WINDOW AND DOOR THERMAL

PERFORMANCE REQUIREMENTS IN

CANADIAN BUILDING CODES

PREPARED FOR:

The CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
Ottawa, Ontario, Canada, K1A 0E4
CANMET Contract No. 23440-94-1101
March, 1993

PREPARED BY:

Enermodal Engineering Ltd.
368 Phillip Street
Waterloo, Ontario, Canada, N2L 5J1
Phone (519) 884-6421; Fax (519) 884-0103
E-mail: office@enermodal.com

SCIENTIFIC AUTHORITY:

Roger Henry
Buildings Group
The CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario, Canada, K1A 0E4

Second Reprint November 17, 1999

CITATION

Enermodal Engineering Ltd., *Window and Door Thermal Performance Requirements in Canadian Building Codes.* Prepared under CANMET Contract No. 23440-94-1101. The CANMET Energy Technology Centre, (CETC) Energy Technology Branch, Energy Sector, Department of Natural Resources Canada, Ottawa, Ontario, Canada, 1994, (35 pages).

Copies of this report may be obtained through the following:

The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario, Canada, K1A 0E4

or

Intellectual Property and Technical Information Management
Library and Documentation Service Division, CANMET
Department of Natural Resources Canada
555 Booth Street, 3rd Floor, Room 341
Ottawa, Ontario, Canada, K1A 0G1

DISCLAIMER

NOTE

Funding for this project was provided by the Federal Panel on Energy Research and Development, Department of Natural Resources, Government of Canada.

Catalogue No. M91-7/321-1994E
ISBN 0-662-22874-X

EXECUTIVE SUMMARY

Many organizations have started to use the CSA A440.2 window energy ratings and U-values in the specification and promotion of high-performance windows. It was noted however that there appeared to be a wide variation in requirements and versions of this and other standards referenced. This project sought to compare these energy performance levels for doors and windows in residential and commercial building environments.

Reviewed are requirements for two programs: R2000 and Power Smart, and five building codes: current Canadian codes, proposed 1995 National Energy Codes, and ASHRAE 90.1 and 90.2. Comparisons are made for five Canadian cities. Residential requirements are shown on the basis of ER number, estimated from handbook characteristics if only the U-value was specified.

For residences, most new requirements are similar, except for Vancouver, and call for considerably higher performing windows than the National Building Code. Commercial building requirements are more complex since solar heat gain is treated differently, however in general the 1995 NEC prescribes lower U-vales than ASHRAE 90.1.

RÉSUMÉ

Nombre d'organisations utilisent la norme d'efficacité énergétique CSA A440.2 pour évaluer le rendement des fenêtres et les valeurs U pour en déterminer les spécifications et en faire la promotion. Cependant, il est possible de noter un grande diversité de critères et de versions à l'égard de cette norme et de bien d'autres aussi. Le présente étude a pour but de comparer les divers niveaux de rendement énergétique applicables aux portes et fenêtres d'immeubles résidentiels et commerciaux.

Le projet passe en revue les critères des programmes R-2000 et Power Smart et cinq codes de bâtiment : les codes canadiens actuels, les Codes énergétiques nationaux et l'ASHRAE 90.1 et 90.2. L'on compare les données de cinq villes canadiennes. Les critères résidentiels sont établis à partir du rendement énergétique, estimé à l'aide des données officielles lorsque seule la valeur U est connue.

Pour les résidences, les nouveaux critères se ressemblent, sauf dans le cas de Vancouver, et exige des fenêtres considérablement plus efficaces que ne le requiert le Code national du bâtiment. Dans le cas du bâtiment commercial, les critères sont plus complexes puisque les gains de chaleur solaires sont traités différemment mais il demeure qu'en général le Code énergétique national 1995 prescrit des valeurs U moindres que celles de l'ASHRAE 90.1.

TABLE OF CONTENTS

1.0 INTRODUCTION

The advent of new window technologies has meant that there is now a wide range in window (and door) thermal performance. High-performance windows incorporate low-emissivity glass, gas-filled cavities and improved frame designs. Low-heat-loss doors are constructed of foam insulation and high-performance glazing units. CSA Standards have been written to allow for a uniform means of rating the thermal performance of windows (CSA A440.2) and doors (CSA A453).

Building codes have long been a means of controlling the energy efficiency of buildings. These codes give mandatory minimum performance levels for building construction components and mechanical equipment. Incentive or voluntary programs can be equally important in achieving energy-efficient buildings. These programs encourage a higher level of energy efficiency by offering financial incentives or market recognition. The recent changes in window and door performance have meant that codes and incentive programs have re-addressed the thermal performance requirements for these building components. This report documents the thermal performance requirements for windows and doors in building energy-efficiency standards appropriate to Canada.

Five building codes are reviewed in this report:

- current national and provincial building codes,
- proposed 1995 National Energy Code for Houses,
- proposed 1995 National Energy Code for Buildings,
- ASHRAE 90.1 for commercial buildings, and
- ASHRAE 90.2 for low-rise residential buildings.

Two incentive programs are also reviewed:

- R2000 program, and
- Power Smart program.

The window and door requirements contained in these codes and programs are summarized in the following sections.

2.0 WINDOW AND DOOR REQUIREMENTS - RESIDENTIAL

2.1 National and Provincial Building Codes

The current National and Provincial Building Codes, with the exception of Ontario, require windows to be at least double glazed. Specifically, the code requirements are as follows:

- All doors separating a heated space from an unheated space shall have a thermal resistance of not less than RSI 0.7 where a storm door is not provided.
- All sliding glass doors separating a heated space from an unheated space shall have a thermal resistance of not less than 0.30 $m^{2o}C/W$.
- All glazing separating a heated space from an unheated space shall have a thermal resistance of not less than 0.30 $m^{2o}C/W$.
- Where an enclosed space, such as a sun porch, veranda, or vestibule, is separated from a heated space by glazing, the unheated enclosure may be considered to provide a thermal resistance of 0.16 $m^{2o}C/W$, which is equivalent to single glazing.

The code does not describe how these basic values are calculated and whether they include frame and edge-of-glass effects.

The exception to this requirement is the Ontario Building Code that specifies a minimum ER for electrically space-heated homes. The Ontario Building Code makes the following additional provisions for homes that are heated with electricity:

- When electric space heating is used, all sliding glass doors separating a heated space from an unheated space shall have an ER not less than -13 ER.
- When electric space heating is used, all glazing separating a heated space from an unheated space shall have an ER not less than -13 ER for openable windows and 0 ER for fixed glazing.

- The energy rating shall be determined in conformance with CAN/CSA-A440.2-M, *"Energy Performance Evaluation of Windows and Sliding Glass Doors".*

2.2 Proposed National Energy Code for Houses, 1995

The National Energy Code for Houses, 1995, is a proposed document outlining the minimum regulations for energy efficiency in new small buildings, 3 stories or less in height, and comprising less than 600m^2 for residential occupancy. It takes into account climate, fuel types, and construction costs. The code establishes a standard of construction for those features that affect building energy efficiency. It is hoped that, once finalized, the regulations found within this code will be adopted by many of the provinces and territories. In fact, it has been recommended that the National Building Code be cross-referenced with this code.

The National Energy Code for Houses, 1995, establishes minimum thermal requirements for windows, doors and other glazed areas. The thermal characteristics of windows and doors are to be based on the total area including all related frame and sash members, in addition to the glazing.

It is proposed that windows and doors defined by CSA Standard A440.2 "*Energy Performance of Windows and Sliding Glass Doors*" which include horizontal sliders, vertical sliders, tilt-turn, casements, projecting, fixed windows and sliding glass doors shall have a label indicating an ER (energy rating) not less than those indicated in Table 2.1. The ER is region specific, taking into account climate, and fuel types available.

Skylights, and other glazed areas inclined less than 60° from horizontal, not exceeding 2% of total roof area do not have to comply with the energy ratings, but must be at least double glazed. Any other windows not described above shall have an overall heat transmittance not to exceed the U-values shown in Table 2.1.

Windows and glazed areas separating unheated spaces, such as porches, from heated spaces are considered to have an effective thermal resistance similar to that of single glazing of 0.16m$^{2\circ}$C/W and can be added to the window.

The glass inserts in doors do not have to meet the minimum ER in Table 2.1 providing that they are double glazed. Doors that separate heated space from unheated space or external doors must have a RSI greater than 0.38 m$^{2\circ}$C/W. The thermal requirements for doors was reviewed during the September meeting of National Energy Code Committee to address recent standard development for doors. The committee has indicated that they intend to revise the document to reference CSA A453 *"Energy Performance of Swinging Doors"*.

For air infiltration requirements, all windows and doors shall comply with relevant federal, provincial or territorial appliance or equipment energy efficiency act. In the absence of such an act, the minimum requirement is an A2 air leakage classification of CAN/CSA-A440 for windows and CAN/CGSB 82.1 for doors. Swinging doors must have an air leakage requirement of less than 2.54 l/s/m^2 when tested in conformance with ASTM E 283, or it must be weatherstripped on all edges and have an added storm door. Pre-hung insulated steel doors must conform to CAN/CSGB 82.5 "Insulated doors".

Table 2.1

NATIONAL ENERGY CODE FOR HOUSES 1995 (PROPOSED)

ATLANTIC CANADA:

	WINDOWS & SLIDING GLASS DOORS WITHIN THE SCOPE OF CSA A440.2						WINDOWS AND SLIDING GLASS DOORS OUTSIDE THE SCOPE OF CSA A440.2 U-value (W/m^2 °)		
	Operable & Fixed Glazing with Sash ER (W/m^2)			Fixed Glazing without Sash ER (W/m^2)					
Heating Source	Electricity, Other	Propane	Oil Heat Pump	Electricity Other	Propane	Oil Heat Pump	Electricity Other	Propane	Oil Heat Pump
Newfoundland Zone A	-10	-13	-13	0	-3	-3	2.4	2.6	2.6
Zone B	-6	-13	-13	4	-3	-3	2.2	2.6	2.6
Zone C	-13	-10	-10	-3	0	0	2.6	2.4	2.4
Zone D	-13	-10	-10	-3	0	0	2.6	2.4	2.4
Prince Edward Island	-6	-13	-13	4	-3	-3	2.2	2.6	2.6
Nova Scotia	-10	-10	-13	0	0	-3	2.4	2.4	2.6
New Brunswick	-13	-13	-13	-3	-3	-3	2.6	2.6	2.6

NATIONAL ENERGY CODE FOR HOUSES 1995 (PROPOSED)

CENTRAL CANADA:

	WINDOWS & SLIDING GLASS DOORS WITHIN THE SCOPE OF CSA A440.2						WINDOWS AND SLIDING GLASS DOORS OUTSIDE THE SCOPE OF CSA A440.2 U-value (W/m^2 °)		
-	**Operable & Fixed Glazing with Sash** ER (W/m^2)			**Fixed Glazing without Sash** ER (W/m^2)					
Heating Source	All Sources			All Sources			All Sources		
Quebec Zone A	-13			-3			2.6		
Zone B	-10			0			2.4		
Zone C	-10			0			2.4		
Zone D	-10			0			2.4		
Zone E	-6			4			2.2		
Zone F	-6			4			2.2		
Heating Source	Electricity, Other	Oil Propane Heat Pump (as)	Natural Gas Heat Pump (gs)	Electricity, Other	Oil, Propane Heat Pump (as)	Natural Gas Heat Pump (gs)	Electricity, Other	Oil Propane Heat Pump (as)	Natural Gas Heat Pump (gs)
Ontario Zone A	-10	-13	-13	0	-3	-3	2.4	2.6	2.6
Zone B	-10	-13	-13	0	-3	-3	2.4	2.6	2.6
Heating Source	Electricity, Other	Oil Propane	Natural Gas Heat Pump (gs)	Electricity, Other	Oil Propane Heat Pump (as)	Natural Gas Heat Pump (gs)	Electricity, Other	Oil Propane Heat Pump (as)	Natural Gas Heat Pump (gs)
Manitoba Zone A	-6	-6	-6	4	4	4	2.2	2.2	2.2
Zone B	-3	-3	-3	7	7	7	2.0	2.0	2.0

NATIONAL ENERGY CODE FOR HOUSES 1995 (PROPOSED)

WESTERN CANADA:

	WINDOWS & SLIDING GLASS DOORS WITHIN THE SCOPE OF CSA A440.2						WINDOWS AND SLIDING GLASS DOORS OUTSIDE THE SCOPE OF CSA A440.2 U-value (W/m² °)		
	Operable & Fixed Glazing with Sash ER (W/m²)			Fixed Glazing without Sash ER (W/m²)					
Heating Source	Electricity, Oil, Propane & Other	Natural Gas Heat Pump		Electricity, Oil, Propane & Other	Natural Gas Heat Pump		Electricity, Oil, Propane & Other	Natural Gas Heat Pump	
Saskatchewan Zone A	-10	-13		0	-3		2.4	2.6	
Heating source	Electricity, Other	Oil Propane Heat Pump	Natural Gas	Electricity, Other	Oil Propane Heat Pump	Natural Gas	Electricity, Other	Oil Propane Heat Pump	Natural Gas
Alberta Zone A	-13	-13	-13	-3	-3	-3	2.6	2.6	2.6
Zone B	-10	-13	-13	0	-3	-3	2.4	2.6	2.6
Zone C	-10	-13	-13	0	-3	-3	2.4	2.6	2.6
British Columbia Zone A	-13	-13	-24	-3	-3	-14	2.6	2.6	3.2
Zone B	-13	-13	-13	-3	-3	-3	2.6	2.6	2.6
Yukon Zone A	-10	-13	--	0	-3	--	2.4	2.6	--
Zone B	2	-13	--	12	-3	--	1.7	2.6	--
Zone C	2	-10	--	12	0	--	1.7	2.4	--

NATIONAL ENERGY CODE FOR HOUSES 1995 (PROPOSED)

NORTHWEST TERRITORIES:

	WINDOWS & SLIDING GLASS DOORS WITHIN THE SCOPE OF CSA A440.2						WINDOWS AND SLIDING GLASS DOORS OUTSIDE THE SCOPE OF CSA A440.2 U-value (W/m² °)		
	Operable & Fixed Glazing with Sash ER (W/m²)			Fixed Glazing without Sash ER (W/m²)					
Heating Source	Electricity, Other	Propane	Oil Heat Pump	Electricity, Other	Propane	Oil Heat Pump	Electricity, Other	Propane	Oil Heat Pump
Northwest Territories Zone A	-6	-13	-13	4	-3	-3	2.2	2.6	2.6
Zone B	2	-10	-13	12	0	-3	1.7	2.4	2.6
Heating source	Electricity, Other	Oil Propane Heat Pump	Natural Gas	Electricity, Other	Oil Propane Heat Pump	Natural Gas	Electricity, Other	Oil Propane Heat Pump	Natural Gas
Zone C	2	-10	-13	12	0	-3	1.7	2.4	2.6
Heating Source	Electricity, Other	Propane Heat Pump	Oil	Electricity, Other	Propane Heat Pump	Oil	Electricity, Other	Propane Heat Pump	Oil
Zone D	2	2	-10	12	12	0	1.7	1.7	2.4
Heating Source	Electricity, Other	Oil Propane Heat Pump		Electricity, Other	Oil Propane Heat Pump		Electricity, Other	Oil Propane Heat Pump	
Zone E	2	-10		12	0		1.7	2.4	
Zone F	2	-13		12	-3		1.7	2.6	
Zone G	2	-13		12	-3		1.7	2.6	
Zone H	2	-13		12	-3		1.7	2.6	

2.3 ASHRAE 90.2-1993 Energy-Efficient Design of New Low-Rise Residential Buildings

Although ASHRAE 90.2 is not referenced by code in Canada, it is widely used in the U.S. and sometimes in Canada. It is designed for single-family houses, multi-family structures, 3 stories or less in height, and manufactured houses such as mobile homes and modular houses.

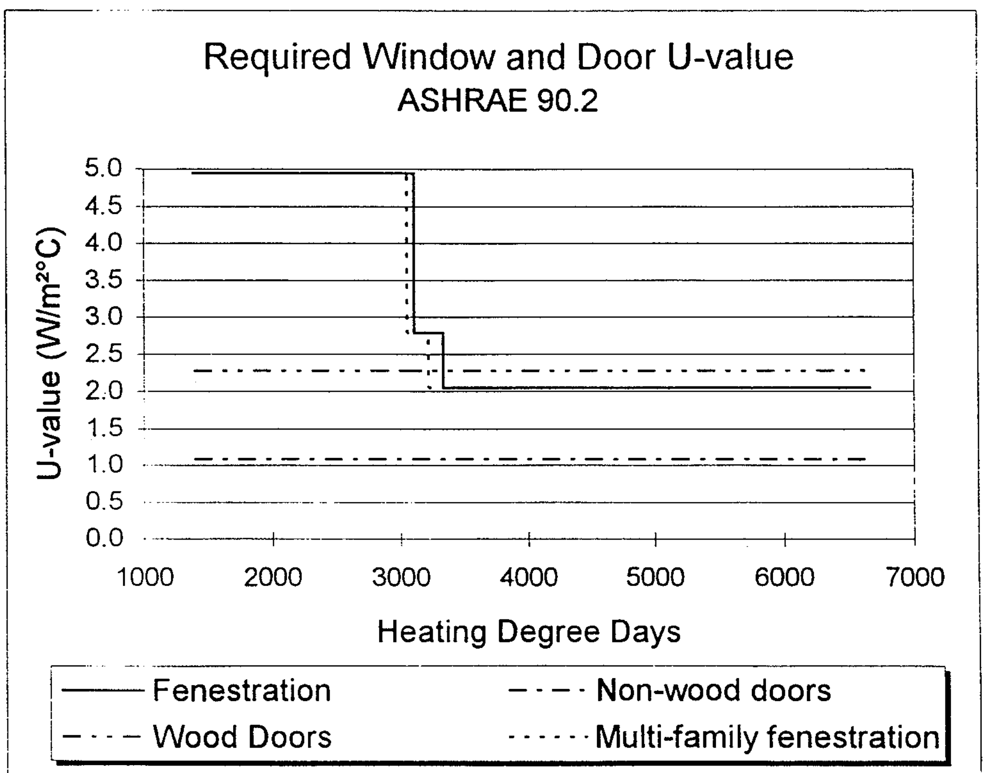
Figure 2.1 shows the maximum allowable U-values for fenestration products, wood doors and non-wood doors. This graph was produced assuming in Canada all ducts are within conditioned spaces and that the number of cooling degree-hours is relatively small. Fenestration systems include windows, glass doors, skylights, and other light-transmitting materials such as glass blocks. The requirements apply to all operable or fixed glazed assemblies. Fenestration that is thermally separated from the conditioned space, such as solariums, greenhouses, sunrooms, are excluded these requirements provided that it is separated by envelope components that meet the standard.

For almost all of Canada (Vancouver excepted), windows must have a U-value of 2.0 W/m^2K (0.36 $BTU/hr{*}ft^{2}{}^{\circ}F$). The opaque portion of wood and non-wood doors must have a U-value of 2.3 W/m^2K (0.40 $BTU/hr{*}ft^{2}{}^{\circ}F$) and 1.1 W/m^2K (0.19 $BTU/hr{*}ft^{2}{}^{\circ}F$) respectively. The glazed portion of any door must meet the thermal requirements for fenestration. Thermal transmittance values are to be determined in accordance with the 1989 ASHRAE Handbook of Fundamentals, Chapter 27 or NFRC 100-91.

The air leakage requirements vary with type of window and door. The following table summarizes the various air leakage requirements.

Type of Window or Door	Air leakage requirement
1. Aluminum windows	- 0.37 cfm/ft of sash crack
2. PVC windows	- 0.37 cfm/ft of sash crack
3. Wood windows	- 0.34 cfm/ft of sash crack
4. Manufactured housing windows	- 0.50 cfm/ft of sash crack
5. All other types of windows	- 0.34 cfm/ft of sash crack
6. Aluminum sliding doors	- 0.37 cfm/ft^2 of door area
7. PVC sliding doors	- 0.375 cfm/ft^2 of door area
8. Wood sliding doors	- 0.34 cfm/ft^2 of door area
9. Manufactured housing sliding doors	- 0.50 cfm/ft^2 of door area
10. Swinging doors	- 0.50 cfm/ft^2 of door area
11. Manufactured housing swinging doors	-1.0 cfm/ft^2 of door area

Figure 2.1 ASHRAE 90.2 Window and Door U-value Requirements



2.4 R-2000 Program

R-2000 is a program designed to encourage the construction of energy-efficient residential buildings. The main energy-efficiency criteria is that the predicted energy consumption of R-2000 homes must be below a specified energy performance target. In addition, R-2000 technical requirements specify minimum wall R-values. Although high performance windows are recognized in R-2000 literature produced by Natural Resources Canada, the R-2000 Program does not require anything more than the minimum requirement specified in the Building Code. Windows must be at least double glazed and metal window frames must be thermally broken (except in the warmest areas).

2.5 Power Smart

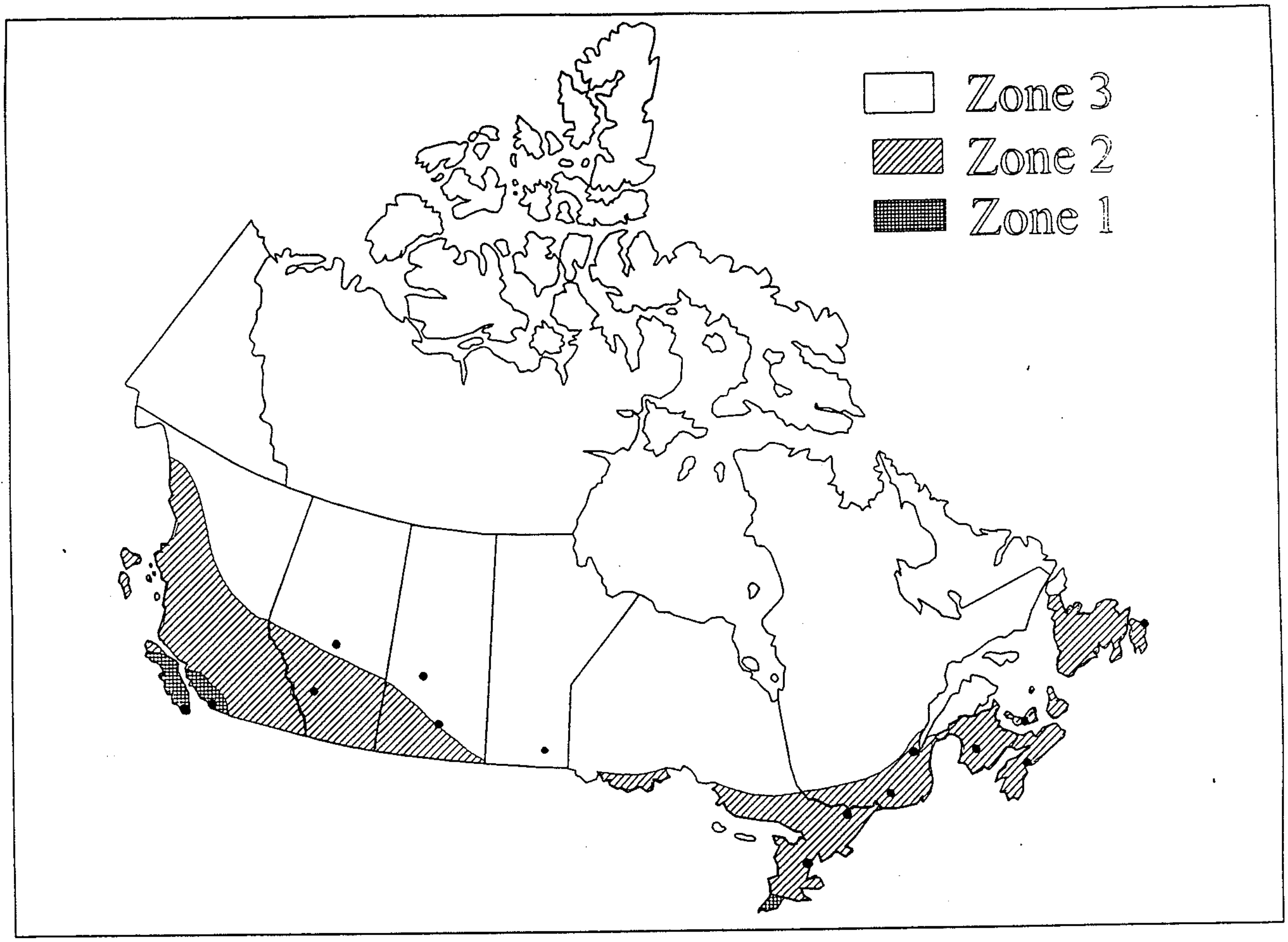
Power Smart is a Product Endorsement Program developed by BC Hydro and adopted by most of the utilities in Canada. The objective of the program is to provide the public with energy-efficient product alternatives and help them make energy conscience choices. For window manufacturers, this requires a label for their products with a Power Smart Saves Certification Mark listing the window's Energy Rating.

For high-performance Windows, Power Smart requires that windows shall meet or exceed CAN/CSA A4440-M90 *Windows* classification levels A3 for air tightness, B3 for water tightness, and C3 for wind load resistance. Windows must also have an Energy Rating (ER) determined by CSA A440.2-93 equal to or better than the following:

Climate	Degree Days	Energy Ratings	
		Operable Windows	Fixed Windows
Zone 1	≤ 3500	-18	-10
Zone 2	>3500 but ≤ 5800	-13	0
Zone 3	> 5800	-6	+2

Figure 2.2 divides Canada into the three Power Smart zones. Power Smart also requires that windows qualifying for Zones 1 and 2 must specify the geographic area on their label.

Figure 2.2



3.0 WINDOW AND DOOR REQUIREMENTS - COMMERCIAL

3.1 National Energy Code for Buildings, 1995

The National Energy Code for Buildings, 1995 is a proposed document of minimum code regulations for the energy efficiency of (commercial) buildings. This proposed code is intended to apply to new buildings and to additions to existing buildings, but not to farm buildings. It covers all buildings not covered by the National Energy Code for Houses, 1995. This code establishes a standard of construction for the energy efficiency of buildings. It takes into account climate, fuel types and cost, and constructions costs.

The National Energy Code for Buildings establishes minimum thermal requirements for windows, doors and other glazed areas. Table 3.3.1.B of Appendix A lists the maximum allowable total window U-value as a function of the fenestration-to-wall ratio and the window SHGC. The table is broken down into operable or fixed windows, buildings that are cooled or not cooled, and fuel type. An example of these tables is shown in Figure 3.1. Figure 3.2 presents this information in graphical form for Ottawa. The maximum allowable U-values range from 3.4 W/m^2K in southern B.C. to 0.7 W/m^2K in the Arctic.

The overall U-value and SHGC for windows that are within the scope of Standard CAN/CSA A440.2 are to be determined in accordance with that standard. The thermal properties of any other forms of fenestration and sliding glass doors not covered by CAN/CSA A440.2 shall be determined by Appendix B of this code, which has tables for fixed and operable windows giving total window U-value and SHGC for a variety of glass and frame combinations, or by calculations carried out using ASHRAE Handbook of Fundamentals, 1993 or by lab tests acceptable to the relevant jurisdiction.

Skylights and other glazed areas inclined less than 60° from horizontal not exceeding 2% of total roof area do not have to comply with Table 3.3.1.B, but must be at least double glazed. The glass insert in a door must be double glazed provided that it is less than 10% of the door area. Where there is an enclosed unconditioned space, such as a vestibule, sun porch or veranda, that is separated from the conditioned space by windows or other glazed areas, the unconditioned enclosure may be considered to provide an additional thermal resistance of 0.16 $m^{2\circ}K/W$, equivalent to a single pane of glass.

Figure 3.1

Ontario - Zone A
Buildings

Table 3.3.1.B.1 - Fenestration for Cooled Buildings. **Principal Heating Source: Electricity, Other**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	1.1	1.1	1.1	1.0	1.8	1.7	1.5	1.4
>0.3 - 0.4	1.4	1.3	1.3	1.2	2.1	1.9	1.8	1.6
>0.4 - 0.5	1.6	1.5	1.4	1.4	2.3	2.1	1.9	1.8
>0.5 - 0.6	1.8	1.7	1.6	1.5	2.5	2.3	2.1	2.0
>0.6	2.0	1.8	1.7	1.6	2.7	2.5	2.3	2.1

Table 3.3.1.B.2 - Fenestration for Buildings that are Not Cooled. **Principal Heating Source: Electricity, Other**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	0.9	1.0	1.0	1.0	1.6	1.5	1.5	1.4
>0.3 - 0.4	1.2	1.2	1.2	1.2	1.9	1.8	1.7	1.7
>0.4 - 0.5	1.5	1.5	1.5	1.5	2.2	2.1	2.0	1.9
>0.5 - 0.6	1.8	1.7	1.7	1.7	2.5	2.3	2.2	2.1
>0.6	2.0	1.9	1.9	1.9	2.7	2.6	2.4	2.3

Table 3.3.1.B.3 - Fenestration for Cooled Buildings. **Principal Heating Source: Oil, Propane, Heat Pump**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	1.7	1.6	1.5	1.4	2.7	2.4	2.1	2.0
>0.3 - 0.4	1.9	1.8	1.6	1.5	2.9	2.6	2.3	2.1
>0.4 - 0.5	2.1	1.9	1.7	1.6	3.1	2.7	2.5	2.2
>0.5 - 0.6	2.2	2.0	1.8	1.7	3.2	2.8	2.6	2.3
>0.6	2.3	2.1	1.9	1.7	3.4	3.0	2.7	2.4

Table 3.3.1.B.4 - Fenestration for Buildings that are Not Cooled. **Principal Heating Source: Oil, Propane, Heat Pump**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	1.2	1.2	1.2	1.2	2.2	2.0	1.9	1.8
>0.3 - 0.4	1.6	1.5	1.5	1.5	2.5	2.3	2.2	2.1
>0.4 - 0.5	1.8	1.8	1.8	1.7	2.8	2.6	2.4	2.3
>0.5 - 0.6	2.1	2.0	2.0	1.9	3.1	2.9	2.7	2.6
>0.6	2.3	2.3	2.2	2.1	3.4	3.1	2.9	2.8

Table 3.3.1.B.5 - Fenestration for Cooled Buildings. **Principal Heating Source: Nat. Gas**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	2.7	2.3	2.1	1.9	3.5	3.0	2.7	2.4
>0.3 - 0.4	2.9	2.5	2.2	2.0	3.7	3.2	2.8	2.5
>0.4 - 0.5	3.0	2.6	2.3	2.1	3.9	3.3	2.9	2.6
>0.5 - 0.6	3.1	2.7	2.4	2.1	4.0	3.4	3.0	2.7
>0.6	3.2	2.7	2.4	2.1	4.1	3.5	3.0	2.7

Table 3.3.1.B.6 - Fenestration for Buildings that are Not Cooled. **Principal Heating Source: Nat. Gas**

Solar Heat Gain Coefficient	Maximum Overall Heat Transmittance of Fixed Glazing without Sash (W/m²·°C)				Maximum Overall Heat Transmittance of Operable or Fixed Glazing with Sash (W/m²·°C)			
	Fenestration to Wall Ratio - FWR				Fenestration to Wall Ratio - FWR			
	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7	≤0.4	>0.4 - 0.5	>0.5 - 0.6	>0.6 - 0.7
≤0.3	1.9	1.8	1.7	1.6	2.9	2.6	2.4	2.2
>0.3 - 0.4	2.2	2.1	2.0	1.9	3.2	2.9	2.7	2.5
>0.4 - 0.5	2.5	2.4	2.3	2.2	3.5	3.2	2.9	2.8
>0.5 - 0.6	2.8	2.6	2.5	2.4	3.8	3.5	3.2	3.0
>0.6	3.1	2.9	2.7	2.6	4.1	3.7	3.5	3.3

Column 1	2	3	4	5	6	7	8	9

Figure 3.2

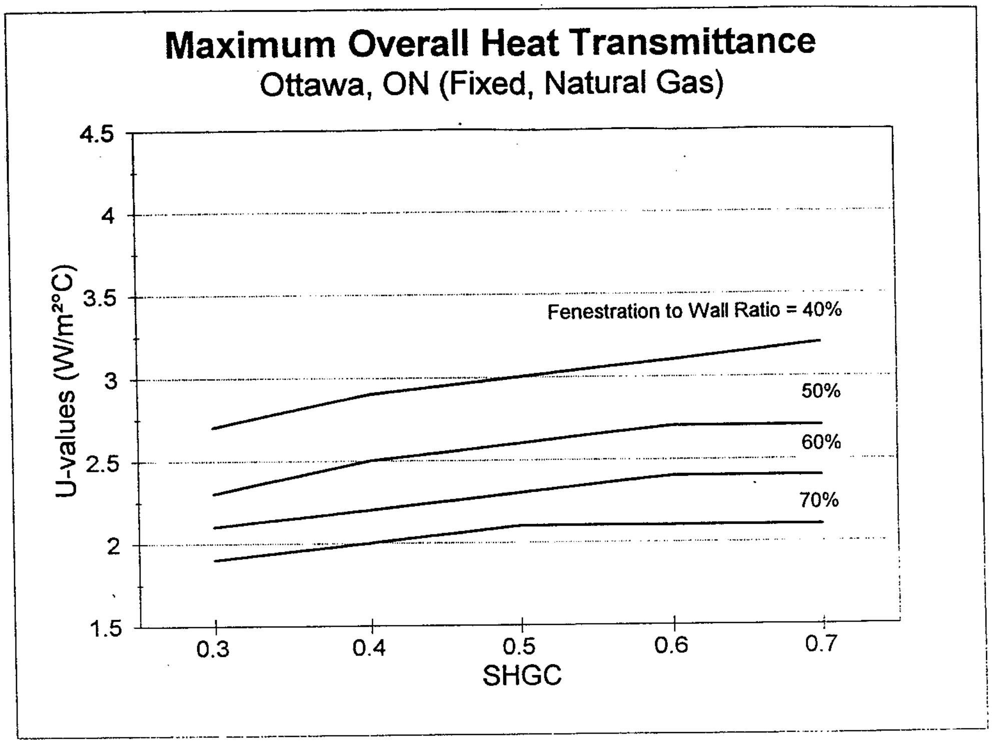
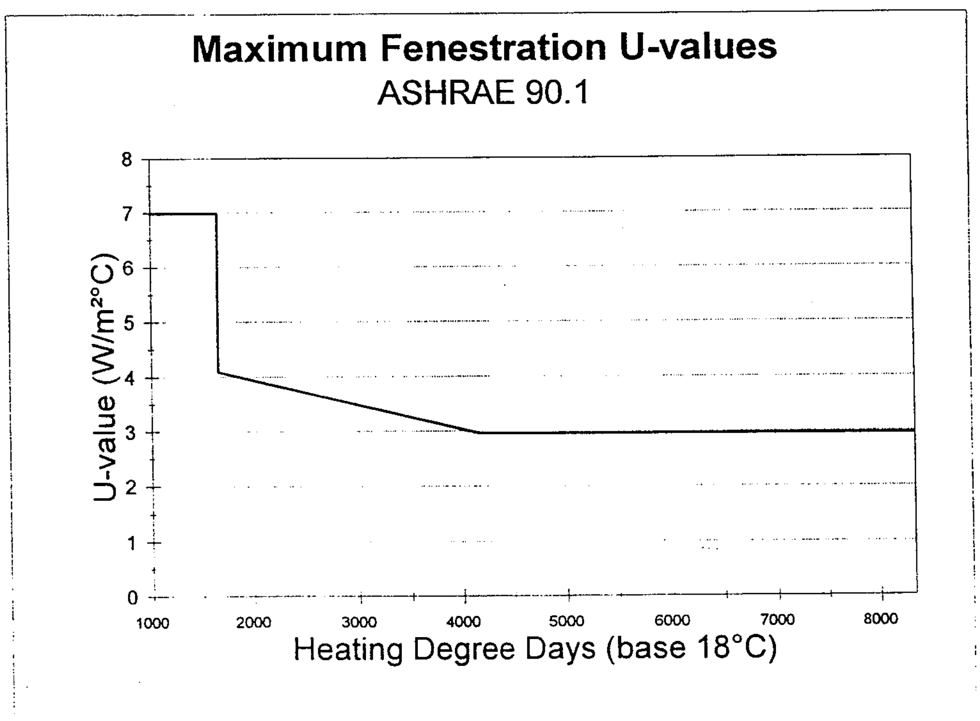


Figure 3.3



Doors that are part of a building envelope are to have an overall heat transmittance of not more than 1.1 $W/m^{2o}C$ through their insulated portion. The thermal requirements for doors was reviewed during the September meeting of National Energy Code Committee to address recent standards development in doors. The committee has indicated that they intend to revise the document to reference CSA A453 *"Energy Performance of Swinging Doors"*.

Windows and sliding glass doors must have an air tightness of at least an A2 air leakage classification of CAN/CSA-A440 for windows and CAN/CGSB 82.1, for sliding doors. Swinging doors must have an air leakage rate less than 2.54 $l/s/m^2$ in conformance with ASTM E 283, or be weatherstripped on all edges and protected by a storm door or an enclosed unconditioned space. Doors that are used for the movement of vehicles or the handling of materials, door assemblies that are part of a building envelope shall be designed with air leakage less than 17.0 $l/s/m^2$ in conformance with ASTM E 283. Air curtains cannot be used in place of exterior doors. Prehung insulated steel doors must conform to the requirements of CAN/CGSB 82.5 "Insulated steel doors".

3.2 ASHRAE 90.1- Energy Efficient Design of New Buildings except Low-rise Residential Buildings

ASHRAE/IES Standard 90.1 - 1989 is a commercial building energy-efficiency standard. The Ontario Building Code suggests that a commercial building be constructed with good engineering practice and that the ASHRAE 90.1 standard is considered "good practice". The purpose of this standard is to provide minimum energy-efficiency requirements in the design of new buildings or new additions to existing buildings.

ASHRAE 90.1 prescribes a maximum allowable U-value according to the heating degree-days. For locations with greater than 4160 Celsius Degree-Days (7,500 Fahrenheit Degree-Days), the maximum allowable U-value is 2.95 W/m^2K (0.52 $BTU/hr*ft^{2o}F$). Higher maximum values are permitted in warmer locations (see Figure 3.3). Similar values are required for skylights, although skylights cannot be used in locations with over 8300 Celsius Degree-days (15,000 Fahrenheit Degree-Days).

ASHRAE 90.1 also limits the maximum allowable fenestration-to-wall ratio for buildings. The standard contains 38 tables known as Alternate Component Packages (ACP), see Figure 3.4. Each table is climate based and defines the relationship between window U-value, SHGC and window-to-wall ratio. The maximum allowable fenestration-to-wall ratio is a function of internal load density, external shading, daylighting options and the fenestration type. Figures 3.5 to 3.12 highlight the percent fenestration allowable as a function of window type for locations in Canada.

The thermal transmittance of fenestration assemblies consider centre-of-glass, edge-of-glass and frame components. The overall U-value is based on one of the following methods:

1) Results from lab test of centre-of-glass, edge-of-glass and frame assemblies tested as a unit at winter conditions.

2) Overall generic product C (commercial) in Table 13, Chapter 27, 1989 ASHRAE Handbook of Fundamentals.

3) Calculations based on the actual area for centre-of-glass, edge-of-glass and frame assemblies and on the thermal transmittance of components derived from 1) or 2) above or a combination of the two.

It has also been recently approved that the procedure for determining overall U-value used by the National Fenestration Research Council (NFRC 100-91- *NFRC Procedure for Determining Fenestration Product Thermal Properties, 1991 Edition)* is an acceptable method.

The SHGC (or Shading Coefficient) for fenestration is obtained from Chapter 27, 1989 ASHRAE Handbook of Fundamentals or from manufacturer's test data.

The air leakage requirements for fenestration varies with the construction material. Windows should meet one of the following standards for air leakage:

1) ANSI/AAMA 101-1988 Aluminum Prime Windows and Sliding Glass Doors

2) ASTM D 4099-83, PVC windows

3) ANSI/NWMA I.S. 2-80 Wood window units (improved performance rating only)

Figure 3.4

ALTERNATE COMPONENT PACKAGES FOR: TABLE NUMBER: 8A- 33

HDD50 =	4001 - 5000	Alpena MI	Dillon MT	Lewistown MT	Minneapolis MN	Sioux Falls SD
CDD65 =	0 - 1150	Bangor ME	Eau Claire WI	Madison WI	Montreal PQ	
VSEW =	560 - 845	Burlington VT	Fredericton NB	Mason City IA	Ottawa ON	
		Charlottetown PE	Green Bay WI	Massena NY	Pierre SD	
		Cutbank MT	Huron SD	Miles City MT	Rochester MN	

DESIGN PARAMETERS			MAXIMUM PERCENT FENESTRATION				
			Fenestration U-Value (Uof)				
			Base Case			Perimeter Daylighting*	
Internal Load Density (ILD) Range	Projection Factor (PF) Range	Shading Coefficient (SCx) Range	0.52 to 0.40	0.39 to 0.31	0.30 to 0.00	VLT < SC	VLT >= SC
						N/A	N/A
0.00 - 1.50	0.00 - 0.25	1.00 - 0.72	23	25	26		
		0.71 - 0.61	26	29	31		
		0.60 - 0.51	28	33	36		
		0.50 - 0.39	31	37	42		
		0.38 - 0.26	30	43	51		
		0.25 - 0.00	29	42	60		
	0.26 - 0.50	1.00 - 0.72	30	34	37		
		0.71 - 0.61	33	39	44		
		0.60 - 0.51	33	43	50		
		0.50 - 0.39	32	48	56		
		0.38 - 0.00	31	48	66		
	0.51 +	1.00 - 0.72	35	42	48		
		0.71 - 0.61	34	47	55		
		0.60 - 0.51	33	50	62		
		0.50 - 0.00	32	48	68		
1.51 - 3.00	0.00 - 0.25	1.00 - 0.72	19	20	21		
		0.71 - 0.61	22	24	25		
		0.60 - 0.51	25	28	30		
		0.50 - 0.39	28	32	35		
		0.38 - 0.26	32	38	43		
		0.25 - 0.00	33	45	57		
	0.26 - 0.50	1.00 - 0.72	26	28	30		
		0.71 - 0.61	29	33	36		
		0.60 - 0.51	32	37	41		
		0.50 - 0.39	34	42	47		
		0.38 - 0.00	34	47	57		
	0.51 +	1.00 - 0.72	31	35	39		
		0.71 - 0.61	34	41	46		
		0.60 - 0.51	35	45	52		
		0.50 - 0.00	35	49	58		
3.01 - 3.50	0.00 - 0.25	1.00 - 0.72	17	18	19		
		0.71 - 0.61	20	22	23		
		0.60 - 0.51	23	25	26		
		0.50 - 0.39	26	29	31		
		0.38 - 0.26	30	35	39		
		0.25 - 0.00	33	45	53		
	0.26 - 0.50	1.00 - 0.72	23	25	27		
		0.71 - 0.61	26	30	32		
		0.60 - 0.51	29	34	37		
		0.50 - 0.39	32	38	43		
		0.38 - 0.00	34	45	52		
	0.51 +	1.00 - 0.72	28	32	34		
		0.71 - 0.61	32	37	41		
		0.60 - 0.51	34	41	46		
		0.50 - 0.00	35	45	53		

MAXIMUM WALL U-VALUE (Uow) Light-Weight Walls		
ILD Range 0.00 - 3.50		
Percent Fenestration	HC Range	All Insulation Positions
0-100	0.0 - 4.9	0.065

MAXIMUM WALL U-VALUE (Uow) Mass Walls			
ILD Range 0.00 - 1.50			
Percent Fenestration	HC Range	Interior Insulation	Exterior Insulation
23	5.0 - 9.9	0.067	0.086
	10.0 - 14.9	0.072	0.098
	15.0 +	0.076	0.10
68	5.0 - 9.9	0.067	0.083
	10.0 - 14.9	0.071	0.094
	15.0 +	0.075	0.097
ILD Range 1.51 - 3.00			
Percent Fenestration	HC Range	Interior Insulation	Exterior Insulation
19	5.0 - 9.9	0.068	0.089
	10.0 - 14.9	0.073	0.10
	15.0 +	0.078	0.11
56	5.0 - 9.9	0.067	0.087
	10.0 - 14.9	0.072	0.099
	15.0 +	0.077	0.10
ILD Range 3.01 - 3.50			
Percent Fenestration	HC Range	Interior Insulation	Exterior Insulation
17	5.0 - 9.9	0.068	0.090
	10.0 - 14.9	0.074	0.10
	15.0 +	0.079	0.11
53	5.0 - 9.9	0.067	0.088
	10.0 - 14.9	0.073	0.10
	15.0 +	0.077	0.11

OTHER ENVELOPE CRITERIA			
	Minimum R-Value		
Wall Below Grade	12		
Unheated Slab on Grade	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4
	Maximum U-Value		
Roof	0.045		
Wall Adjacent to Unconditioned Space	0.11		
Floor over Unconditioned Space	0.039		

The values of internal load density (ILD), projection factor (PF), shading coefficient (SCx), and fenestration U-value (Uof) used to enter this table shall be rounded to two decimal places. The values of heat capacity (HC) shall be rounded to one decimal place. This table represents stringent criteria. Use of the System Performance path (the ENVSTD program) can produce criteria that are substantially less stringent, in some cases, and can provide greater compliance flexibility.

Units for variables: U-values - Btu/(hr.-sq.ft.-F) R-values - (hr.-sq.ft.-F)/Btu ILD - W/sq.ft. HC - Btu/(sq.ft.-F)

* Perimeter daylighting must use daylight sensing controls

Figure 3.5

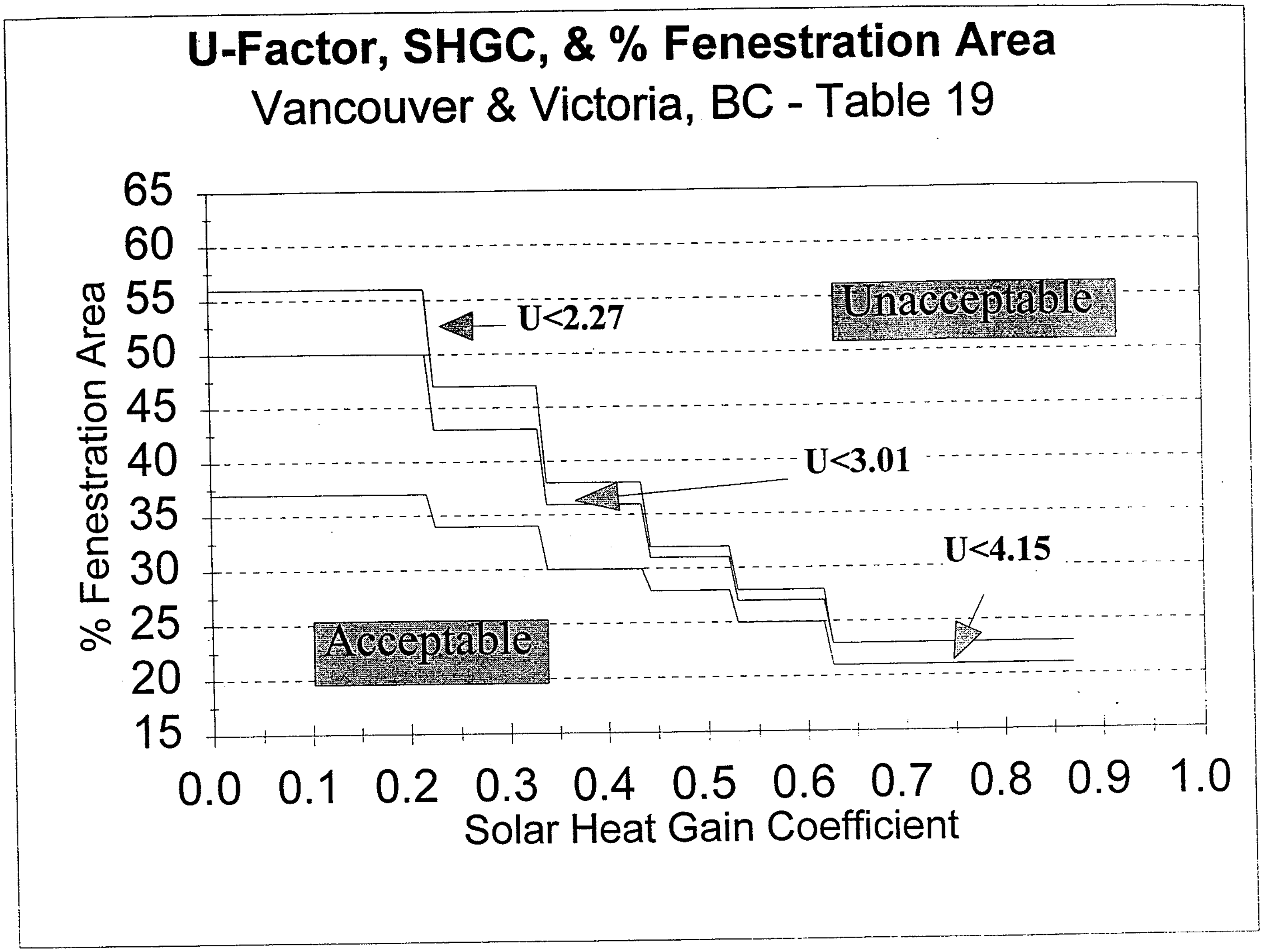

U-Factor, SHGC, & % Fenestration Area
Vancouver & Victoria, BC - Table 19
65
60
55
50
45
40
35
30
25
20
15
% Fenestration Area
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Solar Heat Gain Coefficient
U<2.27
U<3.01
U<4.15
Unacceptable
Acceptable

Figure 3.6

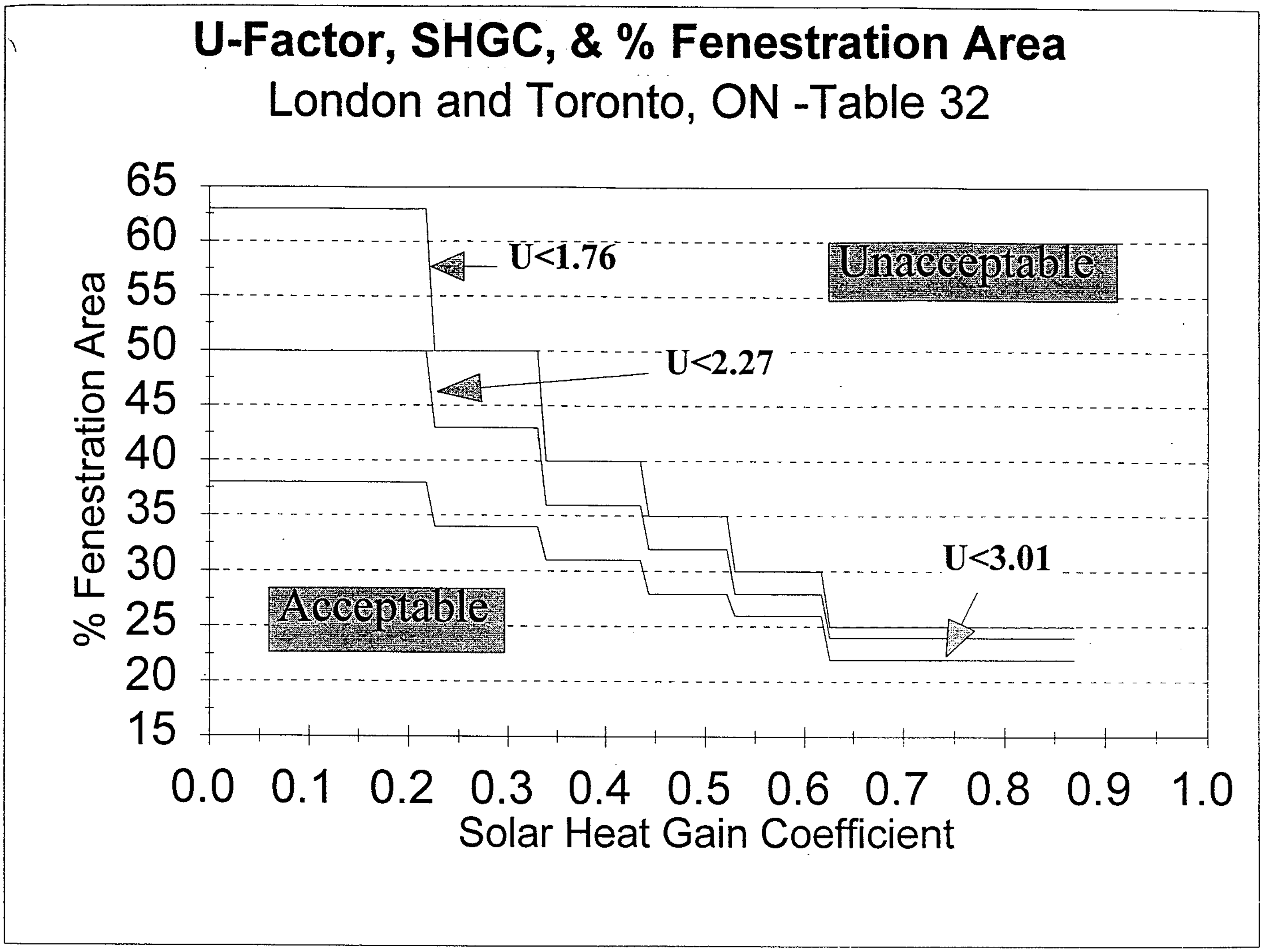

U-Factor, SHGC, & % Fenestration Area
London and Toronto, ON -Table 32
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
U<1.76
Unacceptable
U<2.27
U<3.01
Acceptable
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Solar Heat Gain Coefficient

Figure 3.7

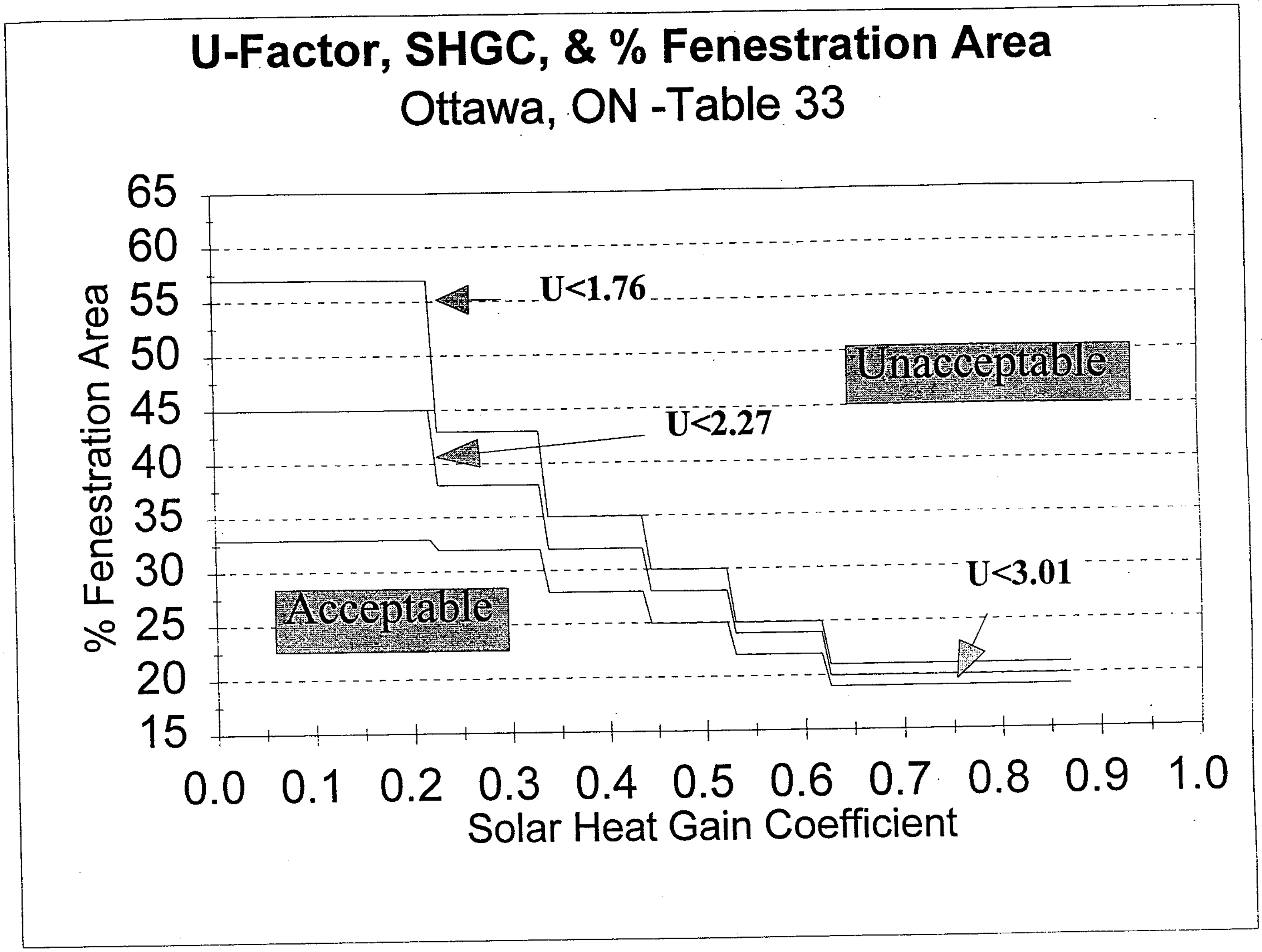

U-Factor, SHGC, & % Fenestration Area
Ottawa, ON -Table 33
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
U<1.76
Unacceptable
U<2.27
U<3.01
Acceptable
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Solar Heat Gain Coefficient

Figure 3.8

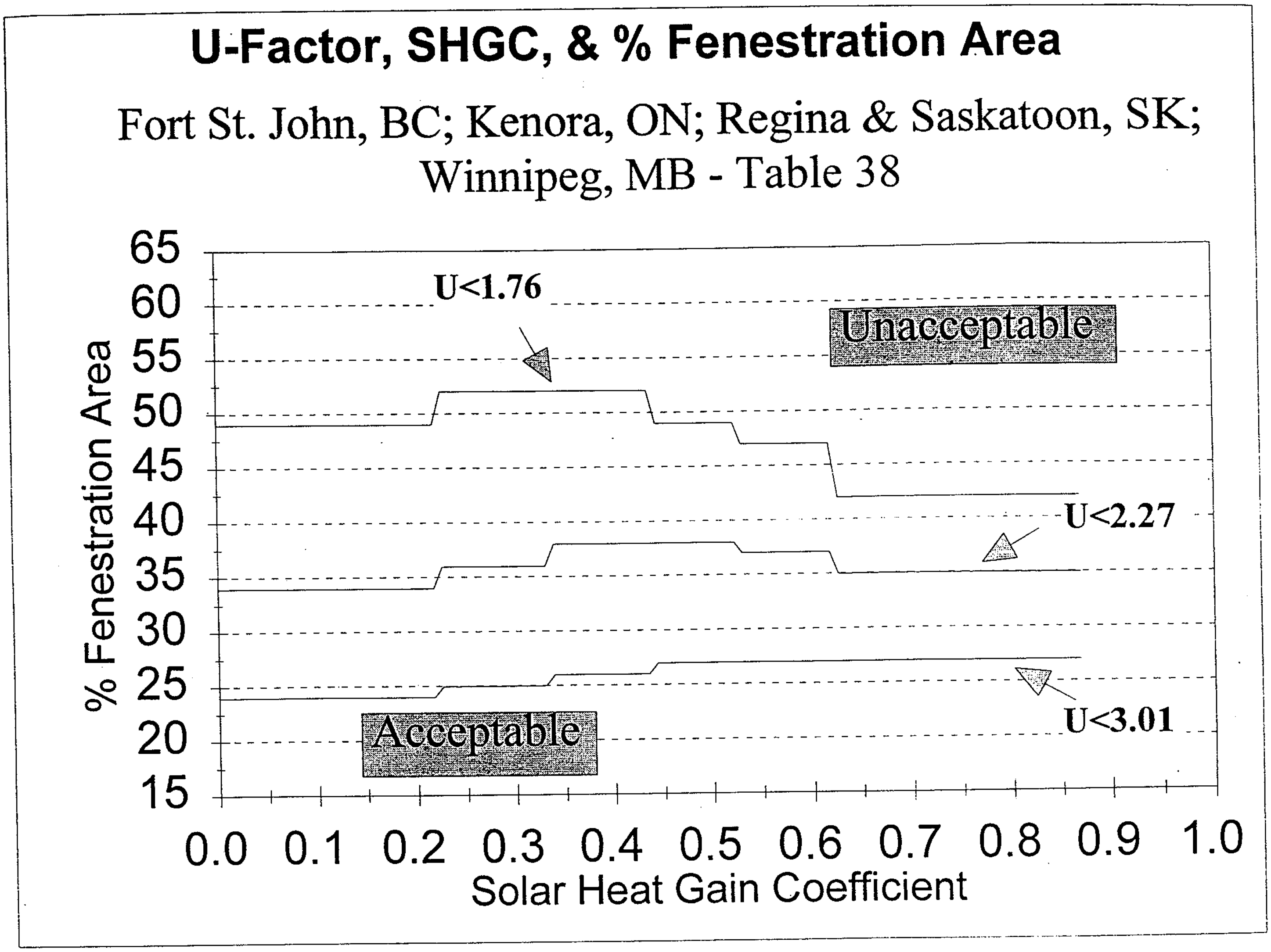

U-Factor, SHGC, & % Fenestration Area
Fort St. John, BC; Kenora, ON; Regina & Saskatoon, SK; Winnipeg, MB - Table 38
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
U<1.76
Unacceptable
U<2.27
U<3.01
Acceptable
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Solar Heat Gain Coefficient

Figure 3.9

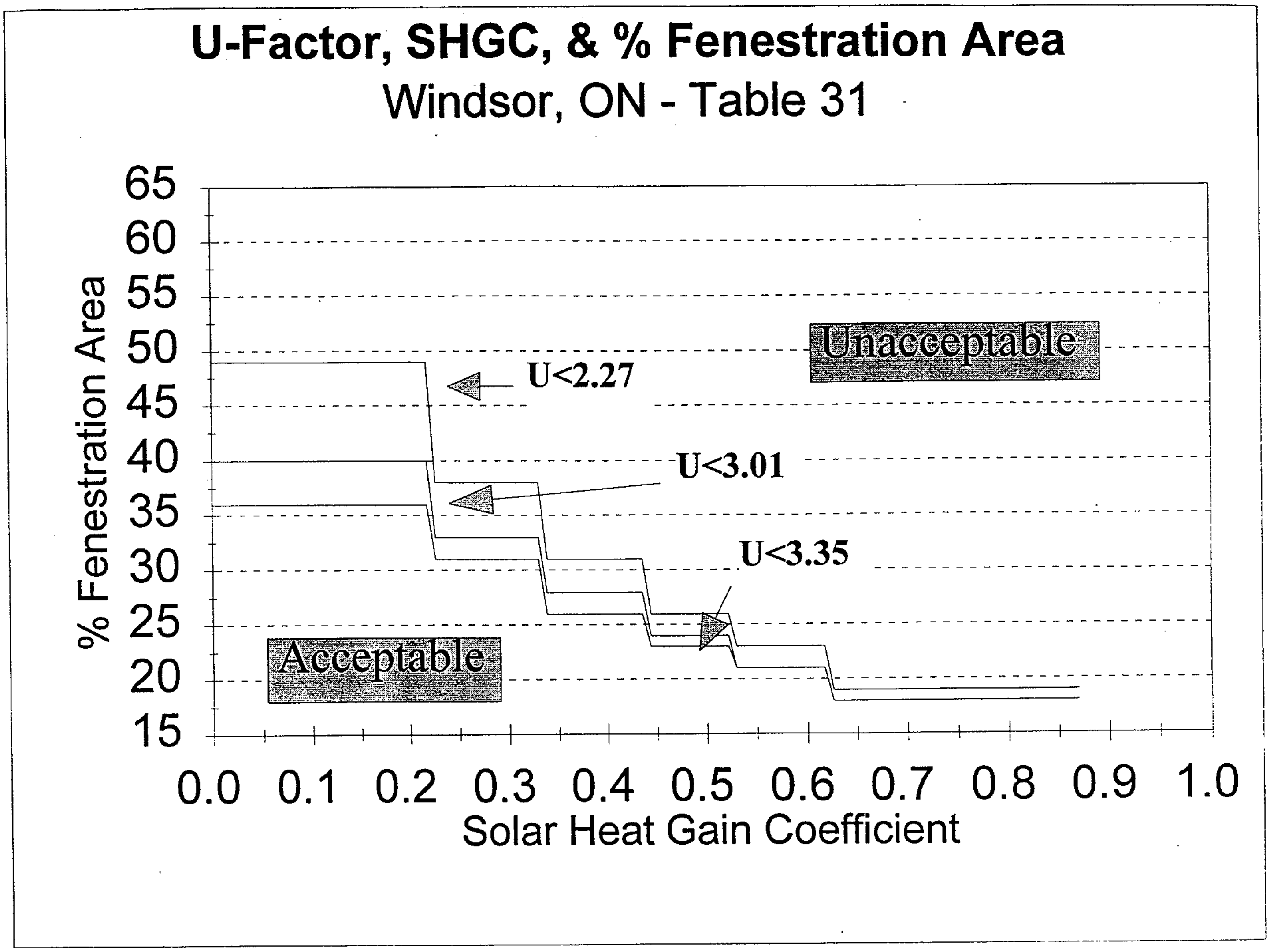

U-Factor, SHGC, & % Fenestration Area
Windsor, ON - Table 31
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
Unacceptable
U<2.27
U<3.01
U<3.35
Acceptable
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Solar Heat Gain Coefficient

Figure 3.10

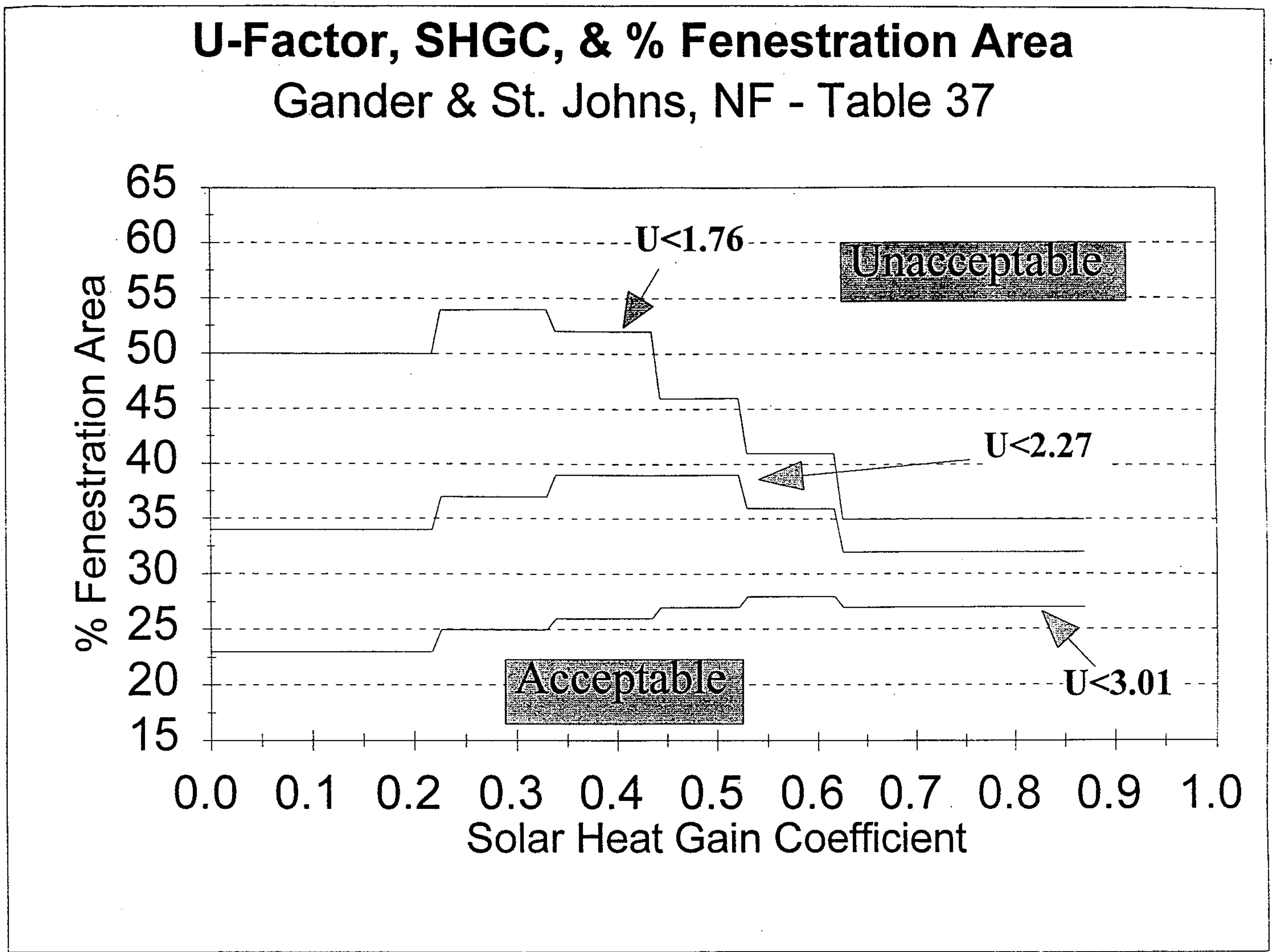

U-Factor, SHGC, & % Fenestration Area
Gander & St. Johns, NF - Table 37
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
U<1.76
Unacceptable
U<2.27
U<3.01
Acceptable
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Solar Heat Gain Coefficient

Figure 3.11

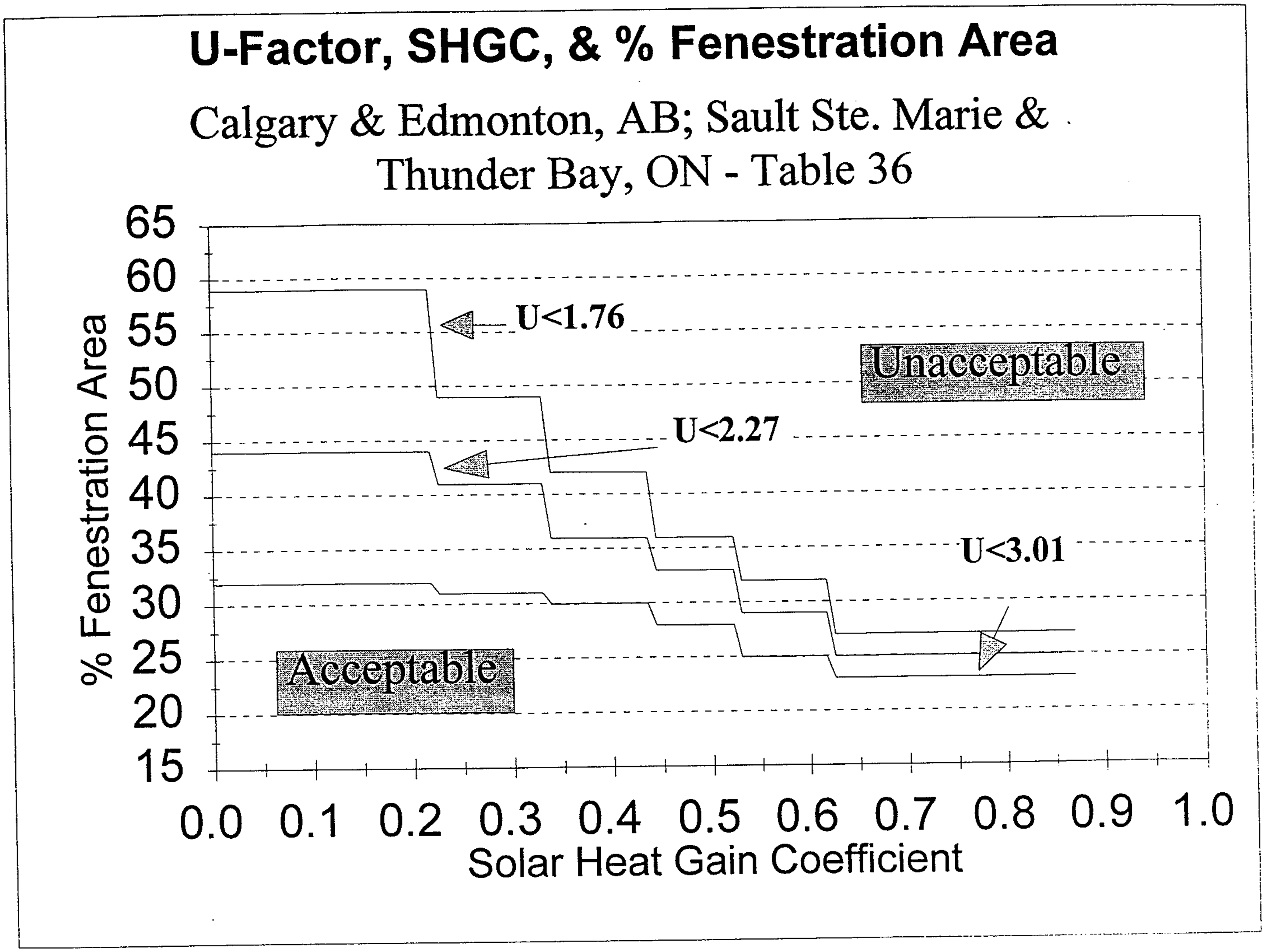
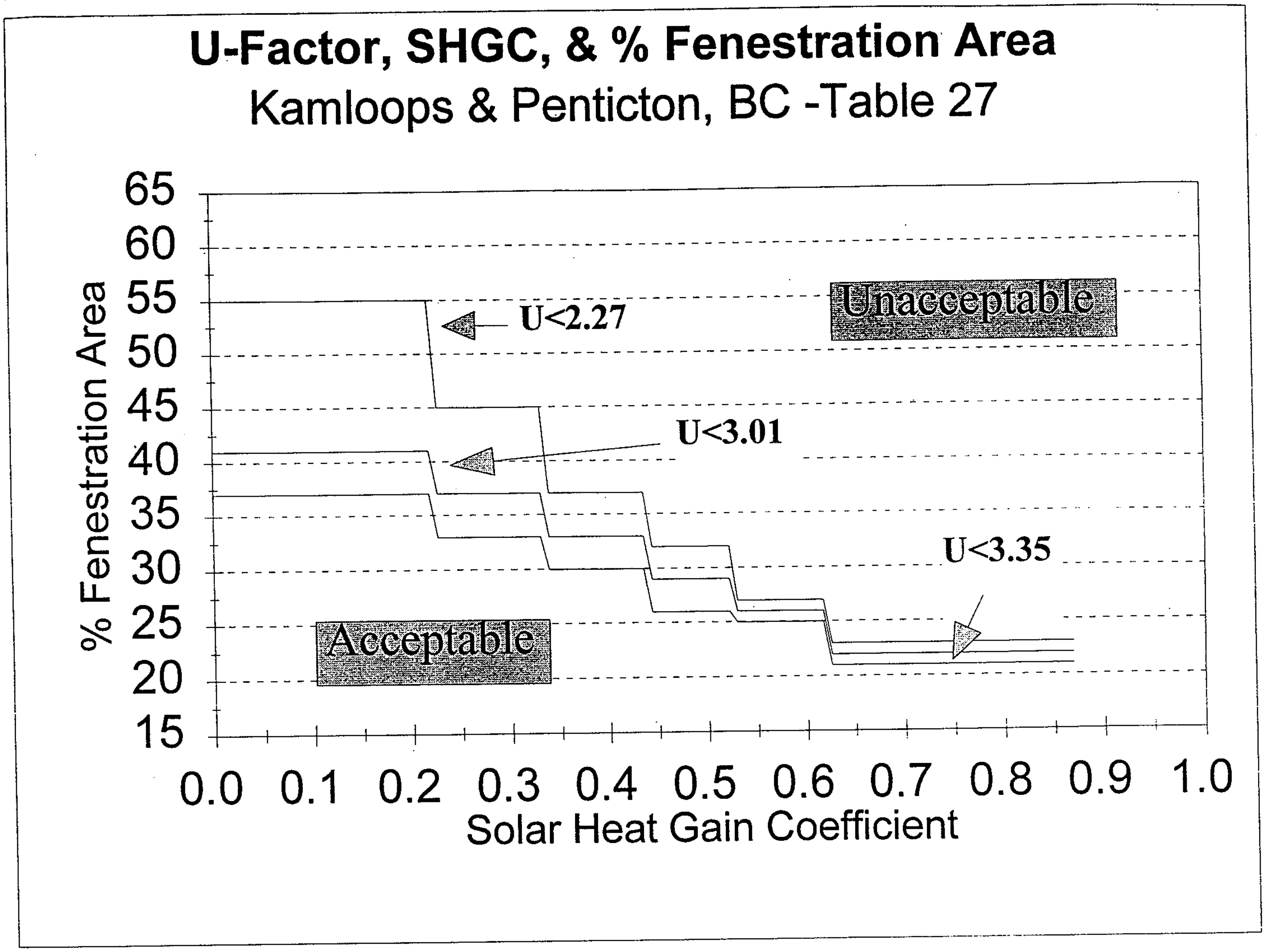

U-Factor, SHGC, & % Fenestration Area
Calgary & Edmonton, AB; Sault Ste. Marie & Thunder Bay, ON - Table 36
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
U<1.76
U<2.27
U<3.01
Unacceptable
Acceptable
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Solar Heat Gain Coefficient

Figure 3.12


U-Factor, SHGC, & % Fenestration Area
Kamloops & Penticton, BC -Table 27
% Fenestration Area
65
60
55
50
45
40
35
30
25
20
15
Solar Heat Gain Coefficient
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
U<2.27
U<3.01
U<3.35
Unacceptable
Acceptable

Sliding doors should meet one of the following standards for air leakage:

1) ANSI/AAMA 101-1988 Aluminum Prime windows and Sliding glass Doors
2) ANSI/NWMA I.S.3-83 Wood Sliding Patio doors

Commercial entrance and swinging doors will limit air leakage to a rate less than 1.25 cfm/ft^2 of door area and residential swinging doors to a rate less than 0.5 cfm/ft^2 , when tested in accordance with ASTM E283-84.

It has also been recently approved that the procedure for determining overall U-value used by the National Fenestration Research Council (NFRC 100-91- *NFRC Procedure for Determining Fenestration Product Thermal Properties, 1991 Edition)* is an acceptable method.

The SHGC (or Shading Coefficient) for fenestration is obtained from Chapter 27, 1989 ASHRAE Handbook of Fundamentals or from manufacturer's test data.

The air leakage requirements for fenestration varies with the construction material. Windows should meet one of the following standards for air leakage:

1) ANSI/AAMA 101-1988 Aluminum Prime Windows and Sliding Glass Doors
2) ASTM D 4099-83, PVC windows
3) ANSI/NWMA I.S. 2-80 Wood window units (improved performance rating only)

Sliding doors should meet one of the following standards for air leakage:

1) ANSI/AAMA 101-1988 Aluminum Prime windows and Sliding glass Doors
2) ANSI/NWMA I.S.3-83 Wood Sliding Patio doors

Commercial entrance and swinging doors will limit air leakage to a rate less than 1.25 cfm/ft^2 of door area and residential swinging doors to a rate less than 0.5 cfm/ft^2 , when tested in accordance with ASTM E283-84.

4.0 COMPARISON OF CODES AND PROGRAMS

It is difficult to make a direct comparison between the various codes and incentive programs because they use different evaluation criteria (ER verses U-value) and different regional boundaries (degree-days verses provincial boundaries). To solve this problem, the codes and programs were compared as they would be applied in five Canadian cities: Vancouver, Winnipeg, Toronto, Ottawa, and Halifax.

Figures 4.1 through 4.5 summarize the residential window requirements in the codes and programs reviewed in this document. The codes and programs are compared on the basis of Energy Rating. Where an Energy Rating is not defined by the code, an ER was estimated given the required overall U-value for the window. For example, ASHRAE 90.2 specifies that for Ottawa the overall U-value must be less than to 2.04 $W/m^{2o}K$. According to the 1993 ASHRAE Handbook of Fundamentals, Chapter 27, this value corresponds to a triple glazed operable wood/vinyl window with a metal spacer. The SHGC can be easily calculated for this product using the VISION3 program. Assuming a casement window with an A3 air infiltration rating, the ER can be calculated at -11. The same procedure was used for estimating other ER values.

The figures show that all of the energy-efficiency codes and programs require much higher performing windows than is currently required under the National Building Code. Interestingly, Power Smart, 1995 National Energy Code, and ASHRAE 90.2 require very similar product ER values. The only exception is Vancouver, where ASHRAE 90.2 permits a much higher U-value product. Referring back to Figure 2.1, it can be seen that Vancouver is just slightly warmer than where ASHRAE 90.2 makes a significant reduction in allowable U-value.

Table 4.1 compares the window requirements for commercial buildings for the same five Canadian cities. The required Window U-value applies to all operable and fixed glazed window assemblies, including windows, skylights, glass doors and the glass portion of doors.

Figure 4.1

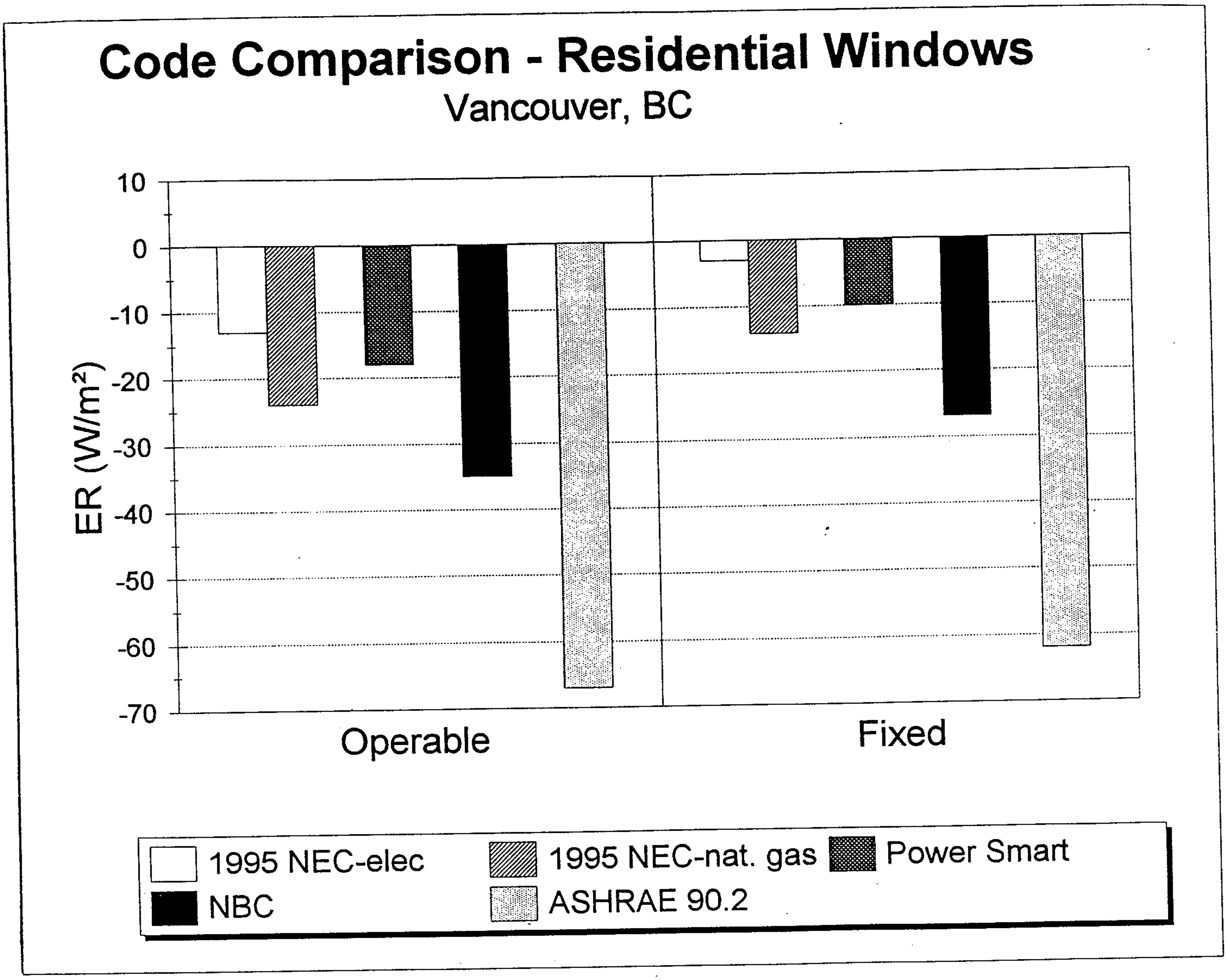

Code Comparison - Residential Windows
Vancouver, BC
10
0
-10
-20
-30
-40
-50
-60
-70
ER (W/m²)
Operable
Fixed
1995 NEC-elec
1995 NEC-nat. gas
Power Smart
NBC
ASHRAE 90.2

Figure 4.2

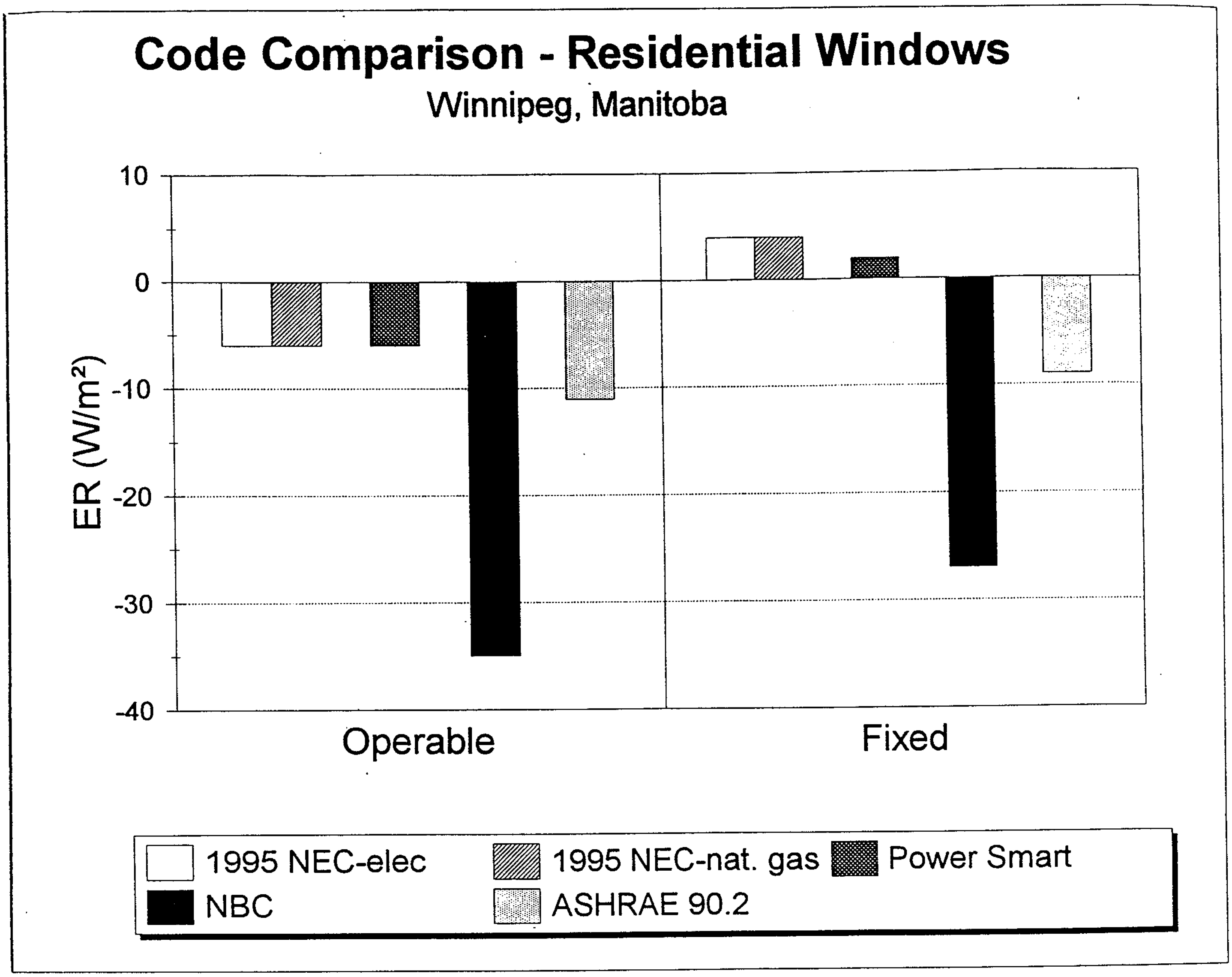

Code Comparison - Residential Windows
Winnipeg, Manitoba
ER (W/m²)
10
0
-10
-20
-30
-40
Operable
Fixed
1995 NEC-elec
1995 NEC-nat. gas
Power Smart
NBC
ASHRAE 90.2

Figure 4.3

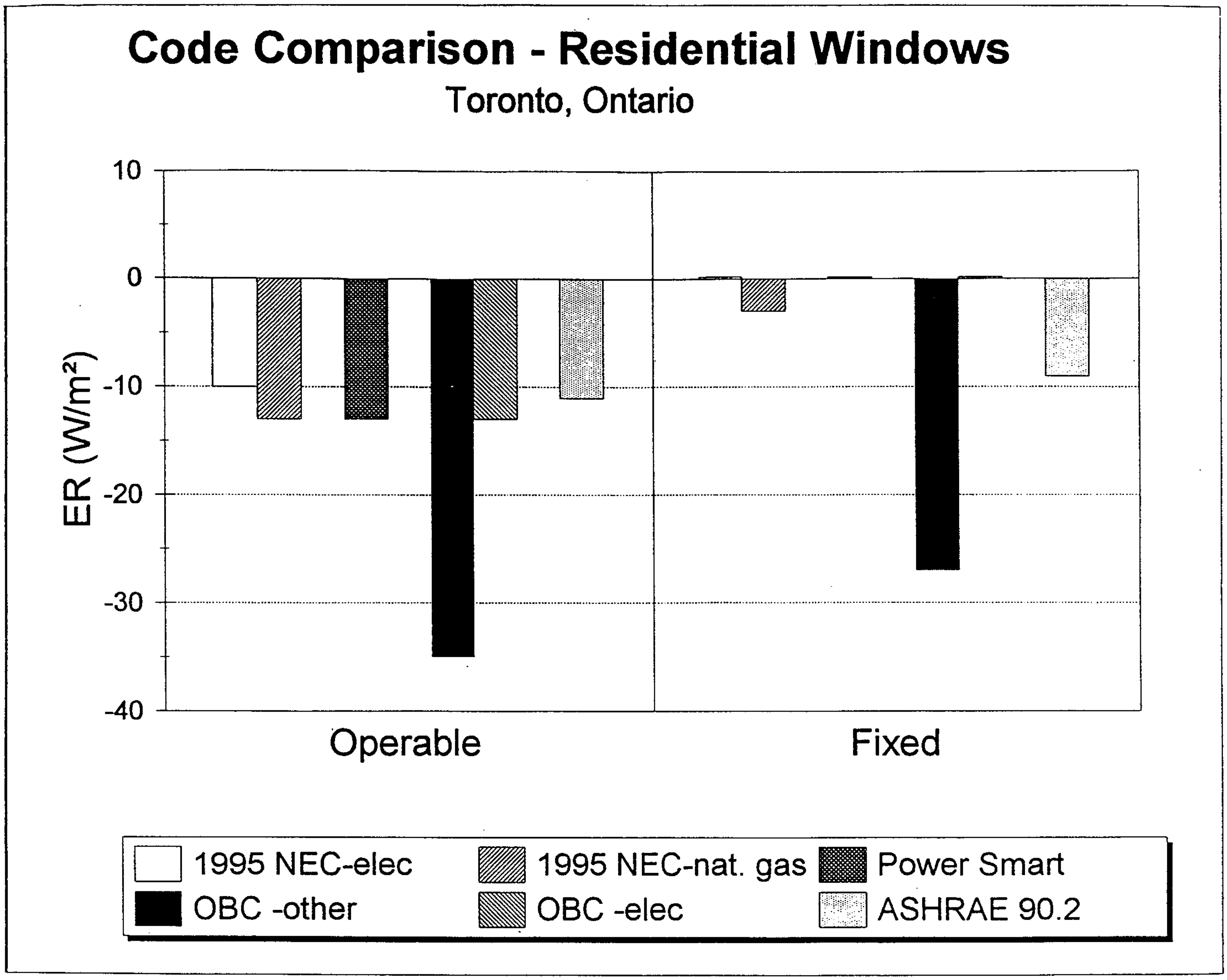

Code Comparison - Residential Windows
Toronto, Ontario
10
0
-10
-20
-30
-40
ER (W/m²)
Operable
Fixed
1995 NEC-elec
1995 NEC-nat. gas
Power Smart
OBC -other
OBC -elec
ASHRAE 90.2

Figure 4.4

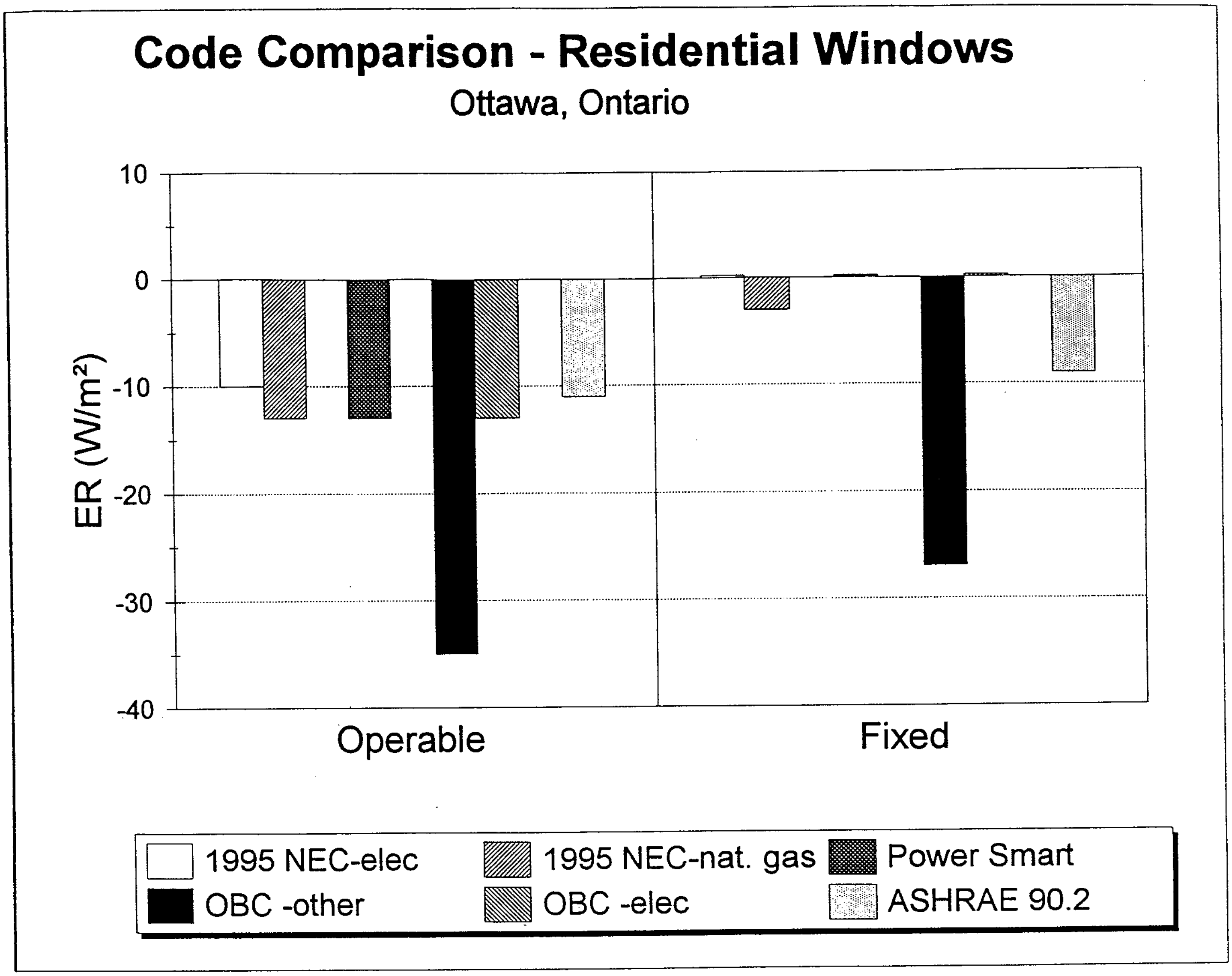

Code Comparison - Residential Windows
Ottawa, Ontario
10
0
-10
-20
-30
-40
ER (W/m²)
Operable
Fixed
1995 NEC-elec
1995 NEC-nat. gas
Power Smart
OBC -other
OBC -elec
ASHRAE 90.2

Figure 4.5

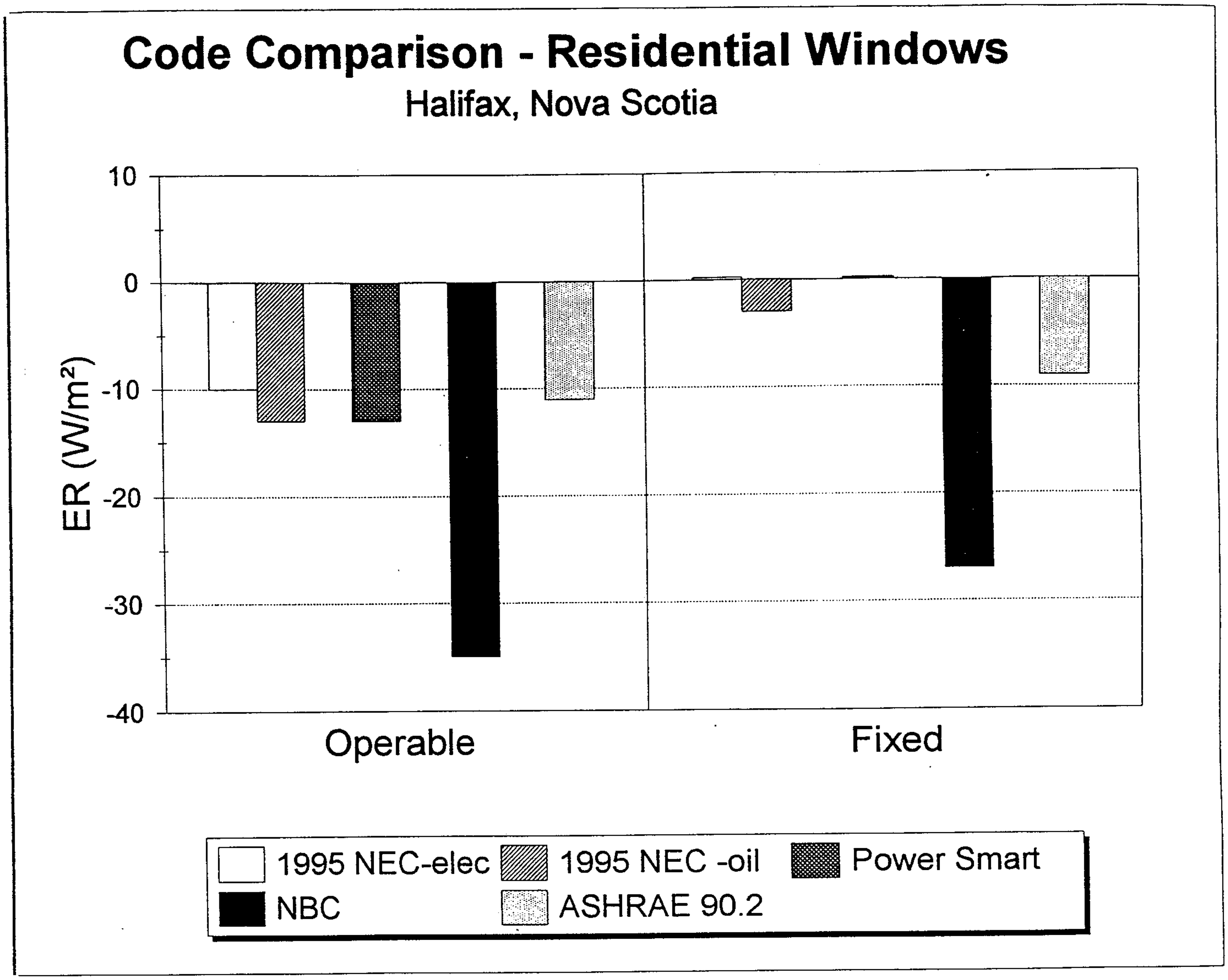

Code Comparison - Residential Windows
Halifax, Nova Scotia
10
0
-10
-20
-30
-40
ER (W/m²)
Operable
Fixed
1995 NEC-elec
1995 NEC -oil
Power Smart
NBC
ASHRAE 90.2

Table 4.1: Required Commercial Building Window U-Value (W/m^2k)[1]

Vancouver

Window SHGC	1995 NEC U-Values		ASHRAE 90.1 U-Values
	Elec.	Natural Gas	
≤ 0.3	1.7	3.4	4.1
0.45	2.1	3.8	2.95
≥ 0.6	2.3	4.0	N/A

Winnipeg

Window SHGC	1995 NEC U-Values		ASHRAE 90.1 U-Values
	Elec.	Natural Gas	
≤ 0.3	1.3	1.4	2.2
0.45	1.7	1.7	2.2
≥ 0.6	1.9	1.9	2.2

Toronto

Window SHGC	1995 NEC U-Values		ASHRAE 90.1 U-Values
	Elec.	Natural Gas	
≤ 0.3	1.0	2.7	2.95
0.45	1.6	3.0	2.2
≥ 0.6	2.0	3.2	1.7

[1] - For 30% Window-to-Wall Ratio, Air-Conditioned Building

Ottawa

Window SHGC	1995 NEC U-Values		ASHRAE 90.1 U-Values
	Elec.	Natural Gas	
≤ 0.3	1.0	2.7	2.95
0.45	1.6	3.0	1.7
≥ 0.6	2.0	3.2	N/A

Halifax

Window SHGC	1995 NEC U-Values		ASHRAE 90.1 U-Values
	Elec.	Natural Gas	
≤ 0.3	1.4	2.0	2.95
0.45	1.8	2.3	1.7
≥ 0.6	2.1	2.5	N/A

Table 4.1 shows the window U-value required for a 30% window-to-wall ratio for three different SHGC values. The 1995 National Energy Code generally requires lower U-values than ASHRAE 90.1. Somewhat surprising is that the two codes have a different trend with SHGC. For the NEC, the maximum allowable window U-value can increase as the SHGC is increased; implying that solar gain is a benefit. In ASHRAE 90.1, the opposite is true. As the SHGC is increased, the maximum allowable U-value decreases and in some cases high SHGC windows are not permitted.

5.0 CONCLUSIONS

This report examined seven building code and incentive programs. The new energy-efficiency codes and programs require windows with much lower U-values than the current building codes. The 1995 National Energy Code for Houses, Power Smart and ASHRAE 90.2 require similar window thermal performance for most Canadian climates. Operable windows Energy Ratings range from approximately -20 in Vancouver to -6 in Winnipeg.

Residential doors must have a U-value of less than 2.3 W/m^2K, ASHRAE 90.2 requires non-wood doors to have a U-value of less than 1.1 W/m^2K.

The requirements for commercial buildings are more complex. In general, the 1995 National Energy Code for Buildings requires lower U-values than ASHRAE 90.1. The two codes treat solar heat gain differently. The NEC permits higher U-values for higher SHGC and ASHRAE 90.1 requires lower U-values with higher SGHC and, in some cases, does not allow high SHGC windows.