Thin-Triple Windows - Now a Cost-Effective Envelope Trade-Off for High-Performance Homes

Theresa Gilbride and Katherine Cort, Pacific Northwest National Laboratory
Robert Hart, Lawrence Berkeley National Laboratory
Brad Begin, Alpen High Performance Products
Steve Byers, EnergyLogic
Karla Butterfield, Steven Winters Associates

ABSTRACT

Thin-triple pane windows are coming down in price due to some unprecedented changes in the window manufacturing industry, including the recent expansion in the number of U.S. manufacturing lines producing thin-triple pane windows. These insulating glazing units (IGUs) can provide the performance of a traditional triple-pane window with the thickness of a double-pane IGU, allowing them to drop into double-pane window frames in existing homes. More importantly, U.S. window makers can use them in place of double-pane IGUs in their high-speed production lines, paving the way for lower cost, high-performance windows for high-volume U.S. home builders. This paper will touch on these developments and the U.S. Department of Energy (DOE) research that led to them. Recent energy modeling analyses of single-family and multi-family homes are presented showing how thin triples can be a cost-effective tradeoff against other envelope measures to help builders in mixed and cold regions meet higher Energy Rating Index (ERI) targets. Non-energy benefits of thin triples are also addressed, including resiliency, sound mitigation, condensation control, and comfort.

Introduction

Thermal transfer and air leakage through the building envelope make up the largest HVAC loads in most regions, and windows alone are estimated to be responsible for approximately 10% of building energy use (Hart et al. 2019), despite their proportionally small area of the envelope (Figure 1).

Of all the envelope components, windows have a disproportionate impact on heating and cooling loads and can account for 30 to 50% of envelope heat loss in a new home. While a typical new home has a wall insulation value of R-20 (U=0.05), most double-pane windows will have an R-value of 3 or lower (U-value of 0.28 or higher). In a typical 2,000 ft^2 home with windows comprising 15% of the exterior walls, double-pane windows with a U-value of 0.28 would have a UA (U-value x surface area) of 84 UA (UA = total heat loss through the window surface). If high-performance triple-pane U-0.14 windows were installed instead, the UA drops in half to 42 UA (Begin et al. 2025).

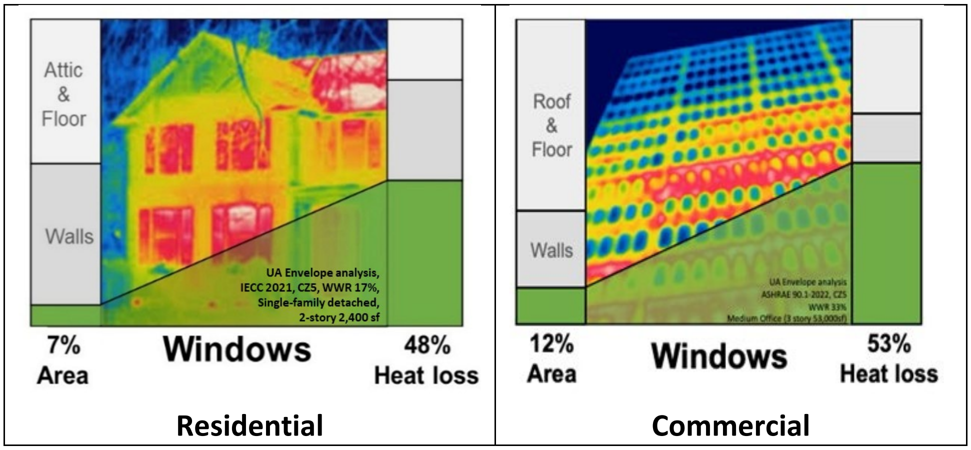


Figure 1. Windows account for nearly half of the heat loss through the envelope in American homes and commercial buildings (Source: LBNL).

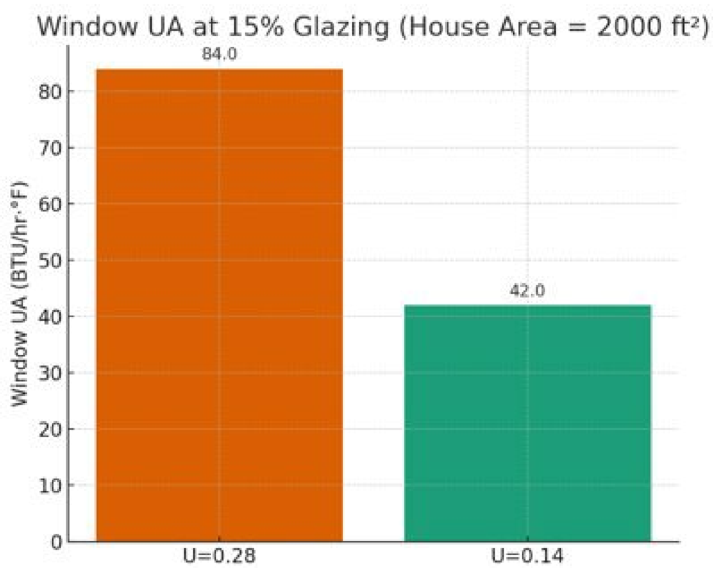


Figure 2. In a typical home with windows comprising 15% of exterior wall area, replacing double-pane U-0.28 windows with high performance triple-pane U-0.14 windows cuts window UA in half (Source: Begin, Byers, Sylvestre 2025).

The window industry has been marked by many technological breakthroughs in the 20th century that each helped to foster dramatic change in the industry, contributing to more affordable and efficient window products for consumers. Four of the most prominent are described below and their adoption level is shown in Figure 3 (Begin et al. 2025):

1. **Invention of the Float Glass Process** – by Pilkington in 1959, dramatically increased the size of glass sheets that could be produced, making it much faster and cheaper to manufacture large amounts of glass at one time, thus making window glass much more available and affordable. After being licensed for the U.S., Europe, and Japan in 1965, the float glass process soon dominated the industry, capturing 90% of all glass production by 1980.

2. **Transition from Single- to Dual-Pane Insulated Glass Units** – the invention of the float glass process made the next big transformation – from single-pane to double-pane windows – economically feasible. Between 1970 and 2010, double-pane windows went from 10% of window sales to 90% of window sales in the U.S. market.
3. **Commercialization of Low-E Coatings on Glass** – The third big innovation was the addition of low-emissivity coatings on window glass. Starting in 1980, IGUs with low-e coatings grew to 75% of the window market by 2010.
4. **Rise of Vinyl Windows** – The use of vinyl (uPVC) window frames also had a mercurial rise – going from 1% of the market in 1975 to 63% of the market by 2010.

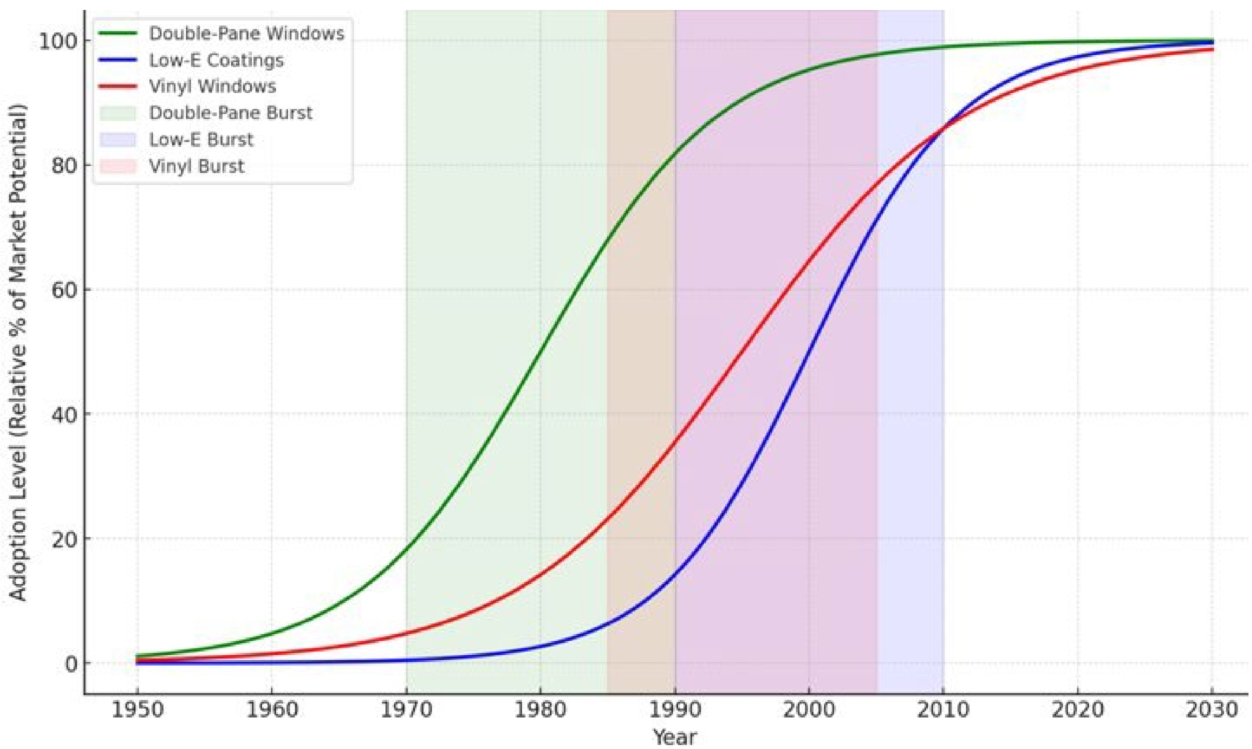


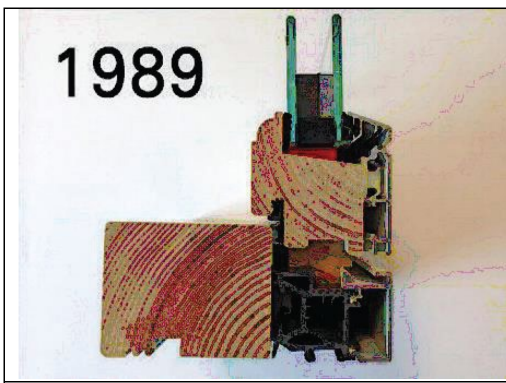
Figure 3. Breakthrough innovations in the window manufacturing industry spurred transformative changes in the 1960s to early2000s but innovation has slowed in the past 10 years (Source: Alpen High Performance Products).

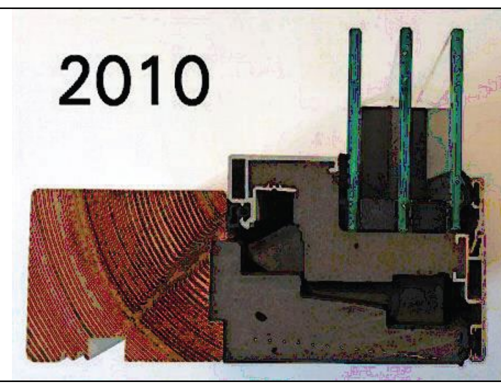
These four innovations caused dramatic changes in window manufacturing from the 1950s to the 2010s. However, there have been no radical breakthrough technologies in the window industry for the past decade or more. While triple-pane windows and vacuum insulated glass (VIG) hold the promise of significant performance improvements, there has been no notable uptick in sales of either technology in the U.S. window market. As of 2023, triple-pane windows made up less than 5% of sales, a number that hasn't changed much since at least 2010 (Selkowitz 2023; Hart et al. 2019). Is the window industry poised for a triple-pane breakthrough?

Thin-Glass IGU Technology

Previous Barriers to Triple Pane Installation

Triple-pane windows have been around for decades, but their use has been minimal in the United States. Market analyses conducted by researchers at Pacific Northwest National Laboratory (PNNL) confirmed that uptake has been hampered by several factors – builders felt they were too expensive, too hard to find, too heavy, and too wide (Cort and Gilbride 2019; Gilbride et al. 2019). Width of the windows has been a significant issue for two reasons. The width of a typical triple-pane window plus sash can be 5 or more inches. This exceeds the width of the 2x4 exterior walls that were typical of homes built throughout the country before recent advances in building energy codes and that are still common in warmer regions (Cort and Gilbride 2019; Gilbride et al. 2019). The width of a typical triple-pane IGU can be up to 1-3/8 inches while for double-pane IGUs a width of 3/4-inch is common. Most window manufacturers who have set up their assembly lines to handle the ¾-inch width of double-pane IGUs; the assembly lines would need to be retooled to accommodate the wider triple-pane IGUs. Window makers are reluctant to do that retooling unless there is a demonstrated sizable demand for the triple-pane product, so they are hesitant to advertise the fact that they can produce them. That lack of advertising, and concurrent lack of information provided by manufacturers regarding triple-pane window performance specifications and pricing, has contributed to a lack of demand by builders (Cort et al. 2024).





Conventional double-pane wood-framed windows have a 3-inch sash	European typical triple-pane windows have a 5-inch sash.

Figure 4. Typical triple-pane windows use three typical-thickness glass panes (1/8-inch or 3 to 4 mm each) separated by ½-inch gaps filled with air or argon gas for a total insulated glazing unit width of 1-1/4 inch to 1-3/8 inch (25 to 35 mm), while a typical double-pane window has an IGU width of 3/4 to 7/8 inch (19 to 28 mm).

Thin Triple Technology Development

Could thinner triple-pane windows be the answer? In the 1980s, some window manufacturers began experimenting with a "suspended film" process developed by Southwall Technologies that consisted of stretching a sheet of plastic between two panes of glass to create a third layer. In 1989, researchers at Berkeley Lab filed a U.S. Statutory Invention for a "thin triple-pane" window that used a non-structural thin pane sandwiched between two typical-thickness glass panes. The thin center pane was held in place with clips and the gaps on either side of the center pane were filled with krypton gas, creating an IGU that was thinner than a typical triple-pane IGU. These ideas were later refined in a 2008 paper by Arasteh et al. to validate the performance of non-structural center layers without hermetic seals at the perimeter (Arasteh et al. 2008). Commercialization stalled because there was no economically viable thin glass at the time.

Since then, several factors have come into play to make thin-triple-pane windows more available and affordable. The thin glass (≤1mm) manufacturing industry has expanded dramatically, going through a transformation akin to the float glass transformation of the 1900s. Innovations in thin glass manufacturing from the 1980s to the 2020s have increased the size of thin glass sheets that can be produced from 2 ft^2 to as much as 103 ft^2. These advances, spurred on by the burgeoning cell phone and flat screen TV markets, have brought the price down while dramatically increasing the availability of thin glass, making use of thin glass in a thin triple-pane window much more economically feasible (Begin et al. 2025).

Thin triple IGUs typically consist of two typical-thickness (1/8-inch, 3 mm) sheets of glass on the outsides, a thin center pane of glass that is 0.5 to 1.6 mm thick, warm-edge spacers to support the center pane, and krypton or argon gas to fill the sealed cavities between the center pane and outer panes. Krypton allows for thinner cavities than argon without impacting thermal performance.

These two improvements, the use of thin glass for the center pane and the use of krypton rather than argon for the gas fill, have made possible a product that has the potential to transform the window industry again – a thin-triple IGU that can perform as well as a typical-width triple-pane window while fitting into the same frame as a double-pane window. This removes a major industry impediment – concerns about retooling frame manufacturing lines to accommodate the wider typical triple-pane IGUs – and opens the way to the production of thin-triples in the industry (Hart et al. 2019).

Thin Triple Performance

From a manufacturing performance standpoint, the exterior and interior glass panes used to make thin-triples are identical to those used in typical double-pane windows, so only the thin glass and the krypton are not already in the window makers' supply chains. Some window manufacturers make their own IGUs and frames. Many window makers buy their IGUs from a larger regional or national IGU manufacturer. There are two IGU makers currently supplying their versions of thin-triple IGUs to the market and at least two window manufacturers who have recently added multiple high-speed production lines to produce thin-triple IGUs for use in their own windows. A growing number of other window manufacturers are beginning to offer thin-glass triple and even quad-pane options in their window lines.

In terms of the thin triples' thermal performance, it's worth noting that, unlike wall insulation, window thermal performance is often stated in U-factor which is a measure of the overall window heat transfer ($Btu/hr \cdot ft^2 \cdot F$), rather than in R-value (resistance to heat flow). R-value is the inverse of U-value, so a triple-pane window with an R value of R-5 would have a U-factor of 0.20 (0.20 = 1/5). These properties account for the performance of the window construction (glass, spacer, sash/frame) and the air films on the indoor and outdoor surfaces.

The thermal performance for thin triple-pane fixed picture windows that have been certified by the National Fenestration Rating Council (NFRC) and are available in today's market ranges from a U-factor of U-0.20 to U-0.14, which is on par with typical triple panes (e.g., IGU width of 1-1/4 in. to 1-3/8 in.) and is a significant performance improvement over the traditional double-pane low-e fixed picture window, with U-factors of 0.30 to 0.27 (Hart et al. 2020).

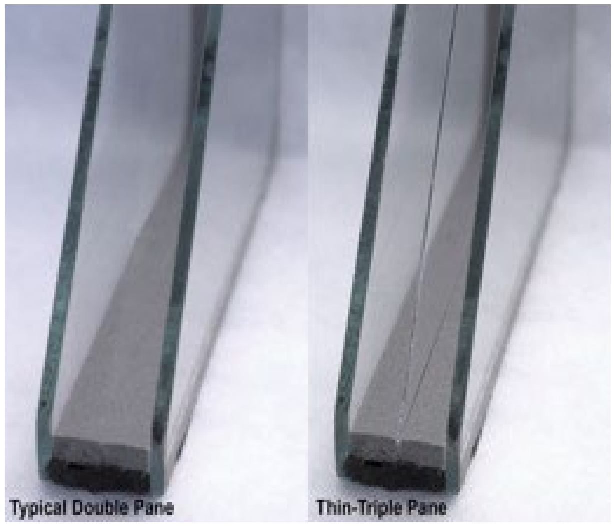


Figure 5. Thin-triple IGU technology utilizing thin glass as a non-structural center layer enables raising of IGU thermal performance from R-5 to R-8 hr ft^2 °F/Btu. (Source: LBNL).

High-Performance Homes

The performance gains that triple-pane windows provide have become increasingly beneficial to builders as residential building codes and voluntary home certification programs like ENERGY STAR Certified Homes and the U.S. Department of Energy's Efficient New Homes (DENH) program encourage higher-performing building envelopes. While minimum U-values ranging from 0.50 for zone 1 to 0.27 for zones 6, 7, and 8 can be met with double-pane windows, the minimum U-value for northern regions in the most recent version (Version 7.0) of the voluntary ENERGY STAR window specification is $U \leq 0.22$, a value that is challenging to find in a double-pane window product. (Note that the voluntary ENERGY STAR window specification does allow U-factors of 0.23 to 0.26 for windows with solar heat gain coefficients of ≥ 0.35 to 0.40.) (Many builders are following performance paths rather than prescriptive paths to compliance with local requirements and voluntary efficiency program criteria. These performance paths require builders to compute the total conductance of the building envelope by multiplying the U factors of each of the individual components of the proposed building envelope by its surface area and summing the total or by running an energy model to determine total envelope and comparing that to a target home total Energy Rating Index (ERI) calculated based on compliance with prescriptive measures.

$$\text{Total UA} = \Sigma\ (\text{U-factor} \times \text{Area})$$

In seeking to reduce their total ERI scores, builders are realizing that windows are typically the poorest performing component of the building envelope and upgrading to higher performing thin-triple windows might be an easy way to improve overall envelope performance. Thin-triple windows require no adjustments to home designs developed for double-pane windows. Using higher performing windows to achieve overall envelope performance may also help builders avoid other more challenging modifications to typical construction practices to accommodate higher insulation values in other building components. Do the data back up these assumptions?

Tradeoff Analysis

A tradeoff analysis was conducted using a software widely used by HERS raters. Two home energy raters conducted the analyses using real homes and apartments that had been previously modeled for home certifications in climate zones 4 and 5 in Connecticut and Colorado. Various scenarios were run to show tradeoffs, using a home built with a high-performance prescriptive envelope target as the baseline. The Connecticut rater ran two of each building type with six window performance levels and five envelope tradeoff scenarios. The tradeoff scenarios were as follows:

- Keep the high-performance prescriptive envelope target and change window performance only.
- Change window performance and remove continuous exterior wall insulation.
- Change window performance and decrease foundation insulation.
- Change window performance and decrease ceiling insulation.
- Change window performance, remove continuous exterior wall insulation, and decrease foundation insulation.

The window performance levels that were analyzed included windows that met the voluntary ENERGY STAR Version 7 specifications, windows that met DENH Version 2, and windows with U values of U-0.20, U-0.14, and U-0.10. For simplicity, only the U-0.20 (R-5) window scenarios are shown here. The total building UA for one baseline single-family home in each scenario in zones 4 and 5 are shown in Tables 1 and 2. Similar scenarios were run for two multifamily buildings in zones 4 and 5, including an analysis of the whole building and analyses of a single top floor, midfloor, and bottom floor apartment unit in each building. Results of the analysis of one whole multifamily building are shown in Table 3. The percents by which each scenario exceeded or fell short of the baseline (a building that met a high-performance prescriptive envelope target) are shown in green for “performed-better-than” and red for “performed-worse-than” the baseline. It should be noted for scenarios that fell short of the high-performance target, nearly all included a ceiling insulation tradeoff that dropped the ceiling R value from R-60 to R-29. R-29 was selected because that is a common R-value for ceiling cavity insulation for a cathedral ceiling. This scenario did not take into account other ways a builder might increase cathedral ceiling R values, such as using spray foam rather than fibrous insulation or using rigid foam layers above the roof deck.

Table 1. Comparison of tradeoffs including reduced ceiling, exterior wall, and foundation insulation when double-pane windows are replaced with U-0.20 (triple-pane) windows in a single-family home in zone 4.

Single-Family Home A (CZ 4)						
Metrics	**Hi-Perfm Target**	**U-0.20**	**U-0.20 + <Wall ci**	**U-0.20 + <Foundation**	**U-0.20 + <Ceiling**	**U-0.20 + <Wall ci + <Foundation**
Ceiling R	60	60	60	60	29	60
Wall R (cavity)	20	20	20	20	20	20
Wall R (continuous)	5	5	0	5	5	0
Window U	0.3	0.2	0.2	0.2	0.2	0.2
Door U	0.3	0.3	0.3	0.3	0.3	0.3
Floor R	0.033	0.033	0.033	0.033	0.033	0.033
Foundation Wall R	R10	R10	R10	R5	R10	R5
Slab R, depth	R10, 4v	NA	NA	NA	NA	NA
Building UA	**545.9**	**444**	**497**	**486**	**468.3**	**536.8**
vs. Hi-Perfm Target	-	-19%	-9%	-11%	-14%	-2%
Heating Load (kBtuh)	**38**	**33**	**35**	**34**	**34**	**37**
Cooling Load (kBtuh)	**27**	**27**	**27**	**27**	**27**	**27**

Table 2. Comparison of tradeoffs including reduced ceiling, exterior wall, and foundation insulation when double-pane windows are replaced with U-0.20 (triple-pane) windows in a single-family home in zone 5.

Single-Family Home A (CZ 5)						
Metrics	**Hi-Perfm Target**	**U-0.20**	**U-0.20 + <Wall ci**	**U-0.20 + <Foundation**	**U-0.20 + <Ceiling**	**U-0.20 + <Wall ci + <Foundation**
Ceiling R	60	60	60	60	29	60
Wall R (cavity)	20	20	20	20	20	20
Wall R (continuous)	5	5	0	5	5	0
Window U	0.3	0.2	0.2	0.2	0.2	0.2
Door U	0.3	0.3	0.3	0.3	0.3	0.3
Floor R	0.033	0.033	0.033	0.033	0.033	0.033
Foundation Wall R	R15	R15	R15	R5	R15	R5
Slab R, depth	R10, 4v	NA	NA	NA	NA	NA
Building UA	**539.8**	**437.9**	**485.4**	**485.4**	**462.2**	**532.9**
vs. Hi-Perfm Target	-	-18.9%	-10.1%	-10.1%	-14%	-1.3%
Heating Load (kBtuh)	**44**	**38**	**41**	**41**	**39**	**44**
Cooling Load (kBtuh)	**30**	**29**	**30**	**30**	**29**	**30**

Table 3. Comparison of tradeoffs including reduced ceiling, exterior wall, and foundation insulation when double-pane windows are replaced with U-0.20 (triple-pane) windows in a whole multifamily building in zones 4 and 5.

Multifamily, Whole Building A		**CZ 4**				**CZ 5**			
Metrics	**Hi-Perfm Target**	**U-0.20**	**U-0.20 + <Wall ci**	**U-0.20 + <Ceiling**	**U-0.20 + <Ceiling + <Wall ci**	**U-0.20**	**U-0.20 + <Wall ci**	**U-0.20 + <Ceiling**	**U-0.20 + <Ceiling + <Wall ci**
Ceiling R	60	60	60	29	29	60	60	29	29
Wall R (cavity)	20	20	20	20	20	20	20	20	20
Wall R (continuous)	5	5	0	5	0	5	0	5	0
Window U	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Door U	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Floor R	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Foundation Wall R	R10/R15	R10	R10	R10	R10	R15	R15	R15	R15
Slab R, depth	R10, 4v	NA	NA	NA	NA	NA	NA	NA	NA
Building UA	**2618**	**2238**	**2517**	**2388**	**2667**	**2238**	**2517**	**2388**	**2667**
vs. **Hi-Perfm Target**		-14%	-4%	-9%	1.9%	-15%	-1%	-9%	1.9%

The Colorado rater ran three scenarios in zone 5 – a single-family home over an unconditioned crawlspace, an end-unit two-story townhome over a conditioned crawlspace, and a two-story townhome over a walk-out basement. He modeled each home with envelope options at five performance levels: the High-Performance Prescriptive Target, an alternate High-Performance Target, the Better Performance Target, and to the two voluntary prescriptive performance levels ENERGY STAR Version 3.2, DENH Version 2. He compared three window performance levels - U-0.20, U-0.14, and U-0.10 windows – and modeled tradeoffs for exterior wall insulation, foundation insulation, and ceiling insulation. For simplicity, only the tradeoffs for U-0.20 windows are shown in Table 4 below.

Table 4. Comparison of three Colorado homes in zone 5 modeled to **the High-Performance Prescriptive Target** and then with triple-pane windows, allowing envelope tradeoffs (shown in gold).

Metrics	**1- Single-Family, Crawlspace**		**2 - Townhome, Conditioned Crawlspace**		**3 - Townhome, Walkout Basement**	
	Hi-Perfm Target	**U-0.20 + <Ceiling + >knee wall + <Wall ci**	**Hi-Perfm Target**	**U-0.20 + <Ceiling + <Wall ci**	**Hi-Perfm Target**	**U-0.20 + <Wall ci**
Windows	U-0.32, SHGC-0.40	U-0.20, SHGC-0.30	U-0.32, SHGC-0.40	U-0.20, SHGC-0.30	U-0.32, SHGC-0.40	U-0.20, SHGC-0.30
Exterior Doors	U-0.20	U-0.20	U-0.20	U-0.20	U-0.20	U-0.20
Roof Deck	NA	NA	NA	NA	NA	NA
Flat Ceiling	R60	R60	R60	R49	R60	R60
Exterior Knee Wall Insulation	NA	R21	NA	NA	NA	NA
Exterior Wall Cavity Insulation (2x6)	R20 + R5 ci	R21	R20 + R5 ci	R21	R20 + R5 ci	R23
Floors over unconditioned space	R30	R30	R30	R30	R30	R30
Slab insulation (on grade)	NA	NA	NA	NA	R10, 4v	R10, 4v
Crawl Foundation Wall	NA	NA	15	NA	NA	NA
Finished Basement Wall	NA	NA	NA	NA	R19	R19
Unfinished Basement Wall	R15	R15	R19	R19	NA	NA
Rim Joist Insulation	R30	R30	R30	R30	R30	R30
UA Compliance, % above	7%	16%	8%	16%	5%	11%
Hi-Perfm Target HERS	56	48.99	51	48.8	55	47

Note that once a home is constructed, envelope retrofits like adding insulation and replacing windows are rarely made; thus, one could argue that any tradeoff made away from enhanced envelope insulating measures at the time of construction is likely an opportunity lost over a significant portion of the life of the building. This tradeoff analysis is meant to highlight the value added from high-performance windows in a high-performance design and is not necessarily recommended as a course of action for all measures.

Other Considerations (Co-Benefits)

Home builders in a survey of DENH builders by PNNL (Gilbride et al. 2019) identified several factors influencing their decisions to purchase and install double or triple-pane windows. Of the DENH builders surveyed, 41% install only triple-pane windows and another 28% install triple-pane windows in most or some of their homes. This corresponds to data collected on all DENH Housing Innovation Award participants in 2013-2019 (100 builders), where 39% of builders reported using triple-pane windows. The builders were asked to identify what benefits they saw in triple-pane windows other than energy-savings. Their responses are shown in Figure 6.

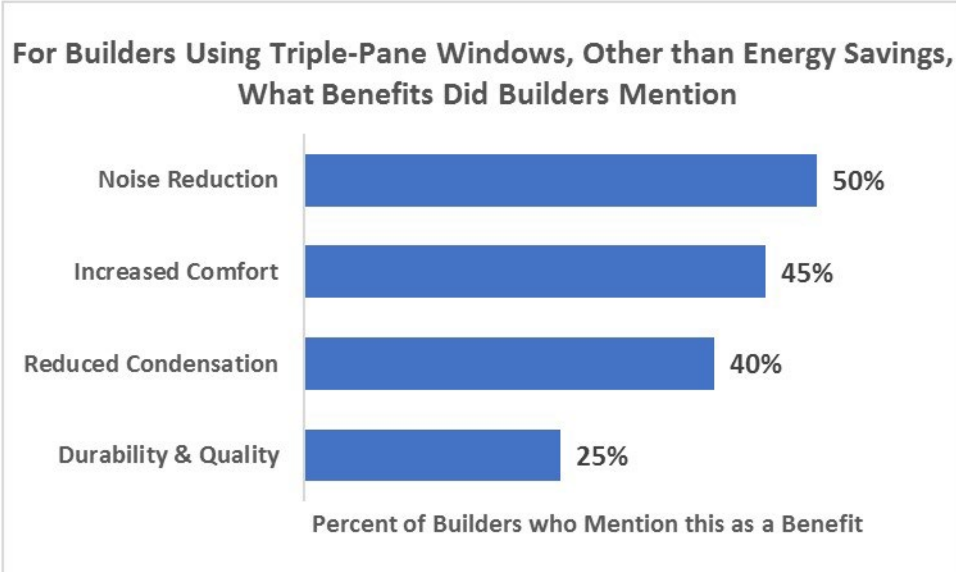


Figure 6. Benefits Builders Mention for Triple-Pane Windows (Gilbride et al. 2019).

Acoustic Control

In addition to the added thermal performance, the thin triple-pane windows demonstrated significant acoustic benefits, reducing sound infiltration by 8 dB to 10 dB in a side-by-side PNNL Lab Home study that measured dB sound infiltration through triple-panes in comparison to double panes (Hunt et al. 2021). An 8- to 10-decibel reduction is perceived as cutting the sound level in half.[1] In a 2019 survey of high-performance home builders, the most prevalent secondary reason that builders gave for using triple-pane windows was noise reduction (see Figure 6). Some builders mentioned homebuyers specifically asking for triple-pane windows for their sound-deadening effects. One builder who constructs urban infill homes commented, "We are building homes next to Boeing Field Airport in Seattle. Planes are flying right overhead, so close you can clearly see them from the houses, and it is so quiet inside you can't hear them" (Gilbride et al. 2019).

Comfort

Comfort was cited by many builders as a reason they installed triple-pane windows. Temperature-related comfort issues are a common source of homeowner complaints and call-backs in new construction. Even when there are no actual drafts caused by air leakage around the windows, home occupants sitting or standing next to a double- or single-pane window on a cold winter day may feel the sensation of a cold draft. This can be due to radiant heat flow from their body toward the cold window and/or due to convective heat flow near the window caused by temperature differences between the room air and the cold window surface. Many builders and homeowners have reported that they don't sense this cold air feeling near triple-pane windows. "You can stand in front of these [triple-pane] windows and not feel any difference in temperature

[1] It has been established that a 6 dB to 10 dB reduction in sound level generally results in an individual's perception of sound being reduced by half (Warren 1973).

from the center of the house," said one upper Midwest builder. A Colorado builder reported, "You can stand next to a triple-pane window on a 1-degree day in a t-shirt. It's too cold for that with a double-pane window," (Gilbride et al. 2019).

Condensation Control

A field study conducted by PNNL in Helena, Montana, in late winter compared the condensation and ice buildup on a window before and after replacement of the original double-pane, vinyl-framed window with thin triple-pane fiberglass-framed windows. As can be seen in Figure 7, condensation and ice buildup were completely eliminated after triple planes were installed (Gunderson et al. 2024).

Figure 7. Helena, MT, field study, March 2021. Left: double-pane, vinyl framed window shows condensation and ice buildup. Right: Same location after replacing double-pane with thin triple-pane fiberglass-framed window, shows zero condensation and ice buildup.

One Habitat for Humanity builder in Michigan said performance and condensation were the reasons his affiliate switched from double- to triple-pane windows. "We used to use double-pane windows but we would get so much condensation, we would literally see rotting of the wood sills and the drywall around the windows, as well as frost on the inside face of the windows and mold on the walls. Since we started installing triple-pane windows, there is zero condensation on the windows, even when it's zero degrees outside and high humidity inside," (Gilbride et al. 2019).

HVAC Impacts

Builders have commented that they can reduce HVAC sizes when they use triple- rather than double-pane windows. One builder noted that he can specify systems of less than 2 tons (<22,000 BTU) for homes up to 3,000 ft^2. Builders also commented that better windows allow them to shorten duct runs and have throws from interior walls or switch from central ducted systems to ductless minisplit systems (Gilbride et al. 2019). Two builders provided data on the impact that switching from double-pane to triple-pane windows had on their HVAC heating load (Table 6). Four homes in Michigan and five homes in Washington were modeled first with double-pane then with triple-pane windows. Heating load reductions of 6% to 17% were achieved by switching to triple-pane windows.

Table 6. Space heating design load reductions due to use of triple-pane instead of double-pane windows in homes built in Michigan and Washington State

House	Double-Pane		Triple-Pane		HVAC Heating Load Reduction
	U-Value	Btu Design Space Heating Load	U-Value	Btu Design Space Heating Load	
MI 1 (Springmont), 900 ft^2	0.31	15,937	0.21	14,942	6%
MI 2 (Denner/Trimble), 1,100 ft^2	0.32	13,191	0.21	12,309	6%
MI 3 (Cedar), 1,200 ft^2	0.32	13,401	0.21	12,435	7%
MI 4 (Gateway), 1,000 ft^2	0.44	22,209	0.21	18,357	17%
WA 1 (16^{th} Ave) 2,730 ft^2	0.27	16,600	0.20	14,400	13%
WA 2 (MLK) 1,057 ft^2	0.27	9,100	0.20	8,200	10%
WA 3 (33^{rd} Ave) 2,635 ft^2	0.27	17,700	0.20	15,900	10%
WA 4 (42^{nd} Ave) 2,595 ft^2	0.27	13,800	0.20	12,200	12%
WA 5 (Flora Ave) 2,646 ft^2	0.27	21,600	0.20	18,800	13%

Conclusion

Triple-pane windows provide an attractive tradeoff to other envelope measures for meeting today's higher performance criteria. Advances in thin glass technology have made feasible the high-volume production of thin-triple-pane IGUs. Thin-triple windows offer many of the advantages of traditional triple-pane windows, such as thermal performance, sound abatement, and condensation reduction, without the barriers of traditional triple-pane windows, such as width, weight, and installation challenges. Every large residential window manufacturer now has some version of a "lightweight" triple-pane product available in one or more product lines. At least one large IGU maker produces thin-triple IGUs. The product is now readily available. Will there be a leap in uptake?

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