Higher Performance and Lighter IGUs with Boro-aluminosilicate Thin Glass

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Abstract

The utilization of boro-aluminosilicate thin glass, with a thickness ranging from 0.5 to 0.7 mm, has facilitated the development of innovative insulated glazing units (IGUs). These new constructions offer enhanced performance, comfort, and reliability compared to IGUs constructed solely with soda-lime glass, while also being lighter. Ultra-thin glass is now being integrated as the central panes in triple and quad IGUs, as well as being laminated to soda-lime glass to improve safety, impact-resistance, and sound transmission reduction while enabling smart window functionality. This paper shares various instances of ultra-thin glass incorporation in IGUs, highlighting their benefits and presenting testing data in accordance with the requirements of the architectural glazing industry.

Keywords

IGU, Laminated Glass, boro-aluminosilicate, ultra-thin glass

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1. The need for higher performance windows

1.1. Higher performance windows to cut energy loss

Buildings account for 40% of the energy consumption in the U.S. and in the European Union, and 36% of the European energy-related greenhouse emissions (Harris, 2022 and European Commission, 2020). Improving building energy efficiency is an important component of any energy consumption reduction effort for cost savings, environmental benefits, or economical development. The ENERGY STAR® program in the U.S. and the recently adopted revision of the Energy Performance of Buildings Directive by the European Commission are two examples of government incentives to improve building energy efficiency.

Although windows compose only 8% of a typical single family home surface area, they represent 45% of thermal energy transmission through the building envelope. (Selkowitz, 2023). In the building envelope, windows are the weak link regarding energy efficiency: whereas building codes may require walls to have an R-value of 3.5 (K·m^2/W), with roofs and floors even higher, windows may only be R-0.6. (*ibid*.)

Higher R-value windows are a low-cost path for improving a building's Energy Rating Index (ERI). ERI is a standardized method for measuring and comparing the energy efficiency of homes. Figure 1 shows that the increase in material cost to improve a building's ERI by 2 points is three times more expensive when the walls are improved than when windows are improved.

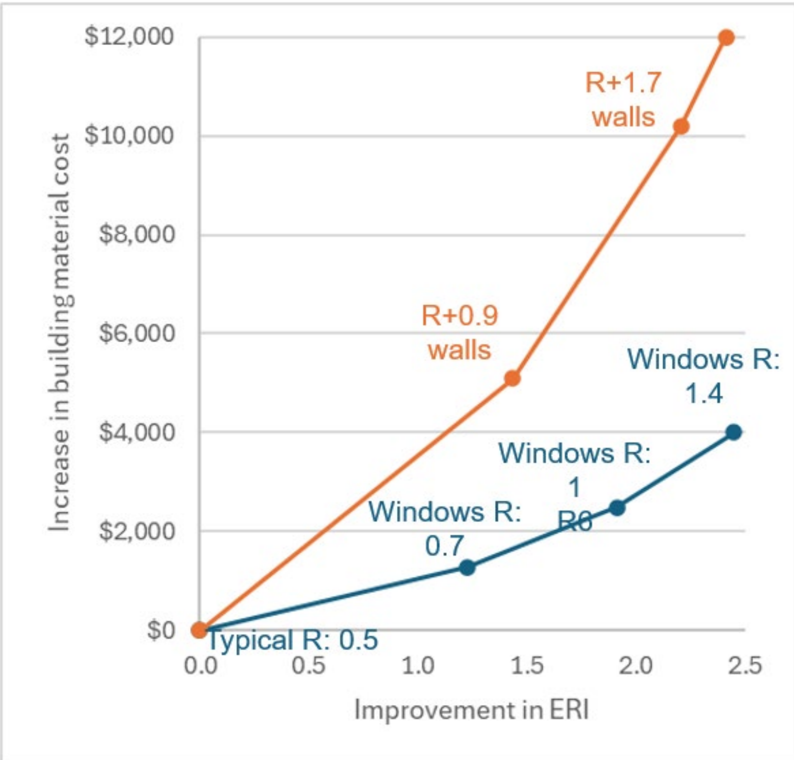

Fig. 1: Increased material costs to improve a building ERI, either with increasing the walls R-value by 0.9 and 1.7, or by improving windows R-value from 0.5 to 1.4. (Wall insulation costs from wholesale prices assuming wall insulation increases linearly with thickness, Corning cost models, and window supplier inputs).

The overall surface area of windows in a building is important for the well-being of its occupants (visual connection to the outside and access to natural light). High performance windows can also be used to increase the window overall surface area without impacting the building envelope's thermal performance. Figure 2 shows an example of increased property comfort and value.

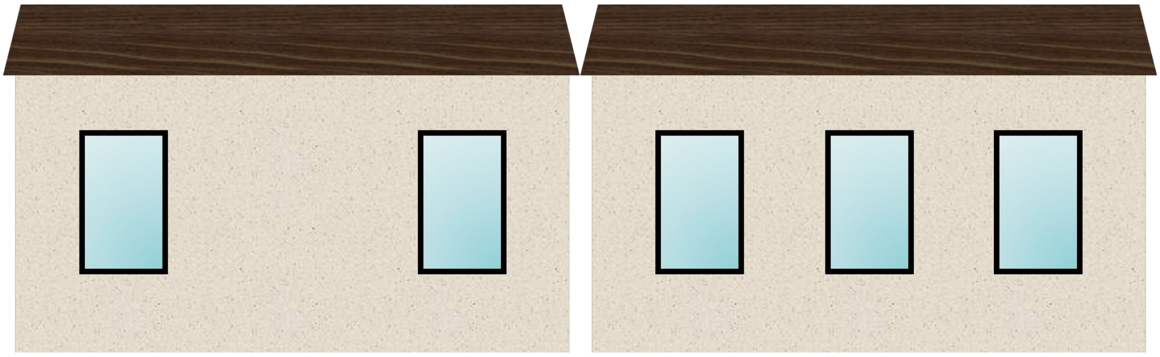

Fig. 2: Two facades with the same overall building envelope thermal conductance. The one on the left has windows with R-0.6, whereas the one on the right has R-0.9 windows.

There is significant room for improvement. Figure 3 indicates how window thermal performance has evolved over time in the U.S. (Lawrence Berkeley National Laboratory, 2025) As of 2023, triple pane windows represented only 2% of residential window sales (FGIA 2024): The typical R-value for windows is still around R-0.5.

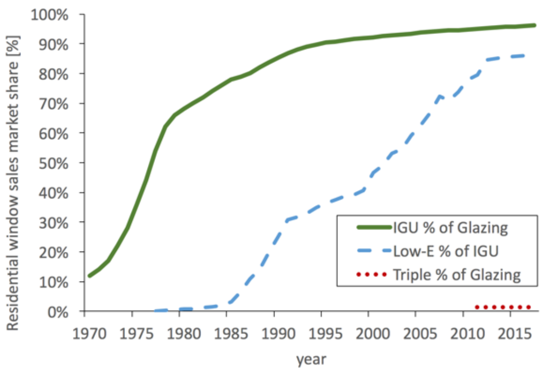

Fig. 3: Evolution of window thermal performance in the U.S.

1.2. Higher performance windows for occupant comfort

Even if the R-value of the walls, floors, and roofs could be cheaply improved, the weakest link in thermal insulation – e.g. the windows – should be considered first for upgrade because of occupant comfort. In cold climates poor insulation leads to cold surfaces, generates cold drafts, and creates extreme radiant discomfort. The windows tend also to be the weakest link in term of sound insulation, which is an additional reason to improve the windows for overall comfort.

That is also why the option to improve window R-value by adding a low-e coating facing the building interior, a "room side coating", is not preferred for comfort. This option reduces the heat transfer between the innermost glass pane and the room and results in the surface temperature of the glass being farther from room temperature. In wintertime the surface temperature can fall below the dew point, leading to interior condensation, mould, and rot. Cold air will also accumulate near the glass surface and drift into the room as it falls, creating drafts.

Figure 4 shows simulations of two windows, both with a U-value of 1.3 W/m^2/K (R-value of 0.8). However, one is a double pane IGU with a roomside coating and the other is a triple pane IGU with no roomside coating. On a day with -10 °C outdoor temperatures and +21 °C indoor temperatures the presence of the roomside coating will cause the double-glazed window to be almost 5° colder to the touch. The cold glass will result in convective air currents causing occupant discomfort twice as far into the room, reducing the habitable living space.

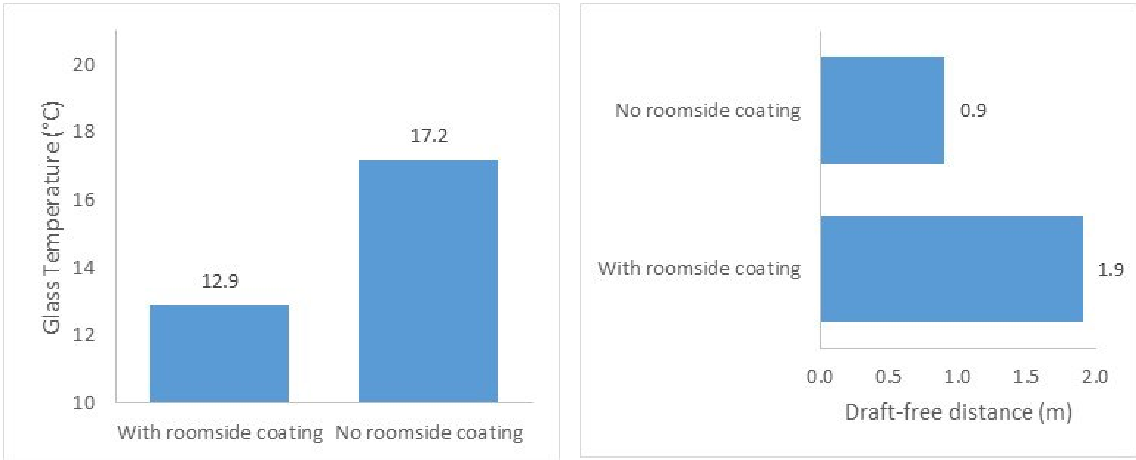

Fig. 4: Simulation results using WINDOW 7.7 for two windows with the same U-value, with or without a roomside coating.

1.3. Higher performance windows to manage solar heat gain

Dynamic glazing can change tint to control solar heat gain and thereby reduce solar loads, particularly during peak times. The windows can be cleared at other times to allow ambient solar energy to offset heat losses, and to replace electric lighting with natural daylight. Studies have shown that smart windows can reduce annual energy consumption by 20%, and more during peak load times (View 2015) and improve occupant well being and productivity. It would be desirable to add solar heat gain control capability without significant increases to window thickness or weight.

1.4. Weight increase

Improving the performance of windows to reduce energy loss, improve occupant comfort, and manage solar heat gain without technology changes has led to a continuous increase of window weight. As a result, transportation, installation, and operation are becoming an issue for cost, environmental impact, and comfort. Installation requires more people, time, and specialized equipment. Operation requires more force and more complex and expensive window mounting hardware.

An extreme example can be seen in Figure 5 below. This dynamic tinted window product contains a total of 27 mm of glass with a combined weight of 66 kg/m^2. This is not practical for installation. New technologies are required.

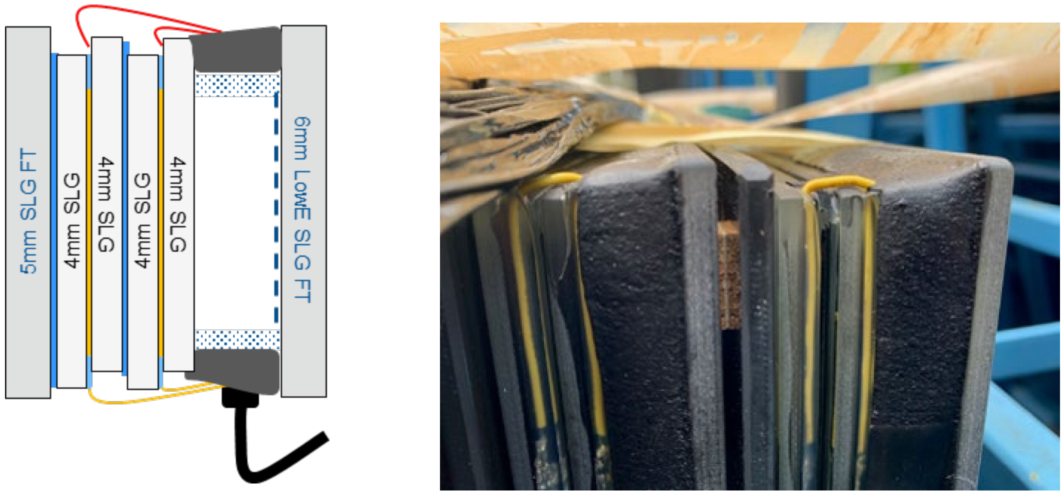

Fig. 5: Schematic and side view of a dynamic smart window.

2. Triple and Quad IGUs with ultra-thin centre panes

The largest gains in window thermal performance arguably come from increasing the number of gas cavities to reduce convective heat transfer, going from single pane windows to double pane integrated glazing units (IGU), to triple and quads.

Moving from a double pane window to a quad pane IGU would typically increase glass weight twofold. However, if 0.5 mm glass is used as the central two panes the same gain in insulation performance can be achieved at nearly the same weight as the double pane (Fig. 6).

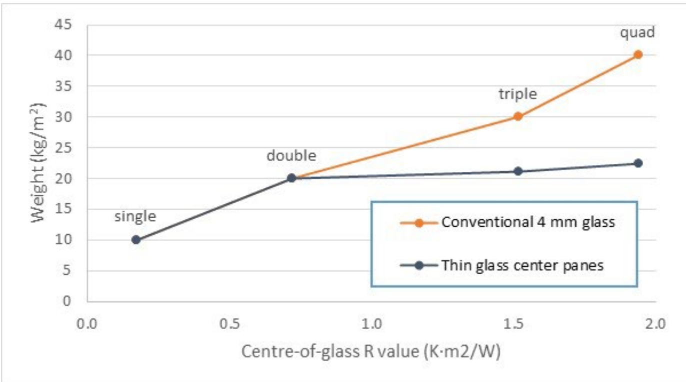

Fig. 6: Weight increase versus R-value for windows using conventional 4 mm glass panes versus 0.5 mm boro-aluminosilicate thin glass centre panes.

The increase of the IGU R-value described above is linked to the thermal barrier created by the alternance of glass and gas cavities. While the outermost exterior and interior panes must have sufficient thickness for overall window rigidity and wind load resistance, higher thickness of the interior centre panes of triple or quad IGUs does not improve the thermal performance. In the past suspended films have been tried to trade glass for gas, improving thermal performance without increasing IGU weight and/or thickness. However, these sometimes lead to issues with buckling, outgassing, or yellowing. Use of ultra-thin (below 1 mm thickness) glass for the central panes in triple or quad IGUs avoids these problems.

For retrofit cases when the IGU thickness is constrained, ultra-thin glass enables improved thermal efficiency with the same footprint of a double pane. Table 1 shows how a double pane window with 28 mm overall thickness (two panes of 4 mm soda lime glass with low-e coating and 90% argon fill) can be retrofit by a triple pane IGU with a 0.5 mm centre glass pane. A 26% improvement in centre-of-glass R-value is achieved for only a 6% increase in weight, and 0% change in IGU thickness.

Table 1: High performance windows for retrofit within double IGU.

IGU attributes	Double pane IGU	Triple pane IGU with 0.5 mm centre glass
Thickness (mm)	28	28
U-value (W/m2/K)	1.4	1.1
R-value (K·m2/W)	0.7	0.9
Weight (kg/m2)	20	21.2

When the IGU thickness is not constrained, ultra-thin glass enables to take full advantage of the thermal efficiency. Figure 6 above illustrates how a quad pane IGU with 16 mm gas cavities can nearly triple the R-value of a double pane IGU. If 0.5 mm centre glass panes are used instead of 4 mm soda lime silicate, the resulting IGU will be 11% thinner (57 mm versus 64 mm).

Use of ultra-thin glass panes does not compromise IGU mechanical performance. Center panes are considered non-structural and are not typically included in calculations for wind load resistance (Hart, Fisher, & Morse, 2023). In experimental tests triple pane IGUs with 0.5 mm thin boro-aluminosilicate centre panes have reached equal or greater static loads as double pane IGUs before breakage. Boro-aluminosilicate glass also has a greater resistance to breakage from thermal stress than conventional soda lime silicate. (Couillard 2025)

3. Laminated glass with ultra-thin glass panes

Laminated glass is commonly used in applications requiring added safety, security, or impact resistance. In these applications the glass plays a secondary role in performance; it is the lamination foil (typically polyvinyl butyral) which is responsible for the added functionality. One glass pane is required for structural integrity, but the second glass ply is present largely to protect the lamination foil. Using thick glass is therefore wasteful for weight, thickness, and embodied carbon.

Corning has tested glass laminates consisting of 3 mm soda lime silicate, 0.76 mm polyvinyl butyral, and 0.5 mm boro-aluminosilicate. These laminates were able to demonstrate compliance with classification 1(B)1 for laminated safety glazing (EN 12600:2002). The laminates were also able to meet P2A performance rating for security glazing resistance (EN 356:1999). The thin glass laminates are thus comparable in performance to thicker, heavier symmetric laminates with two plies of 3 mm soda lime silicate.

One notable application for laminated glass using thin glass panes is in hurricane impact laminates. One company has used thin glass in a laminated glass stack design that is nearly half the weight of most impact laminates in use for the market in Florida, under the tightest code regulations for impact performance in the U.S. (MITER Brands, 2025). In this application, laminates consisting of 4.76 mm soda lime silicate, 2.28 mm polyvinyl butyral, and 0.7 mm boro-aluminosilicate are able to withstand static loads up to 5 kPa, as well as pass missile impact and pressure cycling requirements.

4. Fixed or dynamic tint windows

The dynamic window market is still nascent. The need for solar heat gain control is there, but product performance to price ratios have not increased enough yet for the adoption to take off. There are multiple technologies competing. Although it is still early to know which technology will win, ultra-thin glass is highly likely to be part of the solution.

Ultra-thin boro-aluminosilicate enables to add a dynamic cell without significant thickness or weight increase. Moreover, the pristine surface resulting from the fusion forming process (Corning 2023) is smoother than float glass, and free from elemental contaminants and scratches that can lead to defects in smart window electronics. Its lower coefficient of thermal expansion (CTE) reduces thermal breakage when tinted panes rise in temperature.

Modelling of tinted panes in insulated glazing units indicates that the glass temperatures can be quite high. Surface temperatures can approach 100 °C on a tinted pane used as the centre pane of a triple pane window in direct sunlight. Large temperature gradients between the centre and edge of glass is known to cause breakage, potentially at rates greater than 1%. (Cardinal, 2022). Boro-aluminosilicate glass has a CTE of $3.1x10^{-6}$/K, about one third that of soda lime silicate. Thermal stress from temperature gradients is directly proportional to CTE, so the breakage risk for dynamic cells made from boro-aluminosilicate glass can be orders of magnitude lower than in cells made using soda lime glass (Couillard, 2025).

5. Conclusions

As windows performance improves to meet world challenges in energy efficiency, Corning's ultra-thin boro alumino-silicate glass enables the development of innovative insulated glazing units (IGUs). These new constructions offer enhanced performance, comfort, and reliability compared to IGUs constructed solely with soda-lime glass, while also being lighter. Full equipment solutions (Guermeur, Shomo, Ostendarp, & Saksala, 2025) are now available to process ultra-thin glass for integration into windows to improve safety, impact-resistance, and sound transmission reduction while enabling smart window functionality.

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