
The Coming Wave of “Thin Glass” Windows for the United States Passive House Market

BRAD BEGIN

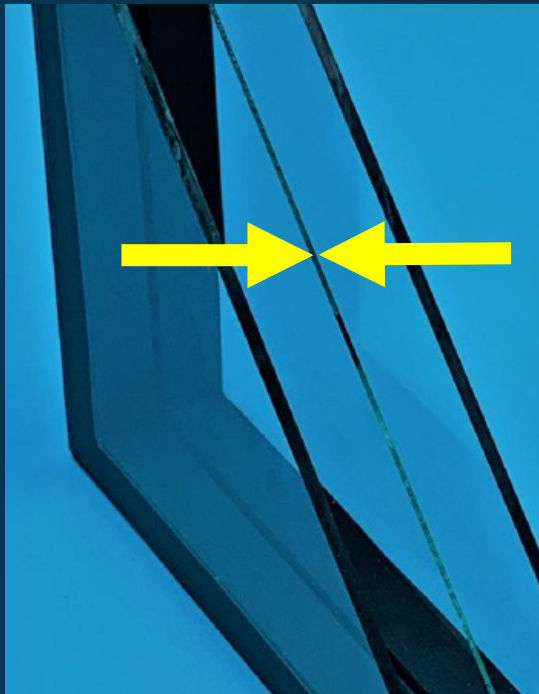
ALPEN HIGH PERFORMANCE PRODUCTS

14TH ANNUAL NORTH AMERICAN PASSIVE HOUSE CONFERENCE

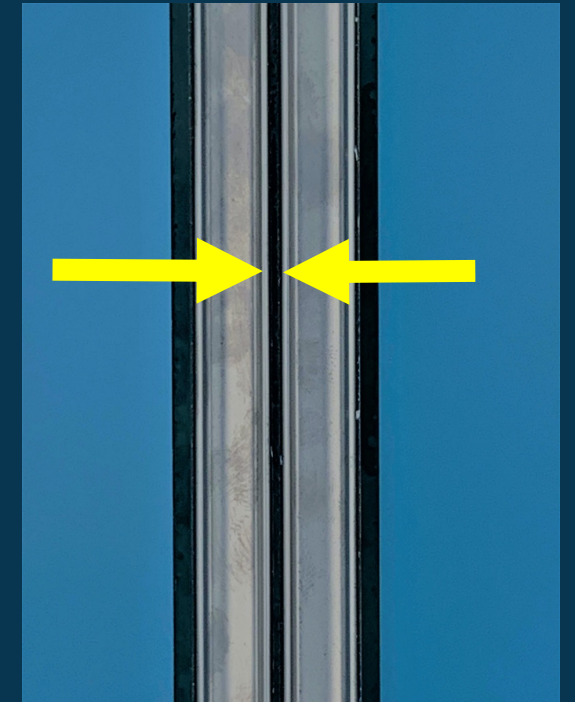
WASHINGTON DC, DECEMBER 6, 2019

What is “Thin Glass”?

THIN GLASS IS *0.7mm* to *1.3mm* THICK



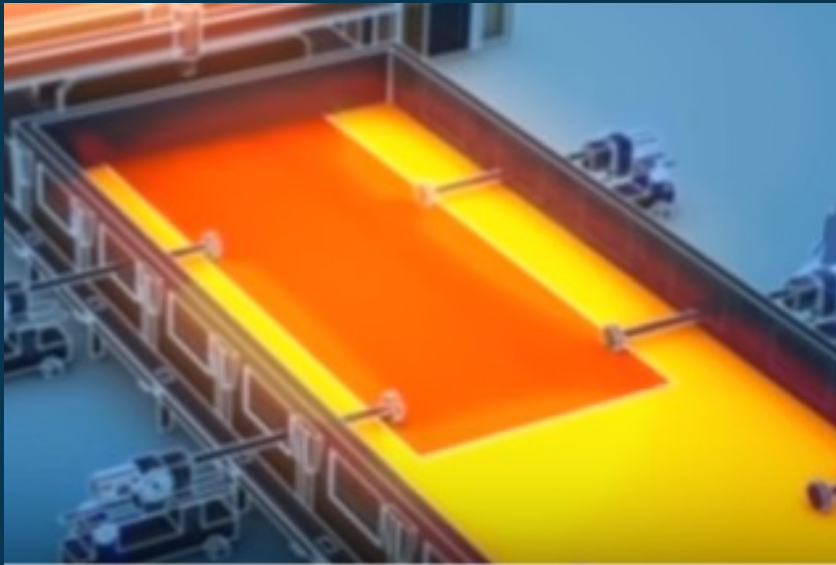
- ***3-4x thinner*** than typical residential glass
- ***6-8x thinner*** than typical commercial glass



What is “Thin Glass”?

THIN GLASS IS MADE IN TWO WAYS:

Horizontal Float Glass Process



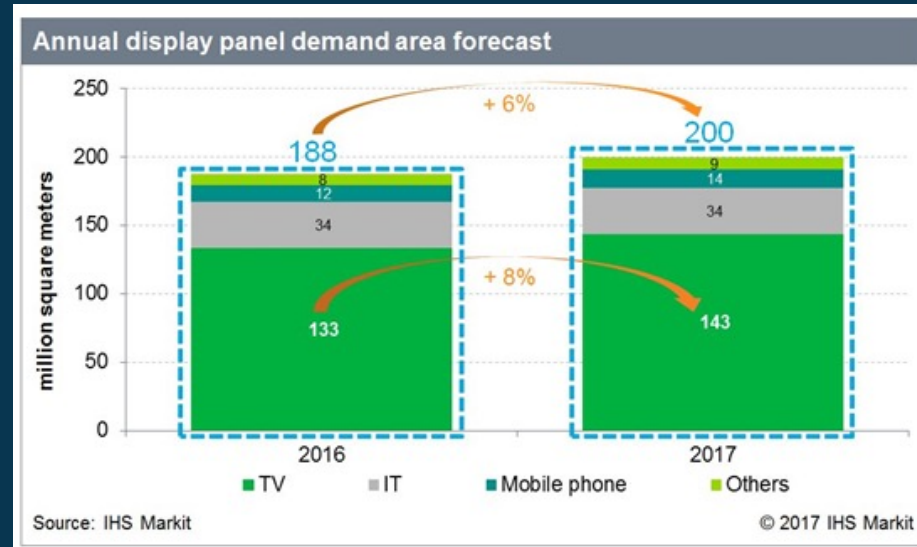
(as traditional glass is made currently)

Corning's **Vertical Casting** Process



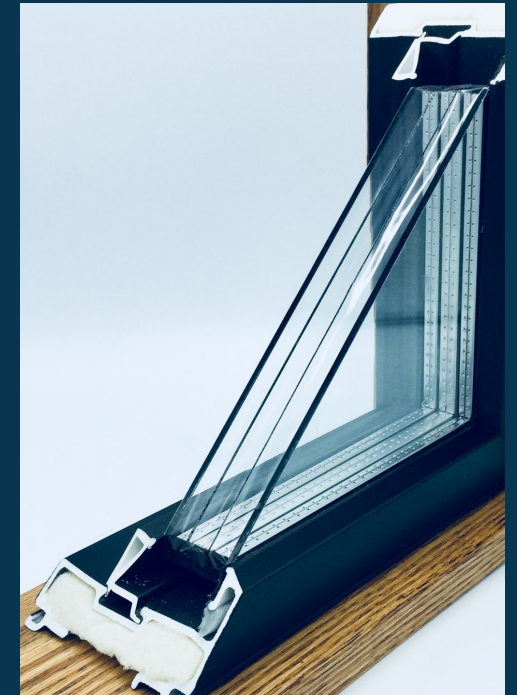
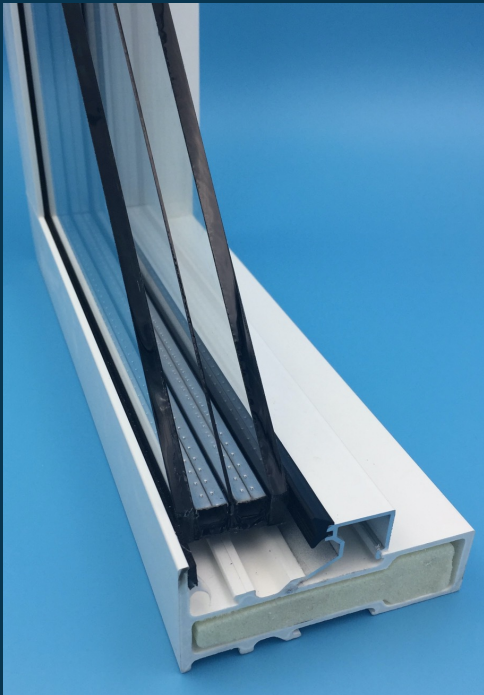
What is “Thin Glass”?

- Thin Glass has been widely used in other well known applications like **smart phones** and **flat screen televisions**.
- As a result, world capacity to produce thin glass has grown dramatically and its use in architectural applications has become feasible.



What is a “*Thin Glass*” Triple or “*Thin Glass*” Quad Window?

1. Typical Window Frame
2. Standard Outside Panes of Glass
3. “Thin Glass” Center Layers
 - One Center Layer for Thin Glass Triple
 - Two Central Layers for Thin Glass Quad
4. Usually **warm edge spacer** and can include **krypton gas** in lieu of **argon gas**



Advantage of Thin Glass: Very Light Weight

0.7 mm THIN GLASS WEIGHS **0.33 LBS /FT²**

WITH THIN GLASS,



A typical 4' x 5' window can become a triple pane product with only **6.6 pounds** of added glass weight

USING NORMAL 3/16" GLASS,



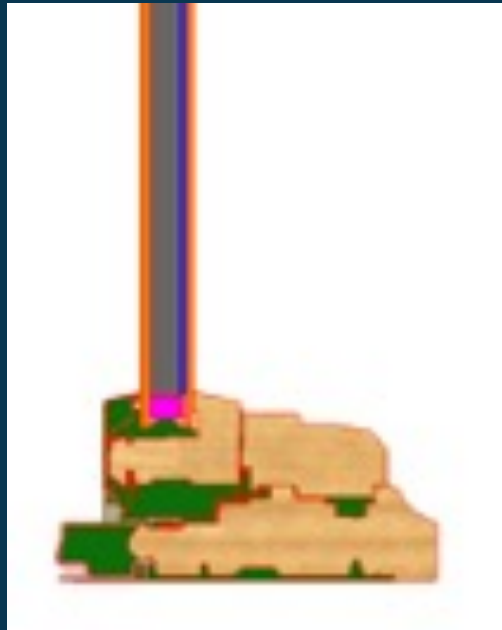
That same 20 ft² window in a traditional triple glazed configuration would need an added **48 pounds** of glass

Is It a Badge of Honor to Need 6 People to Move a Window or Door?



Advantages of Thin Glass

BIG PERFORMANCE UPGRADE



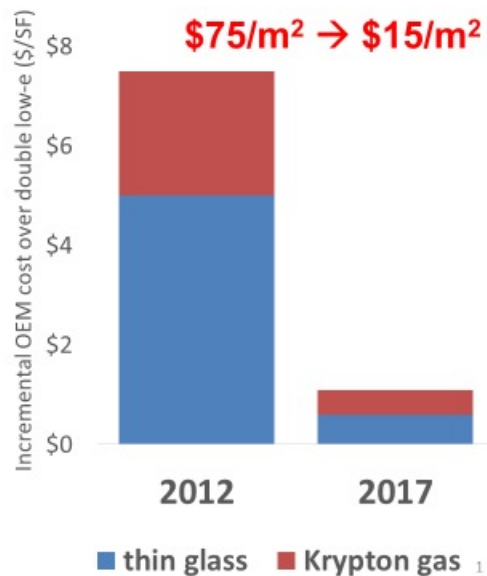
Traditional Timber Frame
Whole Window U-value [BTU/h*ft²*°F]
[1] Double Pane Ar90% + Stainless Steel Spacer
[2] Thin Triple Pane Kr90% + Warm Edge

Traditional Timber Frame			
Whole Window U-Value Improvement			
	1x LoE272	2x LoE180	2x LoE272
Double Pane, Standard	baseline		
Thin Triple		-47.7%	-50.6%

Advantages of Thin Glass

COST EFFECTIVE OPTION

80+% reductions in glass/Kr cost in 5 yrs
(thanks to flat screen TVs, satellite thrusters, LEDs)



- **\$2 to \$4 per square foot** incremental cost over dual pane

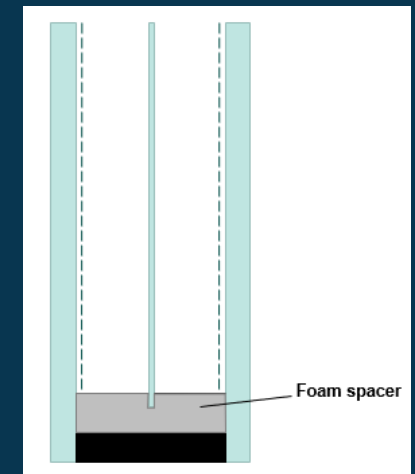
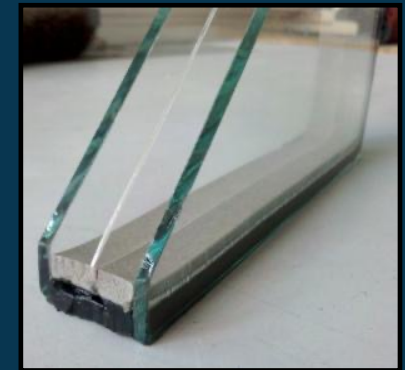
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- **35% to 50% improvement**

Advantages of Thin Glass

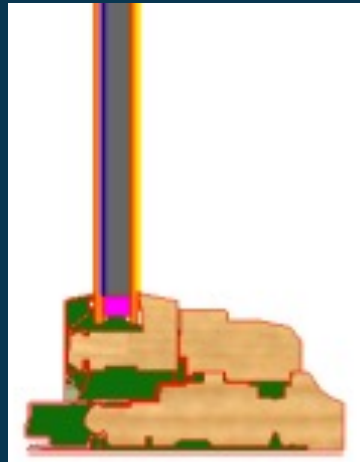
DURABILITY IMPROVEMENT POTENTIAL

- Thin glass not structural so glass does not go to edge of IG perimeter
- Thin glass is less rigid and more flexible so it can withstand greater stresses
 - *0.7 mm glass is **79 times** more flexible than 3 mm glass*
- Creates new spacer opportunities for uniquely designed **grooved spacers**
- Less edge area of glass leads to less opportunity for edge damage and stress cracks



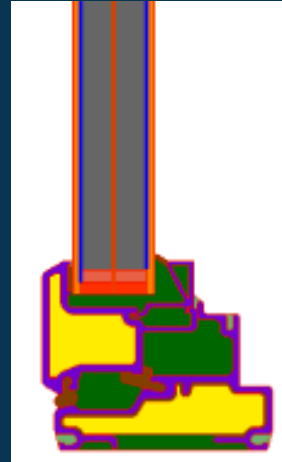
Advantages of Thin Glass

REDUCED CONDENSATION RISK



36.4°

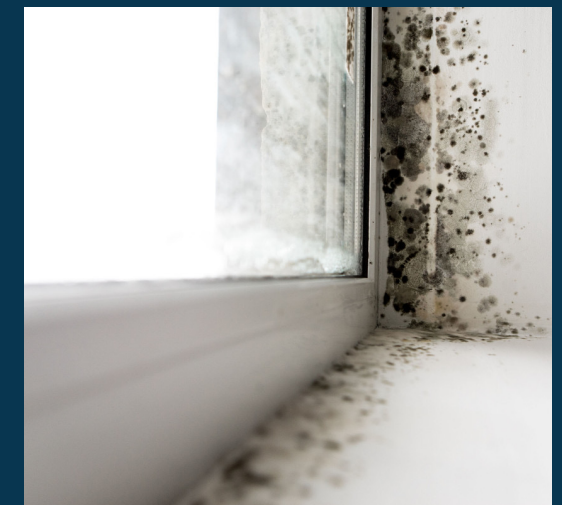
Clad Wood Frame, Dual Pane
Low-E #2 and #4
Stainless Spacer, Argon



58.4°

Fiberglass Frame, Thin Triple
Low-E #2 and #5,
Warm Edge Spacer, Argon

Internal Edge of Glass Temperature (0° Outside, 70° Inside, F)



Advantages of Thin Glass

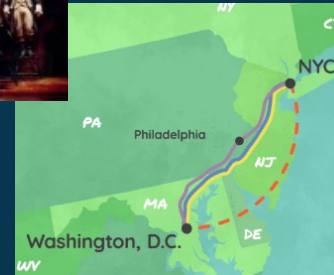
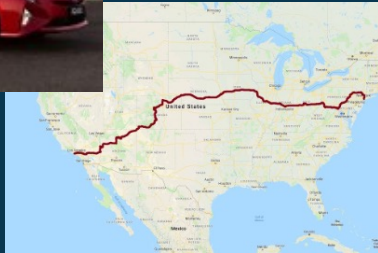
LESS ENERGY INTENSIVE AND LOWER EMBODIED ENERGY

- Glass manufacturing is an extremely energy intensive business
- Traditional float line glass uses **9.3 million** (or more) **BTUs of energy PER TON** of glass
- One gallon of gas =137,381 BTUS of energy

Glass Thickness	BTUs of Energy	Square feet of glass per ton
4 mm	9.3 million	994 ft ²
3.2 mm	9.3 million	1,224 ft ²
0.7 mm	9.3 million	5,553 ft²

Translating Reduced Energy Intensity into Real Life

On a reasonably good sized home, energy savings (in gas equivalent) in glass production from substituting Thin Glass triple for traditional European triple pane (4mm/4mm/4mm) would allow:



Someone with a 2020 Prius to drive from the West Coast to New York City to protest climate change at the UN and then go see Hamilton that night and have enough gas left over to drive to Washington DC and protest climate change outside the White House

Durability and Shock Testing

- **All Field Testing to Date Successful**
- **Thermal Stress Shock**
 - Rapid Temperature Cycling at Lawrence Berkley National Labs
 - 162° Delta T Temperature Range (-22°F to 140°F)
 - Simulated Thermal Stress Crack Risk
 - Results: No Failure



Manufacturing Experiences: Ease in Handling and Manufacturing

LEARNINGS:

- Easy to Handle and Process
- Relative Flexibility Advantageous
- Less Fragile than Expected
- Large Sizes Handled Easily
- Made with Multiple Spacer Types with No Issues
- Thin Glass Can Be Set Inside of Outside Panes



The Unique Role of Thin Glass in US in Passive House Community

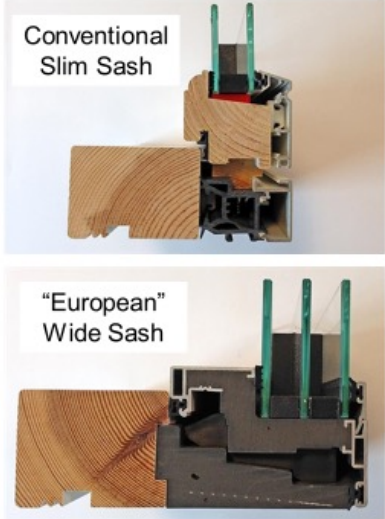
NARROWER FRAMES PREFERRED BY CONSUMER IN UNITED STATES

IS DIFFERENT WORSE?

Sash/Frame and IGU Dimensions

Typical U.S. Window
~80% are sliders
Slim sash/frame

Typical European Window
Most Tilt/Turn or Fixed
Wide sash/frame



Lawrence Berkeley National Laboratory

More Viewing Area

Frame to Glass Area Very Different

Outswing Operation


Many High Quality North American Windows

Low Air Infiltration

Overall Window Values Can Equal or Exceed Wide Triples with Heavy Frames


Passive House Viable Options

Calculation based on ISO 10077-2, EN 673, EN 410

Product name: Alpen Zenith ZR-6 Casement Thin Glass Triple		Center-of-glass properties					
ASHRAE/IECC /DOE North American Climate Zone	North, East, West - facing South-facing	 Passive House Institute US		Alpen SolarControl-6 TGT + Krypton No Grids			
		Whole-window installed U-value		Ucog-Value			
Climate specific recommendations:		W/m2K	BTU/hr.ft2.F	SHGC	W/m2K	BTU/hr.ft2.F	
8		0.92	0.16	0.271	0.649	0.114	
7		0.90	0.16	0.271	0.615	0.108	
6		0.86	0.15	0.271	0.565	0.100	
5		0.85	0.15	0.271	0.551	0.097	
4	✓	0.82	0.14	0.271	0.520	0.092	
Marine North	✓	0.80	0.14	0.271	0.495	0.087	
Marine South	✓	0.77	0.14	0.271	0.459	0.081	
3	✓	0.79	0.14	0.271	0.476	0.084	
2 West	✓	0.78	0.14	0.271	0.468	0.082	
2 East	✓	0.78	0.14	0.271	0.468	0.082	
Alpen Zenith ZR-6 Casement Triseal Premium	FRAME		Psi-spacer		Psi-opaque		
	Frame height		U-frame		Ψ		
	mm	in	W/m2K	BTU/hr.ft2.F	W/mK	BTU/hr.ft.F	
	Head	73 2.86	1.13	0.20	0.037	0.021	0.124
	Sill	73 2.86	1.13	0.20	0.037	0.021	BTU/hr.ft.F
left jamb	73 2.86	1.13	0.20	0.037	0.021	0.072	
right jamb	73 2.86	1.13	0.20	0.037	0.021	Grade B	

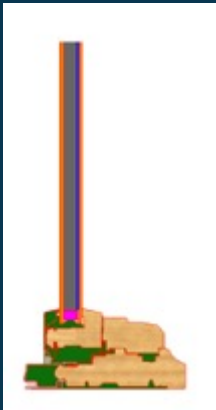
Valid through December 2021

Calculation based on ISO 10077-2, EN 673, EN 410

Product name: Alpen Tyrol TR-6 Thin Glass Triple Tilt-Turn		Center-of-glass properties					
ASHRAE/IECC /DOE North American Climate Zone	North, East, West - facing South-facing	 Passive House Institute US		Alpen SolarControl-6 PH+ TGT No Grids			
		Whole-window installed U-value		Ucog-Value			
Climate specific recommendations:		W/m2K	BTU/hr.ft2.F	SHGC	W/m2K	BTU/hr.ft2.F	
8		0.88	0.15	0.266	0.627	0.110	
7		0.85	0.15	0.266	0.591	0.104	
6		0.82	0.14	0.266	0.537	0.095	
5	✓	0.81	0.14	0.266	0.522	0.092	
4	✓	0.80	0.14	0.266	0.512	0.090	
Marine North	✓	0.80	0.14	0.266	0.514	0.091	
Marine South	✓	0.80	0.14	0.266	0.518	0.091	
3	✓	0.80	0.14	0.266	0.516	0.091	
2 West	✓	0.81	0.14	0.266	0.527	0.093	
2 East	✓	0.81	0.14	0.266	0.527	0.093	
Alpen Tyrol TR-6 Thin Glass Triple Tilt-Turn Triseal Premium	FRAME		Psi-spacer		Psi-opaque		
	Frame height		U-frame		Ψ		
	mm	in	W/m2K	BTU/hr.ft2.F	W/mK	BTU/hr.ft.F	
	Head	117 4.61	0.94	0.17	0.030	0.017	0.152
	Sill	117 4.61	0.94	0.17	0.031	0.018	BTU/hr.ft.F
left jamb	117 4.61	0.93	0.16	0.030	0.018	0.088	
right jamb	117 4.61	0.93	0.16	0.030	0.018	Grade B	

Valid through December 2021

Big Thermal Improvement and Apple Pie Weight Increases – Important Tradeoffs

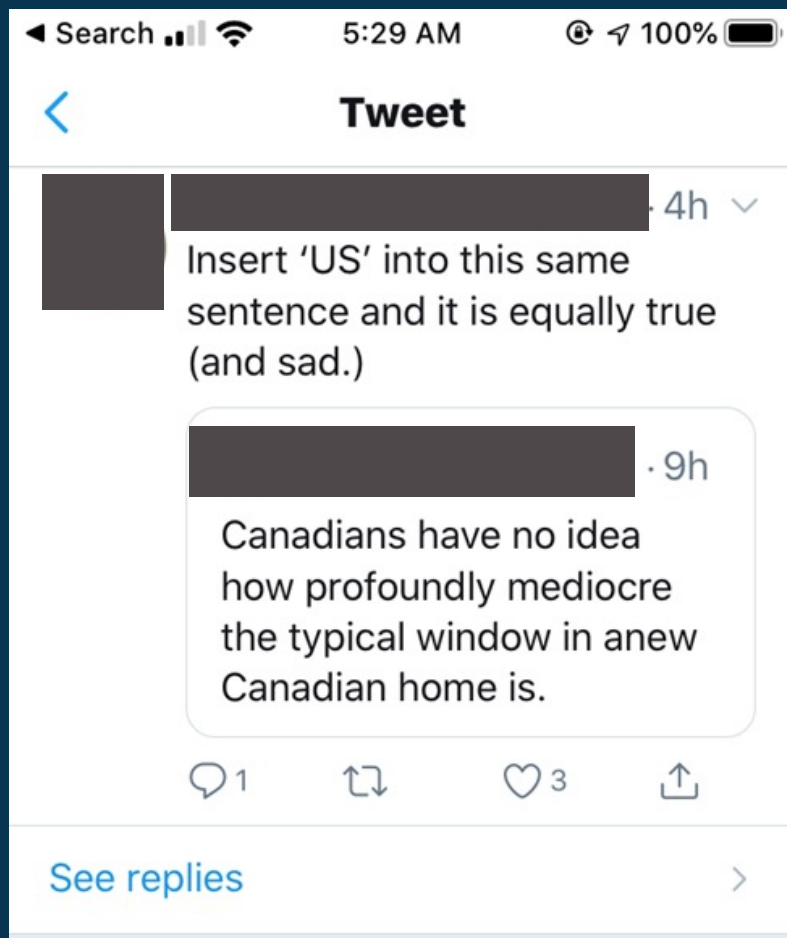


Traditional Timber Frame
Whole Window U-value [BTU/h*ft²*°F]
 [1] Double Pane Ar90% + Stainless Steel Spacer
 [2] Thin Triple Pane Kr90% + Warm Edge

Traditional Timber Frame			
Whole Window U-Value [BTU/h*ft ² *°F]			
	1x LoE272	2x LoE180	2x LoE272
Double Pane, Standard	0.2653		
Thin Triple		0.1388	0.1311

Traditional Timber Frame			
Whole Window U-Value Improvement			
	1x LoE272	2x LoE180	2x LoE272
Double Pane, Standard	baseline		
Thin Triple		-47.7%	-50.6%

Concluding Thoughts



We urge you to challenge the US window industry to step up its game.

Thin Glass triples provide a pathway for well-made US-style windows to meet the needs of the passive house community.

Questions?



ALPEN HIGH PERFORMANCE PRODUCTS

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