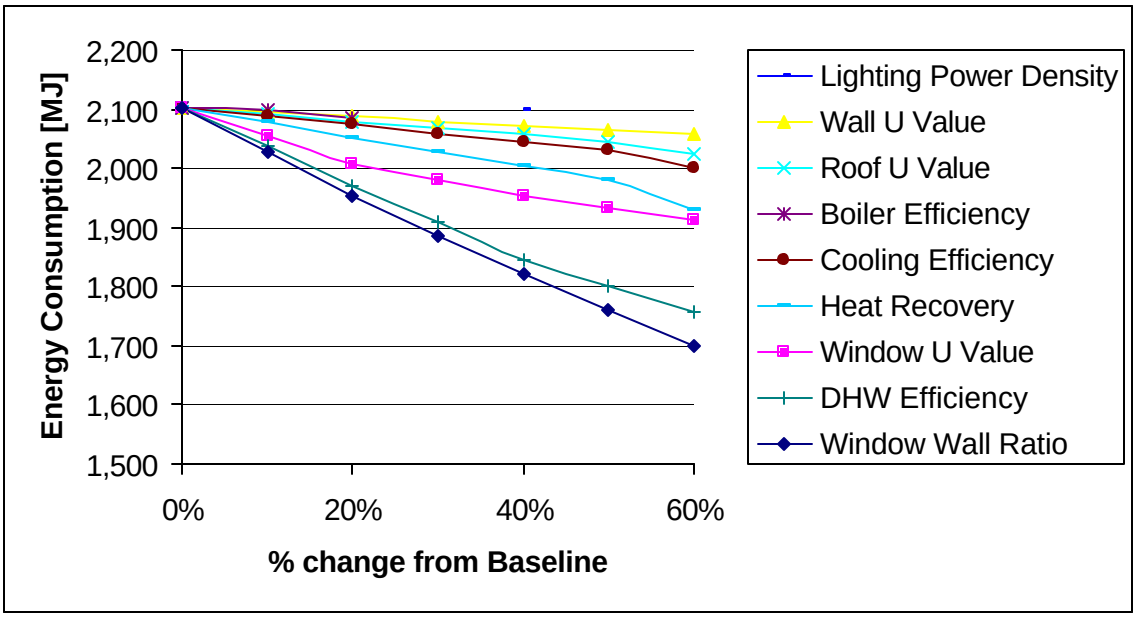


Figure 2: Parametric Impact of changes to Building Performance

1.3. Commercial Windows

Commercial windows are installed into commercial and institutional buildings. They are distinct from residential style windows due to the higher structural loads imposed as well as requirements for non-combustible construction. Segments considered in the analysis include:

- Large office
- Medium office
- Large non-food retail
- Medium non-food retail
- Food retail
- Large hotel
- Medium hotel/motel
- Hospital
- Nursing homes
- Large schools
- Medium schools
- University college
- Restaurant/tavern
- Warehouse/wholesale
- Mixed use
- Small commercial
- High-rise MURB

[4] This analysis is for a new Multi-unit residential building, and is limited to that building segment.

1.4. Report Structure

This report provides an overview of the current market for glazing products with a focus on the commercial sector. The report provides information on trends and opportunities in the context of increasing the energy performance of commercial buildings. The report is structured into the following sections:

- Section 2 provides a description of the components and performance of commercial glazing with an emphasis on energy related design.

- Section 3 provides a situation assessment to introduce the reader to the commercial glazing market in terms of relevant codes, standards and related studies.

- Section 4 includes a market assessment of the commercial glazing market, based on the results of a market survey.

- Section 5 provides an estimate of the technical potential energy savings associated with improving the thermal performance of commercial glazing.

- Section 6 summarises the current status of the residential Energy Star windows program in British Columbia, and includes an estimate of the current saturation of Energy Star residential window market saturation in BC.

- Section 7 provides a set of recommendations and conclusions as a basis for developing policy on commercial glazing to enhance the thermal performance.

2. Energy Efficiency of Commercial Window Products

This section provides an overview of the characteristics of windows that affect their thermal performance.

2.1. Impact of Window Characteristics on Thermal Performance

A range of factors may contribute to the thermal performance of commercial glazing. This section provides an overview of the most significant factors, including:

- Style
- Component design
- Fabrication
- Operation
- Location
- Building type
- Amount of window coverage

A summary of the impact of these factors on thermal performance of commercial glazing is in Table 2.

Of the glazing characteristics identified in Table 2, managing the following will have the greatest impact on building energy use:

- Component design
- Operation
- Location
- Building type
- Amount of window coverage

These characteristics are defined in the ASHRAE 90.1 prescriptive requirements, as noted in Table 6. Component design has a significant impact on energy performance, and is further described below.

Table 2: Characterisation of Commercial Windows and Impact on Energy Performance

Characteristic	**Description**	**Impact on Energy Performance**
Style	• Curtain Wall • Window Wall • Storefront • Punched Windows • Hybrid products	For a test specimen of a fixed size, the thermal performance of different window styles will not vary significantly. Indirect differences may arise from thermal bridging of sill flashing in punched windows and high air leakage in storefront installations among other things.

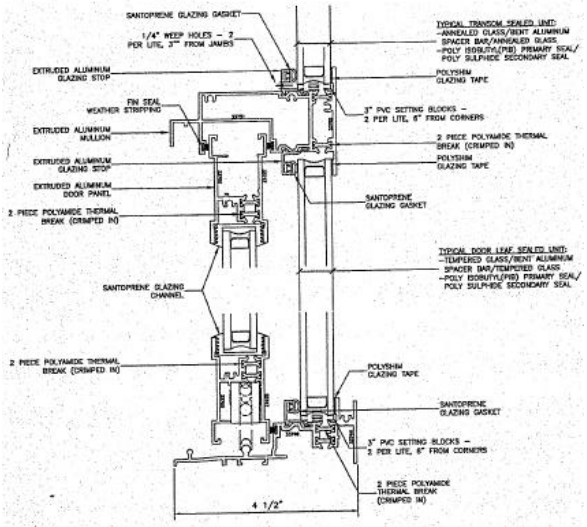
Characteristic	Description	Impact on Energy Performance
Component Design	• Frames • Glazing • Spacers • Fills	Component construction is a significant determinant of window performance, as shown in Table 3.
Fabrication	• Site assembled • Plant assembled • Hybrid	Fabrication technique has significant impact on quality of construction and productivity. This impacts the energy efficiency indirectly through the air-tightness of the units.
Operation	• Operable • Fixed	The portion of operable glazing impacts thermal performance due to increased frame material from sashes.
Location	• Orientation • Climate zone • Passive solar landscaping or awnings	Orientation impacts cooling requirements of glazing, with south and west facing glass receiving the greatest solar gain. Climate zone has impact due to temperature differences between interior and exterior spaces.
Building Type	• Internal load dominated • External load dominated • Combustible/non-combustible	The building type has significant implications on glazing performance due to need to limit solar gain in warmer climates with high internal gains. Similarly buildings with combustible construction can utilize non-metal frames with lower thermal transmittance.
Amount	• Window wall ratio	Window wall ratio has a significant impact on energy performance of the building, as increased glazing leads to increased heating load and in some cases larger cooling requirements.

2.2. Component Design

This section provides an overview of glazing component design related to energy use including:

- Frames
- Glazing
- Spacers
- Gas Fills

Typical performance of a range of windows is presented in Table 3 as a basis for characterising thermal performance. As can be seen, single glazed aluminium frame windows (typical of many older store front systems and older apartments) have a thermal transmittance that is 50% higher than typical windows currently being installed into low rise apartments.



Typical Commercial Window Profile

Table 3: Typical Performance of Commercial Glazing[5]

Description	Thermal Transmittance (U-Value)	Solar Heat Gain Coefficient (SHGC)
Single glazed clear with aluminium frame	5.7	0.68
Double glazed clear with aluminiu m frame	3.6	0.61
Double glazed soft-coat low-e coat with aluminium frame	2.47	0.43
Double glazed clear with vinyl frame	2.57	0.58
Double glazed soft-coat low-e coat with vinyl frame	1.82	0.39

2.2.1. Frames

Commercial window frames are generally aluminium extrusions. While vinyl and fibreglass frames are also used in the commercial sector, their use is limited due to fire rating and structural limitations. Due to code requirements a thermal break is installed within the frame to eliminate thermal bridging. The thermal break is typically a polyamide material and provides a thermal separation between the interior and exterior sides of the frame.

[5] Results are based on simulations of windows using Windows 5.2.

2.2.2. Glazing

As noted previously, insulated glass is required for new construction by the BC Building Code. Insulated glass is composed of two or more sheets of glass separated by hermetically sealed cavities. While triple and quadruple glazing is available, its use is limited. Similarly, single glazed material is still available for the retrofit of existing buildings.

Gas Filled Sealed Insulated Glazing

Filling the cavity with gases that have greater density than air can increase the insulating value of insulated glazing (IG) units. Argon, and krypton are the most commonly used fills. There remains concern over the long term retention of fill gases in IG units. Can/CGSB-12.8 includes test requirements for long term durability of fill materials.

2.2.3. Spacers

The glass sheets in an IG unit are separated by a continuous spacer. The spacer may be metallic, plastic or a composite material. Most IG units are made with a metallic spacer constructed of roll-formed aluminium or steel. In a typical IG unit, these metallic spacers may act as a thermal bridge, conducting heat through the assembly. Warm edge spacer technologies have been developed to address this issue, and may improve the overall insulating value of the IG unit by up to 30%, depending on unit size and make-up. A range of warm edge spacers have been developed utilising metallic and non-metallic materials. INDEX, Swiggle, Super Spacer and TPS are examples of proprietary warm edge spacer products.

2.2.4. Low Emissivity Coatings

Low-emissivity (low-e) coatings are made of thin layers of pure metals or semi conductors. Coatings are made selective by doping them[6] to provide the desired transmittance. Coating on glass can be characterised as either hard coating or soft coating. An alternative method for using low-emissivity coatings is to apply them to a thin plastic film that is incorporated into the window.

A soft coating generally consists of a thin layer of pure metal on a sheet of glass. The application is done using the sputtering process. Examples of metals used to soft coat windows are tin, silver, gold, indium and copper. With the exception of gold, these metals oxidize readily; consequently they must be used in sealed units to protect the coatings. Typical performance of insulated glazing units with and without low-emissivity coatings is summarised in Table 3. As can be seen, addition of a soft coat low-e film can reduce the thermal transmittance of a double glazed unit by 30%. In addition to reduced thermal transmittance, low- e coatings generally reduce the solar heat gain coefficient of IG units, thus reducing overheating from direct sunlight.

Hard coating is done by the pyrolytic process, which involves spraying a semiconductor material, such as tin oxide (SnO_2), on to hot glass coming off a float line. The coating is baked on to the glass as it cools, forming a hard durable coating. Glass coated in this

[6] Doping refers to selective addition of material to alter the spectral and thermal characteristics of the film.

manner can be handled and cut like ordinary glass. The trade off for increased durability and better handling qualities is reduced thermal performance.

Suspended films and applied films can be used to produce low-emissivity glazing. Suspended films are generally thin polyester or mylar films with a metal oxide layer vacuum-deposited on the film. The technology is similar to soft coated glass, and like soft coated glass, suspended films must be used in a sealed unit. Suspended films must be kept under constant tension to ensure that no ripples develop that would impair the visual performance of the glazing. Care must also be taken, because of the different thermal expansion coefficients of the various materials, to ensure that the film is constantly under tension. Films are generally mounted in their own frame or between two spacers in the sealed unit. Thermal resistances for this type of unit are around RSI 0.56.

Coating Location

Low-emissivity coatings can be placed in different locations in a window. The nature of soft coatings restricts their location to the interstitial region of a sealed unit. If the surfaces in a double glazed unit are numbered (outside to inside) one through four (Figure 3) then soft coatings can only be placed on surfaces 2 or 3. In climates where solar heat gain is to be maximized, the coating should be on surface 3. In a window in an environment where solar heat gain is to be minimized, surface 2 is appropriate. The same rules apply for hard coatings. The placement of coatings on surface 4, the interior surface, should be avoided. In winter this surface will become colder than usual because of the heat reflected, increasing the condensation potential.

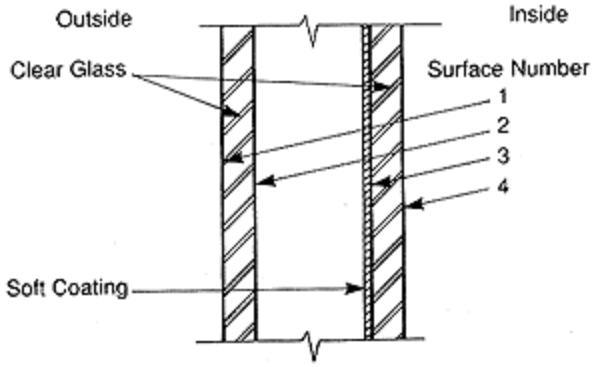


Figure 3: **Soft Coating Location.**

2.2.5. Spandrell Glass and Deflection Headers

The non-vision areas of curtain wall systems are known as spandrels. Spandrels are generally constructed of glass and are opaque. Spandrell areas hide insulation and the edge bands of floors in high-rise construction. Deflection headers are made of aluminum. When used, they retain the head of the window and allow for differential vertical movement of the floor above the window.

2.2.6. Emerging Glazing Technology

The innovations in glazing described above represent recent technological advances. In this section, emerging technologies are briefly described.

Aerogels

Aerogels have been described as transparent insulation. Silica aerogels consist of a bonded network of silicone pebbles smaller than the wavelength of visible light. Aerogels can have a thermal conductivity lower than that of still air because they contain as much as 97% air by volume in pores smaller than the mean free path of air molecules, thus resulting in increased thermal resistance within the cavity of an IG unit.

Switchable Glazing

Research into switchable glazing includes visual performance and function as well as improvements in thermal performance. In a switchable glazing, optical properties of the glazing are changed and the change is reversible. The most useful and potentially applicable switchable property is the chromogenic phenomenon in which materials change their reflectivity and absorptivity. Thermochromic, electrochromic, and photochromic processes are examples of chromogenic processes. *Electrochromic glazing* changes its optical properties when an electric current goes through the unit. A thin metallic film is deposited on the glass in a process similar to the production of low-emissivity glazing. Another technique involves sandwiching a liquid quartz film between two layers of glazing.

Evacuated Glazing

Evacuated glazing is designed to achieve higher levels of thermal performance by using a vacuum to inhibit any kind of conductive or convective heat losses. A system under development by the Solar Energy Research Institute uses combinations of glazing technology to produce an evacuated glazing unit with a thermal transmittance of 0.6 for a 38 mm unit. An evacuated unit would consist of two panes of glass, laser welded at the edges to provide a seal. A vacuum would be maintained between the panes. A very low-emissivity coating, less than 0.1, would be applied on surface 2 of the unit. This combination would substantially decrease the amount of heat transferred through the window.

2.3. Characterising the Energy Performance of Windows

Energy efficient glazing design is primarily concerned with reducing heat loss (including conduction, convection and radiation), controlling solar gain, and increasing visible light transmission. Commercial glazing performance is generally described in terms of:

- Thermal transmittance
- Solar heat gain coefficient
- Visible light transmittance
- Energy rating
- Air Leakage[7]

[7] Depending on the building type, its orientation and loads, the relative importance of thermal transmittance, solar heat gain and air leakage vary. For example, in large offices in the Lower Mainland,

These concepts are briefly described below.

2.3.1. Thermal Transmittance

The rate of heat loss through a window is known as the thermal transmittance (U-value) and is measured in units of W/sq m*K. The thermal transmittance is the inverse of thermal resistance (RSI-value), which is the typical unit to measure heat loss through solid walls. Heat loss through windows occurs through the glazing and the frame and sash framing elements of operable windows. Due to the widespread use of aluminium frames in the commercial sector, frame heat loss in commercial windows is more significant in the commercial sector than in the residential market that is dominated by vinyl frames which has a lower thermal transmittance than aluminium.

2.3.2. Solar Heat Gain Coefficient

The solar heat gain coefficient (SHGC) is the portion of solar heat that passes through a window. In general, the SHGC ranges from 0.2 for insulating glass unit with reflective coating to 0.9 for a single glazed window. A high SHGC may be desirable to reduce heating requirements in far northern climates of BC, while a low SHGC may be desirable to reduce cooling loads in the southern portion of the province. As noted above, however, the orientation of the glazing is significant in determining the preferred SHGC. While solar gain is considered beneficial in many parts of the country, there is significant potential for summer over-heating in BC, particularly in buildings with large internal loads.

2.3.3. Visible Light Transmittance

The visible light transmittance (VLT) of glass is the portion of visible solar radiation (light) that passes through the glass. High VLT is desirable in most buildings to reduce artificial lighting. There is also an aesthetic trend to increase the visible light transmittance in new buildings to enhance the connection between interior and exterior spaces.

2.3.4. Air Leakage

Air leakage affects energy consumption through heat loss from increased displacement of tempered air with the exterior through air leaks. In many buildings, air leakage can be among the most significant components of heat loss, as shown in Figure 1. While significant, there are no requirements for air barrier performance defined in the building code.

2.3.5. Energy Rating

The energy rating (ER) provides an indicator of window performance of on the basis of how much heat the window can contribute in order to reduce winter heating. The ER rating applies to residential occupancies only. The ER is calculated by estimating the solar gain through a window and subtracting heat loss and air leakage. The result is a net

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reducing the thermal transmittance (while keeping the solar heat gain coefficient constant) will likely result in an increase in energy use of the building due to a larger cooling load.

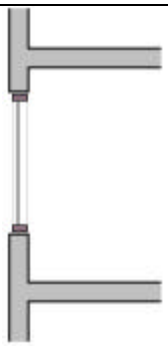
energy gained or lost. In principle, this is a useful concept, but in practice, the rating favours the use of glass with a high SHGC, resulting in potential overheating in parts of British Columbia.

2.4. Description of Commercial Window Products

A range of commercial window products exists in the market place. In general, the market is dominated with aluminium thermally broken frames, and double glazed insulated glazing units. A summary of commercial glazing products is presented in Table 4. A detailed description of the use and characteristics of these systems is presented in the Glazing Contractors Manual (2003).

Table 4: Commercial Glazing Products

Configuration	Description	
Curtain Wall	Aluminium curtain walls are modular assemblies, built from aluminium members and assembled into frames with panels of glass or other cladding materials.	 Curtain Wall Cross Section
Window Wall	Window walls are floor to ceiling windows commonly used for residential high-rise buildings. When used in conjunction with slab edge covers, they resemble curtain walls in appearance and function. Unlike curtain walls which are located outside the building structure, window walls are supported and span from slab to slab. In general, these systems are factory glazed.	 Window Wall Cross Section

Configuration	Description	
Storefront	The term storefront has historically been used in a functional sense to describe any glazing system used to frame display windows and commercial shop fronts. In general, these systems are designed for economy and aesthetic appeal, and issues such as energy performance and resistance to rain penetration are secondary among designers.	
Punched Windows	Punched windows are generally rebate systems (i.e., they do not have a nailing flange for attachment to the building) using either vinyl or aluminium frame. Whereas curtain and window wall systems are part of the building envelope, punched windows are inserted into the building enclosure.	 Punched Window Cross Section
Hybrid products	New window products are continually being developed to meet emerging market conditions. For instance, there are shop glazed unitized curtain wall systems that are partially glazed on the site. In addition, some window manufacturers offer heavy duty residential products for institutional use.	

3. Situation Analysis

This section provides background information on related market research and an overview of relevant codes and standards.

3.1. Related Market Studies

Two relevant studies have been completed to characterise the non- residential fenestration market, and provide a point of departure for the current study. This section summarises the results of previous analysis and summarises the major conclusions and areas of further research.[8]

3.1.1. Energy Star for Commercial Windows Feasibility Study

Natural Resources Canada commissioned a study completed by Enermodal Engineering (Enermodal, 2005) to assess the feasibility of an Energy Star program for commercial windows. The study includes results of a market survey as well as technical analysis in order to describe the opportunities and barriers to be considered in the development of an Energy Star program for commercial windows in Canada.

Nationally, savings from an Energy Star commercial window were estimated at 90 peta-joules, resulting in a 1.1% reduction in GHG emissions. Concerns identified over the development of an Energy Star program for commercial windows include:

- How to deal with solar heat gain
- Certification of site glazed products versus plant assembled products
- Cost of certification

These issues are relevant to the development of a commercial window program in BC. A national working group has been established to assist resolve the non-technical issues identified above.

Based on a life cycle cost analysis, interim Energy Star thresholds values are summarised in Table 5. As can be seen, for the Lower Mainland, curtain walls would need to achieve a performance level of 2.6 W/Sq m*K. This level of performance can generally be achieved using thermally broken frames and low-e glass.

[8] A baseline assessment of the residential windows market was also reviewed. Results of that analysis are described as they relate to the residential market survey.

Table 5: Proposed Energy Star Thresholds[9]

Zone	Curtain Wall [W/Sq m*K]	Fixed [W/Sq m*K]	Operator [W/Sq m*K]	Sample
A	2.6	2.3	3.3	Soft coat low-e
B	2.4	2.1	3.1	Soft coat low-e, argon fill, thermally broken aluminium edge spacer
C	2.2	1.9	2.9	Soft coat low-e, argon fill, 9 mm thermal brake
D	2.0	1.7	2.7	Soft coat low-e, argon fill, 19 mm thermal brake
Base	3.65	3.2	4.0	

3.1.2. A Characterisation of the Non-residential Fenestration Market

The Northwest Energy Efficiency Alliance (NWEEA) completed a study to characterise the commercial glazing market in the US northwest.[10] The analysis includes a detailed description of the supply chain, from primary glazing manufacturers through to glazing contractors.

Trends relevant to the BC market include:

- A shortage of labour is pushing the industry to more manufactured windows
- The rapid uptake of low-e coatings driven largely by adoption of state energy efficiency codes for buildings. For example, the City of Seattle requires certification for all fenestration, due to the adoption of increasingly stringent energy codes.

Barriers to the increased adoption of energy efficient products were reported as:

- Incremental capital cost
- Concerns over the longevity of some features, in particular spacer gas fill
- Tendering processes that favour the low bid, particularly for non-owner tenanted projects.

Opportunities to enhance the market penetration of energy efficient glazing products include:

- Improved education of designers and consumers through enhanced tools, and
- Increase efforts on the retrofit market.[11]

[9] A zone map for the Energy Star Program is presented in Figure 4.
[10] Eley 2002.
[11] No follow-up analysis was identified to update the status of addressing these opportunities.

3.2. Relevant Standards and Codes

The 2006 BC Building Code and the Vancouver Building Bylaw (1998) are the primary resources that define the minimum requirements for commercial glazing systems. This section provides an overview of the relevant code requirements.

3.2.1. BC Building Code, 2006[12]

The BC Building Code establishes minimum standards to meet its objectives related to:

- Safety
- Health
- Accessibility for persons with disabilities
- Structural sufficiency of buildings.

The BC Building Code is not concerned with energy efficiency or conservation. The 2006 BC Building Code includes multiple clauses relevant to the thermal performance of commercial glazing systems. Specifically,

- Section 5.3.1.2, Sentence 2 states:
  - All metal framed glazed assemblies separating interior conditioned space from interior unconditioned space or exterior space shall incorporate a thermal break to minimize condensation.
- Section 3.1.5.4 , Sentence 5 states:
  - Combustible window sashes and frames are permitted in a building required to be of non-combustible construction provided that;
    - each window in an exterior wall face is an individual unit separated by non-combustible wall construction from every other opening in the wall,
    - windows in exterior walls in contiguous storeys are separated by not less than 1m of non-combustible construction, and
    - the aggregate area of openings in an exterior wall face of a fire compartment is not more than 40% of the area of the wall face.[13]
- In accordance with Section 5.10.1, insulated glazing units shall be installed that comply with CSA/CGSB-12.8-97[14].

3.2.2. Vancouver Building Bylaw, 1998

The Vancouver Building By-law (VBBL) is applicable in the City of Vancouver. Energy Utilization is covered in Section 6.4 and requires compliance with ASHRAE 90.1 2001.[15]

[12] The BC Building Code is currently being revised. The 2006 version will supersede the 1998 version on December 15, 2006.
[13] This clause permits the use of vinyl frame windows for buildings where a non combustible separation is maintained between windows.
[14] This clause requires that double glazed units be used that are manufactured in accordance with the requirements defined in CSA/CGSB-12.8-97
[15] Work is underway to require conformance to the 2004 version of ASHRAE 90.1

The specific requirements for the thermal performance of windows are summarised in Table 6[16]. These results are presented for all thermal regions in BC as a basis of comparison. In general, the construction industry achieves these performance levels through use of low-e coating, which has resulted in significant increases in the sales of low-e products.

It should be highlighted that the prescriptive requirements defined in Table 6 account for variations in:

- Component Construction
- Operation
- Location
- Building Type
- Amount of glazing

Compared to the proposed Energy Star requirements defined in Table 5, the ASHRAE requirements are less restrictive and reflect the diversity of products inherent in the commercial glazing market.

Table 6: ASHRAE 90.1 (2001) Glazing U-Values[17]

	Lower Mainland, Vancouver Island			
	Non-residential		Residential	
Vertical Glazing, % of wall	U value [W/Sq m*K]	SHGC	U value [W/Sq m*K]	SHGC
0 - 10%	U fixed 3.24 U oper[18] 3.8	SHGC all 0.49 SHGC north 0.64[19]	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.64
10.1 - 20%	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49
20.1 - 30%	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49
30.1 - 40%	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49	U fixed 3.24 U oper 3.8	SHGC all 0.49 SHGC north 0.49
40.1 - 50%	U fixed 2.61 U oper 2.67	SHGC all 0.36 SHGC north 0.64	U fixed 2.61 U oper 2.67	SHGC all 0.36 SHGC north 0.64

[16] The requirements are presented for major three urban centres of British Columbia, not just the City of Vancouver. Additional locations may be found in ASHRAE.
[17] In cases where the window/wall ratio is greater than 50%, ASHRAE 90.1 prescriptive compliance path are not applicable.
[18] "oper" refers to operable windows.
[19] "north" refers to north facing glazing.

3.2.3. CSA-A440.2-04

CSA-A440.2-04, "Energy Performance of Windows and Other Fenestration Systems" provides measurement and calculation methods for establishing the following window properties for both residential and commercial applications:

- overall coefficient of heat transfer (U-value)
- solar heat gain coefficient (*SHGC*)
- air leakage
- visible light transmission (*VLT*)

The scope of CSA A440.2-04 includes commercial window products, however, there is no building code requirement for thermal performance of commercial windows beyond the requirement for double glazed units and thermally broken frames.[20]

In addition to the Canadian Standard, relevant US standards include the American Architectural Manufacturers Association AAMA 1503, "Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections" and NFRC 100 series of standards[21]. Work is ongoing to harmonize the CSA A440.2-04 and relevant NFRC standards. (See text box for sample rating.)

3.2.4. Energy Star Residential Window Program

In 2003, Natural Resources Canada released a document entitled "ENERGY STAR Criteria for Windows Doors and Skylights". Generally, Energy Star labelled products are factory built, intended for small residential and light commercial applications. To meet the Energy Star criteria, products typically have some or all of the following features:

- double or triple glazing with a sealed insulating glass unit
- low-emissivity (low-e) glass
- inert gas, such as argon or krypton, in the sealed unit
- low-conductivity or "warm edge" spacer bars
- insulated frames, sashes and door cores
- good air-tightness

Sample NFRC Rating

The performance requirements by region for Energy Star residential windows is summarised in Figure 4 and Table 7. In the case of residential applications, the recent

[20] Use of this standard is voluntary, and may be included as a product specification.
[21] http://www.nfrc.org/technicaldocs.aspx

penetration of vinyl frames has enabled widespread conformance to the standard. There are currently only 2 aluminium frame products certified in the BC market place.[22]

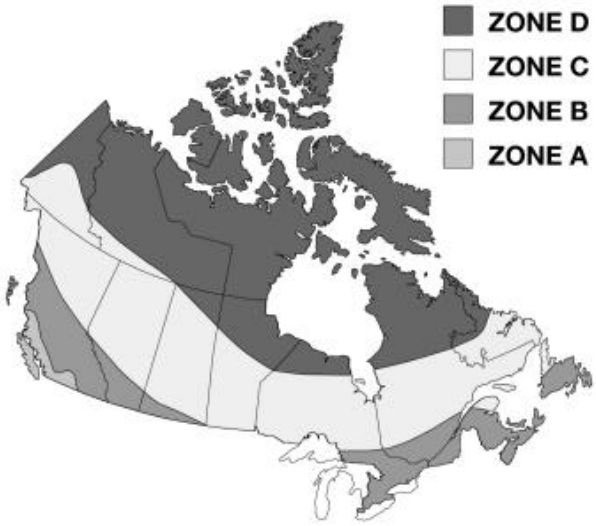


Figure 4: Energy Star Zones for Residential Windows in BC

Table 7: Energy Star Performance Requirements for Residential Windows[23]

Zone	Maximum Thermal Transmittance (U-Value)[W/sq m*K]
A	2.0
B	1.8
C	1.6
D	1.4

3.2.5. Energy Efficiency Act Regulation for Manufactured Fenestration Products

As of January 2009, manufactures fenestration products shall be required to achieve a performance corresponding to a maximum U-value of 2.0 w/(m^2 • K)[24]. Details of this regulation are still under development.

3.3. Commercial Windows Programs

There are limited precedents of government funded commercial window programs available to assess the market transformation potential from program activities in BC. This section provides a summary of two commercial window programs, sponsored by Manitoba Hydro and the Northwest Energy Efficiency Alliance, respectively.

[22] http://oee.nrcan.gc.ca/energystar/english/consumers/windows-search.cfm?text=N&printview=N
[23] In addition to the Thermal Transmittance, the Energy Star Program includes a compliance path based on energy rating (ER)
[24] Ref. http://www.qp.gov.bc.ca/statreg/reg/E/389_93.htm#section7

3.3.1. Manitoba Hydro Commercial Building Envelope Program

Manitoba Hydro offers a commercial window incentive as part of a larger Commercial Building Envelope Program. The program is designed to encourage building owners in both new and retrofit projects. The program provides financial incentives for installing energy efficient window systems.[25] The financial incentive ranges from $25/sq m to $60/sq m of glazing. It should be highlighted that while the program focuses on commercial buildings, the performance thresholds required to receive the incentive (a U-value ranging from 2.0 to 1.4) means that most projects will utilize vinyl windows and be involve only small commercial projects.

3.3.2. Northwest Energy Efficiency Alliance Commercial Window Initiative

The Northwest Energy Efficiency Alliance currently implements a commercial window initiative (CWI) in Idaho, Washington, Oregon, and Montana. The focus of the CWI is to promote energy-efficient manufactured commercial windows rated by the National Fenestration Rating Council (NFRC). The thresholds for the program eligibility include:

- a U value less than 2.4
- a SHGC less than 0.4
- a VT greater than 0.25[26]

3.4. Summary and Implications for the Current Study

Significant research has been completed to characterise the commercial glazing market with an effort to improve the energy performance of the commercial sector. These previous efforts highlight that the commercial glazing market is distinct and more complex than the residential glazing market. These additional complexities arise from structural and fire rating requirements, as well as significant diversity in internal and external loads impact on orientation, building segment and occupant activity. Simply patching on commercial glazing requirements to the existing residential Energy Star program will likely result in failure, as factors related to solar heat gain, visible light transmittance and air leakage are significant.

A comparison of the thermal transmittance of window standards or programs reviewed in this section is summarised in Figure 5.

[25] http://www.hydro.mb.ca/power_smart_for_business/building_envelope.shtml
[26] http://www.nwalliance.org/projects/projectdetail.asp?PID=70

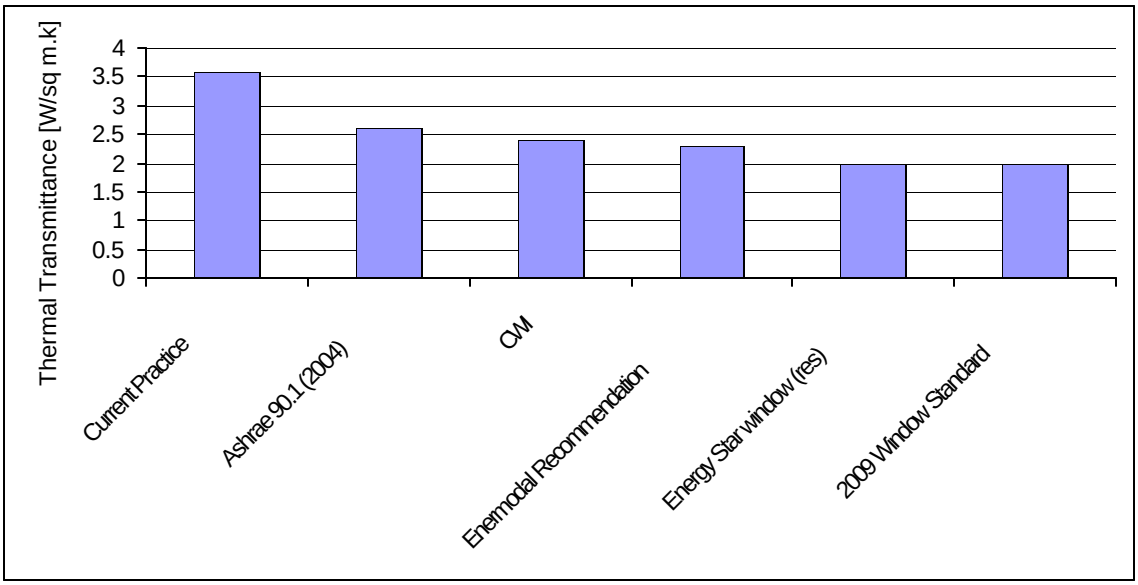


Figure 5: Comparison of Window Thermal Performance

4. Commercial Window Market Assessment

4.1. Commercial Glazing Distribution Chain Model

This section provides an overview of the actors involved in the manufacture, design and purchase of energy efficient glazing products. It is relevant to the development of energy efficient commercial glazing regulations, as these actors will be directly impacted by product regulations.

4.1.1. Supply-Side Market Characteristics

Supply-side agents serving the commercial fenestration market in British Columbia include primary glass manufacturers (PGMs), secondary manufacturers, distributors, and glazing contractors. Some market actors offer products and services that place them at several possible points in the supply chain (e.g., manufacturing, distribution, and/or installation). Given this fact, the nomenclature used in this report to categorize these actors should be considered descriptive of their primary supply-side activity. Secondary activities (e.g., installations performed by a vertically integrated manufacturer) are described in conjunction with their primary activity classification.

Primary Glass Manufacturers (PGMs)

Primary glass manufacturers are companies that manufacture sheet glass from sand and cullet. These manufacturers produce float glass products that are purchased by secondary manufacturers and glazing contractors. No primary glass manufacturers have production facilities in British Columbia. PGMs, depending upon their market focus, provide flat glass products with varying degrees of secondary processing ranging from specialized coatings to insulated glass units (IGUs).

Secondary Manufacturers – Fabricators and Glazing Contractors

Fabricators

Secondary manufacturing of commercial glazing products in British Columbia includes both fabricators and glazing contractors. The primary attributes of these two groups can overlap. They are best distinguished by their size and degree of vertical integration. The fabricators that were interviewed for this study generally do not deal directly with building owners / developers or the design community but rather service the demand for window products from residential and commercial glazing contractors. These manufacturers were either specialized on one or two products or generalized to a broad range of commercial and residential fenestration components. An example of a specialized fabricator would be the fabricator that produces extruded aluminium components for windows, curtain wall systems, entrance and storefront systems, and spacers. Generalized manufacturers have a broader focus that includes secondary processing of glass and non-glass components. While not a comprehensive list, their products and services can include cutting, tempering and opacifying of flat glass, gas filling, spacer bar bending, and assembly of IGUs. Some manufacturers also act as distributors of windows and component product lines for other manufacturers. Typically, they do this to expand their service capability.

Glazing Contractors

The largest glazing contractors operating in British Columbia are typically characterised by their ability to both manufacture and install finished commercial glazing products including punched opening windows, curtain walls, store front and other architectural glass products (e.g., sun shades, structural glass, spandrels, etc.). These firms deal directly with architects and other building science specialists (window wall consultants, building envelop consultants, etc.) regarding the specification of fenestration products for a new construction project. The larger glazing contractors in British Columbia are typically more vertically integrated than described in the 2002 Eley Associates report.[27] That is, the largest BC glazing contractors have the productive capability and trained staff to design, manufacture, assemble, and install their product, rather than being limited to installing window products manufactured by other firms. These firms have the expertise and productive capability to supply a broad range of architectural glass products, although several specialize in a single product category (e.g., factory glazed unitized curtain wall systems). These glazing contractors take float glass product acquired from a PGM or fabricator and apply various secondary processes including, but not exclusive of, cutting, tempering, laminating, coating (e.g., soft low-e sputter coats, reflective tints, etc.), and the final assembly of insulated/sealed glass units to meet various architectural specifications.

Some glazing contractors indicated they prepare their product in accordance to the window specifications provided by architects, rather than advise or influence the designer's product choices. Other glazing contractors indicated they have a working relationship with architects, leading the glazing contractor to have some influence on the final product selection and specification.

Glazing contractors are represented in the Province by the Glazing Contractors Association of British Columbia[28]. In addition to glazing contractors, the association membership also includes a range of larger design and product vendors, and therefore represents an important trade association.

4.1.2. Demand-Side Market Characteristics

The key demand-side actors of the commercial fenestration market include building owners/developers, architects, and building science specialists (consultants), and glazing contractors.

Building owners/developers

The specifications of fenestration products required for the commercial and institutional building market is driven by aesthetics and cost, which in turn, is directly influenced by the motivations of the building owners/developers. These motivations are often directly related to whether they intended to retain ownership of the building once completed, and if so, whether the building's primary tenant will be the building owner or whether the property will be leased.

[27] Eley Associates 2002, p. 18.
[28] http://www.gca-bc.org/

Developers that do not intend to retain ownership of the property over the long-term are generally less concerned with the thermal performance characteristics of the window products installed in their buildings. The incremental cost of improving the thermal performance characteristics of the fenestration products is a barrier for these developers as energy savings from the improved performance are unlikely to accrue to them once the building is completed (i.e., either from a higher sale price, or through reduced operating costs). Building owners that intend to retain ownership of the property once completed have a somewhat greater motivation to improve the energy performance of their properties, although this is, in part, dependent upon whether the owner intends to be the building's principal tenant or whether the building will be leased. Leased tenants often bear the cost of heating and cooling the building through their triple net lease agreements. Since tenants, in effect, pay for the cost of heating and cooling the building, owners are generally less concerned with energy efficiency of their building systems and fenestration products.

There are exceptions to this generalization. One glazing contractor recalled a private sector client who intended to own the property over the long-term and was concerned about rising energy costs. In this case, the private sector client was seeking to build a legacy building and considerable emphasis on the thermal efficiency of the fenestration choices. This client, however, was viewed as the exception rather than the norm.

Institutional owners/developers such as federal, provincial or municipal governments represent a third category of owner/developer where the buildings are designed using a set of criteria established in the context of long-term ownership and a desire to minimize operating costs. While not exclusive to this particular group, there are several examples of buildings currently under construction (e.g., expansion of the Vancouver Convention and Exhibition Centre), or recently completed (e.g., 401 Burrard Street, Vancouver) that have been designed to showcase the environmental benefits of green building design and the incorporation of technologies with energy performance characteristics that exceed industry standards.

Architects

Architects are retained by the building owner/developer. Together, they represent the principal demand-side agents responsible for specifying fenestration systems. Factors that influence the choice of fenestration products for the building include, but are not exclusive of, aesthetics, cost, and building codes. Building owners or architects will engage the services of building envelope consultants or other building science specialists (e.g., curtain wall consultants). Architects sometimes consult with glazing contractors on fenestration specifications but more often the window specifications are provided to the glazing contractor and the onus is placed on the contractor to meet those specifications.

Supply-side actors surveyed for this study identified architects as key influencers in the choice of fenestration products for commercial buildings in general and the thermal performance characteristics of fenestration products specifically. In this capacity, glazing contractors and other supply-side agents felt that architects should be targeted with

programming to improve their awareness and understanding of high thermal efficiency fenestration products and designs.

Building Science Specialists

There are a number of specialists that may be engaged in the design and/or specification of fenestration products for commercial buildings. They typically deal directly with architects and building owners / developers during the design and construction phases of commercial buildings.

Curtain wall consultants specialize in the design and performance of curtain wall assemblies. Engaged by the building owner or the architect, these specialists are engaged primarily in the design of larger commercial office buildings.

Mechanical Engineers concern themselves with the performance of the architect's glazing choice primarily because it affects the performance of the HVAC system. However, their role is reactionary not prescriptive and most supply side actors interviewed suggested that mechanical consultants will typically have only limited influence on the choice of windows for commercial products.

Building envelope consultants address the design and performance of the building envelope including exterior walls, glazing, roofing and waterproofing.

Thermal performance specialists are sometimes hired by glazing contractors and manufacturers to evaluate the thermal performance of their window products. The glazing contractor provides the design specifications of the window system for a commercial project (e.g., the specifications representing unitized curtain wall assembly for one floor of a multi-story high rise) to the specialist who, in turn, uses a computer program such as Lawrence Berkeley National Laboratory's WINDOW to calculate window thermal performance indices including U-values, solar heat gain coefficients, shading coefficients, and visible transmittances based on these specifications. Some contractors consider this method of evaluating the thermal performance of the glazing system to be superior to those required to meet existing codes and standards such as ASHRAE 90.1 and CSA A440.2-04, as it evaluates the glazing design and product choice as a system, complete with vertical and non-vertical fenestration elements.

4.1.3. Summary

The actors identified above will be directly impacted by any changes proposed to the requirements for commercial glazing systems. Key opportunities for industry input as the Province as it develops commercial glazing regulation include the Glazing Contractors Association, as well as the BC Building Envelope Council.

4.2. Commercial Glazing Market Survey

A survey of the commercial glazing market was completed to better understand trends and opportunities in the BC marketplace. A total of seventeen interviews were completed. The number of respondents by market actor is summarised in Table 8. The discussion guide used to conduct the interviews is found in Appendix 1. Potential survey candidates were identified through a variety of means, including industry databases and the consulting team's knowledge of commercial building sector. Industry databases and/or membership lists from the following organizations were reviewed:

- Glazing Contractors Association of British Columbia
- Industry Canada (Canadian Company Capabilities database)
- Architectural Institute of British Columbia
- Canadian Window and Door Manufacturers Association
- British Columbia Manufacturers Directory
- Frasers Online Industry Search Engine

Table 8: Commercial Glazing Market Survey Structure

Discipline	Number of Respondents
Manufacturer	8
Developer	1
Designer (engineer/architect)	3
Regulator	2
Specialist Consultant	3
Total	17

All firms contacted reported being extremely busy – attributed to both the current construction boom in British Columbia, and the traditionally busy autumn period. This proved to be a significant challenge to scheduling and completing interviews. The current phase of the commercial construction cycle in British Columbia means that the majority of firms in the industry are operating at or near full capacity. One manufacturing company representative epitomized the current level of economic activity in the industry by remarking "business is walking in through the door". Another indication of how busy the industry is at present led another firm to comment that costs (pricing) of fenestration had become secondary to the ability of manufacturers to deliver their product to the construction contractors on time.

Below is a summary of the major discussion points and opinions of the survey respondents.

Market Share of Window Systems

- Multiple respondents noted that over 80% of business is for new construction.
- Larger envelope firms stated that approximately 40% of their designs use punched windows, while 60% is curtain/window wall construction, and that 95% of sales

are now factory built product. It should be highlighted however, that this consultant works primarily in large buildings, with limited involvement in the small retail segment that appear to use mainly storefront products which are largely site built.

- Almost all commercial windows are aluminium frame, only a small portion are vinyl – primarily low rise residential and some health care. One estimate of the market share for non-aluminium frames was 5%.
- The largest manufacturer estimated he has 30% market share and sells 200,000 sqm of commercial glazing in BC per year. Based on this estimate, the commercial glazing market is 670,000 sq m. If 80% of the market is for new construction, the market for new glazing may approximately 530,000 sq m. These results are consistent with the estimate developed in Table 11.
- Most respondents had difficulty estimating the portion that is operable, although one respondent estimated the percentage range of operable windows in the multi-family residential high rise market to be approximately 10% to 15%[29]. In general, operable windows are limited to:
    - Multi-unit residential buildings
    - Schools
    - Nursing homes and hospitals
    - Hotels and motels.
- Energy efficiency is not marketed directly but it is always a concern and a goal of window fabricators and glazing contractors to promote this.

Energy Efficient Glazing Systems

- Multiple respondents identified the need to move beyond low-e thermally broken frames as the basis to define energy efficient glazing.
- Most respondents noted that it is not possible to define a single value that delineates an energy efficient commercial glazing product. There was general agreement that the energy efficiency threshold depends on a variety of factors, including the type of building, its orientation, shading, window wall ratio and location. Most respondents confirmed that a one size fits all approach is not the preferred option to define energy efficient glazing. However, one respondent proposed a U-value of 1.8 and SHGC of 0.3 to represent an energy efficient glazing target.
- There is significant innovation in low-e technology to reduce cost and improve performance. In addition, manufacturers are providing a diverse range of low-e products, including triple coating and polarisation of low-e coating to improve performance.
- Mechanical engineers, envelope consultants and architects are key actors involved in specification of glazing systems.
- A number of firms were not familiar with the residential Energy Star windows program.
- Based on survey responses, the market penetration of energy efficient components is summarised in Table 9.

[29] By area.

Table 9 Market Penetration of Energy Efficient Glazing Products

Technology	Market Penetration
Aluminium Frame with thermal break	100% of aluminium frames are thermally broken due to code requirements in new construction.
Double glazed unit	100%
Vinyl Frame	5%
Low-e	50%
Argon fill	5%
Warm edge spacer	5%

Market Trends

- Multiple respondents note that the market penetration of low-e glass for new construction is approximately 50%, however, some noted the high penetration of low-e glass is skewed by performance requirements in the City of Vancouver.
- There is an increasing trend towards polyamide thermal break, with hybrid vinyl/aluminium frames.
- There is an increase in the portion of factory built systems over the last few years resulting in improved quality and productivity. In addition, pressure from a lower quality labour force is driving a push to factory assembled curtain wall construction.
- Increases in the price of energy are a significant driver for increase in performance of glazing.
- The increased use of glass in high rise construction is a significant driver in industry right now and is reducing the efficiency of buildings. Multiple respondents noted that it is cheaper and simpler to install a window wall than a solid wall, reinforcing the trend to more glass[30].
- Low rise residential buildings market is largely made up of vinyl frames.
- The industry is extremely competitive in terms of first cost this has a significant impact on innovation and quality.
- Multiple respondents noted the portion of argon fill is dropping due to concerns over cost effectiveness and durability[31].
- In the City of Vancouver, use of ASHRAE 90.1 enables averaging of window performance, which adds complexity and reduces overall performance. It was noted that until recently, sites with both part 9 and part 3 construction were built to part 3 to permit lower energy efficiency requirements.
- 100% of commercial new construction uses thermally broken frames due to code requirements, however thermal bridging (typically sill flashing)is a growing concern that undermines the drive to more efficient glazing systems.
- The trend in spacers is towards four corner bending and away from "cut and layout" – more efficient, cost effective, and better quality control.

[30] One respondent noted that reducing the number of sub-trades on projects reduces costs and timelines, and this was a major push to increasing glazing.

[31] The Insulated Glazing Manufacturers Association (IGMA) has been conducting studies of the durability of sealed units for past 25 years. They are also conducting studies into the permeability of sealant compounds used in IGUs.

- The BC Building Code and the Vancouver Building Bylaw continue to provide defined minimum performance levels for glazing in the commercial sector, and multiple respondents endorsed increasing the stringency of the standard.

Cost for Window Upgrades

- Price is the primary driver in defining market share of energy efficient products.
- Low-e-coating costs roughly $10 -20/ sq m.
- Only 5% of sales use argon fill.
- 5% use warm edge spacers at a cost of $0.4/m.

Most buyers do not understand the importance of life cycle costing, and energy costs are still a relatively small portion of business costs.

Role of Codes And Standards to Support Innovation

- In general, there was broad agreement among those surveyed that codes and standards are the most important means to improve the efficiency of glazing noted by respondents.
- One respondent noted that ASHRAE 90.1 does not go far enough and that CSA A440.2-04 is not relevant to the commercial market.
- Concern was raised that Energy Star costs more and will scare away prospective buyers.
- Codes currently set the minimum performance standard in BC. Cost is a more important driver for innovation, due to the cost competitive nature of the industry.
- Financial incentives/disincentives were supported by many of the respondents as a means to increase the uptake of energy efficient products. However, removal of the PST exemption was resisted by smaller speciality firms.
- Multiple respondents noted that codes need to incorporate the trade-off between heating and cooling loads – one size does not fit all. One respondent recommended a matrix approach similar to the glazing table in ASHRAE 90.1, to reflect the diversity of building type, window area and orientation.
- Several large glazing contractors felt their firms would benefit from regulations or incentives to improve the thermal efficiency standards of commercial fenestration products. They indicated that much of their product line was already efficient, thus the amount of adjustment to new codes or standards was expected to be minimal.
- One respondent argued that now was a good time to make changes to the building codes for commercial fenestration as most firms, thanks to the current building boom, would be able to absorb the additional costs without undue financial hardship.

Potential Allies and Opponents to Increased Efficiency

- BC Hydro and BC Building Envelope Council were noted as potential allies by respondents.
- The Home Builders Association was viewed as the most significant opponent due to the significance of multi-unit residential buildings.

- Developers and contractors who want to keep cost down are significant opponents.
- Discussion with a number of industry experts suggest there is little interest in the United States for an Energy Star commercial window program at this time. Similarly, progress on the development of a Canadian Energy Star rating is not a high priority at the federal level.
- Harmonisation of the National Fenestration Ratings Council (NFRC) and CSA A440.2-04 was observed to be a positive move, which supports sales of Canadian products into the United States.
- A components-based web-enabled tool to rate site-manufactured product is to be developed by 2009 in the US by the National Fenestration Rating Council.

4.2.1. Summary of Market Survey

In general, the results of the commercial market survey are consistent with previous experience of the consulting team. One notable difference is the higher penetration rate for low-e glazing products. The results support a review of provincial energy efficiency requirements for commercial glazing, and many of the larger players supported an adjustment of the current PST exemption to encourage innovation in energy efficiency.

In general there has been a significant shift to factory assembled products, due to increased productivity, enhanced quality and innovation in unitised systems. This is consistent with the provinces current regulation, which covers factory built windows. However, a significant portion off the market continues to site build their products, including storefront glazing systems. While the scope of the current regulation is not expected to cause a shift from factory built to site built products, it does leave a considerable gap, as the storefront product represents a significant portion of commercial glazing market.

4.3. Market Barriers

This section provides an overview of the barriers to increased market uptake of energy efficient glazing systems. Consistent with other analyses, the barriers are presented in terms of the "five A's":

1. Availability
2. Accessibility
3. Awareness
4. Affordability
5. Acceptance

Availability addresses the availability of current technology to satisfactorily meet the desired improvements in the thermal efficiency of commercial fenestration products. The findings from the survey and industry review suggest that there are few barriers limiting the availability of higher performance fenestration components in the BC market. The technology for improved fenestration in the commercial and institutional new building and replacement market including double glazing, thermally broken frames, low-e coatings, and high performance spacers is well established in the British Columbia non-

residential market. These products are readily available from a variety of agents in the supply-chain including PGMs, distributors, and secondary manufacturers. The commercial glazing market is moving away from dark tints and reflective coatings to the increased use of glass with higher VLT. To achieve this, there is a greater use high performance tints and low-e coatings. This trend partly explains the increased use of low-e coatings in commercial fenestration.

Accessibility refers to the ability of the market to respond to the changes required to meet improvements in thermal efficiency of fenestration products/systems for commercial buildings in British Columbia without undue supply constraints or other limitations. This ability includes having a sufficient number of market actors / players (manufacturers, distributors, manufacturers, installers / contractors) that can implement the changes without undue market influence or disruption. A number of accessibility barriers were identified in the survey, including

- The pace of non-residential and multifamily residential construction in British Columbia had one glazing contractor arguing that the ability for glazing contractors to deliver fenestration product specified by the developer on time (i.e., to meet the construction schedule) is more important than any incremental cost increase that occurs because of a change in minimum standards for window thermal efficiency through the building code or a window certification process. Indeed, some respondents argued that the incremental costs of raising the thermal performance of commercial windows could be readily absorbed within the current industry's operating margins. Respondents qualified this assertion by adding that the smaller manufacturers and glazing contractors may find it more difficult to meet these higher performance standards because of their limited financial resources, and the tendency to rely upon older manufacturing equipment and processes.
- The difficulty in measuring and/or certifying fenestration products on the basis of their U value and SHGC was raised only by one interview candidate but has been identified as a risk factor for certification of commercial windows products in other studies.[32] Certification or testing is particularly problematic for commercial projects where the fenestration is site assembled ("stick built"). The product would need to be assessed on-site or through simulation – processes that have proved challenging for contractors and installers operating in U.S. jurisdictions where NFRC certification is a requirement. Certification would most likely require evaluating the appropriateness and integrity of the installation. There are multiple factors that mitigate this barrier however. First, the industry appears to be shifting towards factory built products due to productivity and quality assurance benefits. Second, the NFRC is currently developing a test standard for site assembled products. Finally, as part of the City of Vancouver ASHRAE 90.1 compliance, the performance of glazing is required to meet NFRC standards. Based on discussions with City of Vancouver staff, site built versus factory built glazing has not been a significant issue.

[32] Eley 2002, Enermodal 2004.

- Fabricators, and other manufacturers tend to stock the product that is most demanded by specifiers and/or the larger glazing contractors. The ability for these market agents to respond to codes or standards requiring fenestration components with improved thermal performance characteristics may require some lead time. However, this is not expected to be a significant issue.
- Codes or standards that require changes to production processes and equipment may pose a disparate degree of dislocation to smaller fabricators and secondary manufacturers because of their limited resources. Given the limited number of interviews with smaller industry players, however, the degree of potential dislocation to these smaller producers is difficult to qualify at this time. To the contrary, information provided through interviews with larger firms indicated that the industry has been undergoing continuous technological improvement, particularly through the increased use of automated manufacturing processes. In some cases, the adoption of new technology and processes has been necessitated by industry product trends (e.g., growing demand for low-e soft coatings, laminating, ceramic frits, and structural glass, etc.). In other cases, the adoption of new manufacturing technologies or processes has been driven by competition / cost considerations and/or the desire to improve product quality.
- Certification of factory assembled product (e.g., fully unitized curtain wall) controls for some of the factors that affect the quality of installed product (one the most important in southwest British Columbia being the weather). One glazing contractor reported using a consultant to simulate the thermal performance of their fenestration systems using window specifications provided directly from the contractor's computer-aided design system. This contractor argues this method is more appropriate for evaluating modern glazing systems because the current standards do not accommodate the growing use of horizontal and non-vertical glass surfaces.

Awareness refers to the industry actors' knowledge of the relevant technologies, and their relative costs and benefits that drive efficiency improvements in commercial fenestration. Benefits also include those of a non-monetary nature (e.g., improved comfort, improvements in natural lighting, increased worker productivity, etc.). Survey respondents identified various barriers to awareness:

- Several glazing contractors highlighted the need to raise the awareness among architects of high performance fenestration products and systems, including improving their understanding of relative costs and benefits of these systems. Improved awareness of fenestration product performance was also identified as critical for building owners / developers. In the words of one interview candidate – "owners need to know when they are getting good advice".
- Mechanical engineers, window wall consultants, and other technical specialists, should be considered as key targets for any dedicated initiatives to improve awareness of high efficiency fenestration products.

Affordability addresses the financial barriers related to technologies and processes required to raise the thermal efficiency standards for commercial fenestration relative to

current (baseline) efficiency levels. Affordability can be defined on both a first cost and a life cycle cost basis.

- The tendency of the development community to base decisions on first cost rather than payback or life cycle costing poses a significant barrier to the adoption of higher performance fenestration components. This barrier is particularly evident for building owners / developers that do not intend to retain ownership of the property beyond completion or intend to cover the building's operational costs via its tenants' lease arrangements. Both situations effectively achieve the same outcome – the operational costs of the property once completed are not borne by the principal developer of the property. It is unrealistic to expect a radical change in the decision processes for this particular group of decision makers based on increased education and awareness of the long-term benefits (expressed in payback, life cycle costs, or other means). Rather, these efforts should be concentrated on architects and other key influencers of these decision makers.
- Replacing fenestration in high-rise buildings is considerably more expensive than in residential applications where punched opening applications are predominant. Commensurately, some expressed concern about the long-term financial liability from the mandatory specification of fenestration technologies whose longevity was suspect (e.g., argon gas). These respondents were concerned that they would be held accountable for windows manufactured to code but that failed prematurely.

Acceptance refers to the acceptance of the new fenestration performance specifications by supply-side and demand-side agents in the new and retrofit commercial windows market. Acceptance is predicated on a thorough understanding of the relative costs and benefits of the energy efficiency measures in question, supported, if necessary by codes, standards, and/or financial incentives/disincentives. As noted previously, it is estimated that more than 50% of the commercial glazing market includes low-e glass, suggesting there has been significant acceptance of that particular technology. Based on the survey responses and literature review, a range of acceptance barriers were identified. Specifically:

- The process by which mechanical engineers determine the specifications of HVAC systems has been documented in other studies as a potential barrier to realizing energy efficiency improvements from higher performing commercial window systems. In particular, mechanical engineers may be reluctant to downsize HVAC systems even though the fenestration choices for the property suggest this is appropriate. This reluctance may stem from fears of incorrectly sizing the large and complex HVAC systems required for large non-residential buildings combined with the tendency for mechanical engineers to rely upon the HVAC specifications from similarly sized buildings.[33]
- Argon fill – concerns persist regarding the reliability of this product over the lifetime of the window assembly.

[33] Eley 2002.

- Specification of standards for U factor, SHGC, and/or VLT require testing protocols that can be consistently and accurately applied across the industry.
- Concern over compliance and enforcement of new standards was identified. For example, it was noted by one respondent that a significant cause of BC's recent "leaky condo" crisis was the result of windows that did not meet the basic code requirements because there was no enforcement.
- Notwithstanding the previous acceptance barriers, it was noted by multiple respondents that they supported enhanced codes and standards as they were applied and enforced equitably and equally across the industry (i.e., ensuring "a level playing field").

4.4. Summary of the Market Assessment Findings

Based on the market survey, the commercial glazing market is estimated at an 80/20 split between new and retrofit construction. The market penetration of low-e glass in the province was estimated at 50%. This relatively high penetration rate is driven largely by the ASHRAE 90.1 energy utilisation requirements in the City of Vancouver. While low-e glass has historically been a benchmark to delineate an energy efficient product, many respondents highlighted there is no established single threshold for an energy efficient commercial glazing product. They identified the need to move beyond low-e, and to address issues related to orientation, window wall ratio and other factors. In short, many respondents felt the need to move to a systems based optimisation where the glazing performance is adjusted to optimise building (not window) energy performance. Those respondents familiar with ASHRAE 90.1 promoted its use, while acknowledging that it has shortcomings. On the basis of the market survey, the primary barriers to more widespread adoption of energy efficient commercial glazing products remains the price gap for improved performance and the limited understanding of clients related to the benefits of energy efficient commercial glazing.

4.4.1. Defining an Energy Efficient Commercial Glazing Product

Based on responses from the survey, it should be highlighted that there is no definitive description of what constitutes an energy efficient glazing system for the commercial sector. Due to the diversity of activity, orientation, and climate, a window that minimizes energy use in one application may not be optimal in an alternative application. For example, buildings may be classified as external load dominated or internal load dominated. In external load dominated buildings (such as apartments) increased solar gain is usually beneficial to reduce heat loads. In internal load dominated building such as offices, reducing solar gain to minimize cooling loads is frequently more important. Even within the same building, it may be beneficial to consider one set of glazing performance parameters on the south and west facing walls to manage solar heat gain, while on the north and east building faces, to minimise heat loss. Therefore in order to characterize optimal glazing performance, a systems approach is required rather than a

one size fits all approach. In developing a regulation for windows, it is recommended the province consider adoption of the ASHRAE 90.1 requirements for windows.[34]

[34] The prescriptive requirements defined in ASHRAE 90.1 are limited to buildings with less than 50% glazing. In the case where the glazing area is greater than 50%, the performance for ASHRAE requires a trade-off compliance path.

5. Energy Savings Potential

This section provides an estimate of the commercial glazing market, and the potential energy savings resulting from increased performance.

5.1. Commercial Building Segmentation

The commercial building stock in British Columbia is summarised in Table 10 and broken down by segment. Data is based on the BC Hydro Conservation Potential Review (2003), as it represents the most detailed data available to characterise the commercial building stock. As can be seen, there is an estimated 71 million square meters of commercial floor area in the province. Approximately 60% of the floor space is in small retail and high-rise apartments. It should be highlighted that the current analysis excludes low-rise residential as it is predominantly vinyl frame residential style windows.[35]

Table 10:Commercial Sector Segmentation and Floor Area [Sq m]

Segment	2005	2010	Annual Increase
Large office	5,203,000	5,885,000	136,000
Medium office	1,437,000	1,621,000	37,000
Large non-food retail	3,879,000	4,525,000	129,000
Medium non-food retail	1,260,000	1,469,000	42,000
Food retail	669,000	748,000	16,000
Large hotel	1,156,000	1,348,000	38,000
Medium hotel/motel	648,000	749,000	20,000
Hospital	1,527,000	1,710,000	37,000
Nursing homes	296,000	344,000	10,000
Large schools	3,444,000	3,794,000	70,000
Medium schools	2,226,000	2,440,000	43,000
University college	2,690,000	2,966,000	55,000
Restaurant/tavern	867,000	973,000	21,000
Warehouse/wholesale	2,426,000	2,789,000	73,000
Mixed use	594,000	668,000	15,000
Small commercial	30,558,000	35,087,000	906,000
High-rise MURB	11,996,000	13,478,000	296,000
Total	70,875,000	80,593,000	2,571,000

5.1.1. Estimate of Commercial Glazing

Based on the floor area estimate noted above, an estimate of the commercial glazing market in 2005 is presented in Table 11. The estimate is based on the results of commercial building audits completed by BC Hydro to characterise new and existing buildings[36]. To generate the estimate of the replacement of glazing in existing buildings,

[35] An estimate of the low-rise market is presented in the next section.
[36] Ref BC Hydro Conservation Potential Review, Commercial Sector Appendices, 2003.

the in-stock glass was combined with the turnover rate[37]. To estimate installations in new glazing, commercial building construction activity was combined with window wall ratios. As can be seen, the commercial glazing market is estimated at almost 600,000 Sq m per year, with new construction representing almost 70% of the market. As can be seen, small commercial and high-rise construction dominates this market. This estimate is consistent with the total sales estimate provided through the market survey. However, the split between new and retrofit activity is lower in this estimate than in the market survey. The rationale for using this lower estimate is that it is based on building audits completed by BC Hydro, and is therefore judged to be more accurate.

Table 11: Commercial Glazing Market by Segment and Vintage, 2005 [Sq m]

Glass (Sq m)	Turnover of Existing	New	Total
Large office	25,200	52,800	78,000
Medium office	4,800	9,900	14,800
Large non-food retail	4,300	11,400	15,700
Medium non-food retail	300	800	1,100
Food retail	700	1,300	1,900
Large hotel	4,400	11,700	16,100
Medium hotel/motel	1,500	3,900	5,400
Hospital	2,600	5,000	7,600
Nursing homes	300	800	1,100
Large schools	2,000	3,300	5,300
Medium schools	1,900	2,900	4,700
University college	3,400	5,500	8,900
Restaurant/tavern	1,200	2,400	3,600
Warehouse/wholesale	2,000	4,800	6,800
Mixed use	2,100	4,300	6,400
Small commercial	79,000	187,300	266,300
High-rise MURB	51,200	101,200	152,500
Total	187,000	409,300	596,300

A regional breakdown of the glazing market is presented in Table 12. As can be seen, approximately 85% of the commercial glazing market occurs in the Lower Mainland and Vancouver Island. BC has a significant diversity of climate. Having the majority of commercial space in the warmer parts of the province means that if a measure that reduces heating load is cost effective in the Lower Mainland and Vancouver Island, it will generally be cost effective in the Southern and Northern interior of the province.

[37] The turnover rate was estimated from survey responses to estimate new versus retrofit activity.

Table 12: Commercial Glazing Market by Segment and Region, 2005 [Sq m]

Segment	Lower Mainland	Vancouver Island	Southern & Northern Interior	Total
Large office	67,600	8,100	2,300	78,000
Medium office	10,700	2,500	1,600	14,800
Large non-food retail	11,100	2,400	2,200	15,700
Medium non-food retail	700	200	200	1,100
Food retail	1,000	500	400	1,900
Large hotel	13,300	1,700	1,200	16,100
Medium hotel/motel	3,200	1,100	1,000	5,400
Hospital	5,200	1,500	900	7,600
Nursing homes	1,000	100	100	1,100
Large schools	3,400	800	1,100	5,300
Medium schools	2,400	1,100	1,300	4,700
University college	6,900	1,400	600	8,900
Restaurant/tavern	2,500	700	500	3,600
Warehouse/wholesale	5,800	600	400	6,800
Mixed use	5,400	600	400	6,400
Small commercial	152,600	53,000	60,700	266,300
High-rise MURB	115,000	24,000	13,400	152,500
Total	407,800	100,300	88,300	596,300

5.1.2. Commercial Glazing Performance

An estimate of glazing performance by segment for existing and new buildings is presented in Table 13. The performance of the existing stock reflects the mix of single and double glazed products. The thermal transmittance of the new stock is consistent with double glazed aluminium frame thermally broken windows with a mix of clear and low-e glazing units (refer to Table 3). These estimates are based on building audits completed by BC Hydro, and are consistent with the estimate from the BC Government Review of Energy Performance of Buildings in BC (REPBC).[38]

This data demonstrates that while the performance of commercial glazing is improving (lower U-value and SC), there is a trend towards increase window wall ratio (WWR) and so more glass. Anecdotally, it was noted by multiple survey respondents that it is cheaper to install window wall into high-rise apartment buildings than to install solid walls, so the trend towards increased glazing is not likely to reverse in the near term. In addition to increased space heat load from the increase in glazing area, there is also a trend to increased overheating in south and west facing apartments, which requires additional cooling equipment.

38 Enersys Analytics, Life-Cycle Economic Assessment of Energy Performance Standards Applied to British Columbia Phase II: Cost Effectiveness of Achieving CBIP in Vancouver, 2004

Table 13: Commercial Glazing Performance for Existing and New Buildings, By Segment and Vintage[39]

	Existing			New		
	U-value	SHGC	WWR[40]	U-value	SHGC	WWR
Large office	4.8	0.65	0.4	3.65	0.6	0.6
Medium office	4.8	0.65	0.3	3.65	0.6	0.5
Large non-food retail	4.48	0.8	0.05	3.2	0.6	0.1
Medium non-food retail	4.8	0.78	0.1	3.2	0.6	0.1
Food retail	4.48	0.8	0.1	3.2	0.6	0.11
Large hotel	4.04	0.65	0.3	3.2	0.6	0.4
Medium hotel/motel	4.04	0.57	0.3	3.2	0.6	0.4
Hospital	3.7	0.65	0.15	3.2	0.6	0.2
Nursing homes	4.04	0.6	0.28	3.2	0.6	0.2
Large schools	4.1	0.89	0.13	3.2	0.6	0.15
Medium schools	4.1	0.89	0.13	3.2	0.6	0.15
University college	5.7	0.65	0.3	3.2	0.6	0.3
Restaurant/tavern	4.48	0.8	0.05	3.2	0.6	0.05
Warehouse/wholesale	4.48	0.8	0.05	3.2	0.6	0.05
Mixed use	3.7	0.65	0.25	3.2	0.6	0.25
Small commercial	4.48	0.8	0.25	3.2	0.6	0.25
High-rise MURB	4.48	0.8	0.3	3.65	0.6	0.45[41]

5.2. Potential Energy Savings From Energy Efficient Glazing

5.2.1. Methodology

As noted above, archetypal building characteristics were obtained from the BC Hydro Conservation Potential Review. The seventeen building archetypes were modeled using the CBIPScreen[42] web tool to model energy use. The tool estimates annual energy use and operating cost by end use and fuel. Baseline window performance was defined using Table 13. The window upgrade was assumed consistent with the proposed Energy Star threshold for fixed windows in climate zone A (See Table 5). This standard was applied to both the retrofit and new market, and used Vancouver weather data.

5.2.2. Energy Savings from Proposed Energy Star Thresholds for Commercial Glazing

The energy savings associated with upgrades to the windows are summarized in Table 14. Energy savings range from 16% energy saving for large offices to 2% for large-non-food retail. The average savings in the retrofit market (weighted by floor area) is 10%.

[39] Ref. BC Hydro Conservation Potential Review, Commercial Sector Appendices, 2003.
[40] Window wall ratio
[41] Ref Estimate based on Enersys Analytics, Multiunit Residential Characteristics Study: Phase 1 Model Definition, Terasen Gas, 2006
[42] http://cbipscreen.nrcan.gc.ca/

Similarly, energy saving in new buildings range from 12% in high-rise MURBs to 1% in schools. The average savings in the retrofit market (weighted by floor area) is 6%. Savings are 8% for the overall commercial glazing market. The difference in savings is due to range across the segments in terms of the window wall ratio, internal gains, and building size and aspect ratio. The Enermodal report[43] estimates a 7.6% savings nationally. In general, the savings are larger as the window wall ratio increases. In addition, the savings in the new market tend to be lower than the savings in the retrofit market since the new market already has a higher performance baseline.

Table 14: Energy Savings from Proposed Energy Star Threshold by Segment and Vintage (U-Value =2.3)

Segment	Existing	New
Large office	16%	9%
Medium office	14%	8%
Large non-food retail	2%	4%
Medium non-food retail	3%	4%
Food retail	6%	2%
Large hotel	7%	7%
Medium hotel/motel	5%	7%
Hospital	3%	2%
Nursing homes	9%	11%
Large schools	7%	1%
Medium schools	9%	1%
University college	7%	5%
Restaurant/tavern	8%	2%
Warehouse/wholesale	8%	2%
Mixed use	9%	4%
Small commercial	9%	4%
High-rise MURB	9%	12%

Model results indicated that increasing the solar heat gain co-efficient in a number of the building types resulted in an increase in electricity consumption due to increased solar gain in internal load dominated buildings from increased air conditioning load. This finding highlights the importance of proper design to minimise loads, and the commonly expressed survey response that "one size does not fit all".

5.3. Cost of Window Upgrades

The cost of windows by type and region is summarised in Table 15. These are typical costs assuming typical quantities and quality and were obtained from a quantity surveyor[44]. While these estimates represent current prices, it should be highlighted that there has been significant price escalation in the BC construction market over the last three years. These escalations make it difficult to project future prices with accuracy.

[43] Enermodal 2005
[44] Ref. Personal Communication Denis Walsh and Associates.

Table 15: Typical Installed Window Costs [$/Sq m]

	Lower Mainland	Vancouver Island	Kamloops	Prince George
Storefront	624	686	686	702
Punched Window	517	569	569	582
Curtain wall	721	793	793	811
Window wall	570	627	627	641

The up-charge for operable windows is generally $400 to $500. The costs in Table 15 are for new construction, and include labour and materials. It is estimated that 20% should be added to these estimates for retrofit installations.

The incremental cost of upgrades to improve the thermal performance of windows is summarised in Table 16. Information from survey respondents and the Enermodal report are summarised. It should be highlighted that survey respondents noted there is significant mark-up in low-e glass, and the manufacturing cost is significantly less than the market cost.

Table 16: Incremental Cost of Energy Efficiency Improvements

Feature	Survey Response	Enermodal
Low-e coating	$10/Sq m	$18/Sq m
Argon gas fill	$10/Sq m	$8/Sq m
Improved spacers	$4/m	$3/m
Thermal break	$4/m	$7/m

The sales and current level of PST exemption is summarised in Table 17. As can be seen, the current PST exemption results in $25 million in lost revenue for the Province. If the Province were to provide a PST exemption on only that portion of glazing that is low-e, the provincial revenue potential is estimated at $13 million per year.

Table 17: Revenue Potential from PST Exemption

Glazing Sales [Sq m/year]	593,000
Unit Cost [$/sq m]	$608
Annual Sales	$361,000,000
PST Lost @7%	$25,000,000
Portion that is currently energy efficient	50%
Revenue potential from ratcheting incentive	$13,000,000

5.4. Energy Star Standards

A life cycle cost assessment for window upgrades was completed, using the assumptions in Table 18. Results are summarised in Table 19 and Table 20 for retrofit and new construction, respectively. The incremental capital cost for the retrofit windows assumes

an upgrade from double glazed clear glass to double glazed low-e glass with argon fill.[45] The upgrade in new construction assumes installation of aluminium frame thermally broken frames with doubled glazed clear glass going to low-e argon filled units. A 20% price premium has been assumed for the retrofit installation.

Table 18: LCC Assumptions

Electricity price	$0.0515/Kwh
Electricity escalation rate	2%
Natural gas price	$10.64/GJ
Natural gas escalation rate	2%
Discount rate	8%
Upgrade Cost (Retrofit Construction)	$31/Sq m
Upgrade Cost (New Construction)	$26/Sq m

As can be seen, the proposed Energy Star rating has a positive LCC for all retrofit projects and generally positive for new construction. Exceptions in the new construction include the medium sized schools and warehouses. This is likely due to the relatively small portion of heat load through the glazing.

Table 19: LCC for Retrofit Construction

Segment	Cost	Savings	LCC	Payback (Years)
Large office	($99,993)	$185,513	$85,520	8
Medium office	($56,654)	$146,560	$89,905	6
Large non-food retail	($27,342)	$186,732	$159,390	2
Medium non-food retail	($4,501)	$204,136	$199,635	0
Food retail	($2,995)	$11,458	$8,463	4
Large hotel	($94,773)	$116,281	$21,508	12
Medium hotel/motel	($35,538)	$78,769	$43,231	7
Hospital	($42,321)	$81,138	$38,817	8
Nursing homes	($14,954)	$47,727	$32,772	5
Large schools	($13,613)	$77,416	$63,803	3
Medium schools	($4,787)	$17,784	$12,997	4
University college	($27,918)	$108,840	$80,922	4
Restaurant/tavern	($1,765)	$6,740	$4,976	4
Warehouse/wholesale	($3,056)	$7,146	$4,089	6
Mixed use	($4,461)	$9,553	$5,092	7
Small commercial	($3,206)	$9,578	$6,372	5
High-rise MURB	($88,228)	$160,266	$72,038	8

[45] It is assumed that when a builder owner completed a window retrofit, the installation will comply with the requirements of the building code.

Table 20: LCC for New Construction

Segment	Cost	Savings	LCC	Payback (Years)
Large office	($83,865)	$107,488	$23,623	11
Medium office	($47,517)	$63,356	$15,839	11
Large non-food retail	($22,932)	$68,109	$45,177	5
Medium non-food retail	($3,775)	$56,252	$52,477	1
Food retail	($2,512)	$4,123	$1,612	9
Large hotel	($79,487)	$125,631	$46,143	9
Medium hotel/motel	($29,806)	$70,851	$41,045	6
Hospital	($35,495)	$51,147	$15,651	10
Nursing homes	($12,542)	$68,481	$55,939	3
Large schools	($11,418)	$11,795	$377	14
Medium schools	($4,015)	$2,705	($1,310)	21
University college	($23,416)	$70,783	$47,367	5
Restaurant/tavern	($1,480)	$1,717	$237	13
Warehouse/wholesale	($2,563)	$2,022	($541)	19
Mixed use	($3,741)	$3,807	$66	15
Small commercial	($2,689)	$3,808	$1,119	11
High-rise MURB	($73,997)	$105,014	$31,016	10

Based on this analysis, the proposed Energy Star Standard is cost effective across all retrofit and the majority of new construction activity.

A sensitivity analysis was completed to explore the robustness of the results. Increases in the escalation rate for electricity and natural gas increases the savings. In contrast, a 20% increase in the cost of the upgrades lowers the savings. However, the LCC remains positive across all segments in the retrofit market. In new construction and assuming a 20% increase in prices, the LCC is negative for large and medium schools, restaurants, warehouses and mixed use, while remaining positive for all other segments.

5.4.1. Energy Savings and Financial Impacts of an ASHRAE 90.1-2004 Standard

The analysis was repeated, assuming U-values defined by ASHRAE 90.1-2004 to assess the energy savings and cost effectiveness of that program. Based on ASHRAE 90.1 U-values, the energy savings from implementation of a window standard is estimated at 4 GWh/year of electricity and 30,000 GJ/year of natural gas. The standard would not impact new construction for the majority of segments due to the low-e window wall ratio of the buildings modeled. However, it would impact multi-unit residential buildings and offices, where typical window wall ratios exceed 40%.

5.5. Summary

Implementation of the proposed Energy Star performance thresholds for commercial glazing will result in 8% decrease in energy consumption in the commercial building

sector, corresponding to a savings of 17 GWh/year of electricity and 100,000 GJ/year of natural gas. The Energy Star standard is cost effective, with the exception of medium schools and warehouses.

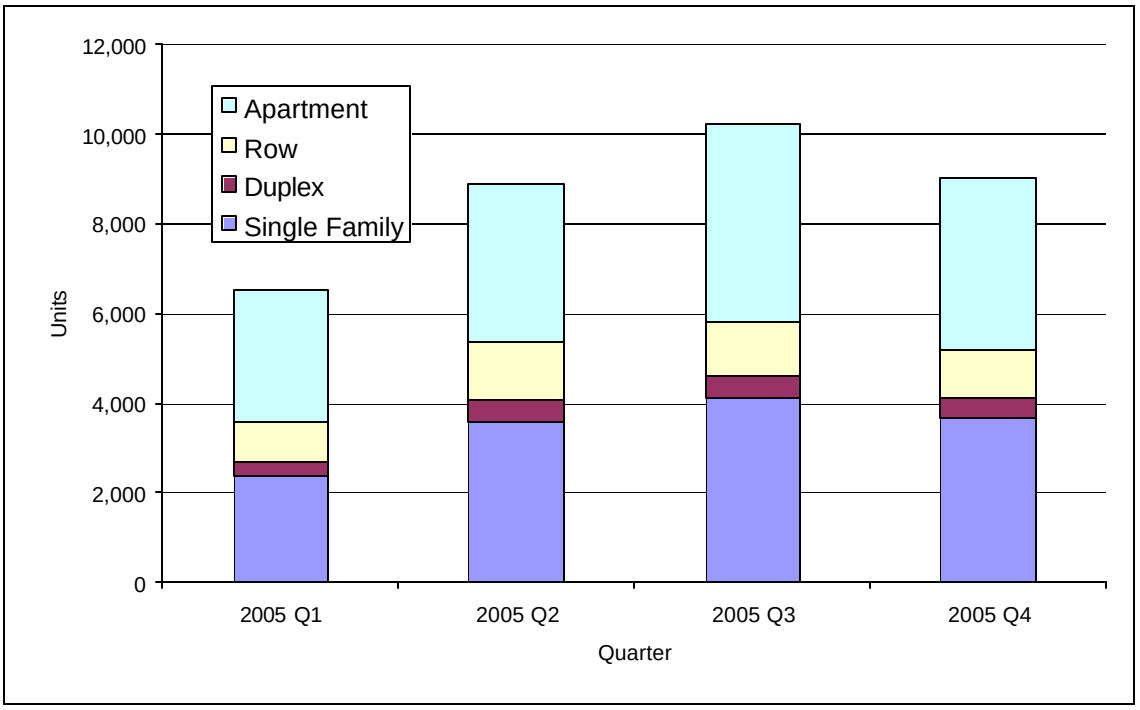
6. Residential Window Market Update

While the focus of this study is the commercial window market, a second survey was completed to assess the market penetration of Energy Star windows in British Columbia and assess the overall performance of the program for firms serving the BC market. This section provides an estimate of the current saturation of Energy Star qualified products in the residential sector and summarizes the results from the survey.

6.1.1. Residential Construction Activity

In 2005, a total of 34,700 dwelling units were built in BC, including 13,700 single family dwellings 1,800 duplexes, 14,700 apartments, and 4,500 row houses. A breakdown of activity by dwelling type and period is summarised in Figure 6.

Figure 6: Construction Activity Statistics (2005)[46]



To estimate the amount of glazing installed in new construction, a range of resources were reviewed including:

- The Energuide for Houses Database, queried for homes built after 1996
- A recently completed survey for the BC Hydro New Home Program
- The Heschone Mahone estimate of glazing as a portion of floor area

The market for glazing in new construction is estimated at 580,800 Sq m (based on combining estimates of construction activity with glazing area results) in 2005.

[46] CMHC, Housing Now, 64151_2006_Q03, 2006

Table 21: Residential Glazing Market by Segment in New Construction, 2005 [Sq m]

Segment	Glazing Area
Single family	385,200
Duplex	35,700
Row	71,400
Low-rise MURB	88,400
Total	580,800

6.2. Residential Window Stock

The residential window market was estimated as part of a previous market assessment (Heschone Mahone Group Inc., 2004). Based on that assessment, the market for residential windows ranges between 660,000 Sq m/year and 800,000 Sq m/year for both new and retrofit. To obtain those results, the Heschone Mahone Group utilised a range of survey data and secondary research. The report estimates that there is a 70/30 split between new and retrofit construction[47]. Assuming this split between new and retrofit activity, and combined with the estimate for glass in new construction in Table 21, the total residential window market is estimated at 0.83 million square meters in 2005.

6.3. Residential Supplier Survey Results

To understand the penetration of energy efficient glazing in the residential market, a survey of manufacturers serving the British Columbian market was completed. The survey questionnaire is presented in Appendix 2. The objectives of the survey included estimating the sales of Energy Star residential windows and collecting respondents' feedback on various aspects of the Energy Star program. The survey focused on residential window manufacturers who are currently selling Energy Star product in British Columbia or are in the process of having products certified. In total, 20 surveys out of a possible 31 were completed, for a 65% completion rate. A minimum of three attempts was made to complete a survey with each company. A summary of the survey findings is presented below.

Customer Profile

- Manufactures sell to a range of customers, including retailers, contractors and homeowners.
- A number of the firms contacted are not currently Energy Star qualified, but they are already producing a high performance package and selling into the market. Respondents noted that the Energy Star is a means to certify improved performance.
- Of those companies already certified at the time of the interview, the majority had been certified for one year or less.

[47] A survey of BC market representatives consistently estimate the market of new and retrofit residential windows are equal in size.

Market Share of Energy Efficient Windows

- For those with product already certified, Energy Star windows represented 15% to 90% of their residential window lines.
    - Larger firms focusing on the new housing market estimated the proportion of their sales of Energy Star products to be 15% to 20%
    - The smaller firms focusing on specialty products and the retrofit market estimate their sales of energy star products in the 50% to 80% range.
    - Sales of Energy Star windows is growing.
- Four of the companies with certified product reported an increase in the market share of Energy Star Products in the past year, the remaining five companies indicated no change in market share. Respondents who had increased market share noted the market for low-e residential windows has doubled in last three to four years.

Awareness of Energy Efficient Glazing Products

- Respondents noted that customers are generally aware of Energy Star certification, but are not clear what it means in terms of improved performance. This gap represents both a barrier and an opportunity for increased sales of Energy Star window products.

Costs

- The cost premium for Energy Star windows is approximately $30/Sq m ($3/Sq ft).
- Costs for Energy Star products have levelled out as the market has matured.
- One large manufacturer noted the cost to manufacture low-e glass is very low, however, there is significant spoilage which increases costs.
- Respondents noted that ongoing trends imply that the price premium of Energy Star Products could be reduced to equal the current value of the PST exemption.

Promotions and Training

- Those firms in the process of certification are not promoting the program or training staff.
- With the exception of one small manufacturer, all companies with Energy Star certified products are actively promoting their products through various media including the web, product literature, displays and materials in their company showroom, and in radio, TV, and/or in print media. These firms also had trained their staff on the Energy Star brand.

Sales Expectations

- Respondents expressed concern that if they their products are not certified, there will be regulations imposed regarding performance or certification.
- Generally, smaller firms do not support regulation and wish to maintain a "level playing field" relative to the larger manufacturers. Conversely, the larger manufacturers support increased regulation and adjustment of the current PST exemption to support increased market uptake of energy efficient products.
- Seven of the nine companies with certified products expected their sales of Energy Star windows to increase over the upcoming year. The remaining two

firms expected sales to remain the same as 2006. Promotions, the MEMPR/BC Hydro incentive, certification assistance, a growing awareness of Energy Star and the environment, and concerns about energy costs were given as reasons for the expected increase in sales over the next 12 months.

Satisfaction & Other

- Enforcement of the Energy Star rating is seen as a significant issue, especially since many windows have not met basic code requirements (A1, B1, C1) in recent years.
- Ongoing concern over durability of IG units fills with argon to retain the fill was expressed.
- Firms with Energy Star certified products rated the overall satisfaction with the Energy Star program as an average of 2.9 on the one to five scale, where one represented "not satisfied at all" and five represented "extremely satisfied".
- A key source of dissatisfaction for firms with Energy Star certified products was Natural Resources Canada's website designed to assist homeowners in the selection of Energy Star certified product[48]. Issues about the site included:
    - Over complicated and difficult to navigate
    - Inconsistent level of detail on Energy Star window products by participating firms. Some firms had thousands of listings while others had posted considerably less. The inconsistency of representation led one firm to suggest that some companies were deliberating overpopulating the site to gain a competitive advantage.
    - Firms reported that consumers find the site difficult to use to complete their incentive applications for BC Hydro. Some firms have had to allocate resources to assist consumers in completing their applications.

6.4. Penetration of Energy Efficient Residential Glazing

A range of data sources were explored to estimate the penetration of Energy Star glazing into the residential market, including the BC Hydro Residential End Use Survey, participation in the BC Hydro windows program and respondents of the residential survey.

6.4.1. 2006 BC Hydro Residential End Use Survey

BC Hydro conducts a comprehensive survey of residential customers on a periodic basis. Based on the 2006 BC Hydro Residential End Use Survey, which includes over 4,000 respondents, 15% of post 1996 homes have low-e glass installed in their homes. However, only half of those are low-e with argon fill, as summarised in Table 22. The survey does not specifically ask homeowners whether their glazing is Energy Star labelled, but the presence of low-e and argon fill provides a relatively good estimate of the market penetration of energy efficient glazing prior to the Energy Star residential program commencing in 2005. These estimates are consistent with the Heschone Mahone estimate that 15% to 20% of the residential glazing market has energy efficient glass, albeit, not Energy Star rated. A limitation of this survey is that it includes high-rise

[48] http://oee.nrcan.gc.ca/energystar/english/consumers/windows-search.cfm?text=N&printview=N

apartment buildings, and it is not possible to distinguish high-rise from low rise MURBs in the data set.

The results of the Residential End Use Survey cannot be used directly to infer market current penetration rates of Energy Star windows. The data in Table 22 are for houses built since 1996. There is no way to disaggregate the data to assess market penetration in the retrofit market or new construction (i.e., built in the last year). However, this data does provide a lower bound "reality check".

Table 22: Energy Efficient Glazing in the Residential Sector[49]

Region	Low E	Low-E argon fill
Lower Mainland	12%	5%
Vancouver Island	16%	8%
Southern Interior	23%	12%
Northern Interior	26%	13%
Total	15%	7.4%

6.4.2. Energy Star Window Rebate

BC Hydro as part of its MEMPR-supported Window Rebate Program tracks the sale of Energy Star windows. Based on that information, the sale of Energy Star windows is estimated at 20,000 Sq m in the new market and 25,000 Sq m in the retrofit market. Assuming a market size of 800,000 Sq m, the penetration of Energy Star windows is estimated at 6%. This estimate likely understates the true market share for Energy Star windows in new and retrofit sales as some proportion of Energy Star window purchases likely occur without the purchaser applying for the BC Hydro incentive. Some degree of non-participation in rebate and incentive programs exists for all energy efficiency initiatives, driven, in part, by a lack of awareness of the program or the incentive, the size of the rebate relative to the purchase price, and/or the degree of administrative difficulty (hassle factor) in obtaining the rebate. Reports from the residential Energy Star survey suggest that consumers are having problems completing the application forms for the program, in part due to difficulties using the Natural Resources web site. This feedback supports the argument that some proportion of Energy Star window purchases are going unclaimed, and that the market share estimate based on rebate submissions understates the true market share for Energy Star windows.

As can be seen in Table 23, there were significantly more participants in the retrofit market than for new construction, however, the amount of glass purchased was lower. This reflects the trend of homeowners who install high performance glazing as part of an addition or renovation, or who complete window replacements on only a portion of their glass.

[49] Ref 2006 BC Hydro Residential End Use Survey

Table 23: Energy Star Market Profile

	Number of Participants	Average area of Energy Star Glazing (Sq m)
New	464	44.6
Retrofit	1,823	14

6.4.3. Market Survey data

Based on the residential manufacturers survey, the penetration Energy Star glass and the relative market size are shown in Table 24. Combining the survey respondents' estimate of sales with relative market size, the penetration of Energy Star windows is estimated at 20% to 30%[50]. This estimate is higher than the results based on the uptake of incentives presented in the last section and suggests that the uptake for the incentive is limited.

Table 24: Survey results of Market Penetration for Energy Star Windows

	Estimated Sales of Energy Star products	Relative Market Size	Market Penetration
Retrofit Construction	50%	30%	15%
New Construction	7% - 20%	70%	5% to 14%
Estimated Penetration of Energy Star Windows			20% to 30%

6.5. Summary

Based on the survey results of residential manufacturers, the market share of Energy Star windows is estimated at between 20% to 30%, corresponding to between 170,000 Sq m/year to 250,000 Sq m/year of product for 2005.

[50] To generate this estimate, the market penetration of energy efficient product was multiplied with the relative market size for retrofit and new windows, that these were added to provide an overall industry estimate of the market penetration.

7. Conclusions and Recommendations

The commercial glazing market is estimated at 600,000 sq m per year. The split between new and retrofit activity is estimated at 70% new and 30% retrofit. Eighty-five percent of the commercial glazing market is located in the Lower Mainland and Vancouver Island, and approximately 70% of the market includes high-rise residential and small commercial buildings. Finally, it is estimated that 50% of the commercial glazing market uses low-e glass.

There are three major commercial glazing archetypes, including storefront, punched windows and window wall/curtain wall. These archetypes represent functional rather than energy performance characteristics, as the materials used throughout the sector are similar (aluminium frames and double insulated glazing units) and the opportunities to improve the thermal performance are common to all the archetypes.

A range of energy efficient components exist to enhance the performance of commercial glazing, including:

- Low-e films on the glass
- Improved thermal breaks in the frames
- Insulating spacers to separate the glass sheets in the insulted glazing units, and
- Inert gas fill

In general, these energy efficient components are widely available. There are a range of additional opportunities to reduce energy use in commercial buildings, and optimising the glazing for orientation and expected load, and accounting for window wall ratio as part of the glazing design offer significant benefits.

The costs for energy efficient glazing components are summarised in Table 25.

Table 25: Incremental Cost of Energy Efficiency Improvements

Feature	Survey Response	Enermodal
Low-e coating	$10/Sq m	$18/Sq m
Argon gas fill	$10/Sq m	$8/Sq m
Improved spacers	$4/m	$3/m
Thermal break	$4/m	$7/m

An assessment of the market barriers to increased adoption of energy efficient glazing products reveals that price and limited understanding of the benefits of improved glazing performance hinder the market adoption of energy efficient products.

An analysis of the proposed Energy Star thresholds for commercial glazing was completed. It was estimated that implementation of the threshold would reduce energy use in the commercial sector by 5%. Implementation of the measures has a positive life-cycle cost for all building types in new construction. The life cycle cost is positive in

retrofit construction for all segments, except for medium schools and warehouses, due to their lower glazing areas. The payback period is immediate to up to eight years in new construction and ranges from one to fifteen years in the retrofit market. Electricity savings are estimated at 18 GWh/yr and natural gas savings are estimated at 100,000 GJ/yr. Should the ASHRAE 90.1 standard be chosen, it is estimated to result in a 4 GWh/yr savings in electricity and a 30,000 GJ/Yr savings in natural gas. Whereas the Energy Star standard would impact all commercial building segments, the ASHRAE standard would have a significant impact on offices and multi-unit residential buildings.

It is recommended that British Columbia continue to work with the federal government to develop an Energy Star rating for commercial glazing products to offer a voluntary labelling program to promote innovation and recognise "best in class" products. This is consistent with development of the Energy Star brand in other product categories. However, to protect the market transformation to low-e products that has occurred throughout the province and to stop back slippage, it is recommended that the prescriptive performance requirements defined in ASHRAE 90.1 be considered for implementation by the Province of British Columbia. ASHRAE 90.1 offers multiple benefits compared to the current Energy Star threshold:

- The standards are sensitive to the window wall ratio, orientation and occupancy
- The standard includes thresholds for U-value and solar heat gain
- The standard requires product certification (NFRC)
- The ASHRAE standard forms a part of the building code in the City of Vancouver, and adoption by the province results in a "level playing field" throughout BC.
- ASHRAE 90.1 is consistent with "good engineering practice", and the performance levels are based on life cycle costing to ensure cost effectiveness.

7.1. Residential Window Market Survey

Analysis was conducted to assess the penetration of Energy Star certified residential windows. Based on the BC Hydro window incentive uptake and the BC Hydro Residential End Use Survey, is estimated that Energy Star rated residential windows account for 20% to 30% of all residential window sales.

8. References

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Glazing Contractors Association, Glazing Systems Specification Manual Version 2, Glazing Contractors Association of BC, 2003

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Hechone Mahone Group, A baseline Assessment of the Residential Windows Market in British Columbia, 2004.

9. Appendix 1: Commercial Window Discussion Guide

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tel: (604)732-9106 fax: (604)732-9238 www.sheltair.com

Discussion Guide
Commercial Window Market Assessment

Introductory
Explain purpose of call / discussion

Research into commercial windows market conducted for a stakeholder group exploring options to improve the energy efficiency of windows in the commercial building market

- MEMPR
- CMHC
- Terasen Gas
- BC Hydro
- NR Can
- WDMA-BC

Explain role of interviewer – neutral third party that will keep all comments confidential unless requested otherwise. *Market sensitive information will be averaged out*.

Obtain permission to proceed or reschedule
Study verification contact person name and phone number if requested: _____

Corporate title of interview respondent _____

Years working with windows (fenestration products or related industry) ___

Activity in the Industry

- Manufacturer
- Architect/Engineer (*use interview specific prompts indicated in brackets when necessary*)
- Glazing contractor

Market share of window systems

1. Excluding small residential, what sectors of the market do you sell to?
   - builders/developers – commercial /institutional industrial including large MURB
   - glazing contractors – commercial / institutional industrial including large MURB
   - glazing contractors – residential excl large MURB
   - smaller residential home builders
   - other _____
2. What portion of your business is new construction versus renovation?

3. What are the total annual square metres of fenestration products that your firm is involved with?

4. What portion of your sales (*windows you spec*) to the non-residential sector is:
   - Aluminium frame
   - Vinyl frame
   - Hybrid
   - Other

5. What significant trends, if any, in frame materials or design features have you noticed over the last 5 years?

6. What portion of your sales (*windows you spec*) to the non-residential sector is
   - Punched windows
   - Curtain wall/window wall
   - Store front
   - Other (e.g., decorative or otherwise not affecting the efficiency of the building envelop)

7. What portion of commercial sales are operable?

8. What significant trends, if any, in the market share for these window types have you noticed over the last 5 years?

9. What portion of your sales (*windows you spec*) are fabricated in the shop versus fabricated on site?
   - Punched windows
   - Curtain wall/window wall
   - Store front

10. What significant trends, if any, in the market share for these window types have you noticed over the last 5 years?

Energy Efficient Glazing Systems

11. How would you characterise a high efficiency commercial window?
    - What portion of your sales (*windows you spec, products you sell*) would fall into this category?

12. Who and/or what determines the window specifications related to energy?

13. How are the window specifications determined?

14. What are the drivers that determine the energy efficient features for non-residential windows:
    Prompts:

- Price
- Codes
- Architect, Engineer, Contractor
- Owners
- Other

15. What portion of your non-residential installations utilize:
    - Double glazing?
    - Low-e coating? (hard coat versus soft coat)
    - Argon fills?
    - Insulated spacers?
    - Thermally broken frames?

16. Is the portion of high efficiency products similar for new versus retrofit construction?
    - (if no) What is the relative proportion for each?

17. What is the current market penetration of low-E glass?
    - (prompt, if necessary) One study estimated it at 14%. Do you agree with this estimate?
    - What portion of the non-residential market will be low-E in 5 years?

18. What is the current market penetration of aluminum frames that are thermally broken?
    - (prompt, if necessary) One study estimated it at 66%. Do you agree with this estimate?
    - What portion of the non-residential market will use thermally broken aluminum frames in 5 years?

19. What is keeping low-E glass and thermally broken frames from having higher market penetration?
    Prompts:
    - Product availability?
    - Consumer Awareness?
    - Cost?
    - Codes?
    - Durability?
    - Other?

(*if not specifically addressed, confirm barriers are the same or different for the two products*)

20. In general, how does energy efficiency fit into your firm's marketing strategy?

Market Trends

21. What sort of opportunities and challenges do you see in the next few years for energy efficient commercial glazing systems?

22. What is the most important market trend today affecting the market share of energy efficient glazing products?
    Prompts:
    - Awareness
    - Materials
    - Costs
    - Competition
    - Partnerships

23. Do you expect this trend to continue over the next 5 years? Why?

Cost for window upgrades

24. In general what is the price premium for improved window performance?
    - Triple glazing [$/sqm]
    - Low-E coating [$/sqm]
    - Argon fill [$/sqm]
    - Insulated spacers [$/m]
    - Thermally broken frame [$/m]

25. How are these prices likely to change over the next 5 years?

26. How would this premium change with increased market penetration of energy efficient products?

27. Do you use life cycle costing to promote energy efficient windows to clients?

28. Generally, how much are clients willing to pay for energy efficiency in terms of a cost premium (%)?

Role of Codes and standards to support innovation

29. How are codes (ASHRAE 90.1, CSA A440.2-04) influencing trends?

30. How are green building programs influencing trends?

31. Are you aware of the Energy Star program for residential windows?
    - Would you support a similar initiative for commercial glazing products?

32. What would you see as the primary barriers to a commercial window labelling program?

33. Would you support financial incentives or disincentives as a means to increase the performance of commercial windows?

34. Would you support codes (minimum U value or SHGC)? for commercial window products?

Potential allies and opponents to increased efficiency

35. Who are the most important trade allies to support energy efficient commercial glazing systems?

36. Who are the most significant opponents of energy efficient commercial glazing systems?

Final Questions

37. Do you have any suggestions on ways to increase the penetration of energy efficient windows?

38. Are there other industry experts or market actors you suggest we talk to?

39. Any other comments?

Thank and terminate

10. Appendix 2: Residential Window Survey

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Draft Discussion Guide

Energy Star Residential Windows – Manufacturers' Survey

Interviewer instructions and prompts in italics

Target audience: manufacturers of Energy Star residential windows serving the BC market

Introductory

Explain purpose of call / discussion

I am conducting a short survey of residential window manufacturers that produce Energy Star certified windows for the British Columbia market. The primary purpose of the survey is to evaluate the progress of the residential windows Energy Star initiative in British Columbia. It is a short survey and should only take about five minutes.

The primary sponsors of the survey are:

- MEMPR
- CMHC
- Terasen Gas
- BC Hydro
- NR Can
- WDMA-BC

Explain role of interviewer – neutral third party that will keep all comments confidential unless requested otherwise

Obtain permission to proceed or reschedule.

Study verification contact person name and phone number if requested:

Andrew Pape-Salmon, P.Eng., MRM
Manager - Energy Efficiency and Community Energy Solutions
Ministry of Energy, Mines and Petroleum Resources Government of British Columbia
email: Andrew.PapeSalmon@gov.bc.ca
Tel: 250-952-0819

Questions

1. To confirm, your firm manufactures windows that are Energy Star qualified?
   - *If no* - are you currently in the certification / training phase for Energy Star certification?
     - *if not, then thank and terminate*
     - *If yes, ask the following questions, then terminate interview*

   How many square metres of fenestration products does your firm produce annually?

   At present, what proportion (%) of the residential windows you sell to the BC market products are considered to be of high efficiency. That is, *Energy Star certified*

   What was the proportion (%) a year ago?

   When do you expect to begin shipping Energy Star certified windows?

   Thank and Terminate

Customer Profile

2. Whom do you ship to (all window products)?
   - wholesalers / distributors
   - retailers
   - builders / contractors
   - other

3. How many square metres of fenestration products does your firm produce annually?

4. How long has your firm been shipping Energy Star certified windows to the BC market?

Market Share

5. At present, what proportion (%) of the residential window products you sell to the BC market, including Energy Star certified products, are considered to be of high efficiency. That is, *Energy Star certified*

6. Has this proportion increased, decreased, or stayed the same since joining the Energy Star program?
   - *If increased or decreased* - Why has it increased / decreased?

7. What was the proportion (%) a year ago?

- *If no figures offered* - Has it increased, decreased, or stayed the same?

8. *If increased or decreased...*Why have they increased / decreased?

Awareness

9. How would you rate your customers' awareness of Energy Star windows?
   - Excellent
   - Very Good
   - Good
   - Fair
   - Poor

10. And how would you rate your customers' understanding of what the Energy Star certification means?

prompt – in terms of thermal efficiency?

- Excellent
- Very Good
- Good
- Fair
- Poor

Costs

11. Have the costs of manufacturing an Energy Star qualifying window increased, decreased or stayed the same since you first starting shipping Energy Star certified units?
    - *if increased or decreased* – What has increased / decreased in cost?

    Prompts:
    - individual window components such as glass, low-e coatings, frame materials, fills, spacers, etc.
    - labour costs
    - fuel / transportation costs
    - mark-ups charged to distributors / wholesalers / retailers
    - marks-ups charged by distributors / wholesalers of individual window components
    - other

Promotions and Training

12. Are you promoting Energy Star windows...
    - on your company website?
    - in product literature and other promotional materials?
    - in displays or material located in your showroom?

- in radio, TV, magazine, or Internet ads?

13. Since joining the program, have you launched any promotional campaigns or changed any promotional campaigns to include Energy Star windows?

14. Have you trained / informed staff who deal with retailers and distributors on Energy Star qualification?

Sales Expectations

15. Have Energy Star certified windows met your sales expectations?
    - *If no/somewhat/partially/etc* - Why haven't they?

16. Do you expect your shipments of Energy Star windows for the BC market to increase, decrease, or stay the same during the next year?

17. What are the most important factors affecting your expected shipments of Energy Star windows to the BC market over the next year?

Prompts:

- changes to the level of construction (new housing starts) or renovation activity
- growing awareness ES products by retailers / builders / contractors / consumers
- sales margins
- input costs (specify)
- availability of window components needed for ES certification
- market acceptance by retailers / consumers
- awareness of the product and its benefits by customers
- the incentive (size/availability) offered by BC Hydro
- changes to municipal, provincial or federal building codes
- other

Satisfaction & Other

18. Finally, using the 1 to 5 scale where 1 is "not at all satisfied" and 5 is "very satisfied", how satisfied overall are you with the residential windows Energy Star program?

19. Are there any recommendations or comments you'd like to pass on to the sponsors of this survey?

Thank individual for their time. Terminate.