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SELECTION AND IMPROVEMENT OF SHGC AND U-VALUE IN LOCATIONS WITH COLD WINTER AND WARM SUMMER

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INTRODUCTION:

- **Overheating is a big issue for building comfort and energy consumption**
- **Change or exchange many parts in our life with changing the seasons**
- **Finding a proper window and IGU isn't so easy**
- **Windsor, Ontario has been selected as a city with warm summers and cold winters**

Outlines:

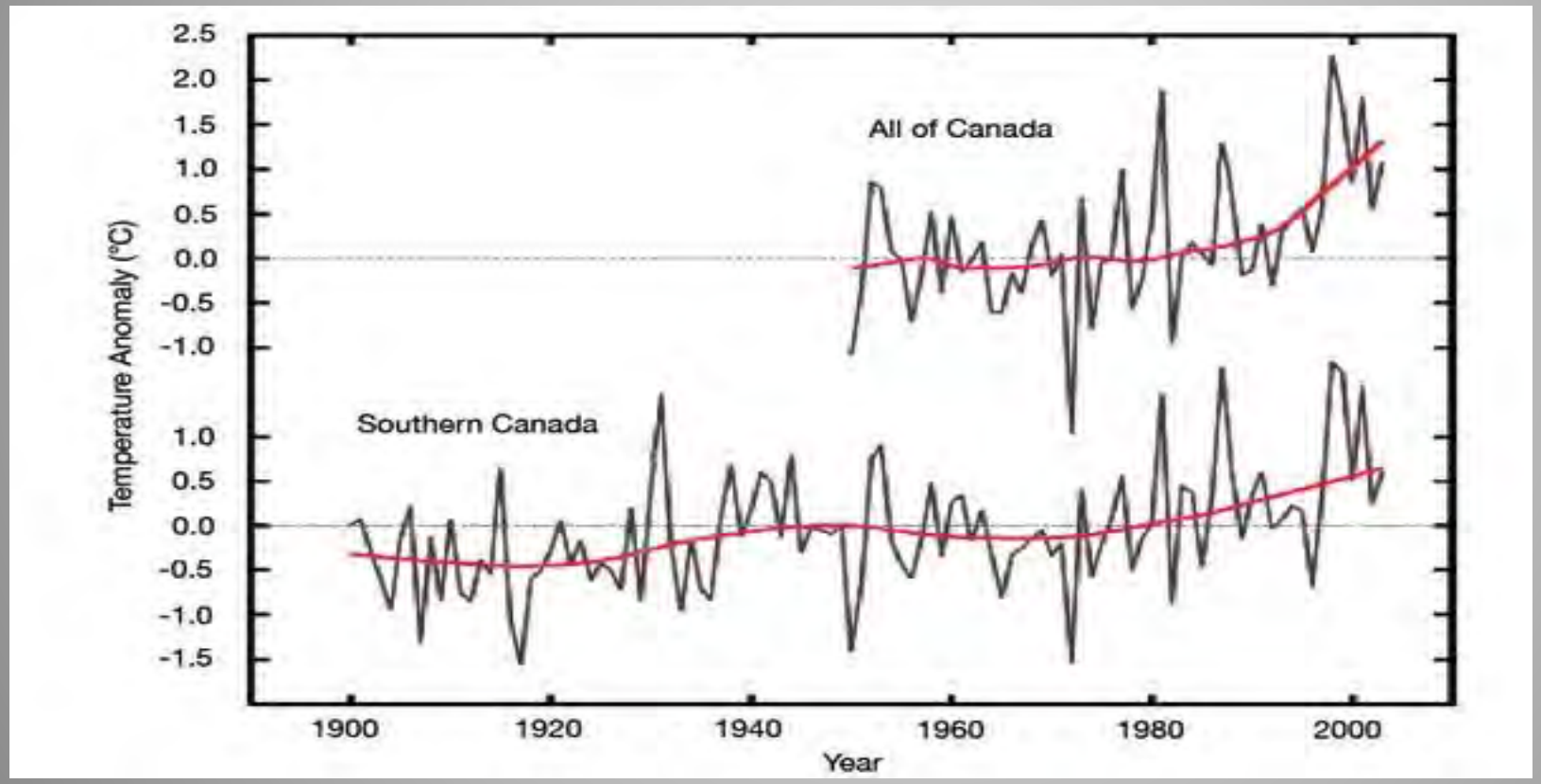
1. **CLIMATE CHANGE AND ITS EFFECT ON WINDOW SELECTION**

2. **IMPROVEMENT OF SHGC& U-VALUE**

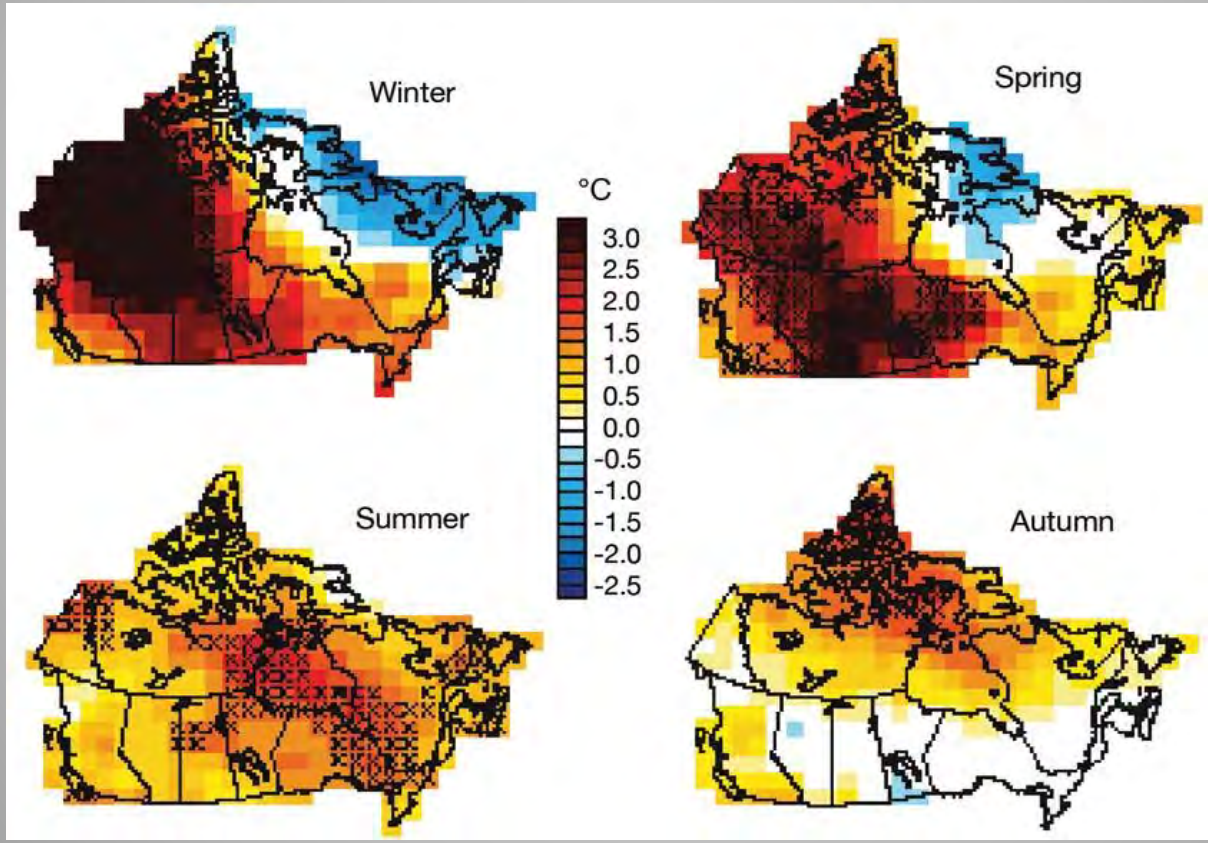
Outlines:

1. **CLIMATE CHANGE AND ITS EFFECT ON WINDOW SELECTION**

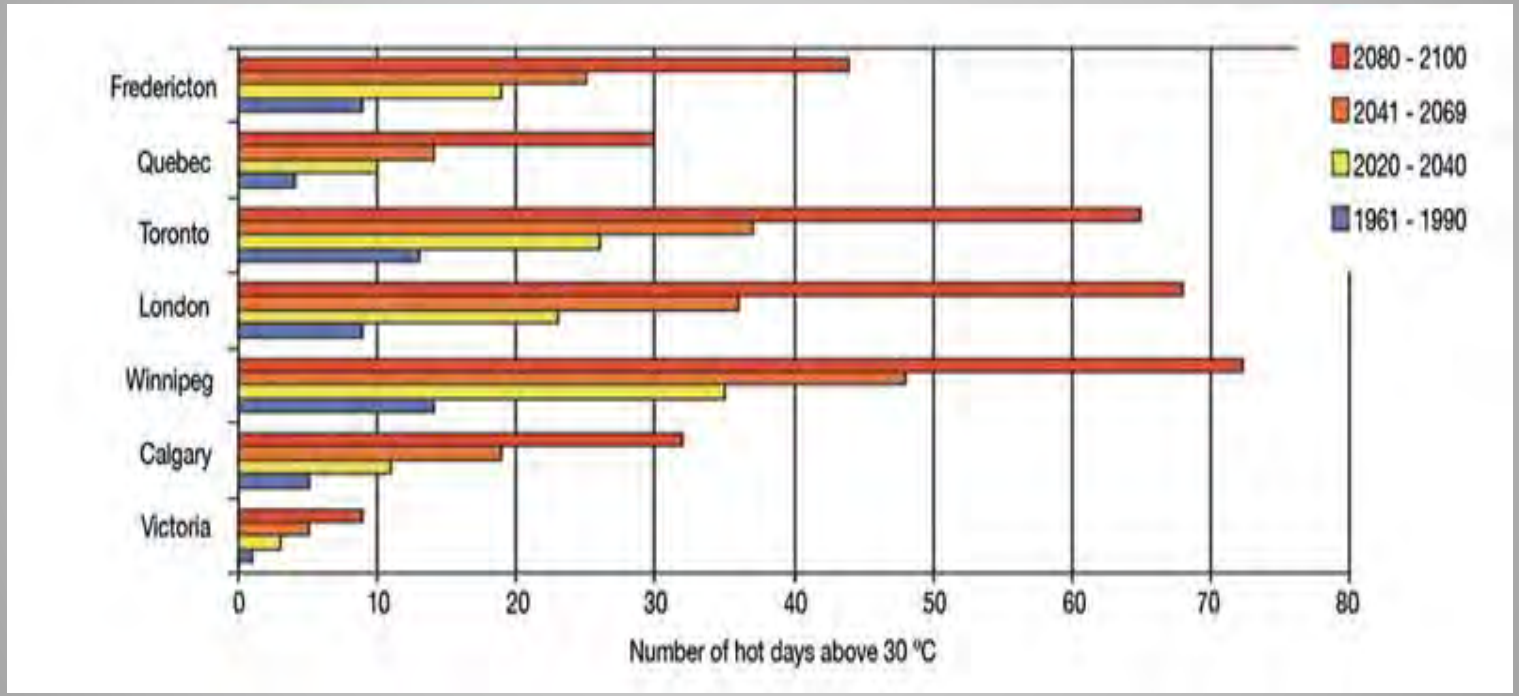
- **The temperature in Canada has increased almost 1.3°C since 1948**



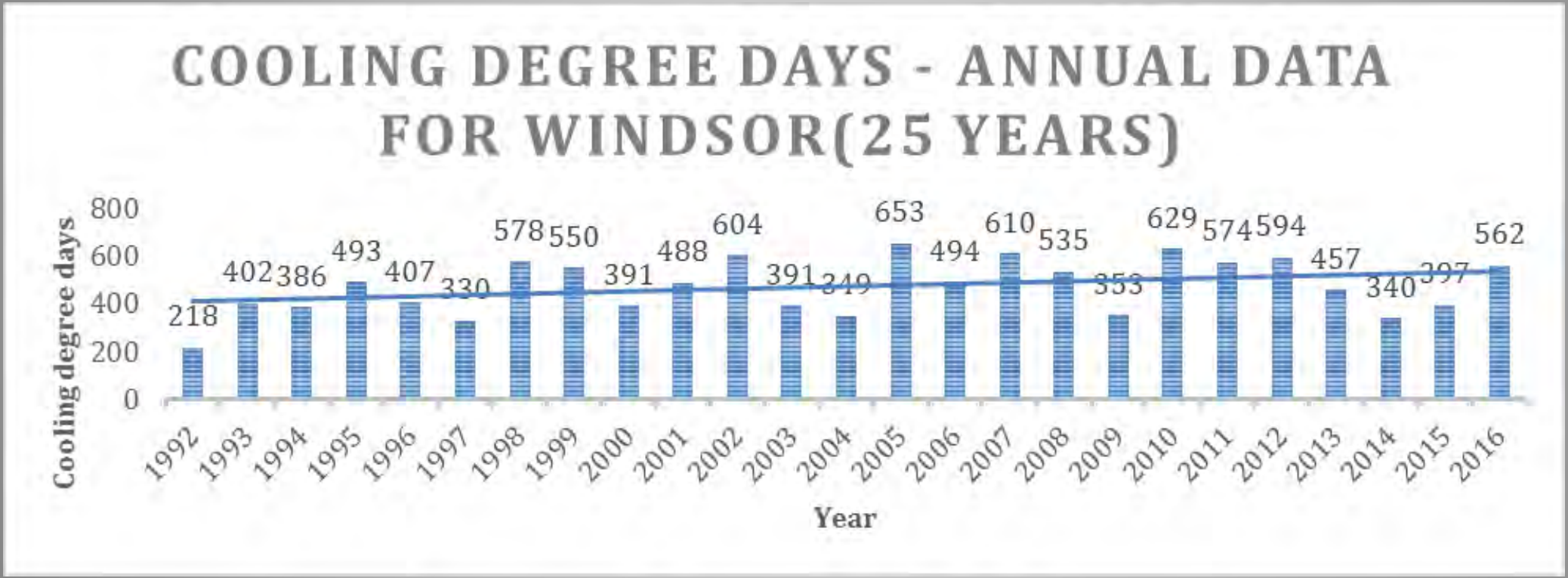
- **Regional distribution of linear temperature trends (°C) observed across Canada between 1948 and 2003, by season. The "X" symbols indicate areas where the trends are statistically significant**



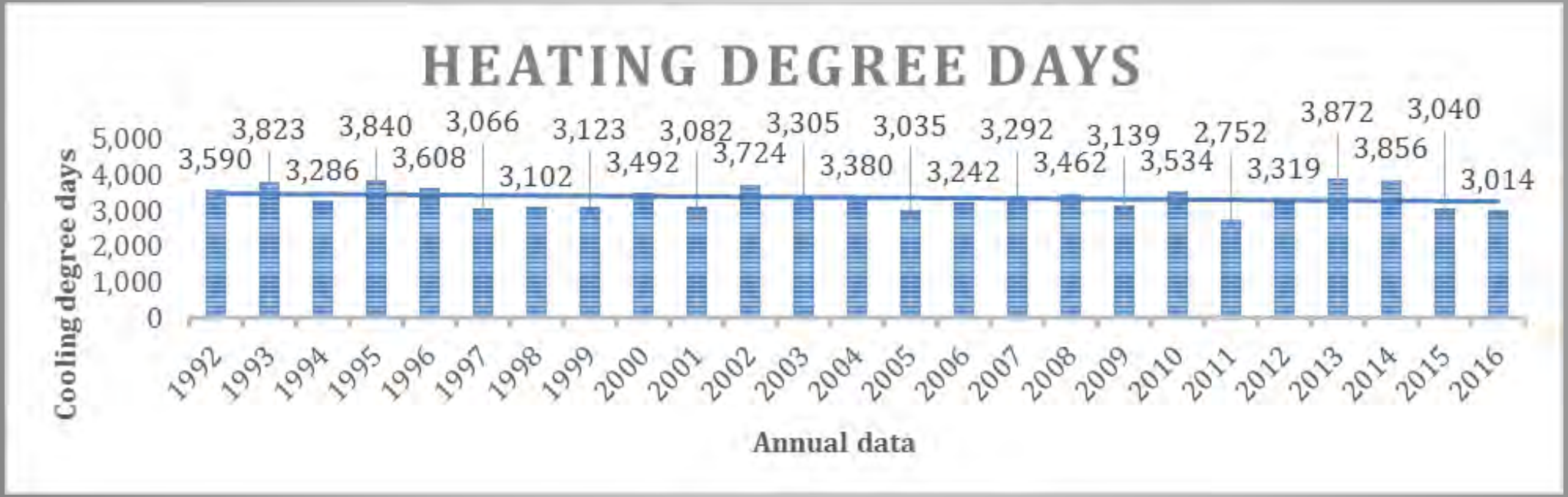
- **Number of days with temperatures exceeding 30ºC, during observed (1961-1990) and future (2020-2040; 2041-2069; and 2080-2100) time periods**



- **The summer season in Windsor has been warmer**



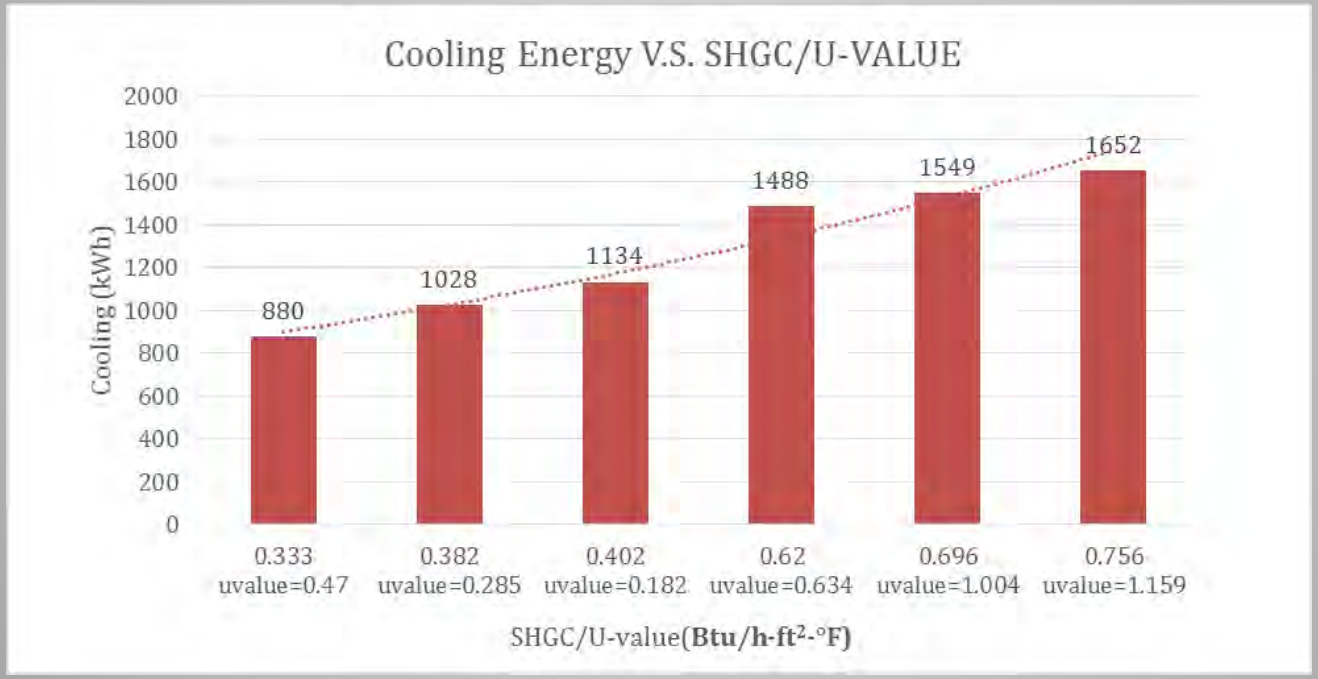
- **The heating demand to increase the daily balance-point temperature up to 18ºC (65°F) is decreasing**



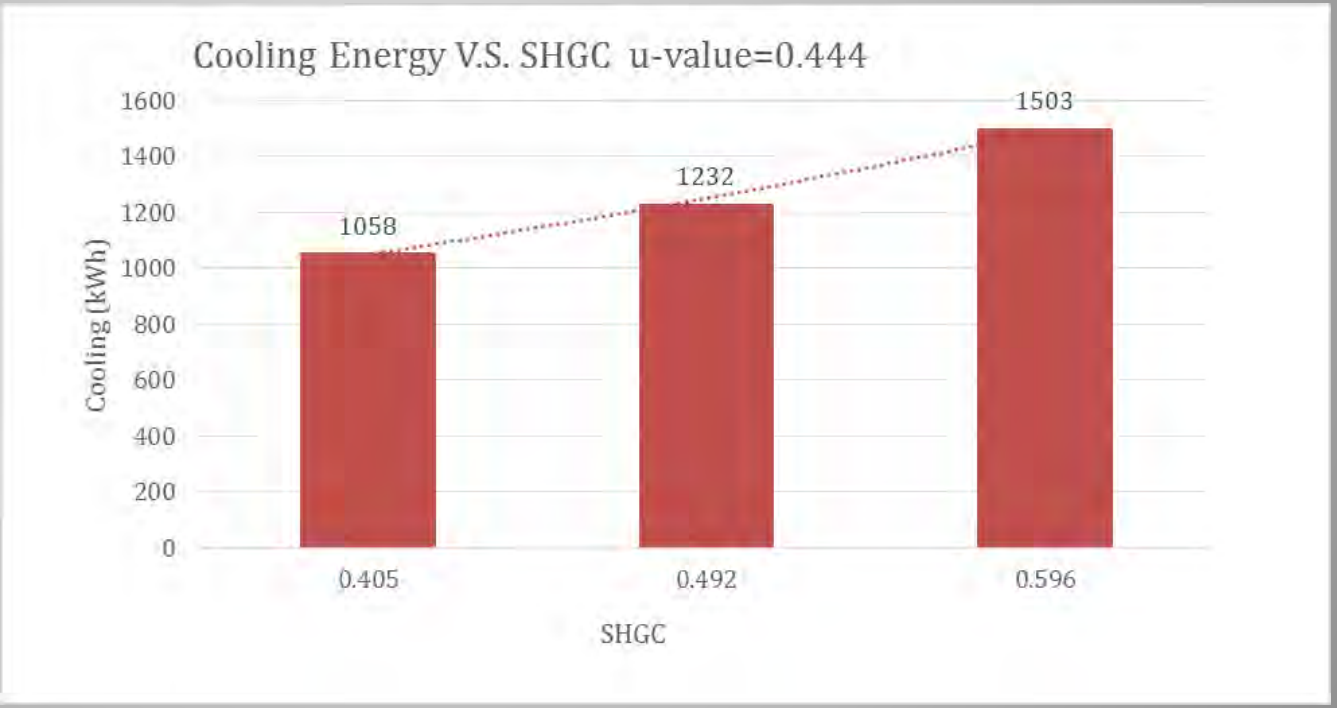
- Different window products were compared to find an energy-consumption trend line affected by U-value and SHGC

window ID	Window name	U-value (W/m2-°C)	SHGC	Heating (kWh)	Cooling (kWh)	Total (kWh)
241	ATB 2 SS Low-E	0.47	0.333	16544	880	17424
351	W/V 3 HT Super	0.285	0.382	14424	1028	15452
451	INS 3 HT Super	0.182	0.402	13175	1134	14309
211	ATB 2 Clear	0.634	0.62	16501	1488	17989
201	ATB 1 Clr	1.00	0.696	19316	1549	20865
101	AL 1 Clr	1.159	0.756	20226	1652	21878
413	INS 2 SS Tint	0.444	0.405	15755	1058	16813
412	INS 2 Bronze	0.444	0.492	15366	1232	16598
411	INS 2 Clear	0.444	0.596	14813	1503	16316

- When SHGC increases, the cooling energy consumption increases accordingly
- U-value is not constant



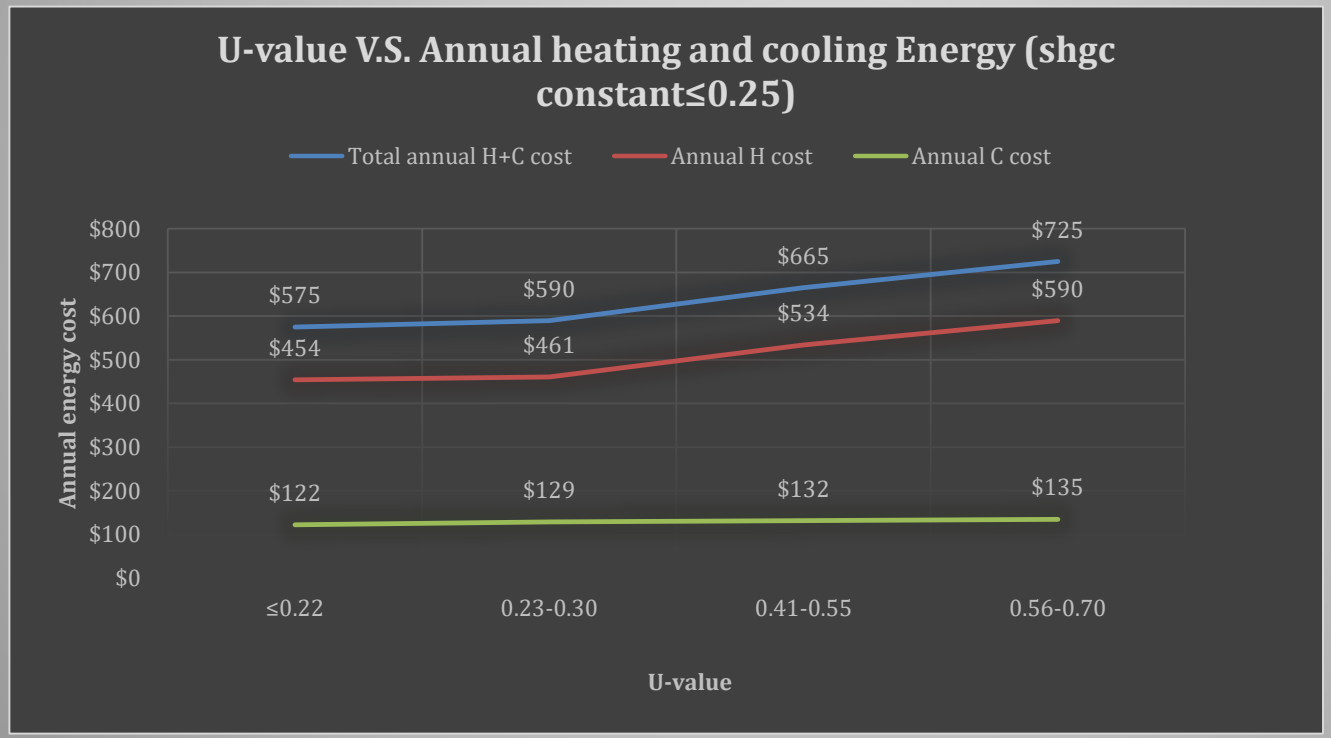
- SHGC changing from 0.405 to 0.596.
- The cooling energy changes from 1058 kWh to 1503 kWh, an increase of 445kWh
- U-value is held constant



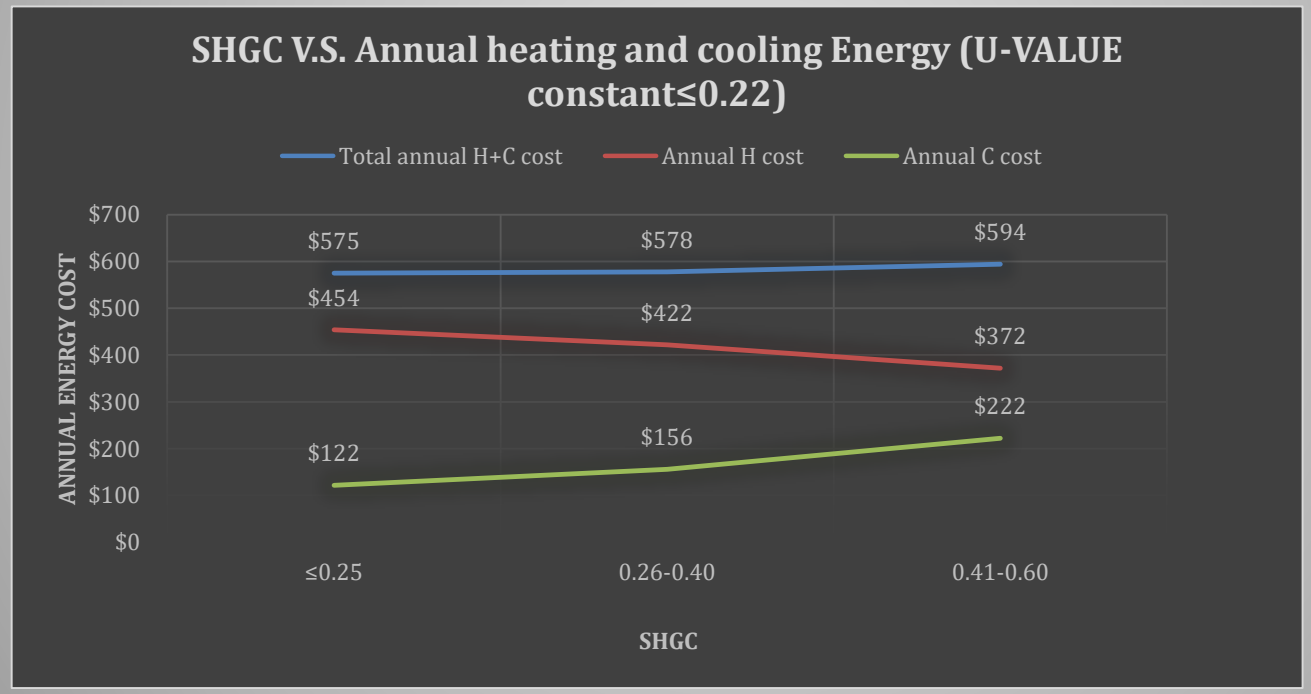
- A list of windows with a range of U-values and SHGCs, along with heating and cooling and total costs Efficient (Efficient Window Collaborative)
- 240-m^2 (2600-ft^2) two-storey building in Windsor /Equal wall / Window areas on all sides/The window area is more than 20% in each orientation/Window have no canopies or overhangs

window ID	Window name	U-value (W/m2-°C)	SHGC	Heating cost	Cooling cost	Total cost
1-6	2 pan LSG Low-E Metal	0.56-0.70	≤0.25	$590	$135	$725
2-11	2 pan LSG Low-E Metal, Improved	0.41-0.55	≤0.25	$534	$132	$665
3-18	3 pan HSG Low-E Non-metal, Improved	≤0.22	0.41-0.60	$372	$222	$594
4-19	3 pan MSG Low-E Non-metal, Improved	≤0.22	0.26-0.40	$422	$156	$578
5-20	3 pan LSG Low-E Non-metal, Improved	≤0.22	≤0.25	$454	$122	$575
6-23	2 pan LSG Low-E Non-metal, Improved	0.23-0.30	≤0.25	$461	$129	$590

- Four windows with SHGC ≤ 0.25 and U-values ranging from 1.25 to 3.97 W/m2-°C (0.22 to 0.70 Btu/h-ft2-°F)
- The best window will decrease total cost to $575 per year



- With a constant U-value ≤ 1.25 W/m^2-°C (0.22 BTU/hr-ft^2-°F) and changing the SHGC, the cooling energy cost increases more than the heating energy cost
- Therefore annual energy costs with the best window in this study would be $575 ($454 is for heating and $122 for cooling)



Outlines:

2. **IMPROVEMENT OF SHGC& U-VALUE**

IMPROVEMENT OF SHGC AND U-VALUE

- **Using removable shading systems**
- **Window design**
- **Window orientation**
- **Dynamic facades and systems**
- **Operable shading layers**
- **Double-skin façades**
- **External shading devices**

Using removable shading systems

- The total energy cost for this system would be $122 + $372= $ 494

$81 lower than a window with U-factor ≤ 1.25 W/m^2-°C (0.22 BTU/hr-ft^2-°F) and SHGC ≤ 0.25

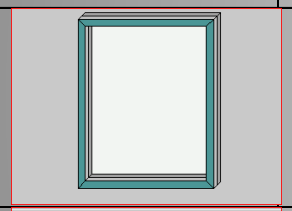
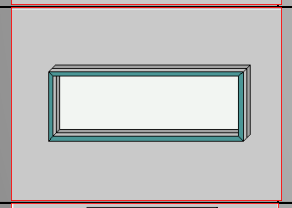
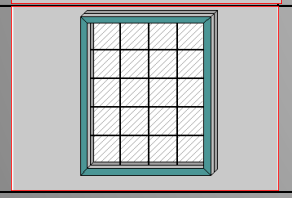
Window ID	U-Factor (W/m2-°C)	SHGC	VT	Total Cost	Heating Cost	Cooling Cost
5-20	≤0.22	≤0.25	≤0.40	$575	$454	$122
3-18	≤0.22	0.41-0.60	0.41-0.50	$594	$372	$222

SHGC from SHGC ≤ 0.25 in summer to SHGC = 0.41-0.50 in winter

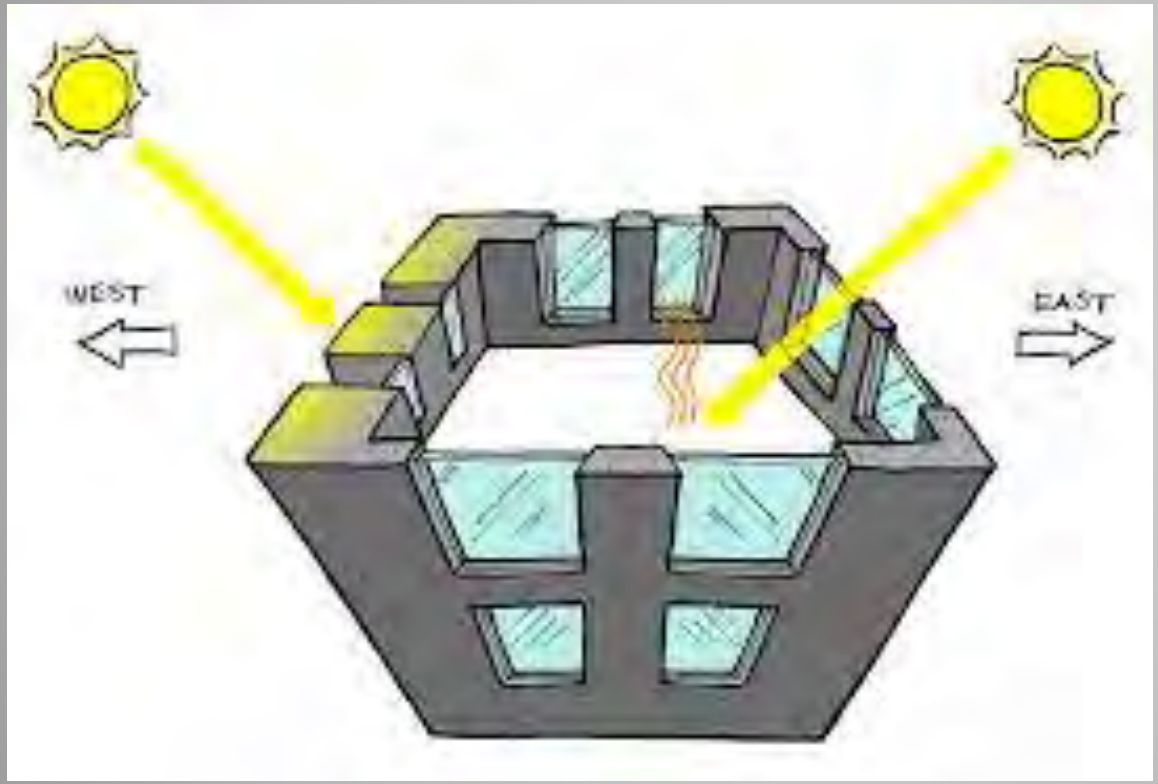
Window design

Window design

- Different geometry and design with the same window area

Window figure	Dimension	Operation	Area (m^2)	U-value	SHGC	VT
	1500x1500	Fixed vinyl window	2.25	1.603 W/m^2-°C	0.232	0.540
	2500X900	Fixed vinyl window	2.25	1.637 W/m^2-°C	0.226	0.524
	1500x1500	Fixed vinyl window	2.25	1.733 W/m^2-°C	0.208	0.471

Window orientation



Window orientation

- Different SHGC and U-values that have the best performance based on the wall orientation

Window facing	For cold climate, choose:	For warm climate, choose:
North	Lowest U-factor	Low U-factor
South	Highest SHGC, Lowest U-factor	Low SHGC and shading
East	Low SHGC or shaded	Low SHGC, Low U-factor
West	Low SHGC or shaded	Low SHGC, Low U-factor

Storm windows

Storm windows

- In the worst case, storm windows improve U-value by 25-35%, and decrease SHGC by 8-20%

Base Window	Storm Type	U-factor, W/m2-°C (Btu/h-ft2-°F)	SHGC	VT
Aluminum double hung, single glazed	None	6.36 (1.12)	0.61	0.65
Worst case mounting	Clear, Exterior	3.81 (0.67)	0.56	0.58
Thermally broken mounting	Low-e, Exterior	2.50 (0.44)	0.48	0.54
Aluminum double hung, double glazed	None	4.26 (0.75)	0.58	0.6
Worst case mounting	Clear, Exterior	3.12 (0.55)	0.51	0.54
Thermally broken mounting	Low-e, Exterior	2.04 (0.36)	0.44	0.5
Aluminum fixed, single glazed	None	6.02 (1.06)	0.72	0.77
Worst case mounting	Clear, Exterior	3.52 (0.62)	0.59	0.62
Thermally broken mounting	Low-e, Exterior	2.38 (0.42)	0.52	0.59
Aluminum fixed, double glazed	None	3.52 (0.62)	0.67	0.71
Worst case mounting	Clear, Exterior	2.67 (0.47)	0.54	0.58
Thermally broken mounting	Low-e, Exterior	1.87 (0.33)	0.48	0.55

Dynamic facades and systems

Dynamic facades and systems

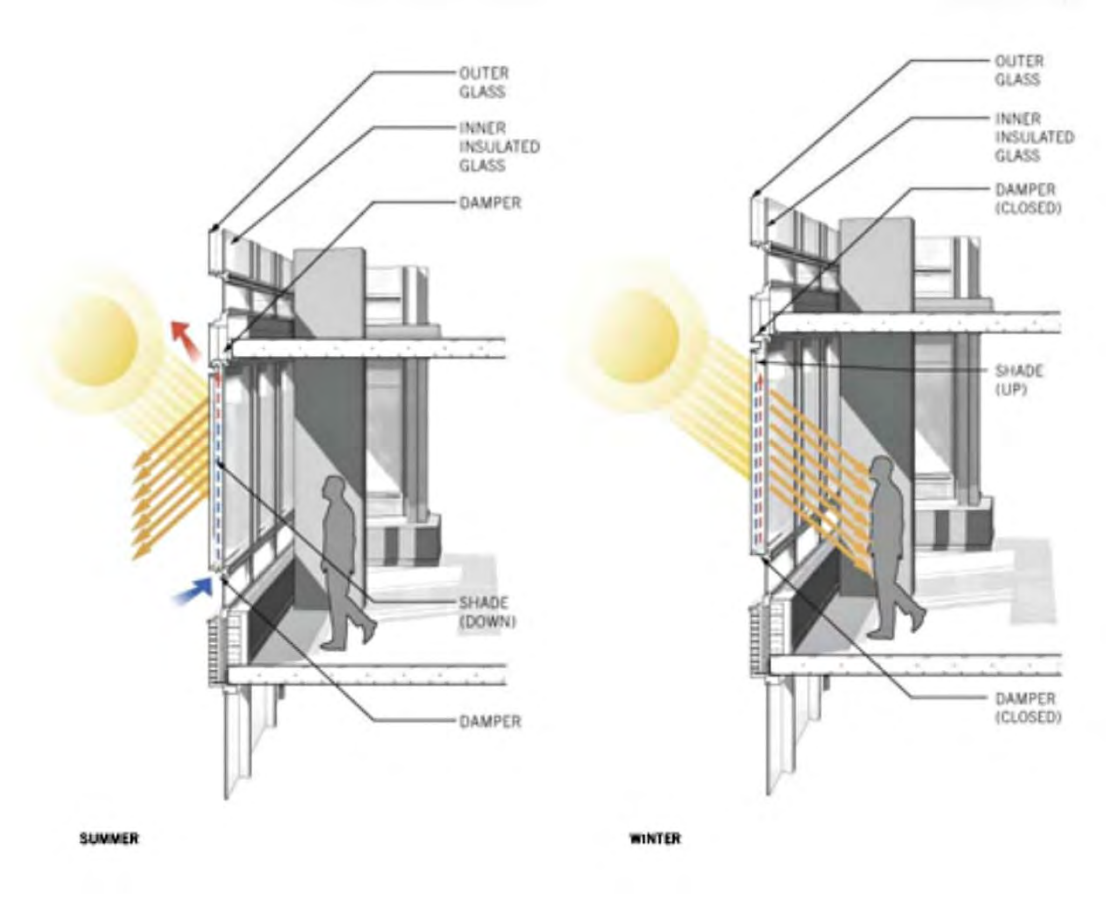
- Difference in energy consumption between Low-e and Dynamic glass based on various end uses
- Atlanta, Miami, Phoenix, New York, and San Francisco

	Average	
	Low-emissivity glass	Dynamic glazing
End use	(Mbtu)	(Mbtu)
Space cooling	575	494
Vent fans	98	78
Pumps	15	14
Miscellaneous Equip	666	666
Area lights	670	518
Space heating	133	163
Hot water	89	90
Total	2246	2021

Operable shading layers

- Shading layers or blinds between glazing layers or in front of the window
- While these layers decrease cooling energy, electricity consumption increases as natural light is replaced with artificial electric lights
- Efficient for privacy and personal security, but not an efficient option for reducing cooling-energy costs

Double-skin façades

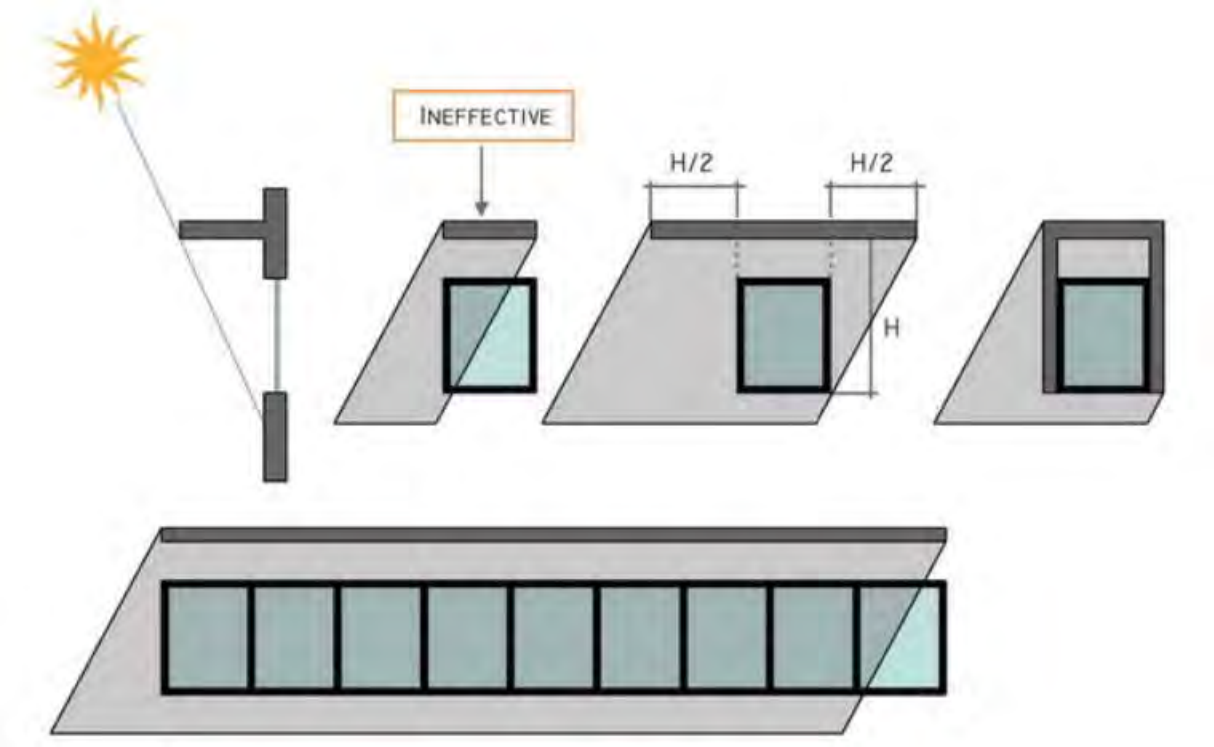


Double-skin façades

- Typically either motorized or manual blinds between the skins is used to reduce SHGC, and venting the air cavity
- Significant reduction of the cooling load

	Annual cooling load for double-skin façade			
Orientation	East	South	West	North
Double-skin façade (kWh/m²)	42.16	40.51	63.73	32.86
Single-skin façade (kWh/m²)	51.19	49.2	77.19	39.98
Energy saving (kWh/m²)	9.03	8.69	13.46	7.12
Energy saving percentage %	17.6	17.7	17.4	17.8

External shading devices



External shading devices

- Installation cost and safety considerations
- Not able to block sunlight from all angles, especially at low angles at the beginning and end of the day
- A new methodology(Concordia University) Uw= $\frac{\sum UgAg+\sum UfAf+\sum I\psi\Psi}{At}$
- $I\psi$ is the vision area perimeter and Ψ is linear thermal transmittance in this equation
- Exterior shades can improve the glazing U-value by 25%

CONCLUSION

- There are many tools and methods to select the best SHGC and U-value for a window
- To optimize for the best performance (i.e., reduced energy consumption and increased occupant comfort
- The study shows that U-factor ≤ 1.25 W/m2-°C (0.22 BTU/hr-ft2-°F) and SHGC ≤ 0.25 is the best choice for Windsor, Ontario
- In terms of U-value and SHGC improvement, many methods have been considered

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Thank you

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Questions?