

October 6, 2023

High Performance Windows: Market Characterization

Center for Energy & the Environment

Developed For

Center for Energy & the Environment
212 N. 3rd Ave. Suite 560
Minneapolis, MN 55401

Developed By

Cadeo Group
3506 N. Vancouver Ave.
Portland, OR 97227



Contributors

Dulane Moran, Jun Suzuki

Please refer questions to:

Dulane Moran, Cadeo

dmoran@cadeogroup.com

503.782.4331

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Executive Summary

In July 2022, Minnesota Department of Commerce approved a market transformation portfolio as proposed by Center for Energy and the Environment (CEE) and known as the Minnesota Efficient Technology Accelerator (ETA). This proposal included an initial portfolio of projects, including one focused on high-performance windows (HPWs).

Designed to increase the comfort and thermal performance of residential buildings in Minnesota, this initiative will encourage the installation of HPWs. HPWs include new “thin triple” residential windows and other products that provide a thermal transmittance (or U-factor) of 0.22 or less. As part of the HPW initiative development, CEE collaborated with other stakeholders involved in the national Partnership for Advanced Windows Solutions (PAWS) to update the ENERGY STAR® specification to Version 7, which will go into effect in October 2023. The Northern Climate Zone (NCZ) specification requires a U-factor of ≤ 0.22 and a solar heat gain coefficient (SHGC) rating of ≥ 0.17 , with tradeoffs for Equivalent Energy Performance (Table 1).¹ CEE’s initiative defines HPW as windows with a U-factor of ≤ 0.22 , aligning with the prescriptive path of Energy Star v7. ENERGY STAR Most Efficient (ESME) will continue to require a U-factor of 0.20 or lower.

Table 1: ENERGY STAR Specifications: Northern Climate Zone Requirements

Path	Version 6 (2016-2023)		Version 7 (Oct. 2023)	
	U-Factor	SHGC	U-Factor	SHGC
Prescriptive	≤ 0.27	Any	≤ 0.22	≥ 0.17
	$= 0.28$	≥ 0.32	$= 0.23$	≥ 0.35
Equivalent Energy Performance	$= 0.29$	≥ 0.37	$= 0.24$	
	≤ 0.30	≥ 0.42	$= 0.25$	≥ 0.40
	—	—	$= 0.26$	

To better understand the market, CEE contracted with Cadeo to investigate the perspectives of three potential sources of market influence: the supply chain responsible for ensuring quality products are available; the professionals involved in specifying windows for new homes; and the energy raters responsible for assessing overall envelope performance of new homes in Minnesota. This research is informed by 51 interviews across seven research tasks (Table 2).

¹ Thin triple windows are an emerging product that uses a thin third pane of glass and krypton instead of argon gas fill. These windows meet the performance criteria of ENERGY STAR V7 and deliver R-5 performance. However, the HPW initiative and the PAWS effort use a broader product description, acknowledging that there are likely to be products with different features that still meet the updated ENERGY STAR criteria.

Table 2: Research Tasks and Number of Interviews

Task	Interviewee Count
Manufacturer interviews	6
Vendor interviews	10
Mystery shopping interviews	20
Interview home energy raters	5
New home builder interviews	6
Multifamily architect interviews	4
Review existing window-focused market and energy efficiency literature	NA

1.1 Findings and Recommendations

This section presents the cross-cutting conclusions and recommendations that emerged from the research described in this report.

Finding #1: The ENERGY STAR Northern Climate Zone (NCZ) options for Equivalent Energy Performance complicate efforts to estimate U-factor from ENERGY STAR market share. Interviews indicate that the market does not see products meeting the equivalent energy performance criteria as unqualified, a potential challenge for CEE’s communication with manufacturers on the new specification. Manufacturers report using the equivalent energy performance solar heat gain coefficient (SHGC) tradeoffs in V6 and say they plan to do so in V7. Interviews with other types of market actors revealed no real discernment between prescriptive U-factor and products that qualify using the SHGC tradeoffs. We heard from multiple sources that a U-factor of 0.27–0.3 is common in Minnesota today. Products with a U-factor in this range could qualify for ENERGY STAR V6 if they are consistent with the equivalent energy performance criteria.

Most market contacts do not track SHGC specifically. Some manufacturers and architects working in multifamily construction noted that high SHGC values create risk of heat buildup in the summer, particularly for multi-story buildings.² However, the typical values available in the current window market (0.3–0.35) are not considered high and manufacturers expressed minimal concerns about the SHGC levels allowed by ENERGY STAR.³ Architects working in multifamily buildings report tracking the SHGC requirements in their designs; when they are concerned about heat buildup, they will search for a different window solution or ensure the cooling system is designed to mitigate potential discomfort.

² These concerns emerged in comments submitted as part of the ENERGY STAR V7 specification update as well.

³ ENERGY STAR V7 requires SHGC levels of 0.35 or higher for products over the prescriptive U-factor of 0.22. (Table 1)

Recommendation #1: If high SHGC values are a concern, consider developing strategies that would increase awareness of the importance of limiting solar heat gain for certain buildings or wall orientation.

Create training and marketing materials to communicate the potential impact of high SHGC in the summer through compelling messages that run during the warm summer months when consumers are experiencing heat and/or high air conditioning costs. Help the supply chain communicate this message so consumers are informed when interacting with window sales staff.

Finding #2: ENERGY STAR V6 products are considered standard practice in the retrofit market.

ENERGY STAR is an established and valuable consumer-facing label used by retailers, manufacturers, distributors, and installers to distinguish a given product line and encourage efficiency. National market studies have indicated that ENERGY STAR V6, which established performance requirements for the Northern Climate Zone (NCZ) in 2016, has had a market share above 80% since it was released.⁴ While there are always areas of uncertainty associated with characterizing local, regional, and national markets for large-volume commodity products, this project did not find evidence that Minnesota's window market is discernably different from the national market, particularly in the retrofit/replacement market.

Recommendation #2: Continue to support the ENERGY STAR brand and recognize manufacturers' efforts to meet the updated requirements of ENERGY STAR V7 through promotional and programmatic support.

Finding #3: The ENERGY STAR label is less important in the new construction market. ENERGY STAR is a consumer-facing product label. The designers, builders, and raters working in new construction are focused on specific product thresholds that will reduce risk. In new construction, risks include supplier capacity, warranty, meeting or exceeding code requirements, occupant comfort, and profitability. Sources indicated that builders focus on cost, code requirements, and durability. They also indicated that windows consistent with ENERGY STAR V6 performance are not uncommon. This is consistent with market transformation theory, which indicates that as an efficient product becomes standard it is adopted with no extra effort or intention on the part of market actors. This mechanism, coupled with a more streamlined and negotiated sales process, makes it difficult to estimate the true percentage of ENERGY STAR V6 products in the new construction market. While we know it is likely lower than the retrofit/replacement market, we do not have sufficient evidence to adjust national estimates of ~80%.

Recommendation #3: Develop strategies that communicate the value of the ENERGY STAR label to the ultimate home buyer and work with existing new home programs (utility, ENERGY STAR, Zero Energy Ready, Enterprise Green Communities) to encourage higher performance windows on program-qualified homes.

Builders are more likely to include a higher cost energy-efficient window product if home buyers value them. Builders need to avoid risk and require a value proposition that fits their business model. In the near term, addressing that value proposition will be easier for those producing high-end, sustainably built, program-affiliated, or custom homes than for high-volume production builders. As the supply of ENERGY STAR V7 certified windows increases and price premiums decrease, the new construction market will be more receptive. Code will always be a powerful lever for influencing new construction, and CEE should

⁴ As reported in Table 1 of the ENERGY STAR Version 7.0 Draft 1 Criteria Analysis Report.
https://energystar.gov/sites/default/files/asset/document/ES_Residential_WDS_Draft_1_Criteria_Analysis_Report.

monitor code developments for the opportunity to embed ENERGY STAR V7 windows as a code-compliance option.

Finding #4: Market segments will adopt V7 windows at different rates. The retrofit/replacement market is expected to adopt these products faster than new construction. Four of the seven interviewed window vendors reported some sales of windows with U-factor at or below 0.22. Manufacturers and those working in new construction report products at or below U-0.22 represent “single digit” sales.⁵ Interview data indicate that homeowners are more willing to invest in high-quality, efficient windows than builders, who are typically focused on meeting code and maximizing profitability per home by keeping costs low. The installers selling their services to homeowners reported almost no work in new construction. Efforts to understand the current market sales by U-factor in different market segments resulted in several specific takeaways:

- **The current sales for products meeting the prescriptive V7 value of U-0.22 are likely 5% or less.** Manufacturers and others in the supply chain interpret U-0.22 as triple pane products, although there are double pane products meeting the V7 criteria. Triple pane windows represent about 2% of window sales.⁶ Without a reliable source for estimating window sales by U-factor, we cannot definitively estimate the portion of all product sales that would meet the prescriptive requirements of ENERGY STAR V7. Products meeting the prescriptive U-0.22 value will be available after the updated specification takes effect in October 2023; however, these sales will start out low. It is not clear how quickly sales of products meeting the prescriptive ENERGY STAR V7 requirements will increase. Market stakeholders report that price will affect the rate of adoption.
- **The current sales for products meeting the V7 requirements are higher than the 0.22 estimates but likely below 10%.** It is important to note that V7 allows for U-factors up to 0.26 with SHGC tradeoffs, which allow for a slightly higher U-factor. We expect the market will respond to V7 requirements by increasing SHGC of U-0.23–0.26 windows, improving the performance of “standard” dual pane windows and expanding production of triple pane products. These efforts will expand the availability of V7 certified products but may not directly increase the availability of windows at or below U-0.22.
- **Awareness and understanding of the ENERGY STAR V7 requirements varies across the window market.** Manufacturers are universally aware of the updated specification and are strategizing about how they will adapt. Existing market research indicates that compliance with V7 will require changes to most existing window designs as manufacturers shift to triple paned products or modify double pane products to achieve higher performance. Distributor/installer awareness of V7 is lower and likely reflects their market niche and typical customer: some report detailed understanding, while others either do not track ENERGY STAR specification updates or wait for supplier information on new product lines and features. Those working in the new construction market (builders, raters, architects) are less attuned to the consumer-facing ENERGY STAR label generally and instead specify products informed by code requirements, vendor

⁵ Selkowitz estimates that less than 5% of 2022 sales would meet the V7 prescriptive requirement with a U-factor of 0.22 in the Northern Climate Zone. The installer research did not include an estimate of volume, so these results are not weighted and should be considered a maximum value.

⁶ Pacific Northwest National Laboratory. 2021. Evaluation of Thin Triple Pane Windows in the PNNL Lab Homes. <https://www.osti.gov/servlets/purl/1811300>

relationships, performance needs for a given building, and other features (color, style, operability). Performance needs can include SHGC for exposed south-facing walls or triple panes for noisy locations.

Recommendation #4: CEE should prepare for a long-term, multipronged effort to shift the market toward performance consistent with ENERGY STAR V7 generally and U-0.22 specifically.

For the retrofit/replacement market:

- Leverage the ENERGY STAR label in promoting windows that meet the prescriptive value of U-0.22 or lower. Additional work will be required to distinguish these products from otherwise qualified ENERGY STAR products using the equivalent energy performance tradeoffs. Program incentives, salesperson training and incentives, extra signage, website resources, and consumer marketing might all be needed to direct attention to the prescriptive U-factor value.
- Promote products that meet the prescriptive specification to reward manufacturers who certify these products with additional marketing that links this level of performance to quality that can stand up to extreme weather, provide energy savings, and increase comfort.

For the new construction market:

- Start with special cases like green building developments, passive house standards, or zero net energy demonstrations. Homeowners and developers in these scenarios are committed to high efficiency solutions and will protect envelope performance over other aspects of a building during value engineering.
- Track and participate in future code development efforts to identify strategies that incorporate high-performance windows as a building envelope feature that will improve overall energy performance analysis.
- Emphasize durability. Architects working on new multifamily buildings report that durability is a primary concern for their projects. Windows must withstand tenant behavior such as leaving them open in extreme weather that leads to failed latches and screens. Combining energy efficiency with durability provides value to both the tenant and owner.
- Emphasize elements that reduce risk to builders, such as pairing efficiency with improved warranties, confirmed availability, and durability, and features that will be more compelling to homebuyers than operational efficiency.

To support overall supply chain engagement:

- Identify the specific product lines that meet the performance qualifications CEE is looking for and ensure those products qualify for incentives or other program benefits.
- Consider adopting simplified nomenclature to facilitate consumer and supply chain discernment. Supply chain contacts used both U-factor and R-value in their discussions with interviewers, noting that R-value allowed them to compare window performance to wall performance.
- To ensure HPWs are part of the consumer choice architecture, CEE should develop and deliver curriculum for distributors and their affiliated installers to make sure they are informed about ENERGY STAR V7 products, can accurately describe them, and are equipped to promote them. This will also help build relationships and connections to the Minnesota supply chain.

Finding #5: The window industry is a busy commodity market experiencing upward pressure on costs and labor. Interviews and industry literature indicate that acquisitions, supply chain disruptions, and

shortages of skilled installers are all leading to a supply-constrained market with corresponding increases in prices for products and labor. High inflation and interest rates are also affecting construction financing and consumer and home buyer budgets. These financial pressures create little appetite for further increases in cost.

Recommendation #5: Support efforts to develop affordable HPW products.

- Work with manufacturers to identify and promote the lowest cost solutions that meet the performance criteria of CEE's HPW initiative.
- Identify subsidies, including tax credits and program incentives, to offset the cost differential associated with low U-factor windows and facilitate consumer access.
- Support ongoing innovation by partnering with labs, universities, and innovators by co-funding research, development, and demonstration projects.
- Help window customers navigate the process with pricing guidelines or project cost caps for incentives.

Finding #6: CEE will need to develop a stable strategy for tracking Minnesota window sales over the long term. Manufacturers do not have clear visibility into sales below distribution/retail. For example, they do not know the portion purchased by general contractors, unaffiliated installers, or homeowners (especially through big box sales). They are also not able to provide sales details at the state level. ENERGY STAR is updating the reporting portal and data submittal requirements, which should provide more detail on the characteristics of shipment data. However, these data are confidential and will not be available at the state level. This makes it imperative that CEE build relationships with local window distributors to obtain market intelligence sufficient to adjust national or regional sales estimates for the Minnesota window market. To obtain regional sales estimates, manufacturers specifically mentioned [Ducker](#) as the best source, even as they complained about the data limitations. Other sources include, [Frontier](#), [Farnsworth](#), and [Principia DemandBuilder](#) (which monitors the building materials market).

Recommendation#6: Review the cost, detail, and coverage of all four of these sources to determine which one will best support long-term market tracking.

Section 2 Introduction and Project Context

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This initiative will encourage the installation of HPWs to increase the comfort and thermal performance of residential buildings in Minnesota. HPWs include new “thin triple” residential windows and other products that provide a thermal transmittance (or U-factor) of 0.22 or less. CEE’s initiative will define HPWs as those with a U-factor equal to or below 0.22.

As part of this initiative development, CEE collaborated with other stakeholders involved in the national Partnership for Advanced Windows Solutions to update the ENERGY STAR® specification to Version 7, which will go into effect in October 2023. The Northern Climate Zone (NCZ) specification requires a U-factor of ≤ 0.22 and a solar heat gain coefficient (SHGC) rating of ≥ 0.17 , with tradeoffs for Equivalent Energy Performance (Table 2-1).⁷ ENERGY STAR Most Efficient (ESME) will require a U-factor of 0.20 or lower.

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In February 2023, CEE contracted with Cadeo to conduct a baseline market characterization to build on existing market intelligence by:

- Conducting in-depth interviews with vendors, designers, contractors, or others who may be involved in product selection for residential window replacement.
- Conducting in-depth interviews with builders to understand their considerations and how likely they are to see HPWs as a solution for code compliance or an attractive feature to home buyers.
- Surveying builders and residential architects to assess overall awareness of and experience with HPWs and inform baseline setting efforts.
- Assessing awareness of the upcoming ENERGY STAR specification update and if or how market actors intend to adapt their sales strategies to promote newly qualified products.

⁷ Thin triple windows are an emerging product that uses a thin third pane of glass and krypton instead of argon gas fill. These windows meet the performance criteria of ENERGY STAR V7 and deliver R-5 performance. However, the HPW initiative and the PAWS effort use a broader product description, acknowledging that there are likely to be products with different features that still meet the updated ENERGY STAR criteria.

- Investigating potential influence points in the path-to-purchase.

This market characterization is expected to inform CEE staff as they intervene in the market to leverage Minnesota's robust window production industry to create lasting market transformational change.

2.1 Literature Review/Market Description

As part of this project the Cadeo team reviewed previous technical and market research reports on the residential window market with a specific focus on understanding the status of low U-factor windows consistent with CEE's product definition (0.22 or lower). This section documents several features of the current and potential market for these products and provides context for the information obtained through primary data collection.

Market Status

ENERGY STAR V6 and V7 specifications both include equivalent energy performance tradeoffs between U-factor and SHGC for the NCZ, reflecting an assumption that higher SHGC allows passive solar heat gain that is beneficial in the NCZ in winter. These tradeoffs offer manufacturers flexible opportunities to meet the specification with a higher U-factor. However, in warm climates and during summer months, higher SHGC introduces risk of heat buildup that can be associated with discomfort and increased use of air conditioning.

The Environmental Protection Agency's (EPA) ENERGY STAR program periodically updates specifications for ENERGY STAR product categories, including residential windows. EPA published the current version (V6) in January 2014, with the NCZ prescriptive and equivalent energy performance criteria for windows taking effect in January 2016. The specification process relied on market tracking data prepared annually, which indicated the market share for ENERGY STAR residential windows has been above 80% since the updated specification was released in 2014.⁸ There is no currently available data source that reports market share by U-factor.

Against this backdrop of high market share for ENERGY STAR-qualified products, a coalition of industry and environmental groups participated in the process through which EPA established the V7 criteria. For the purposes of CEE's HPW initiative, the market share for V6 is less important than the baseline market share for windows meeting the updated specification. According to Steven Selkowitz (2023), there are products meeting both ENERGY STAR V7 prescriptive value (NCZ U-factor of 0.22) and ESME ($U \leq 0.20$) available on the market. This study notes that although ESME lists more than 50 suppliers offering thousands of products that meet this low U-factor requirement, these windows remain a "niche market" representing 2–3% of national sales.⁹ This is consistent with market share estimates of ESME products: less than 1% in new construction and 2.5% in retrofit and replacement.

Selkowitz reports that the most straightforward way to improve U-factor from 0.27 (ENERGY STAR V6) to 0.22 (ENERGY STAR V7) is to improve the insulating glass unit (IGU). These improvements can be made using a variety of strategies that could include changes to coatings, gas fill, shifting to triple pane products, or adjustments to the width of the IGU pocket. Cost increases associated with changes to

⁸ https://energystar.gov/sites/default/files/asset/document/ES_Residential_WDS_Draft1_CriteriaAnalysis.

⁹ Selkowitz, Steven. Study of High-Performance Windows Incremental Manufacturing Cost. Prepared for the Northwest Energy Efficiency Alliance. January 3, 2023. Report #E23-336.

manufacturing processes or upgraded components can result in higher prices for products meeting the U-0.22 threshold, at least in the short term. SHGC values, on the other hand, can be increased or decreased through relatively simple changes to glass coatings that have “modest, well-defined manufacturing cost differentials.”

Market Perspectives: ENERGY STAR V7 Specification

Cadeo staff reviewed the comments submitted as part of the updated ENERGY STAR specification process that drove the eventual ENERGY STAR V7 criteria. Over twenty organizations (including window and door manufacturers, regional energy efficiency organizations, utilities, and industry associations) submitted comments. Proponents of the updated specification argue that a U-0.22 criteria would create the opportunity for thin triple pane windows to gain market share, which would bring down the cost of these products.

Conversely, some partners did not see the need for a specification as stringent as the one proposed during the update process. Andersen Corporation, for example, claimed that the share of their products meeting the NCZ window criteria is lower than 80%. Other commenters expressed concern that consumers may not be willing to pay the cost associated with the increased NCZ window stringency adopted in V7. Other key concerns raised by partners included:

- **Economic climate.** Citing a rapid increase in inflation and ongoing supply chain shortages, some industry representatives cautioned against changing the specification now.
- **Unintended consequences for energy consumption and occupant comfort.** Commenters also argued that the minimum SHGC allowances could increase energy consumption and reduce occupant comfort. Because peak demand for many electric utilities in the NCZ are driven by summer peak cooling loads, SHGC equivalent energy performance tradeoffs could aggravate the demand for cooling as occupants adjust thermostats to achieve comfort in the summer. Some made the case to not establish a minimum SHGC in the NCZ and to instead leave it to the discretion of the builders/homeowners. Others argued that products with very low SHGC used in the NCZ would allow little heat in the winter months. Industry stakeholders argued that a SHGC lower than 0.23 would likely result in using glass or low-e coatings in some products that would result in lower visible transmittance.¹⁰
- **Increased cost and long payback periods.** Industry contacts argued that achieving a U-factor of 0.22 will effectively require triple pane solutions, which carry increased costs that consumers may resist.
- **Market readiness.** Industry commenters argued that thin triples, vacuum glazing, and aerogels are still emerging technologies, some of which are not commercially available or are available with limited capacity. The changes in the V7 criteria will also force manufacturers to redesign and retool clad/wood product offerings, which could take several years and substantial capital investment to accomplish.

A core issue that emerged is whether the updated ENERGY STAR V7 prescriptive threshold for the NCZ will require triple pane products. This is important because while triple pane IGUs are associated with excellent thermal performance, they can add cost, production time, and installation challenges associated

¹⁰ Selkowitz reports that low SHGC values (0.3) cannot be reduced much further without creating a darker view through lower light transmission glass. For this reason, he does not expect to see significant design changes to adjust SHGC.

with additional weight and sash upgrades. In an April 2023 article in *Window+Door Magazine*,¹¹ the authors note that industry comments on the specification reflected concerns about the aggressiveness of the draft criteria for ENERGY STAR V7 and speculation that triple pane IGUs may be required to meet the requirements.

However, this same article (and manufacturer interviews discussed in this report) indicates there are already dual pane IGU products that meet the equivalent energy performance requirements for the ENERGY STAR V7 NCZ. *Window+Door* notes that products meeting 0.26 U-value and ≥ 0.40 SHGC are technically equivalent to those hitting 0.22 U-value in the ENERGY STAR V7. This article referenced a case study that tested an existing double-hung, double pane vinyl window system had an overall product U-value of 0.24 and an SHGC of 0.49 (ENERGY STAR V7 eligible).¹²

2.2 Supply Chain Maps

Cadeo developed the following supply maps based on information from existing market research and supply chain interviews discussed in subsequent sections. Window manufacturers have three primary customers:

- 1 | Distributors or dealers that sell to general contractors, unaffiliated installers, and (occasionally) homeowners.
- 2 | Big box retail, builder supply, and lumberyards who sell to general contractors, unaffiliated installers, and (occasionally) homeowners.
- 3 | Builders, who will often negotiate pricing for large developments or national contracts. Builders also place orders through local distributors or dealers.

Figure 4-1 depicts the residential window supply chain for new construction. The new construction path is simpler than the diffuse replacement market.

¹¹ Ashraf Hussein, "ENERGY STAR 7.0, Making Intelligent Design Decisions," *Window + Door Magazine*, April 13, 2023, <https://www.windowanddoor.com/article/energy-star-70-making-intelligent-design-decisions> (accessed July 20, 2023).

¹² Note that this product would not technically meet the requirements of a product definition requiring U-0.22. <https://www.windowanddoor.com/article/energy-star-70-making-intelligent-design-decisions>

Figure 2–1: Window Supply Chain: New Construction

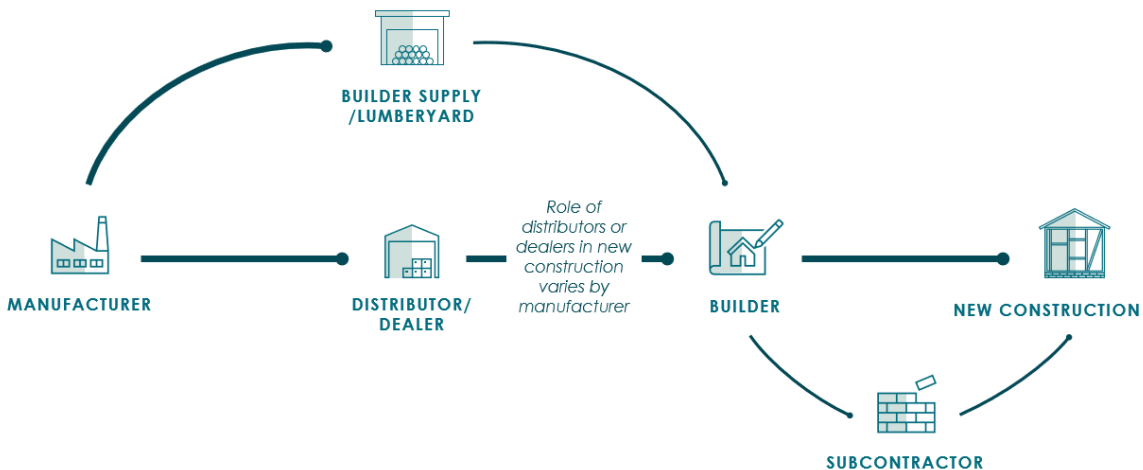
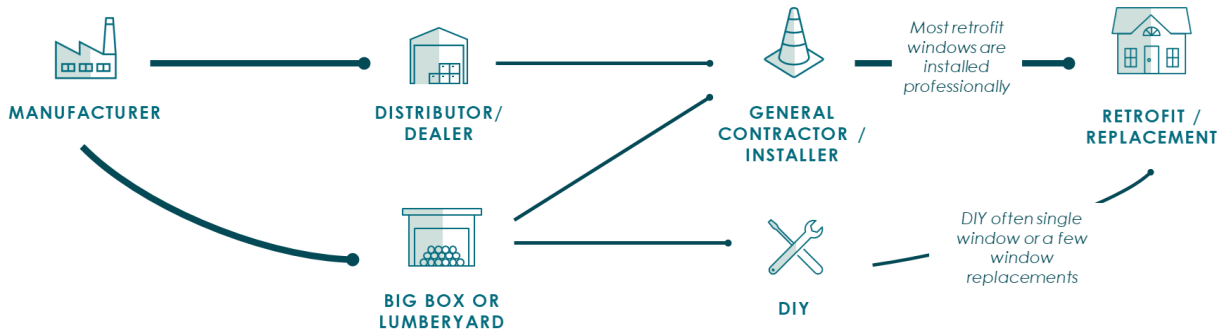


Figure 2–2 depicts the retrofit/replacement market. This market is more diffuse and includes specialized window installers who will estimate, order, and install windows. Homeowners may use a general contractor for window installation, particularly during remodeling projects. Most windows are professionally installed. Big box retail stores are likely to sell directly to homeowners, while distributors, lumberyards, and builder supply entities only occasionally sell to homeowners.

Figure 2–2: Window Supply Chain: Retrofit/Replacement



Section 3 Manufacturer Perspectives

Cadeo interviewed window manufacturers to better understand the dynamics of the residential window market and their perspectives on ENERGY STAR, and to inform market intervention strategies.

3.1 Approach and Disposition

Using sources listed in Window+Door magazine and contacts provided by NEEA and CEE staff, we developed a preliminary population frame of 60 organizations. Prior to launching data collection, the team reviewed each manufacturer on the list, flagging those with confirmed or likely sales in Minnesota as qualified. This process removed 36 manufacturers serving specific regions outside the Midwest, leaving 24 likely qualified organizations. Next, Cadeo developed an interview guide designed to explore manufacturers' sales in Minnesota as well as their distribution channels, experience with ENERGY STAR, expectations for the new ENERGY STAR specification, market trends, and how the new construction and retrofit markets differ. Outreach occurred in May and June of 2023.

Ultimately, Cadeo completed interviews with five manufacturers and a partial interview with a sixth. All six of these manufacturers reported selling windows into the Minnesota market. This section discusses the findings from these interviews.

3.2 Findings

Market Position

Estimating Sales by State or Region

None of the manufacturers could estimate the portion of their residential windows sold in Minnesota. Two contacts provided an estimate for the Midwest (one specifying that region includes 11 states), and both estimated ~20% of sales occur in this region, which is broadly consistent with the portion of the US population in these states.¹³ According to one manufacturer, *"this is a hard question to answer... I expect Minnesota sales would be a single digit percentage, but I don't have an exact estimate for Minnesota specifically."* Others noted that their products are sold throughout the country, sometimes under different brands, and sales are typically tracked by region and not by state.

Role of Distributors

Three manufacturers provided an estimate of the portion of sales flowing through distribution (as opposed to big box, direct-to-builders, and developers). These manufacturers estimated that 30–50% of their residential products flow through distribution with the rest largely sold through big box retail. The residential window market distribution channel includes distributors and lumberyards, and product lines can be designed and marketed for a specific channel. Most manufacturers described a national distribution system that supplies contractors and builders through manufacturer-affiliated distribution or retail. Only one manufacturer sold directly to homeowners through special dealers and a specific consumer-facing brand.

¹³ The Census Bureau's definition of the Midwest includes 12 states: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

None of the manufacturers could estimate the portion of their products sold to general contractors or unaffiliated installers, noting that this occurs through a lumberyard, distributor, or big box retailer. They do not have visibility into the characteristics of purchasers for those organizations.

New Construction

Three manufacturers provided an estimate of the portion of their residential sales associated with new construction. All three described a relatively even split between new construction and retrofit (60/40, 55/45, 40/60) that fluctuates somewhat depending on economic conditions. Several noted that demand increased in new construction recently after being weighted toward retrofit during the COVID-19 pandemic.

- *"The mix depends on the economy. There was a bit of a bump in new construction that is slowing down now. It's 60/40 new to retrofit but goes back and forth. During the pandemic, there were lots of retrofit jobs. Now shifted towards new construction."*
- *"For us, 60/40 retrofit to new construction...that's a nationwide average. The economy varies a bit from location to location. It fluctuates."*
- *"We have data that shows where each product line goes into each market. Things change. It's 55/45 new construction to retrofit right now."*

Manufacturers may have a builder-grade line that is targeted at the new construction market and a separate product line for retrofit projects, or they may offer the same product lines with a different path to market. One manufacturer noted that there is no real difference between their builder grade and premium grade products in performance, but there could be design differences, *"if you want ENERGY STAR or high wind load, those are pretty standard."* According to several manufacturers, builder/developers order products by packages and home, one noting *"even national home builders do it this way, small customizations happen on individual homes... there may be a walk out basement or a laundry room added to a second floor."* Manufacturers provided mixed responses on bulk ordering in the new construction market. One stated that new construction windows are not bulk purchased, they are ordered as needed project by project, while another noted that some national builders will bulk order. Builders typically select and price their products ahead of time through a pricing contract—although small customizations occur.

Manufacturers reported that builders are focused on cost—both the cost of the product and the cost of the construction financing. Increased interest rates have affected builders' construction loans and the high cost of financing is causing a sacrifice in efficiency.

- *"The high cost of money associated with interest rates is causing a sacrifice in efficiency [in new construction]. This is a market we are looking at moving some of our high efficiency products through, shifting from distribution to direct-to-builder. We are working with NEEA and PAWS to engage larger builders and incorporate our products into their designs. The builders have to sell the upgrade to their customers."*
- *"New construction is strictly cost based. The challenge is to find the cheapest code-compliant window. It is entirely driven by code and cost. [In places with performance codes] it's changed the conversation a little—they can make tradeoffs with software. Instead of the cheapest window, they will talk about the cheapest way to hit the performance requirements in the code."*
- *"New construction is generally more standardized with a streamlined path to market...production builders will be looking for standardized sizing and standard products."*

Retrofit and Replacement

In the retrofit and replacement markets, most products are custom ordered or “special sized” as one manufacturer framed it, noting that “custom” implies a special shape. To match the existing openings and accommodate the settling that can occur in older homes, accurate measurements are recommended and used to order replacement windows. Manufacturers could not provide specific estimates of the portion that are custom vs. standard sizes, noting that the standard sizes are often available in big box stores.

- *“In the replacement market, a significant portion are custom sized. These homes have been built for decades and the rough openings are set.”*

Another manufacturer described the path-to-purchase process in retrofit scenarios.

- *“It’s really driven by who is making the decision. In retrofit, it’s the homeowner. When a homeowner makes the decision a bunch of things come up: operability, efficiency, there are lots of things folks want. But they are driven by contractor recommendations. The window seller is trying to get the job and will undercut bids to get the work. There are more sophisticated dealers that want a certain return/margin. They will try to maximize price, promote a brand, promote installation practices... they may talk about efficiency.”*

We sought to understand the prevalence of stocked products and the scenarios in which windows are stocked. Manufacturers’ perspective on this varied a bit, driven by their go-to-market strategy and their relationship with big box retail.

- *“Lumberyards will have a few stocked. Even through COVID, when lead times drastically extended, windows were still custom ordered, with just a few stocked. It’s not just size, it’s also the other features (operability, frame material).”*
- *“New construction is all standard sized if you are smart. Retrofit is almost all custom. Home Depot may have standard sizes that get shoved in sometimes... these jobs can get mangled. They are not energy efficient; they are going to leak.”*

Efficient Sales

We sought to understand manufacturer perspectives on the ratio of sales at different efficiency levels, asking first about estimated sales at or over the U-factor of 0.27. Manufacturers interpreted products at or over 0.27 as qualifying for ENERGY STAR V6 and discussed their estimates of sales qualified for V6 in 2022 (the most recent year). Two estimated that 90% of their sales are ENERGY STAR V6 qualified, one provided an estimate of 80%–90%, and two provided lower estimates of 60% and 66%.

- *“These are pretty standard right now. You can buy a builder-grade ENERGY STAR product. 80-90% of the products we manufacture are ENERGY STAR certified.”*
- *“A 0.27 U-factor is basically ENERGY STAR V6 qualified. We estimate that two thirds (66%) of our products would have met V6. That doesn’t mean customers were choosing that configuration because they wanted to meet ENERGY STAR. We have a wide range of products at a wide range of price points. People are choosing a product; they aren’t really focused on ENERGY STAR.”*

We then asked manufacturers about the portion of their product sales with a U-factor at or below 0.22. Contacts noted that this generally implied triple pane or ENERGY STAR Most Efficient (ESME) qualified products (ESME requires 0.20, not 0.22). Manufacturers estimated that these products are a very small

portion of their total sales, describing “single digits.” One contact noted this could be up to 20% of the retrofit market.

- *“ESME is a very small percentage of products sold. We spend a lot of time with other manufacturers, at code and standard development. This is a commodity market; we are in the same boat. We’d like to see ESME be more effective but it’s a tough sell. Less than 2% of sales.”*
- *“For us this means triple paned. Thinking about NFRC certification, the dual pane with coatings available industry wide can get you down to 0.24 or 0.25. Triple panes require 50% more glass and are substantially more expensive. NFRC certification is testing the whole window performance, not just glass. With dual pane you can really only get to 0.24.”*

Most Efficient Window Product

When asked about their most efficient window products, manufacturers universally described triple pane window products, particularly on casement or fixed windows, with low-e coatings. These products are considered specialty and are typically ordered when a customer wants top-of-the-line efficiency. One manufacturer claimed these products could achieve a U-factor in the “mid-teens,” while another reported these products would achieve U-0.22 or 0.20, depending on the glass package. Another took the opportunity to advocate a shift from U-factor to R-Value, noting *“we are too anal about this language... it’s a shame we’ve settled on U-factor when R-value is in the insulation aisle. With windows we have complicated things. What has helped is big box stores focusing on ENERGY STAR, because it’s a label that is easy to see.”*

ENERGY STAR: Version 6

We followed up with questions about the portion of current sales that meet the current (ENERGY STAR V6) certification. Of the five manufacturers providing an estimate, three estimated that 80%–90% of their national sales are ENERGY STAR and agreed that market estimates of 80% or higher for ENERGY STAR V6 products are accurate. One of these contacts noted that replacement products will almost always be ENERGY STAR, but this is not true for new construction. According to him, new construction will be driven by code. In California the code exceeded ENERGY STAR, making the label irrelevant there.

- *“ENERGY STAR is pretty standard right now. You can buy builder-grade ENERGY STAR products. 80-90% of the products we manufacture are ENERGY STAR certified.”*

Two manufacturers provided lower estimates—in the 60% range—and discussed the EPA ENERGY STAR estimate based primarily on DuckerFrontier reporting. One contact with a lower estimate explained that about half their sales flow through big box stores, which are not known for promoting high performance windows.

- *“Ducker is the best source of information on the national window market. We (and other privately held window companies) will not share sales data to protect competitive position, which makes it hard to disprove or update estimates.”*
- *“Those numbers are likely higher than we would expect in the overall market given the number of variables. Data submissions for shipments will be more detailed in next year’s report...In defense of the window industry, it’s complex getting granular numbers. The variables are hard to track. A product maybe could have met ENERGY STAR but had a feature that didn’t qualify (combination assemblies, special orders, granular manufacturing decisions).”*

ENERGY STAR V7

Manufacturer expectations for ENERGY STAR V7 revealed two main perspectives: a “wait and see” approach and “cautious optimism.”

Wait and See. Smaller manufacturers, or those without existing products likely to qualify, are likely to observe how the larger market adjusts before committing to production or glass fabrication changes that might be required to commit to ENERGY STAR. These manufacturers will want to see that there is sufficient demand to justify the investment.

“The new spec will make these products expensive. Unless there are utility rebates and tax credits to offset costs, sales will be slow.”

Cautious Optimism. Contacts in this camp report they either have products that will meet the updated specification or are very close. These companies report looking at different glass combinations, coatings, and promoting different frame types (one contact noted that aluminum windows will struggle to meet the specification, but thermally broken composite windows should work). Manufacturers did not provide details of updated product plans or manufacturing changes. Residential windows are a highly competitive commodity market with suppliers that serve the entire industry. As one noted “...we are all working on this. We have similar products and suppliers. It’s easy for us to all ramp up together.”

“Sales reps are nervous. Homeowners understand energy efficiency and they know ENERGY STAR. We are so close on this (new) spec, we are looking at different glass combinations.”

Despite the uncertainty in pricing and demand for products meeting the new specification, manufacturers projected confidence that the market would adapt. One contact described having several years to prepare for this change, time his firm used to look at new coatings, glass packages, and glazing and framing options. “There will be a drop [in ENERGY STAR qualified products]” according to one manufacturer, “but ENERGY STAR isn’t code... it was not designed to be 80% of the market like it is today.”

When asked about production changes or plans their companies have made to adapt to the new specification, five of the six manufacturers answering this question¹⁴ reported that they are either making changes in marketing, manufacturing, or product development or have plans to. Those making plans to change production or marketing noted that they had products that could meet the specification with the SHGC equivalent energy performance tradeoff.

- “We will be making tradeoffs on SHGC, a thicker glass package can get you there without overall design change.”
- “We have been doing a lot of training and marketing. We are proud of this. The SHGC tradeoffs are good if the home is properly designed. There were similar tradeoffs in Version 6. In Minnesota, cities get very hot in the summer, but the solar heat gain helps in the winter. Because the sun is lower on the horizon in winter, you can design for summer with awnings, trees, and overhangs.”
- “We have dual pane solutions with coatings that could meet the requirements. We have triple pane. That is the direction the market is going...we are working on that.”
- “It depends on the brand, where you are geographically. To get to performance values showing up in some codes we already have products that meet the updated Northern Climate Zone spec.”

¹⁴ Including the partial complete interview, a smaller manufacturer with less investment in the residential market.

We also asked manufacturers what they thought would help encourage adoption of ENERGY STAR V7 windows. Contacts universally mentioned rebates and utility incentives. Several also mentioned tax credits, citing their experience with Obama-era tax credits that pushed their competitors to develop products with U-factors they were already meeting. Two contacts expressed skepticism that the tax credits as currently designed would affect the market, noting they applied to ESME products only and require a U-factor of 0.20.

- *"Tax credits, utility incentives, policy/code—those are things that can drive the market. Glass is glass, you have to require it by code or drive market conditions so consumers want energy efficiency."*

We asked manufacturers about how they currently promote low U-factor window products and about their plans to increase availability of triple pane windows, including "thin triples." They described developing specialized marketing to target net zero demonstration homes, emphasizing energy savings, emphasizing comfort, and leveraging tax credits, utility incentives or other policies. One contact noted that they regularly customized marketing to address local concerns such as wind impact resistance for homes near the Gulf of Mexico, acoustic performance near highways, and security performance/riot proofing for some building types. According to him, *"the market can meet expectations and the requirements of any customer."*

Manufacturers described the thin triples as less than 1% of the current market, noting that it is expensive to incorporate three pieces of glass in a facility or production line designed for two, *"if the market is there, we will do it. We won't think twice about it."* Two additional contacts mentioned issues with the fact that the center glass is not tempered, which limits use in "hazardous" locations (near doors, close to floors, bathrooms) where falls are possible. Manufacturer contacts reported having other strategies that can get the industry closer to R5 or even R10 windows (0.20 and 0.10 U-value equivalent, respectively).

Market Conditions and Expectations

Manufacturers report that the supply chain challenges that slowed product delivery during the pandemic are easing, particularly those associated with glass supply. Krypton, a core component of several strategies for improved window performance, is no longer perceived as practical. Prices for Krypton skyrocketed during the pandemic, reflecting supply shortages and increased demand. According to one manufacturer, prices increased by 7,000% in recent years. The price of Krypton has declined; however, manufacturers remain wary of exposing themselves to a market with demonstrated volatility.

Manufacturers expect that the future will bring more automation and a continued push toward efficient production and energy-efficient products. One contact speculated that the market is transitioning from dual pane to triple, and this will require 50% more glass from existing glass suppliers. Another contact expects that dynamic glazing will likely become more popular and that if the Krypton supply stabilizes his company might incorporate that. He also expects the market will move further toward triple glazing.

Section 4 Vendor Perspectives

This section discusses the results of interviews with ten window vendors and mystery shopping calls with the same population.

4.1 Approach and Disposition

To understand the sales strategies around HPWs, the Cadeo team conducted interviews with window vendors (i.e., installation and distribution companies) in Minnesota. We used a Cadeo-developed population frame (sample frame equivalent), built from sources including the Blue Book, Yellow Book, manual internet searches, and CEE referrals. This list contained 246 records and included distributors, lumberyards, big box stores, installers, and specialty retailers.

We designed an interview guide to:

- Assess their window sales and business strategies.
- Understand the sales of ENERGY STAR windows.
- Understand awareness and impact of ENERGY STAR V7 specifications.
- Understand barriers and opportunities for HPW.
- Understand window product sales prospects.

We offered a \$100 incentive to complete interviews. In May and June 2023, we made 2 to 3 attempts via email and phone, and we completed interviews with ten eligible companies. We determined ineligible contacts comprised nearly 40% of the sample frame, meaning they did not sell or install residential windows, or their contact information was invalid. Table 4–1 summarizes the call disposition. The total response rate was 7% (completes divided by known and unknown eligibility, 10/ (68+65)).

Table 4–1. Vendor Call Disposition

Disposition	Count	Percent
Complete	10	4%
Refusal and break-off	68	28%
Non-contact (left voice mail, emailed invite, not reached)	65	26%
List Errors		
Missing contact information	1	0%
Bad or wrong number	39	16%
Didn't pass screening	63	26%
Total	246	100%

We used screening questions to categorize respondents into three main roles: installer, distributor, or retailer. We found that the vendor contact roles were not mutually exclusive, as most contacts fit into

multiple categories. Table 4–2 displays the overlap in experience, with many respondents selling and installing windows.

Table 4–2. Substantial Overlap in Respondent Roles (n=10)

Role	Count	Portion Reporting Role
Installer (installs windows)	9	90%
Distributor (sells to other professionals)	4	40%
Retailer (sells directly to customers)	9*	90%

**Six of the nine retailers had a showroom where customers can see and touch window products prior to purchasing them.*

4.2 Findings

These vendor contacts reported their customers include homeowners, renters, general contractors, and developers. Nine of the ten reported that they installed windows in single-family homes in Minnesota, but only one worked on multifamily apartment projects. The others reported working in duplexes, fourplexes, and condos, or “anything that fits the residential code.”

Vendor responses indicate a split in the market between new construction and replacement projects. Half of these contacts reported they do not install windows in new homes. Among those working in new construction, three reported approximately 10% of their projects, one reported 30%, and one reported 85% of their respective projects occur in new homes. We asked those working in both markets if the products installed in new construction differ from those installed in replacement projects. Two of the five contacts working in both markets indicated the quality of windows in new construction is lower than retrofit or replacement, with the remaining three indicating the products are the same but that retrofit projects require windows be custom made to fit existing openings and match existing windows.

Nine of the ten vendors reported that all windows for their retrofit projects are custom sized and ordered, indicating that “nothing is stocked.” The one contact reporting less than 100% indicated that 90% of his windows for retrofit are custom ordered.

Business Practices

Most of the interviewed vendors (6 of 10) reported having a showroom. Those without showrooms will take samples to customers or custom order and deliver windows selected by their customers.

- *“We basically tell people ‘we can get you any window you want.’ That’s why we don’t have a showroom. If they want to see the window, we send them to a manufacturer’s showroom.”*

Nine of the ten vendors reported sourcing windows from multiple manufacturers, reporting that they normally select a few manufacturers and stick with them. They will choose a product based on the design and features a customer wants and the estimated delivery date. Vendors indicated that supply chain issues had improved, noting that while lead times remained extended compared to the pre-COVID market, they had not returned to “normal.”

Five of the ten vendors reported they do not operate with sales incentives or commissions. Three earn commissions and one reported their organization offered sales incentives. One contact noted that

because of the dearth of qualified contractors, installers can “pick their jobs” and will prioritize larger, whole-house projects over smaller jobs of three to five windows.

Vendors offered several factors that drive up the cost of window products, including inflation and increased materials and shipping costs, installation challenges, features (options, colors, glass selected), lack of supply, and damage in shipping.

Characterization of Typical Windows

We asked vendors to describe the most energy-efficient windows they sell. Several contacts hesitated, stating they were not entirely sure before explaining they sold windows that will meet the ENERGY STAR V7 requirements, carried windows with a U-factor of 0.18, and that their product lines included options that “go below 0.2.” Others listed specific brands and occasionally product lines, including Simonton, Marvin Modern, or Signature, Great Lakes ecoSmart, and “Andersen, Marvin, or Pella.” According to one vendor, “Triple pane Krypton are the best, but not the best value for the money. I recommend triple pane with Argon.”

Seven of the 10 interviewed vendors provided estimates of their window sales over the past two years by U-factor. We asked them to estimate their sales over U-0.27 and below U-0.22. The results are displayed in Table 4–3.¹⁵ The results reflect the different market niches served by different vendors. Given the small sample size, these data should be interpreted cautiously, providing qualitative and directional information and not a representative sample of the entire window market in Minnesota.

Table 4–3: Reported Sales by U-factor Bin

Vendor	At or below 0.22	0.22-0.26	Over 0.27
#1	0%	10%	90%
#2	30%	60%	10%
#3	0%	50%	50%
#4	25%	—	—
#5	0%	40%	60%
#6	20%	80%	0%
#7	40%	60%	0%

* Vendor #4 did not provide clear responses to estimate the full distribution.

Perspectives on ENERGY STAR

Vendors reported a variety of approaches to leveraging the ENERGY STAR brand, with five reporting they recommend it (including two noting that they recommend to all customers), and an additional contact

¹⁵ The team removed unclear responses, “don’t knows,” and one installer reporting that virtually all of his windows had a U-factor of 0.22 or lower. It is important to note that these respondents all installed custom windows, primarily in existing homes. These results do not characterize sales through big box stores nor are they weighted to reflect volume.

reporting ENERGY STAR is considered standard now. Three contacts stated they do not push ENERGY STAR, instead focusing on getting their customers whatever window they want.

- *[ENERGY STAR windows are] "the only windows that we sell, and we don't give them an option to buy something that is not ENERGY STAR."*
- *"We just tell customers it's ENERGY STAR rated. People like to hear that."*

We asked window vendors to estimate the portion of their overall window sales last year that were ENERGY STAR certified (V6, current specification as of June 2023). Three were unable to estimate. Of the seven contacts providing an estimate, four reported that 100% of their sales were ENERGY STAR, two reported that 90% of their sales were ENERGY STAR, and one reported 80%. The seven contacts providing an estimate of ENERGY STAR sales confirmed that all these products met the NCZ specification.

Eight of the 10 vendors confirmed that their experience in the Minnesota market is consistent with estimates of 80% ENERGY STAR market share. Several added comments to their response:

- *"[80%] is close. I'm at 100% and that's probably skewed because I won't install cheap crap."*
- *"I don't know the last time I've seen a window that doesn't have an ENERGY STAR label. I don't know if you can even sell that in Minnesota."*

Installers provided mixed opinions on the importance of SHGC, with four reporting they do not sell windows that have an SHGC higher than 0.35 and six reporting they do not really track solar heat gain specifically:

- *"I have no idea. I would have to look at the specifications. SHGC is not super important."*
- *"Most are around that 0.34. SHGC is somewhat important, but it doesn't drive sales."*

ENERGY STAR V7

Only four of the 10 vendors reported that they were aware of the new ENERGY STAR V7 specification. When asked how the market might adjust to the new specification, installers/distributors indicated that they follow the manufacturers and glass suppliers, noting that customers will continue to gravitate to the ENERGY STAR brand, but the additional cost might affect sales.

- *"We will adjust accordingly in Minnesota. The manufacturers know what needs to be done and they pass it along to vendors and customers."*
- *"It all depends on the glass manufacturers. It's forcing the industry to [supply] more efficient glass."*
- *"It will be hard to get people to buy triple pane windows if they don't want to spend extra money."*
- *"This is a cost-relative requirement. Most builders are doing builder grade windows, they won't go for higher costs. High-end builders, they'll do anything."*

When asked what will prevent the sales or installation of ENERGY STAR V7 certified windows, vendors overwhelmingly reported that the price will push customers to make different choices.

Five vendors suggested that tax credits, rebates, and favorable financing could encourage the purchase of ENERGY STAR V7 windows. The other five focused on the need for better education and marketing to consumers, sales training, and efforts that promote long-term energy cost savings.

Window Market Expectations

Vendors provided mixed opinions about how the window market might change over the next 5 to 10 years. Three contacts reported that window efficiency will continue to improve as manufacturers scramble

to meet the ENERGY STAR V7 requirements. Three mentioned concerns about price, noting that price per unit will increase (both because of material cost and inflation). Several discussed concerns about manufacturing—noting that manufacturing could move overseas, and that manufacturing quality has declined. A few took the opportunity to complain about ENERGY STAR and about pricing:

- *“If ENERGY STAR is in control, then in 5 to 10 years we will have a window with a U-value of .001, which is impossible.”*
- *“The price is already ridiculous, and I hope it won’t get any higher because it is stupidly high. I’ve been doing this for 45 years and it’s really been a challenge knowing my price these days.”*

4.3 Mystery Shopping

This section presents the results of mystery shopping calls conducted in May and June 2023.

Approach and Disposition

To understand how the supply chain interacts with potential window purchasers, the Cadeo team conducted mystery shopping interviews with organizations that sell and/or install residential windows.

We designed the mystery shopping task and phone script to:

- Assess awareness and availability of High Performance Windows.
- Understand how high-performance, low U-factor windows are positioned relative to “standard” products.
- Understand the positioning of the ENERGY STAR brand.
- Document product recommendations, including scenarios in which contacts might recommend high-performance products generally.

We used the same population frame developed for the installers and distributors interviews (see Section 4.1). Mystery shoppers spoke with 26 contacts, six of whom provided limited information. We also used these calls to prescreen the population frame, knowing that the initial list likely included a substantial number of unqualified firms. The disposition “did not pass screening” (in Table 4–1. Vendor Call Disposition includes unqualified firms identified during the mystery shopping calls.

Completing the mystery shopping calls was more challenging than expected—the callers made 88 calls to 67 firms. The low cooperation rate reflects the high demand for residential contracting and the multi-stepped purchase process typically required for windows. This multi-stepped process often involves an estimator or installer coming to a home, observing existing conditions, taking measurements, and resolving job details prior to providing pricing.

Purchaser Scenarios

To guide the conversations, the research team developed two purchaser scenarios: (1) a “standard” purchaser wanting to decrease noise, increase comfort, and save on energy bills, and (2) a more “environmental” purchaser willing to spend more to achieve a high level of window performance and home efficiency. Because of challenges reaching contacts with basic questions, we completed more “standard” than “environmental” purchaser scenario calls. Ultimately, we completed 16 “standard” purchaser calls and four “environmental” purchaser calls.

Cross-Cutting Topics

Of the 20 contacts completing a call with our mystery shopper and answering most of the questions, three reported they sell windows to homeowners and do not provide installation. Sixteen will both sell and install in a customized package for homeowners. One contact indicated he worked for a manufacturer but remained helpful and answered most of the questions.

The contact list included lumberyard and retail contacts that sell building supplies but do not install. These contacts offered to provide referrals or encouraged the caller to find a reputable installer to help complete their project. It was common for contacts to provide general information and then refer the caller to a specific person for more detailed information.¹⁶

Contacts sought to be both knowledgeable and helpful, sharing information and acknowledging some of the pricing issues.

- *"The dirty little secret in the window industry is that two companies (PPG and Cardinal) manufacture all the glass and it's all very similar. They make the glass that Marvin, Pella, and all the others buy. If someone wants you to focus on the glass, they are hiding their installation method and the material surrounding the window. There are a lot of other factors that go into window replacement. Glass is just one portion."*

Scenario 1: Standard Consumer

"It's all about the U-factor, but all of them are very similar. Pella is right up there with the top. If you go to Menard's and get them off the shelf you have to customize yourself vs. nicer windows that come straight to you custom for your home. You get what you pay for. Pella and Andersen are the best."

The standard persona sought to reduce road noise and drafts and lower heating bills, asking each contact to recommend a window product that would meet their needs. Contact recommendations included both specific types and styles as well as specific brands or products.

Type or style recommendations included recommending the purchaser obtain double or triple pane windows, and included products with specific noise reduction features, for example Sunrise Windows Noise Reduction Glass (NRG) or Marvin's "STC" glass. "STC" glass refers to sound transmission class and is not typically used as a branding term.¹⁷ Three contacts specifically recommended

the purchaser consider triple pane windows for noise reduction; however, others explained that double pane windows with thicker exterior and thinner interior outperform triple panes. Several respondents offered more generic recommendations noting that all their windows are efficient and rated for noise. Representative comments included:

- *"Marvin's STC [provides] two panes of glass of different sizes that break up the sound waves. If you have an older home, the insulation around the glass is not great—there are likely holes around the insulation. We do a full frame replacement, then get a window custom fit and insulate around the windows. Our competitors will push you into an insert window. Are you going to do siding? Because*

¹⁶ Note that in early 2022, the team completed a similar task for NEEA and consistently heard spontaneous comments about product delays and limited availability related to a global glass shortage. We did not hear about these shortages during this round of mystery shopping, indicating that the supply chain disruptions associated with Covid-19 may be dissipating.

¹⁷ The research team was not able to confirm if this is how Marvin refers to window products with specific noise reduction performance.

siding is a huge portion of the sound noise reduction...windows themselves are a big portion of the walls."

- *"I'd recommend storm windows, but Menards won't sell those anymore. They stopped selling storm windows last year. Menards only sells double pane, none of their products have different sound dampening."*
- *"I'd recommend triple pane and ProVia product lines. The energy and sound reduction are fantastic, and it has a wood interior."¹⁸*
- *"When it comes to sound reduction, it's not the window it's the installation. There are two ways to replace windows: there is a full replacement and a pocket replacement. You want full replacement—make sure no one quotes you on a pocket replacement."*

Brand recommendations typically centered on the brand of windows carried by the firm, although contacts often sought to differentiate themselves somehow from other brands. Andersen, Pella, Marvin, and Hayfield all emerged in multiple responses.

- *"I might suggest Andersen 400 series, and Marvin. These are good brands."*
- *"We strictly sell Pella windows. They have a great warranty. I'd say triple pane (for noise) but those are becoming less popular. Double panes are just as good these days. I'm not a salesperson though...go to the showroom if you want the super expert opinion. You know Andersen and Kolbe. But they aren't the cheapest."*
- *"For sound I recommend double pane glass and solid wood. Vinyl windows and Andersen have hollow frames. For sound you need solid wood."*

Mystery shoppers then probed for additional information on window product costs. Respondents typically provided a cost range, sometimes with a list of variables that would affect pricing. Several would not speculate, noting that an estimator would need to visit the home and provide a bid that reflected the job.

Contacts noted that price is dependent on several factors: the glass, framing and operability options, size, and any additional customization (for example, shape or color). One noted that Andersen 400 is mid-price point, another reported using Gerkin windows for 95% of projects and using Marvin and Andersen to match other windows if necessary.

Scenario 2: Environmental Consumer

The environmental persona asked similar questions but emphasized a motivation to purchase a "really efficient window." In this scenario the purchaser directly linked the window purchase to their aspiration to "make my house as energy efficient as possible." This persona asked for recommendations for the best, most efficient window.

When this purchaser asked about the most efficient, highest quality products, three contacts mentioned vinyl windows, with one noting they had "come a long way." Contacts also mentioned different brands, noting that a vinyl window is \$500–\$600, Pella or Marvin are \$1,200–\$1,500, and that Andersen is an option. Two contacts specifically mentioned triple paned windows, noting they are best for efficiency but cost more. Vendors suggested multiple brands, noting that the efficiency of the major brands is about the same.

¹⁸ According to ProVia's website, more than 90% of their windows are ENERGY STAR certified as of June 2023.

In subsequent questions about how well a product will lower heating bills, vendors again mentioned triple pane windows, adding in additional information about Krypton versus Argon gas, coatings, R-value, and U-value. Vendors offered mixed opinions on the value of premium windows (including triple panes). When pressed to make a recommendation based on efficiency, sellers hesitated to push for a more efficient product given the cost premium. More typically, vendors highlighted performance, comfort, reduced condensation, and noise reduction.

ENERGY STAR

Both personas asked vendors about ENERGY STAR and if they would recommend windows that are ENERGY STAR certified. We found broad awareness of the label but mixed opinions on the value. Among the 15 who provided opinions to mystery shoppers about ENERGY STAR, nine described ENERGY STAR as standard, noting “most windows match their system anyway” and encouraging the shopper with phrases like “as long as you go ENERGY STAR, you’ll get what you need.” Two respondents downplayed the label, claiming to not sell ENERGY STAR windows or noting that the “upgrades are not worth” the cost. Four contacts provided neutral responses, simply indicating ENERGY STAR was available.

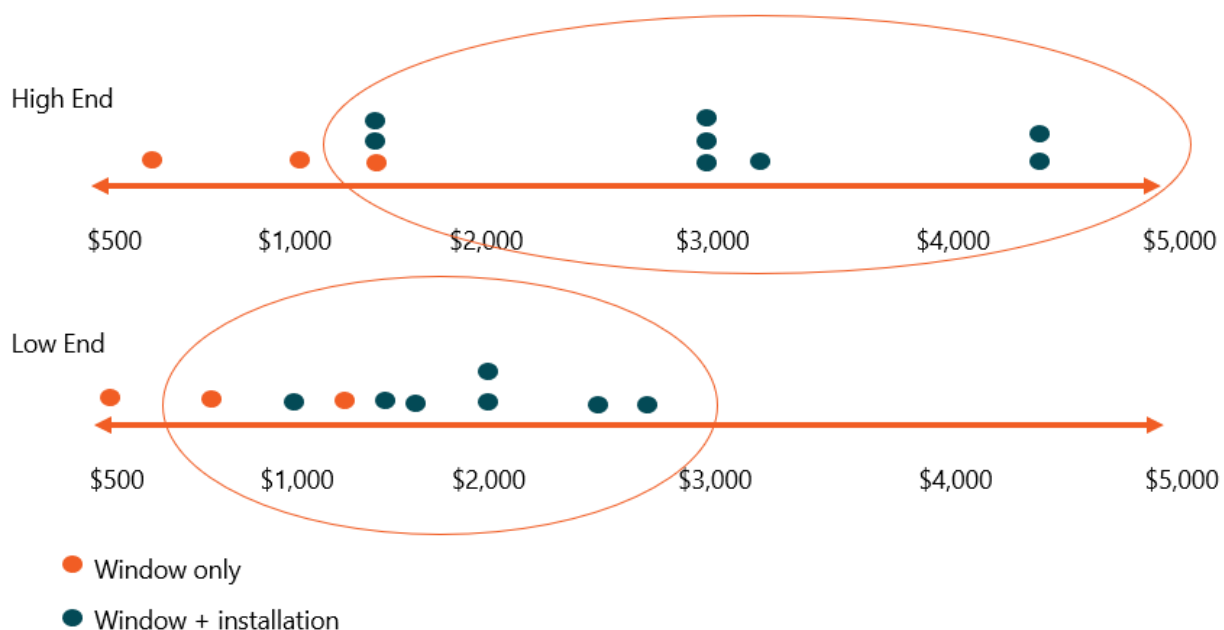
“That’s like a BBB thing. Most windows match that system anyway. And starting in, I think, 2024 their restrictions are going to get even tighter. It’s a triple pane thing. Many manufacturers are upgrading to triple pane to try to get ahead of it and then using that as marketing fluff. But! In the vinyl world it’s mostly no-name windows, generic.”

In discussing ENERGY STAR and “best” windows, vendors sought to describe technical features, mentioning National Fenestration Rating Council (NFRC) ratings, UV performance, and U-Value.

Pricing

Both shopper scenarios requested information about pricing. The range of prices contacts offered varied substantially (Figure 4-1). While we received some price data, the most frequent response to questions was a variation on “it depends.” Some mentioned a range of factors that contribute to pricing variability, including window type, material, grade, efficiency, brand, size, whether custom or not, as well as installation related factors such as house vintage, window location, and trim work. The primary way that quotes are developed is through the site visit, and many gatekeepers at window stores cannot give price data until a salesperson has visited a house.

Figure 4-1: Range of Prices Provided to Mystery Shoppers



Nevertheless, some vendors provided quote ranges. The most common pricing included windows with installation labor included. Vendors offered a wide range of cost estimates with high-end prices exceeding the low end by three to five times. One vendor mentioned that their high-end lines (Kolbe) cost five times the price of their standard “entry point” windows (the Andersen 100 line). Another vendor mentioned that if the respondent wanted specific materials or other moldings, the price might increase to \$6,000.

Acknowledging this range in pricing, vendors shifted to a “trusted advisor” role:

- *“I’m going to be very honest with you—we do in-house install. There is a huge gap in the window industry. At the lower end, a normal double hung window installed is about \$1,500-\$3,000. The higher end is \$2,000-\$4,500. For that, you get a better warranty, a strong brand/company. Pella, Andersen, Kolbe... they will be there no matter what.”*
- *“My advice to you: window shopping is a very confusing process. Some of these window guys are very high pressure, they come out and they try to pressure you to sign a contract that day. They start high with the bids and then offer a bunch of fake discounts. We are a lot more lowkey, we will come out once (and then again with the bid). Our bids are far more informational.”*

Mystery Shopping Takeaways

Shoppers’ first interaction is often with non-technical staff. Window vendors often have staff field incoming requests for information and schedule a salesperson to visit the site for measurements and estimates. This practice reflects the myriad details required to identify window product options and associated pricing—it also reflects the expertise and training that goes into in-home window sales.

The range of project costs is substantial. Seven vendors provided cost estimates, all of whom noted that pricing depends on the product chosen, the quality of the glass, the features, and the size. Installation is a substantial component of the cost, increasing for second-story windows or sites that require carpentry

or repair. Costs ranged dramatically for the few places that gave pricing estimates. Vendors acknowledged a “huge gap” between high-end and low-end windows, regardless of installation costs and other attributes.

Shoppers are faced with pervasive information asymmetry. Many vendor contacts indicated that there was a resident expert for windows, often the estimator who will come out to the site. When the shopper asked about expected price range, many representatives couched this in complexity—mentioning installation considerations, myriad features, measurements, and installation issues that drive pricing. Salespeople sought to build trust, establishing a rapport that included warning the customer to beware of upselling or pressure selling from other installers.

Vendors offered mixed opinions on triple pane windows. When faced with the standard persona’s desire for noise reduction and the environmental persona’s desire for high efficiency, vendors offered a variety of opinions on triple pane windows. Most mentioned cost premiums associated with triple paned windows and among these, many expressed skepticism that the cost is worth it. A minority endorsed triple paned windows. These contacts typically mentioned Minnesota climate and the need for improved window performance when compared to the national average window.

- *“Windows aren't supposed to be triple. It's too heavy.”*
- *“I think that triple pane may be a sales tactic to upsell. It'll cost \$1000–\$2000 more for triple pane.”*
- *“Triple pane is the best.”*
- *“Watch out for the other guys you're talking to; they'll tell you double pane is just as good. In truth, if a window lasts forever, it's not great for business. They make more money off double pane. Before Covid, if you asked installers these questions, they'd all say triple pane. It was about the same price. But now with all the costs going up and having such high overhead costs, to stay competitive they're forced to jack their prices up or cut corners on quality. Me? I don't care. I'm going to put the very best window in with the very best installation and you'll come back once you see how good they perform. I let the windows do the talking.”*

Section 5 The New Construction Market

This section presents the results of interviews with home energy raters, new home builders, and architects working on new multifamily buildings. These respondents all represent different aspects of the Minnesota new construction market.

5.1 Home Energy Raters

This section presents the results of interviews conducted with new home energy raters working in Minnesota in May and June 2023.

Approach

Cadeo combined lists of Minnesota-based energy rating companies available from ZeroReady Partners, the ENERGY STAR Homes program, and contacts known to CEE staff. Our final list contained 23 energy rating firms serving Minnesota, although we could verify recent Minnesota-based projects for fewer than 10 firms.¹⁹ We completed interviews with five firms active in the Minnesota market.

Interviews focused on several topics, all designed to help the team understand the Minnesota new construction market, typical windows used, how raters interact with this market, and opportunities they see to improve shell performance.

We sought to understand:

- The work of their firm, including any programmatic experience.
- How they work with builders.
- Scenarios in which raters would make recommendations on window products, be involved before construction, or be involved in value engineering.
- Typical window performance features they observe.

5.2 Findings

All five interviewed raters worked in both single-family and multifamily buildings. Four of the five indicated that most (~90%) of their work is in single family homes, with one firm focused primarily on multifamily buildings. This multifamily-focused rater reported that his firm works with affordable housing projects that require energy performance ratings to ensure the project meets performance thresholds to qualify for tax credits or public funding.

Raters report working with myriad programs focused on encouraging construction of high-performing, efficient new homes. Programs include ENERGY STAR New Homes (ESNH), Zero Energy Ready/Net Zero Ready, Green Communities, Passive House Institute US (Phius), and multiple utility rebate programs. The specific program requirements differ somewhat, but generally these programs require new homes to meet specific performance thresholds. In addition to programmatic work, most Minnesota-based raters also

¹⁹ The ZeroReady and ENERGY STAR partners lists contained national firms like CLEAResult and Johnson Environmental. It also contained smaller consulting organizations that sign up with national programs but may not provide services in every state indicated in program materials.

conduct blower door testing required for code compliance. Raters pointed out that the code compliance work does not require a HERS rating, just blower door testing.

Working with Builders

Raters described working directly with builders, selling their services and their approach. Rating companies build relationships with builders and will work to match the builder's construction schedule. Raters provide bids and cost estimates that builders include in project budgets prior to construction. Program-affiliated builders are looking to maximize utility incentives at the lowest cost and are aware that an eventual HERS rating will be required. Non-program builders are focused on code, which is *"the worst house you can legally build"* according to one rater, who asserted raters would have more influence on non-program homes if Minnesota builders were encouraged to use the performance code path.

Raters described a range of services, including consulting and scenario analyses that help builders troubleshoot performance issues, understand the implications of changing product lines, or resolve construction process challenges. For affordable multifamily projects specifically, raters report working directly with builders during the design phase and staying involved through the required testing, rough-in inspection, and final rating process. According to a rater familiar with this market, *"These publicly funded projects require energy ratings. They must meet some sort of energy performance program."*

Raters provided mixed descriptions of their interactions with builders during design or pre-construction.

- *"On single-family projects we don't get involved in the design phase at all. I explain to builders we aren't coming in trying to change everything. We give them information that might change things over time."*
- *"We might consult on new home plans. For ESNH or ZER Homes we are brought in at the front end, even before permitting. I like to be involved in the front end to make sure their HVAC guys understand [our role]."*
- *"Luxury home builders bring us in as a trusted third party, as a risk management strategy."*

In describing scenarios when raters might be involved prior to construction, raters described occasionally being contacted by an architect or a homeowner instead of a builder. These projects are typically trying for certification or to hit personal sustainability goals. Raters will provide a forecast of energy savings and help answer questions about aspects of the plan, including points of diminishing returns on attic insulation, U-factor, or triple pane windows, for example. When asked specifically about opportunities to influence shell recommendations that might include windows, one rater hedged, describing a focus on insulation over windows. *"The last few I looked at had pretty good windows but not great. It was four times the cost to go to 0.23 (or meet Phius standards)."*

Value engineering (VE) involves reviewing new construction plans for opportunities to reduce cost while retaining or increasing functionality. VE is often undertaken when bids indicate that project costs will exceed project budget and can result in the selection of lower-cost products. Raters report limited involvement in VE discussions. Two of the five said they simply were not involved in VE, and a third reported limited and informal conversations around VE. Involvement in VE is more common in commercial or multifamily projects where raters described having occasional conversations about windows, doors, flooring, and insulation. For raters, VE conversations tend to center on the performance implications of proposed changes—particularly when a building is required to meet a performance threshold.

Window Decision-Making

We asked raters for their perspective on how builders make decisions about window products. Raters reported that they were rarely, if ever, involved in window product decisions. Instead, raters described code requirements and “status quo” as driving these decisions, noting that builders value the predictability of known suppliers. In addition, their purchasing power can lead to favorable pricing and manufacturer rebates that are “far larger than utility rebates.”

In their experience, large builders (regional or national production builders) leverage their purchasing power by establishing national supplier agreements, which could include variations for local markets. According to raters, builders are focused on meeting minimum code requirements for multiple jurisdictions and are focused on keeping things simple and avoid having to modify plans. “They try to minimize the options, stick with 4–5 window styles. HVAC and windows are negotiated on a national level.”

- “99% are making decisions based on code minimum.”
- “They are looking at warranties. They hate to have call backs. If there are two windows with the same energy performance, they will choose the one with a durability warranty.”

The software used for obtaining a HERS rating for new homes requires inputting U-factor and SHGC values from the NFRC certification sticker, with no field for tracking ENERGY STAR. Raters had uncertain awareness of ENERGY STAR window performance requirements, although several reported seeing the label on windows in the homes they were rating. This led to differing perspectives:

- “The only time I don’t see ENERGY STAR windows is when the architect made a mistake when specifying.”
- “We don’t pay any attention to the attributes other than NFRC sticker. If we are providing suggestions on blower door testing, we’ll provide information on [the performance of] casement vs. slider vs. double hung.”

Typical Window Performance

We then asked raters to describe the typical window performance they see in new homes. Raters reported the typical window they see is a double pane low-e coated vinyl window with a U-factor between 0.27 and 0.30 and SHGC of approximately 0.30.

- “Typical is somewhere between 0.28 and 0.30. SHGC is not really that big a deal for heating climates. Some modelers will consider this, but no consumers or builders are paying attention. Builder upgrades might not reflect U-value at all, the upgrade is just brand.”

We asked raters to describe scenarios in which the window performance would be better or worse than this “typical” window (Table 5–1).

Table 5-1: Scenarios that Result in Better or Worse Performing Windows

When raters see <u>better</u> performing windows	When raters see <u>worse</u> performing windows
✓ Custom projects with a wall of windows might specify better glazing, even triple panes.	✗ A “goofy window” perhaps due to manufacturing faults or an odd shape.
✓ When builders are marketing the energy-efficient aspect of their homes	✗ When the architect made a mistake.

When raters see <u>better</u> performing windows	When raters see <u>worse</u> performing windows
<ul style="list-style-type: none"> ✓ When there are no windows that just meet code. Some types of windows are commonly better. 	<ul style="list-style-type: none"> ✗ When operability combinations result in lower performance. (For example, a window that is half fixed, half operable.)
<hr/>	
<ul style="list-style-type: none"> ✓ When builders are trying to meet program requirements. 	
<hr/>	
<ul style="list-style-type: none"> ✓ Projects designed for special populations (for example shelters) where fixed windows are specified for security reasons. 	

Raters do not track the climate zone rating for the window, noting that it is not an input into the energy model. Four of the five interviewed raters said they had never observed a window rated for a different climate zone, while acknowledging that they generally do not pay attention to the climate zone rating. As one rater noted, “U-value, SHGC, area, shading, overhang, and orientation...those are the inputs.” One rater noted he will occasionally see a window not rated for the Minnesota climate when a builder is new to the state. Four of the five interviewed raters reported that ENERGY STAR windows are common in Minnesota. Four raters offered ENERGY STAR penetration estimates ranging from 75% to 100%.

- *“It’s really common for them to be ENERGY STAR. Right now, the current specification can go up to a 0.30 U-factor, just a little better than code (0.32).”*

Awareness and Perspectives on ENERGY STAR V7

Raters track the requirements of the ESNH program, not the standalone ENERGY STAR window specification. Four of five interviewed raters were unaware of the details of the new window specification, and none had heard from builders about the new requirements. As part of the interview, we provided a brief description of the ENERGY STAR V7 NCZ specifications and asked raters if they had any concerns with the SHGC equivalent energy performance tradeoffs. None of them expressed concern for the higher SHGC allowance for windows with higher U-factors, noting that code doesn’t specify SHGC and neither do builders.

- *We are really focused on the inputs to the software: U value and SHG, not tracking the climate zones or tradeoffs. I assume the products manufactured in Minnesota are appropriate, I’m less sure about manufacturers in other markets.*
- *Haven’t really thought too much about it. Because we are primarily a heating climate, SHGC isn’t really a focus. Yes, can help with comfort in the summer. The tradeoff helps in cost analysis, [but the] focus is on U-factor and code.*
- *Tradeoffs have always been a thing. Even DOE doesn’t force the window requirements on ESNH. Sounds like a big change for builders.*
- *Didn’t know really about the tradeoffs. Realistically, for 99% they aren’t going to do a thing, they aren’t going to beat code. They aren’t thinking about it. They just get quotes from Pella and Andersen, unless someone is really focused on super-efficient homes.*
- *It’s hard to say really, it might be splitting hairs. The biggest variable is the square foot of glass. That will always be the most inefficient part of a wall. The tradeoffs don’t seem that important, maybe for commercial, with curtain wall of glass SHG would be more important.*

Importance of Windows on Performance Calculations

There was general agreement that while high-performing windows help reduce overall energy consumption, they are not a critical component of achieving current program performance thresholds. Raters report that there are less expensive ways to achieve efficiency goals, advocating for better air sealing, increased attic insulation, or upgraded mechanicals instead of prioritizing low U-factor windows.

- *“The problem is that windows are the most expensive things to switch out. It is cheaper to do a better job of air sealing than it is to switch windows and you might attain higher efficiency that way.”*
- *“In my opinion, the difference between 0.30 and 0.27 U-factor is not significant on energy modeling. You might save \$10–\$15 a year doing that. I’d probably recommend upgraded ventilation or mechanicals over upgrading windows. Windows are just lower on the totem pole.”*

When prompted for scenarios where window performance would make a difference, raters mentioned the Phius standard, which they note expects window performance “far above and beyond” standard construction. Raters are most familiar with ESNH, which serves as the foundation on which other programs are built. A few raters noted that homes with many windows, or those receiving a whole home analysis, might benefit from improved window performance.

Market Expectations

We asked raters what they thought would encourage adoption of low U-factor high-performance windows, and what prevents their adoption today. Raters provided several conditions that limit adoption and thoughts on what might encourage the installation of high-performance windows (Table 5-2). Cost emerged as a major barrier, followed by code that does not encourage an integrated approach to envelope performance. One rater reported that Minnesota builders fought a continuous R-5 approach that would have served the state well and better integrated window performance into the overall envelope. Other raters noted:

- *“The way I look at it is builders don’t have a window problem right now. Double pane is working, condensation is better, air leakage is better.”*
- *“It’s a tough sell to focus on the technical performance that’s not fixing a problem. Only focused on energy efficiency for its own sake. It’s pretty good already.”*

Table 5-2: Market Conditions that Encourage or Limit Adoption of HPW*

Could Encourage Adoption	Limits Adoption
Reduced cost, incentives or expanded tax credits	Higher first cost
Updated or performance code	Current code
Design team education, benefits to builders	Lack of interest
Required by programs	Availability or long lead times

*Reflects themes that emerged across five interviews, not organized by count or frequency.

When asked about their expectations for the future, three raters expect increased adoption and production of better performing windows, with lower U-factors and less natural air leakage. One of these contacts discussed the *"battle between layers and films and coatings,"* that led him to expect additional alternatives to triple pane for higher efficiency and more innovation to get a better weight-to-performance ratio. *"It's more the glass industry than windows"* he said, *"as they get more innovative with framing, it will come down to glass."*

Two raters stated they did not expect the new construction market to adopt low U-factor windows without a change to code. As one stated, *"code will drive changes in the window market. You will drag builders kicking and screaming."*

Source of training and information

When asked where they turn for information or training on new products or practices likely to improve the energy performance of new homes, raters offered a variety of sources. They most commonly mentioned online resources, including several specific websites. Raters also reported turning to other professionals, including manufacturers, LinkedIn contacts, or CEE staff. Mentions included:

- General Internet searches (for example BuildingScience.com) (3)
- Manufacturer contacts (2)
- Green Building Advisor (2)
- Conferences (RESNET, International Builder Show) (2)
- YouTube (The Build Show) (1)
- Trainings through Green Home Institute (1)
- CEE (1)
- LinkedIn (for example a LinkedIn network of HERS raters) (1)

5.3 New Home Builders

This section presents the approach and the results of the interviews Cadeo conducted with residential new-home builders.

Approach and Disposition

To understand the current window procurement practices among new-home builders, the Cadeo team conducted interviews with Minnesota home builders that construct single-family and multifamily new construction buildings. Cadeo developed a population frame using a variety of sources, including the list of Minnesota Energy Star Builders, Data Axle (a third-party data aggregation provider), and a list of the top 25 largest builders in Minnesota. This frame contained 267 unique builder organizations based in Minnesota.

We designed an interview guide to:

- Assess the decision process that drives window product selection and procurement.
- Assess common characteristics of windows, including the prevalence of ENERGY STAR windows.
- Understand their awareness of and expected impact from ENERGY STAR V7 specifications.
- Understand market prospects for higher performance windows.

We anticipated completing interviews with new-home builders would be challenging based on our experience contacting installers and distributors. Therefore, we increased the incentive offer from \$100 to

\$500. After making two to three attempts via email and phone in June and July 2023, we completed interviews with six builders. Table 5-3 summarizes the interview disposition. The total response rate was 2%. The high prevalence of non-contact reflects the challenges we had reaching the contacts for recruitment. The fielding period coincided with peak season for builders working to complete projects during long days of mild weather. Future data collection with new home builders should be scheduled during the winter when construction slows down.

Table 5-3. Builders Call Disposition

Disposition	Count	Percent
Complete	6	2%
Refusal and break-off	36	13%
Non-contact (left voice mail, emailed invite, not reached, etc.)	217	81%
Missing contact information	3	1%
Bad or wrong number	4	1%
Didn't pass screening	1	0%
Total	267	100%

Respondent Characteristics

The six completed respondents include builders with the following characteristics:

- Two low-volume multifamily builders (one to two buildings in the last two years, fewer than five in pipeline). These contacts both worked with energy certification programs.
- Three medium-volume builders (15 to 40 homes in the last two years). Two that primarily build program-certified single-family homes and one focused on single-family new construction and major remodels outside of programs.
- One high-volume (120 to 150 homes in last two years) single-family builder that completes new construction and remodeling projects. This contact did not work with energy certification programs.

The small sample size and recruiting process (which allowed builders to refer other builders) means that the data from these interviews is qualitative and not representative of the new construction market. The builders overrepresent the influence of energy programs, which we expected given that the calls introduced CEE and referred to efficient building practices.

Working with Raters

Four of six builder contacts reported they had worked with energy raters through their experiences with Energy Star Homes or Zero Energy Ready Homes programs. Three of them specifically described raters' involvement in the pre-construction phase. In this phase, raters provide energy modeling to inform recommendations on HVAC system sizing. Two builders also mentioned raters' involvement during construction (follow-up performance path test visit) and post-construction (testing and follow-up). The large-volume builder contact reported they do not involve energy raters in their work.

"Right now, ZER allows 'any' SHGC. U-factor 0.25. Will likely influence my selection if it affects the certification programs. If they (programs) drop a sheet in front of me, I look for the most cost-effective window that will meet it."

Window Procurement Practices

All builder contacts stated their window selection and ordering occurs early in the construction process to avoid delays associated with product lead time. One builder said it usually takes three to six months from order to delivery. They prefer all windows to be delivered at the same time so they are ready for installation when needed.

Three of the six builder contacts reported receiving some recommendations from architects on window selection, but only one indicated these recommendations are related to energy performance. Other contacts receive information related to proper opening and window sizing from architects.

Most contacts said they source windows from building material suppliers or distributors (including lumberyards, building supply retailers like Builders First Source, or manufacturer-based distributors or dealers) with who they have a relationship. The high-volume builder reported ordering directly from a supplier that represents several manufacturers.

Builders striving to meet performance requirements of programs reported that window specifications are commonly driven by requirements that specify U-value and SHGC, followed by product availability (based on specifications, including energy performance, color, sizing, material, etc.) and price.

"[We select windows] very early on because the construction [schedule] is laid out as part of the planning and decision-making. The customer has already made decisions about where they want windows and the types of features they want. We need to order so it's there when we are ready to install and make sure we get it in the right color and size. We like them all delivered at the same time so we can make sure everything is in order. If there is a problem, we want to know right away...not day of."

The single-family builders reported considering energy performance, longevity, material type, and noise prevention features when selecting windows. They reported specifying triple pane windows when their clients want them. They also reported that most of their customers are prioritizing decorative and operability aspects over energy performance. Among these builders, there was a consensus that the window selection/ordering process is similar for custom homes, spec homes, or larger-scale housing developments.

Characterization of Common Windows Used

Program-affiliated builders characterized the windows they select as "good" performance dual pane windows from manufacturers like Marvin, Pella, Silverline, Quaker, Andersen 100 Series, and H Window.

These builders reported that 100% of the windows installed in new homes over the past two years were ENERGY STAR.

One builder reported typically installing double pane vinyl “basic cheap” windows, but 80% or more of the windows installed over the past two years were ENERGY STAR. Another builder characterized most windows he installed as “quality vinyl” windows made by Heartland and reported that generally specifying ENERGY STAR windows.

Four of the six builders were aware of thin triple windows (TTW), and two of them said they had installed triple pane windows (note that we cannot confirm they are referring to “thin” triples). One builder specifically mentioned having installed H Window’s triple pane windows.

Awareness and Impact of Energy Star V7

Only one of the six builders interviewed was aware of the new ENERGY STAR V7 window specification. None of the builders interviewed said changes to ENERGY STAR would impact their window selection decisions for new homes. The high-volume builder was quite skeptical that the new construction market would spend money on better windows without an attractive incentive program. Three builders indicated their selection behavior might shift if the certification programs, their funding organizations (for development projects receiving public funds), or rebate/tax credit programs changed eligibility requirements to incorporate the new ENERGY STAR specifications.

A few of the interviewed builders indicated receptivity to the U-factor/SHGC equivalent energy performance trade-offs because heating cost reduction is more important than cooling in Minnesota. However, most they were generally unclear about the benefits and risks of the SHGC trade-offs.

Window Market Prospects

A program-affiliated builder described other builders (not program-affiliated) as generally reluctant to pursue window performance higher than code and wanting to maintain the status quo with window practices. Builders that receive public funds are responsive to changing program requirements.

While some builder contacts acknowledged the importance of energy-efficiency is increasing among new-home buyers, they believe this is generally limited to buyers interested in homes at high price points. These builders explained that energy efficiency home features are a lower priority among buyers of low-mid range single-family homes and first-time home buyers looking for a low-cost starter home.

Sources of Information and Training

Builder contacts report obtaining information on new products or practices that improve energy performance from a variety of sources, including architects, energy raters, material suppliers, green building certification organizations, and trade publications.

5.4 Architects

Approach and Disposition

To understand baseline practices for specifying window systems in new multifamily buildings, Cadeo conducted interviews with Minnesota-based architects working in new multifamily construction. We designed the interview guide to:

- Understand barriers, opportunities, and leverage points for influencing the glazing package.
- Understand current experience with ENERGY STAR and awareness of new specifications.
- Understand the process and considerations for identifying and specifying HPWs.
- Test HPW value propositions in terms of efficiency, SHGC tradeoffs, sound transmittance, etc.
- Understand continuing education practices related to shell and glazing systems improvements.

Identifying specific contacts associated with multifamily building design proved challenging. Cadeo purchased a third-party list of architecture firms in Minnesota using NAICS codes associated with firms likely involved in multifamily residential building design. We combined that with a list of firms known to CEE. The combined list included over 230 unique firms. We reached out via email, offering contacts a \$100 incentive for completed interviews. We completed interviews with four qualified firms.

Role

All four of the interviewed architects worked on multifamily buildings, with each estimating that they had worked on five to eight buildings over the past five years. Two of the four reported that most of their projects were affordable housing, varying in height from two-story townhomes to six-story buildings. The two working in market-rate housing described focusing on four-story buildings with retail on the main floor and three to four stories of housing above. All four contacts described having the lead or project architect role for these projects, including one contact who also provides consulting for Passive House Institute US (Phius) and another who is the director of sustainable practice in their firm. As lead architect, contacts will take a project from design through construction administration, developing the program, meeting with the owner, preparing and working with schematic documents, and shepherding projects through design development, permitting, and construction administration.

Establishing Shell Performance

Two architects described different processes for Phius-type projects and standard processes. In passive house projects, designers consider the shell components and window performance at the beginning of the project and integrate them into the energy model. In these scenarios, architects described starting with the lowest cost option likely to meet the targets. If the modeling process reveals that the building is unlikely to hit performance targets, they will upgrade windows to higher performing versions. This planning usually occurs early in design development.

- *"Typically, [window decisions] are saved until the end [of the design process] but with passive house consulting we talk about it in the beginning."*
- *"At the moment we are working on a project being built to passive house standard, the passive house consultant is recommending a window that is not used much in this market. It's made in Colorado. The contractor is pushing back because they are not familiar with the window...they want one that has good support with the manufacturer, has local representation, and someone who will be there to service the window."*

Most projects are not Phius certified, and architects described a more varied approach to the window selection process in these non-Phius buildings. Two contacts specifically mentioned considering the cold climate in Minnesota and designing for heating rather than cooling load. They will consider shading, R-value, and the performance of product options across manufacturers. Several noted that the attention paid to windows depends on the priorities of the client.

- *“Quite frankly, the subject of windows does not come up. It’s based on the criteria of the client and if they are interested in energy cost or sustainability. I am interested in these things but must balance the budget criteria.”*
- *“I wish I could tell you that it was a highly rigorous process with a lot of analysis, but it’s not always that way. A lot of times it’s how committed the owner might be. The contractor’s comfort level with a new product, especially in the affordable housing sector...most developers want something that is durable and will perform well over the long term, but sometimes it’s difficult for me to get them interested in [a product] also performing well in terms of efficiency.”*
- *“If we are on top of our game, we will look at R-value and U-value for wall assemblies. We’ll figure out what type of assemblies will help us hit the mark we are targeting. We’ll develop those U-values early, establish performance criteria, get bids, talk to reps, and ultimately select a product.”*

Architects reported using both residential and commercial window products in multifamily buildings—particularly in the one-plus-four story buildings, which will have a different window system on the first floor than the residential floors. Windows installed in the residential units are typically residential grade from a manufacturer accustomed to providing products for the multifamily market. Pella, Andersen, and Marvin were all offered as examples of suppliers that will provide both commercial- and residential-grade products. One contact stated, *“ultimately we may not know [if they are residential or commercial], and it doesn’t really matter if they are the low bid and meet the performance requirements.”* This contact noted an exception for products with known or anticipated performance problems, claiming they counsel against vinyl or products with prior issues.

Ultimately, architects must balance myriad factors in window selection, including the overall project budget and the client’s priorities. One contact explained the vendor needs to *“meet criteria with regards to schedules in addition to the performance criteria. The budget is a significant factor, we balance out a lot of criteria.”*

One architect noted that the main difference between low-rise and taller buildings is the requirement for fall protection. Others stated that window procurement processes will change for buildings over five or six stories because they come with a different set of requirements. Notable changes include:

- **Manufacturers will reach out to provide product and pricing information for larger buildings.** *“It’s a big sale for them, and we like to hear what technology they are recommending and if they have solved any issues.”*
- **Less risk tolerance on the part of builders or developers.** *“On most projects I’m trying to push the contractor and owner to get high-performance windows, and I’m having some success on a window provided by Pella that is common in this market. If I’m staying with a familiar manufacturer, it can work.”*

Selection and Procurement

We asked architects to describe the process through which they bid or select window products, focusing on whether they typically establish performance thresholds for glazing systems or specify actual products. Responses revealed some divergence depending on the type of project. Projects prioritizing sustainability or efficiency (including passive house construction) will often specify actual products instead of performance criteria. According to an architect with experience in this market, *“most people and manufacturers look at the NFRC ratings, U-value, and SHGC and we are looking at frame values and center-of-glass. We’ve had people mistake the center-of-glass and gotten the wrong window.”*

The other architects described a more standard process that includes establishing the basis of design and a performance threshold for bidding purposes that includes the look, style, and operability requirements for the building. One architect reported discussing options with vendors prior to releasing the formal specification that goes out for bid along with the entire project. In this case, the consulted vendor will have their product used as the basis of design and the product specifications will be provided to other manufacturers for bidding. For affordable housing projects, or those with public funding, *“it needs to be demonstrably the most competitive bid. Sometimes the vendor we talked to in design development doesn’t get the bid. Most of the time the general contractor knows the vendor they like to use is going to be affordable.”*

Said another, *“We evaluate one manufacturer against the others and the performance threshold. Aesthetics is also important. All these things need to work together. [We are] evaluating a lot of different criteria. One window will stand out.”*

The final product selection decision is made by the design team with input from the client as needed. Decisions ultimately reflect the client, the budget, and the schedule. Architects report participating in this conversation and helping to balance the cost and performance goals. Narrowing options and choosing a vendor can require multiple rounds of cost estimating. If the low bidder does not meet the basis of design, it triggers a conversation between the owner, contractor, and architect—sometimes the basis of design is changed, sometimes the low bidder is asked to change their bid.

We asked architects about factors *other than* efficiency that are important to project developers. All four contacts reported that durability is important for multifamily buildings. They assume that windows will be left open, will be used by a variety of different tenants, and that latches and hinges need to keep working. One contact noted that their specifier will often end up with commercial-grade windows if durability is specified. Durability is followed by cost, operability, and aesthetics as the primary considerations that drive window decisions. The sound transmittance coefficient is considered for buildings constructed near busy roads.

The Role of Code

Architects provided only a few scenarios in which they would specify above-code windows; however, responses indicated that it is not unusual for windows *selected* to exceed code performance. As one architect (who works with passive house or net zero energy buildings and in low-income housing developments) stated, *“In six years I haven’t worked with windows that just meet code.”*

The scenarios for specifying above-code windows included:

- Passive house or net zero energy buildings.
- Low-income housing designed for low energy consumption and bill savings for residents.
- Projects with energy modeling, or when the client has agreed to prioritize thermal comfort and energy savings. *“The struggle is to get the energy modeling done in time to affect decision-making.”*
- When a client is willing to spend more money on window performance.

Value Engineering

Architects described when and how VE typically occurs in their projects and how it might affect window selection. Their experiences varied, reflecting the different types of projects they’ve worked on and the

client motivations that drive project decisions. Projects in which VE was less likely to affect windows included:

- **Publicly-funded affordable housing:** *"I have never had a problem in protecting the windows, I've had more difficulty protecting things with aesthetic value. Things that affect the overall performance of the building or durability get less pressure in VE."*
- **Passive house developments:** *"In passive house, VE happens for other things—we'll take away landscaping, but not anything that affects building performance...we might go with vinyl instead of fiberglass, but it's still a triple pane window."*

The other two architects acknowledged that VE could result in changes to window systems, particularly when bidding reveals a substantial difference between the project budget and forecasted costs. There is typically a stipulated VE period during which the project team will look at options to reduce costs. Both architects described having to make the case for keeping a high-performance window—in these scenarios architects will encourage their clients and the general contractor to consider the long-term implications.

- *"VE in earnest happens after a project is bid. Windows may or may not be affected. Double vs. triple pane would be reviewed, for example. When we integrate the rationale for the performance of the window—the storytelling—then it's less vulnerable in VE."*
- *"Windows are often targeted to save money. As the architect, I often find myself looking at the bigger picture, like a music conductor. It's not atypical that there are some overruns or issues with the budget that will lead the client/contractor to ask us to go in a different direction. I have to bring clarity on what they are getting for the dollar."*

Program Influence

We sought to understand if or how architects engaged with programs promoting high performance multifamily buildings. All four architects had experience designing buildings consistent with program or policy requirements, including Enterprise Green Communities, LEED, ENERGY STAR, and Phius. Even when buildings are designed to meet program performance requirements it is rare for the design team to focus on windows, especially in larger buildings.

- *"As the volume to surface area (the outer envelope) increases, the window performance becomes less impactful. SHG can be more important, but low U-value less so. What is happening is that as the [building] volume gets larger the number of people and number of air changes per hour increases...with more fans, greater filtration, and more mechanicals, the internal loads outweigh the shell/skin."*
- *"In Enterprise Green Communities²⁰ projects, I will just help administer the guidelines and write the narrative. We will talk about windows, but it is a very short conversation."*

Architects noted that the impact of a program on window selection depends on the program requirements. Some programs, like ESNH, are prescriptive while others are more rigorous. As one contact commented, *"The more rigorous the program, the more energy efficiency comes into play."*

²⁰ Minnesota Housing operates with a formal sustainable housing policy that minimizes the consumption of natural resources both during construction and in long-term maintenance and operation.

ENERGY STAR Windows

None of the architects described specifying ENERGY STAR windows in projects, noting that:

- Their projects have windows that exceed ENERGY STAR (V6).
- They pay more attention to solar heat gain than U-factor or ENERGY STAR in multifamily buildings.
- They use manufacturer performance criteria, not ENERGY STAR.

Perhaps unsurprisingly, none of them were aware of the upcoming ENERGY STAR V7 specification. After hearing about the SHGC tradeoffs that allow for higher U-factor in residential windows, architects stated that they consider orientation and potential heat gain when designing multifamily buildings, particularly if a building is likely to need extra conditioning to address perimeter heat gain. However, they also described targeting an SHGC of around 0.4, noting they balance solar heat gain with good visual light transmittance. Architects described considering the needs of each project relative to orientation, expected use, and existing shading:

- *"On larger multifamily projects, I don't do the energy model, the mechanical engineers do that. Some don't seem to be as progressive or as informed as most of the architects I know...You don't always want the same numbers for south- vs. north-facing glass."*
- *"The strategy will be driven by geography. We want a level of sunlight to come in. [Solar heat gain] is always a concern."*

Architects provided insight into the factors that prevent low U-factor high-performance windows from being specified. Cost emerged as a primary barrier, particularly relative to the potential energy savings that accrue with incrementally better windows.

- *"If we don't have enough information on the overall envelope performance during cost estimating, we won't know if it's good enough."*
- *"As you get into higher performing windows, the payback is incrementally less. It could be many, many years before they realize a cost benefit. As we get into better and better windows, it's going to be harder and harder to [justify]."*
- *"The glass itself is not a good insulator. You need technology to enhance the operation of the window assembly to give you the highest R-value."*

Two architects also discussed the effect of inertia and a bias toward familiar suppliers and products, noting that developers are unlikely to change their preferred product without pressure to do so. Code and programmatic requirements both emerged as a strategy to encourage consideration of higher performing windows, followed by attention to other long-term benefits to building occupants and owners, such as reduced noise, lower utility bills, improved protection from water infiltration, or durability.

Information and Market Expectations

We asked architects where they turned for information or training on new products or practices likely to improve energy or window performance. Two contacts noted that they rely primarily on manufacturers to provide information on new products or features. Other sources included:

- Phius window database
- Webinars and conferences
- Building Green (<https://www.buildinggreen.com/>)

- National Council of Architectural Registration Boards (NCARB) continuing education and resources

Architects expect that multifamily buildings will increasingly incorporate triple pane windows to meet code and program requirements. Other trends they expect include fewer leaky sliders or double hung windows, increased awareness of high-performance window features, and more options for program incentives or tax credits as policy increasingly prioritizes efficient energy use.

Section 6 Conclusions and Recommendations

This section presents the cross-cutting conclusions and recommendations that emerged from the research described in this report.

Finding #1: The ENERGY STAR Northern Climate Zone (NCZ) options for Equivalent Energy Performance complicate efforts to estimate U-factor from ENERGY STAR market share. Interviews indicate that the market does not see products meeting the equivalent energy performance criteria as unqualified, a potential challenge for CEE’s communication with manufacturers on the new specification. Manufacturers report using the equivalent energy performance solar heat gain coefficient (SHGC) tradeoffs in V6 and say they plan to do so in V7. Interviews with other types of market actors revealed no real discernment between prescriptive U-factor and products that qualify using the SHGC tradeoffs. We heard from multiple sources that a U-factor of 0.27–0.3 is common in Minnesota today. Products with a U-factor in this range could qualify for ENERGY STAR V6 if they are consistent with the equivalent energy performance criteria.

Most market contacts do not track SHGC specifically. Some manufacturers and architects working in multifamily construction noted that high SHGC values create risk of heat buildup in the summer, particularly for multi-story buildings.²¹ However, the typical values available in the current window market (0.3–0.35) are not considered high and manufacturers expressed minimal concerns about the SHGC levels allowed by ENERGY STAR.²² Architects working in multifamily buildings report tracking the SHGC requirements in their designs; when they are concerned about heat buildup, they will search for a different window solution or ensure the cooling system is designed to mitigate potential discomfort.

Recommendation #1: If high SHGC values are a concern, consider developing strategies that would increase awareness of the importance of limiting solar heat gain for certain buildings or wall orientation.

Create training and marketing materials to communicate the potential impact of high SHGC in the summer through compelling messages that run during the warm summer months when consumers are experiencing heat and/or high air conditioning costs. Help the supply chain communicate this message so consumers are informed when interacting with window sales staff.

Finding #2: ENERGY STAR V6 products are considered standard practice in the retrofit market. ENERGY STAR is an established and valuable consumer-facing label used by retailers, manufacturers, distributors, and installers to distinguish a given product line and encourage efficiency. National market studies have indicated that ENERGY STAR V6, which established performance requirements for the Northern Climate Zone (NCZ) in 2016, has had a market share above 80% since it was released. While there are always areas of uncertainty associated with characterizing local, regional, and national markets for large-volume commodity products, this project did not find evidence that Minnesota’s window market is discernably different from the national market, particularly in the retrofit/replacement market.

²¹ These concerns emerged in comments submitted as part of the ENERGY STAR V7 specification update as well.

²² ENERGY STAR V7 requires SHGC levels of 0.35 or higher for products over the prescriptive U-factor of 0.22. (Table 1)

Recommendation #2: Continue to support the ENERGY STAR brand and recognize manufacturers' efforts to meet the updated requirements of ENERGY STAR V7 through promotional and programmatic support.

Finding #3: The ENERGY STAR label is less important in the new construction market. ENERGY STAR is a consumer-facing product label. The designers, builders, and raters working in new construction are focused on specific product thresholds that will reduce risk. In new construction, risks include supplier capacity, warranty, meeting or exceeding code requirements, occupant comfort, and profitability. Sources indicated that builders focus on cost, code requirements, and durability. They also indicated that windows consistent with ENERGY STAR V6 performance are not uncommon. This is consistent with market transformation theory, which indicates that as an efficient product becomes standard it is adopted with no extra effort or intention on the part of market actors. This mechanism, coupled with a more streamlined and negotiated sales process, makes it difficult to estimate the true percentage of ENERGY STAR V6 products in the new construction market. While we know it is likely lower than the retrofit/replacement market, we do not have sufficient evidence to adjust national estimates of ~80%.

Recommendation #3: Develop strategies that communicate the value of the ENERGY STAR label to the ultimate home buyer and work with existing new home programs (utility, ENERGY STAR, Zero Energy Ready, Enterprise Green Communities) to encourage higher performance windows on program-qualified homes.

Builders are more likely to include a higher cost energy-efficient window product if home buyers value them. Builders need to avoid risk and require a value proposition that fits their business model. In the near term, addressing that value proposition will be easier for those producing high-end, sustainably built, program-affiliated, or custom homes than for high-volume production builders. As the supply of ENERGY STAR V7 certified windows increases and price premiums decrease, the new construction market will be more receptive. Code will always be a powerful lever for influencing new construction, and CEE should monitor code developments for the opportunity to embed ENERGY STAR V7 windows as a code-compliance option.

Finding #4: Market segments will adopt V7 windows at different rates. The retrofit/replacement market is expected to adopt these products faster than new construction. Four of the seven interviewed window vendors reported some sales of windows with U-factor at or below 0.22. Manufacturers and those working in new construction report products at or below U-0.22 represent "single digit" sales.²³ Interview data indicate that homeowners are more willing to invest in high-quality, efficient windows than builders, who are typically focused on meeting code and maximizing profitability per home by keeping costs low. The installers selling their services to homeowners reported almost no work in new construction. Efforts to understand the current market sales by U-factor in different market segments resulted in several specific takeaways:

- **The current sales for products meeting the prescriptive V7 value of U-0.22 are likely 5% or less.** Manufacturers and others in the supply chain interpret U-0.22 as triple pane products, although there are double pane products meeting the V7 criteria. Triple pane windows represent

²³ Selkowitz estimates that less than 5% of 2022 sales would meet the V7 prescriptive requirement with a U-factor of 0.22 in the Northern Climate Zone. The installer research did not include an estimate of volume, so these results are not weighted and should be considered a maximum value.

about 2% of window sales.²⁴ Without a reliable source for estimating window sales by U-factor, we cannot definitively estimate the portion of all product sales that would meet the prescriptive requirements of ENERGY STAR V7. Products meeting the prescriptive U-0.22 value will be available after the updated specification takes effect in October 2023; however, these sales will start out low. It is not clear how quickly sales of products meeting the prescriptive ENERGY STAR V7 requirements will increase. Market stakeholders report that price will affect the rate of adoption.

- **The current sales for products meeting the V7 requirements are higher than the 0.22 estimates but likely below 10%.** It is important to note that V7 allows for U-factors up to 0.26 with SHGC tradeoffs, which allow for a slightly higher U-factor. We expect the market will respond to V7 requirements by increasing SHGC of U-0.23–0.26 windows, improving the performance of “standard” dual pane windows and expanding production of triple pane products. These efforts will expand the availability of V7 certified products but may not directly increase the availability of windows at or below U-0.22.
- **Awareness and understanding of the ENERGY STAR V7 requirements varies across the window market.** Manufacturers are universally aware of the updated specification and are strategizing about how they will adapt. Existing market research indicates that compliance with V7 will require changes to most existing window designs as manufacturers shift to triple paned products or modify double pane products to achieve higher performance. Distributor/installer awareness of V7 is lower and likely reflects their market niche and typical customer: some report detailed understanding, while others either do not track ENERGY STAR specification updates or wait for supplier information on new product lines and features. Those working in the new construction market (builders, raters, architects) are less attuned to the consumer-facing ENERGY STAR label generally and instead specify products informed by code requirements, vendor relationships, performance needs for a given building, and other features (color, style, operability). Performance needs can include SHGC for exposed south-facing walls or triple panes for noisy locations.

Recommendation #4: CEE should prepare for a long-term, multipronged effort to shift the market toward performance consistent with ENERGY STAR V7 generally and U-0.22 specifically.

For the retrofit/replacement market:

- Leverage the ENERGY STAR label in promoting windows that meet the prescriptive value of U-0.22 or lower. Additional work will be required to distinguish these products from otherwise qualified ENERGY STAR products using the equivalent energy performance tradeoffs. Program incentives, salesperson training and incentives, extra signage, website resources, and consumer marketing might all be needed to direct attention to the prescriptive U-factor value.
- Promote products that meet the prescriptive specification to reward manufacturers who certify these products with additional marketing that links this level of performance to quality that can stand up to extreme weather, provide energy savings, and increase comfort.

For the new construction market:

²⁴ Pacific Northwest National Laboratory. 2021. Evaluation of Thin Triple Pane Windows in the PNNL Lab Homes. <https://www.osti.gov/servlets/purl/1811300>

- Start with special cases like green building developments, passive house standards, or zero net energy demonstrations. Homeowners and developers in these scenarios are committed to high efficiency solutions and will protect envelope performance over other aspects of a building during value engineering.
- Track and participate in future code development efforts to identify strategies that incorporate high-performance windows as a building envelope feature that will improve overall energy performance analysis.
- Emphasize durability. Architects working on new multifamily buildings report that durability is a primary concern for their projects. Windows must withstand tenant behavior such as leaving them open in extreme weather that leads to failed latches and screens. Combining energy efficiency with durability provides value to both the tenant and owner.
- Emphasize elements that reduce risk to builders, such as pairing efficiency with improved warranties, confirmed availability, and durability, and features that will be more compelling to homebuyers than operational efficiency.

To support overall supply chain engagement:

- Identify the specific product lines that meet the performance qualifications CEE is looking for and ensure those products qualify for incentives or other program benefits.
- Consider adopting simplified nomenclature to facilitate consumer and supply chain discernment. Supply chain contacts used both U-factor and R-value in their discussions with interviewers, noting that R-value allowed them to compare window performance to wall performance.
- To ensure HPWs are part of the consumer choice architecture, CEE should develop and deliver curriculum for distributors and their affiliated installers to make sure they are informed about ENERGY STAR V7 products, can accurately describe them, and are equipped to promote them. This will also help build relationships and connections to the Minnesota supply chain.

Finding #5: The window industry is a busy commodity market experiencing upward pressure on costs and labor. Interviews and industry literature indicate that acquisitions, supply chain disruptions, and shortages of skilled installers are all leading to a supply-constrained market with corresponding increases in prices for products and labor. High inflation and interest rates are also affecting construction financing and consumer and home buyer budgets. These financial pressures create little appetite for further increases in cost.

Recommendation #5: Support efforts to develop affordable HPW products.

- Work with manufacturers to identify and promote the lowest cost solutions that meet the performance criteria of CEE's HPW initiative.
- Identify subsidies, including tax credits and program incentives, to offset the cost differential associated with low U-factor windows and facilitate consumer access.
- Support ongoing innovation by partnering with labs, universities, and innovators by co-funding research, development, and demonstration projects.
- Help window customers navigate the process with pricing guidelines or project cost caps for incentives.

Finding #6: CEE will need to develop a stable strategy for tracking Minnesota window sales over the long term. Manufacturers do not have clear visibility into sales below distribution/retail. For example,

they do not know the portion purchased by general contractors, unaffiliated installers, or homeowners (especially through big box sales). They are also not able to provide sales details at the state level. ENERGY STAR is updating the reporting portal and data submittal requirements, which should provide more detail on the characteristics of shipment data. However, these data are confidential and will not be available at the state level. This makes it imperative that CEE build relationships with local window distributors to obtain market intelligence sufficient to adjust national or regional sales estimates for the Minnesota window market. To obtain regional sales estimates, manufacturers specifically mentioned [Ducker](#) as the best source, even as they complained about the data limitations. Other sources include, [Frontier](#), [Farnsworth](#), and [Principia DemandBuilder](#) (which monitors the building materials market).

Recommendation#6: Review the cost, detail, and coverage of all four of these sources to determine which one will best support long-term market tracking.

Appendix A summarizes key drivers and barriers by market actor.

Appendix A Key Drivers and Barriers

Key Drivers in Window Decisions	Barriers to Low U-factor/HPW
Manufacturers	
<ul style="list-style-type: none"> • Offer multiple product lines that meet range of consumer or building requirements. • Offer ENERGY STAR label and associate ENERGY STAR with quality. • Maintain or grow market share, compete in national market. 	<ul style="list-style-type: none"> • Lack of dual pane IGU systems that meet U-0.22. • Challenges associated with changes to manufacturing process to integrate third pane. • Cost of raw materials. • Ability to meet ENERGY STAR requirements with SHGC tradeoffs limits commitment to U-0.22. • Lack of consumer demand.
New home builders	
<ul style="list-style-type: none"> • Negotiated suppliers and pricing reduces options • Need to keep up with changes to building codes, meet building code requirements. • Reduce risks associated with performance, supply, durability, and customer satisfaction. • Reduce costs of new home construction: keep home prices accessible and maximize profit. • Meet requirements of efficiency or performance programs (when applicable). 	<ul style="list-style-type: none"> • Unlikely to make extra effort or add costs to acquire windows that are substantially above code. • Do not perceive they have a “window problem,” believing existing dual pane solutions are efficient and sufficient. • Favor existing products and familiar suppliers. • Perceive risks associated with new products and increased cost.
Window vendors	
<ul style="list-style-type: none"> • Maximize profit per job—install more windows at single site/sales location. • Protect reputation as trusted, quality, or low cost (vendors stake out different segments of the market). • Use features to promote window upgrades: frame type, coating, ENERGY STAR status, style, brand. • Use tax credits or program incentives to offset premium product costs (if available). • Educate consumer and provide sufficient options to close a sale. 	<ul style="list-style-type: none"> • Higher cost products create challenges in the sales process. • Perceive lack of consumer demand for higher efficiency. • Workforce limitations increase cost and reduce willingness to upsell. • Variable understanding of product options, tend to stick with trusted products and suppliers. • Variable understanding of ENERGY STAR, benefits of low U-factor windows.
Architects	

- Include low U-factor windows in publicly funded buildings or projects with energy performance targets.
- Passive house design.
- Monitor SHGC on south facing walls, particularly multi-story, multifamily buildings.
- Consider overall building performance and occupant experience.
- Increased costs associated with HPW can lead to their exclusion during value engineering, or when project budget limits are reached.
- Limited project budgets can force tradeoffs between window performance and interior finishes or other desired building features.
- Use mechanical system to mitigate when glass or orientation is likely to create occupant discomfort.

Raters

- Track and promote energy labeling and performance programs.
- Work with a variety of builders; build trusted relationships over time.
- Observe blower door and energy model results, will advocate for better performing building envelopes.
- Do not track ENERGY STAR specifically or check climate zone: energy model only requires U-factor, NFRC, and SHGC
- Promote mechanical upgrades over low U-factor windows for achieving energy savings.

Appendix B Data Collection Instruments

Manufacturer Interview Guide

Email Outreach

Hi [Contact name],

Center for Energy and Environment (CEE) in Minnesota is sponsoring research to learn more about the residential window market. As part of this effort, we are reaching out to contacts with insight into manufacturing and sales of residential windows. Our contractor, Cadeo Group, will likely reach out to schedule an interview with you in the next week or two. Please consider participating in this effort.

This work will help CEE reduce energy consumption in Minnesota by supporting market innovations in window technology. We are happy to send you a copy of our findings when the study is complete at the end of the year.

Add CEE signature line.

Phone Introduction

Hi, my name is ____ and I'm calling from Cadeo, an energy efficiency research firm, conducting research on behalf of Center for Energy and Environment (or CEE) in Minnesota. I am following up on a (EMAIL) you received from CEE staff.

We are hoping to talk with manufacturers about their perspectives on the residential window market and we would love to include your perspective. Your insights will help us shape energy efficiency programs in Minnesota and are incredibly valuable.

We are also happy to send you a copy of our findings when the study is complete.

The conversation should take about 40 minutes.

Is this a good time, or should we schedule a follow up call?

[If continuing on the phone now]

Great -thank you! Before we get started, I wanted to note a few things:

- Your participation is voluntary and your responses are confidential.
- We will not attach your name to any responses for public reporting or share beyond the CEE team, however CEE may follow up with you around opportunities.
- Finally, is it ok if I record the interview for notetaking purposes?

Record if allowed.

Do you have any questions for me before we get started?

Window Sales

We have a few questions to help us understand more about your organization.

Q1. Are your residential windows sold in Minnesota?

1. Yes
2. No (THANK and TERMINATE)

Q4. What portion of your residential windows are sold in Minnesota? (If they can't estimate, ask about the upper Midwest.)

Q5. What distribution channels do your products flow through? (How are your products typically distributed.)

- a) **If unclear:** About what portion of your sales flow through distributors?
- b) What about contractors? Do you sell direct to contractor/installers? If so, about what proportion of sales are direct to contractors/installers?
- c) And homeowners? Do you sell direct to homeowners?
- d) About what portion of your residential sales are for the new construction market?

Q6. Does the path to market differ for new construction? (Probe: do builders bulk order directly from you, or do your distributors usually handle that?)

Q7. Thinking of the retrofit market, what portion are custom ordered?

- a) What types of products are "stocked" for retrofit projects?

HPW Perceptions & ENERGY STAR

Q8. Thinking about your residential sales volume over the past two years:

1. About what portion had a U-Factor over 0.27?
2. And about what portion had a U-Factor at or below 0.22?

Q9. What are the most energy efficient windows you make?

Q10. Do you recommend this product for specific types of projects or customers?

Q11. How does your company leverage the ENERGY STAR brand? (Probe to understand how they position ENERGY STAR products, or if they are considered premium)

Q12. About what portion of your 2022 residential window sales were ENERGY STAR? (Interviewer note: this is the current specification, V6.).

WINDOWS			
CLIMATE ZONE	U-FACTOR ¹	SHGC ²	
Northern	≤0.27	Any	Prescriptive
	=0.28	≥0.32	Equivalent Energy Performance
	=0.29	≥0.37	
	=0.30	≥0.42	
North Central	≤ 0.30	≤ 0.40	
South Central	≤ 0.30	≤ 0.25	
Southern	≤ 0.40	≤ 0.25	

- Q13. Some reports indicated more than 80% of the national window market is ENERGY STAR. In your experience, is the Minnesota (or upper Midwest) market consistent with this?
- Q14. **Are Northern Climate Specification windows distributed differently (For example, are they distributed intentionally in that climate zone?)**
- Q15. What portion of your 2022 residential window sales had a SHGC higher than 0.35? (Probe on risks and benefits for windows with high SHGC, and where they are recommended)

Read: The ENERGY STAR specifications for windows have been updated to version 7.0, which will go into effect in October of this year. ENERGY STAR V7 (Northern Climate) requires a U-Factor of 0.22 or less and SHGC of greater than 0.17. There is a provision allowing for tradeoff between these criteria, where windows with higher SHGC can have a higher U-factor to qualify.

Northern Climate Zone Tradeoffs (only for interviewer reference)	U-Factor	SHGC
	= 0.23	≥0.35
	=0.24	≥0.35
	=0.25	≥0.40
	=0.26	≥0.40

- Q16. **How do you expect the market will adjust to the new ENERGY STAR 7.0 specifications? (Interviewer notes: listen for price increases, limited materials, product availability, technical or manufacturing challenges.)**
- Q17. **Are you preparing to increase your production volume for windows that meet the northern climate spec? Do you anticipate using the tradeoffs to achieve ENERGY STAR V7? (Probe: What barriers do you anticipate in increasing the volume of these products?)**
- Q18. **What do you think could encourage sales and installation of ENERGY STAR 7.0 rated windows? (For example: tax credits, more utility programs, policy?)**
- Q19. How do you promote low U-factor windows (Interviewer notes: are there different strategies for triple pane, sound reduction, high performance buildings, electrification)?

Business Strategies

- Q20. Who are your key partners in Minnesota? (Probe for retailers, distributors, etc.)
- Q21. Do you have any plans to increase production of triple pane windows? (Probe to understand if this includes thin triples. Thin triples are “drop-in” window replacements that uses addition of center thin glass and krypton gas to convert windows to ~R5 performance.)

Other Dynamics

- Q22. What supply chain challenges are affecting the window market today? (Probe for lead times.)
- Q23. What typically drives up the cost of window products? (Probe: is it specific glass features, such as triple or thin triple panes, or is it more frame materials or latching mechanisms, style or something else?)**
- Q24. How do you expect the window market will shift in the next 5-10 years? What do you see coming? (Probe for more efficient product offerings, change of standards, etc.)
- Q25. Finally, we are trying to understand windows sales in Minnesota. Are there data sources you use or would recommend for this kind of information?**
- Q26. Do you have sales data specific to the state that includes U-factor?

Conclusion

Thank you so much for answering our questions! Can we use the email we have on file to send you the \$100 e-gift card?

Installers and Distributors Interview Guide

Phone Introduction

Hi, my name is _____ and I'm calling from Cadeo, an energy efficiency research firm, conducting research on behalf of Center for Energy and Environment (or CEE) in Minnesota. We are hoping to talk with window installers and distributors about their perspectives on the residential window market, and we would love to talk with you. Your insights will help us shape energy efficiency programs in Minnesota and are incredibly valuable. The conversation should take about 15-20 minutes, and to say thank you for your time, we are offering a \$100 gift card.

Is this a good time, or should we schedule a follow up call?

[If continuing on the phone now]

Great -thank you! Before we get started, I wanted to note a few things:

- Your participation is voluntary, and your responses are confidential.
- We will not attach your name to any responses for public reporting or share beyond the CEE team.
- Finally, is it ok if I record the interview for notetaking purposes?

Record if allowed.

Do you have any questions for me before we get started?

Market Roles

We'd like to speak to someone with insight into the residential window market, and your organization's residential window sales.

First, help us understand a bit about your organization--

Q1. Does your firm **install** windows in Minnesota?

1. Yes
2. No

Q2. Does your firm **sell windows directly to consumers** in Minnesota?

1. Yes
2. No

Q3. Does your firm **sell windows to other professionals** in Minnesota?

1. Yes

2. No

[ASK ALL]

Q4. Do you have a space where customers can see and touch window products prior to purchasing them, like a showroom? (Interviewer: record any unique or alternative ways customers are given access in verbatim.)

3. Yes
4. No
- 96. Other, please specify: [Open-ended response]

Window Sales

- Q5. Who is your primary customer? (Probe to understand if they primarily sell to builders/general contractors, or if they supply retailers, or sell directly to homeowners.)
- Q6. Thinking about your residential window sales over the past 2 years, about what portion were for newly constructed homes?
- Q7. And were the remainder in retrofit or replacement projects?
- Q8. [If they work in both new construction and retrofit] How, if at all, do the products installed in new construction differ from retrofit?
- Q9. Do you also work in the multi-family market? [If yes] How do the products for multifamily differ from single family?
- Q10. What portion of your window sales are custom ordered? (Probe to confirm if the remainder are stocked, ordered in bulk/standard size, or some other process.)

HPW Perceptions & ENERGY STAR

- Q11. What is the most energy efficient window you sell?
- Q12. Thinking about your overall sales for the past two years:
1. About what portion had a U-Value over 0.27?
 2. And about what portion had a U-Value at or below 0.22?
- Q13. In what scenarios do you recommend customers consider windows with low U-Values (or U-Value below 0.22)? How often do you recommend customers consider these products?
- Q14. Are there specific types of builders (or architects) most likely to specify these products?
- Q15. How does your company leverage the ENERGY STAR brand? (Probe to understand how they position ENERGY STAR products, or if they are considered premium.)
- Q16. About what portion of overall window sales last year were ENERGY STAR? (Current specification, ESTAR V6).
- Q17. What portion meet the Northern Climate ENERGY STAR specification?

- Q18. Some reports indicated more than 80% of the national window market is ENERGY STAR. In your experience, is the Minnesota market consistent with this?
- Q19. Do you sell windows that have a SHGC higher than 0.35? (Probe on risks and benefits for windows with high SHGC)

Read: The ENERGY STAR specifications for windows have been updated to version 7, which will go into effect in October of this year. ENERGY STAR V7 (Northern Climate) requires a U-Factor of 0.22 or less and SHGC of greater than 0.17. There is a provision allowing for tradeoff between these criteria, where windows with higher SHGC can have a higher U-factor to qualify.

Northern Climate Zone Tradeoffs (only for interviewer reference)	U-Factor	SHGC
	= 0.23	≥0.35
	=0.24	≥0.35
	=0.25	≥0.40
	=0.26	≥0.40

- Q20. Were you aware of this new Energy Star V7 change?
- Q21. How do you expect the market will adjust to the new ENERGY STAR 7 specifications? (Probe on any barriers to selling such as price increases, limited supply/product availability)
- Q22. Do you anticipate any barriers specific to selling or installing Energy Star V7 windows?
- Q23. What aspects of low U-factor windows would you highlight to sell to customers? (Probe on triple pane, sound reduction, high performance buildings, electrification)
- Q24. What do you think could encourage purchase and installations of ESTAR v7 rated windows? (Probe for spiffs for sales team, more training on the benefits of HPW, marketing support, etc.)

Business Strategies

- Q25. Do you typically install or distribute products from a single manufacturer? (If multiple, probe to understand how they choose suppliers.)
- Q26. Are there incentives for sales staff at your organization, or another commission structure? (Probe to understand overall sales strategies – how do salespeople typically frame options for customers? What are the main elements?)

Other Dynamics

- Q27. How is the window market struggling with supply chain challenges, if at all?
- Q28. What typically drives up the cost of window products? (Probe: is it specific glass features, such as triple or thin triple panes, or is it more frame materials or latching mechanisms, style, or something else?)

Q29. Finally, how do you expect the window market will shift in the next 5-10 years? (Probe for more efficient product offerings, change of standards, etc.)

Conclusion

Thank you so much for answering our questions! Can we use the email we have on file to send you the \$100 e-gift card?

Mystery Shopping Guide

Scenario #1: Standard Residential Retrofit

The "Standard Residential Retrofit" consumer lives in a home in St. Paul, Minnesota, that is 80-90 years old, with original wood windows with storm windows. The consumer is concerned about the noise coming through the windows from a busy street as well as the draftiness from around the window casing. The consumer therefore wants windows that will make the home quieter and more comfortable. The consumer also would like the added benefit of decreased heating costs during the winter. This consumer is most motivated by practicality and not necessarily sustainability.

Homes of this era often have double pane windows, but they will have aged and could have some condensation build up from failed seals.

Attribute	Scenario
Persona	Jane, purchased home approximately 2 years ago
Home Age	1940s (about 1700 square feet)
Number of Windows	16 windows (replacing 6 of the windows)
Age of Windows	~40 years
Window type	Single-pane wood windows with aluminum frame storms (both clear glass).
Reason for replacement	Comfort, current windows are drafty Hoping to address noise coming in through windows, quieter home Hoping to save energy, lower heating bills
Home orientation	West
Details (as needed)	Two story home, 14 windows total, mix of W34 X H54 double hung, W30 X H52 casement windows.

-
- Q1. Hi, I think I need to replace some windows in my home, is there someone there I could talk to? I'm not sure about my options.
- Q2. [When get appropriate contact.] Great. I'm at the start of this process and am trying to sort out where to begin! Do you sell windows to homeowners?
- Q3. [If sell] Do you install them as well or do I need to find a contractor?
- Q4. I have an older home and am trying to replace about 16 windows in the living/dining/kitchen room that are old and drafty (They are original windows with storms, and quite drafty). I really want to replace these windows with something that will do a better job of blocking the sound from the road. Is there a specific type of window you would recommend?

- a. How does the price differ for the higher end products?
 - b. What's the range in pricing?
 - c. What's the ballpark installation cost? How should I calculate it?
 - d. Just so I know what I'll be paying for, what drives the difference in sound reduction?
- Q5. What are the best windows you sell for lowering heating bills? (If respondent does not explain, probe to ask what makes them "best" and their benefits)
- Q6. I've heard that Energy Star helps ensure that the windows are efficient. Are these windows that you recommend Energy Star rated?
- Q7. Are these ("best") windows worth it in your opinion?
- Q8. Is there anything else you think I should consider? (Are there any online sources they recommend?)

Scenario #2: The Environmentalist

The Environmentalist consumer lives in a 1960s home in St. Paul, Minnesota, with a mix of original wood windows and vinyl windows installed in the 1980s. The consumer wants to redo their house and upgrade the windows to improve efficiency (and get a consistent, modern look). The consumer is interested in top-of-the-line products that are as sustainable as possible to improve the efficiency of their home. The consumer wants to save energy for both philosophical and cost savings purposes. Finally, the consumer wants aesthetically pleasing, high quality windows. This consumer is willing to spend more to ensure all these priorities are met.

Attribute	Scenario
Persona	Jane, purchased home approximately 2 years ago
Home Age	1960s (single story ranch-style home, approximately 1900 sq ft.)
Number of Windows	12 windows, and replacing 6 of those (All vinyl windows replaced in the 80's or 90's. one picture window with casements to the sides, sliders in the kitchen, bathroom, dining room. There is also a sliding door, but I don't want to deal with that right now.)
Age of Windows	Vinyl windows from the 80s
Window type	80s vinyl, (sliders and one casement picture window)
Reason for replacement	Wants a low energy use house Wants top-of-the line efficient Aesthetics
Home orientation	South

- Q1. Hi, I want to replace some windows in my home, is there someone there I could talk to? I'm not sure about my options.
- Q2. [When get appropriate contact.] Great. I'm at the start of this process and am trying to sort out where to begin! Do you sell windows to homeowners?
- Q3. [If sell] Do you install them as well or do I need to find a contractor?
- Q4. I have an older home and am trying to replace about 6 windows. I'm trying to make my house as energy efficient as possible and replacing these old windows is something I need to do this year. (If needed: I think replacing these windows will help us reduce our heating use and stay comfortable, and also stay cool in the summer since my house faces South. We've done other things to reduce our carbon footprint and are considering solar panels too...) What are the best, most efficient windows you recommend?
- Q5. Just so I know all of the options, is there a higher quality window beyond that? I see this as an investment in my home.
- a. How does the price differ for the higher end products?
 - b. What's the range in pricing?
 - c. What's the ballpark installation cost? How should I calculate it? If it's easier to send via email, you can send it here *[add sample email]*
 - d. Are those energy star windows? I've read those are the most efficient.
 - e. What features should I look for if I want really efficient windows? Are there specific technical terms that I should learn about and watch for as I plan this project?
- Q6. We get a lot of sun on the south side of our house, we're wondering if there are windows that could capitalize on this and reduce our heating bills in the winter? How would this effect the indoor temperature in the summer?
- Q7. Is there anything else you think I should consider? (Are there any online sources they recommend?)

Residential New Construction Interviews: Raters

Outreach

Phone

Hi, my name is ____ and I'm calling from Cadeo, an Energy Efficiency research firm. We are calling on behalf of Center for Energy and Environment as part of a research project focused on understanding new single family homes in Minnesota are constructed and how raters interact with this market, specifically when it comes to shell improvements. Your perspective is very important for helping us understand this market. My questions should take about 15-20 minutes. Is this a good time, or should we schedule a follow up call?

[If referred to a different contact, collect their name/email/number and release contact.]

Thank you for your time today—do you have any questions for me before we get started?

Introduction

Thank you for taking the time to speak with us. Our questions today should take about 20 minutes. All information you provide is voluntary and confidential and will not be shared beyond the team working on this research. Do you have any questions for me before we get started?

We also like to record these calls so the research team can review any notes we may miss during the discussion today. Is it okay with you if we record this call?

Screening Questions [ASK ALL]

First, I'd like to confirm your role:

Q1. I understand that your company is involved in rating new single-family homes in Minnesota, correct?

[IF NO, THANK AND TERMINATE]

Q2. Do you work on other types of buildings? (Multifamily or commercial buildings?)

Q3. What is your role at [COMPANY]?

Q4. Which programs do you work with (including utility or certified home programs)? (Interviewer note: we are looking for specific programs like Zero Ready, ENERGY STAR, utility programs, Passive House, or above code pathways.)

Q5. How do you work with builders? (Interviewer note: We are looking to understand the relationship and potential level of influence. Some possible probes might include: Do they call you early in a project? Are there some builders for which energy rating is standard practice? Are you typically working for a program?)

Q6. [If unclear] Do you do other work with builders outside of these programs?

- Q7. In what scenarios would you be involved before construction? (Interviewer note: do these scenarios involve working with designers or architects?)
- Q8. Do you make recommendations to help builders ensure their homes will meet certification performance thresholds?
- Q9. How are you involved in value engineering conversations, if at all?
- Q10. We want to understand how builders make decisions about shell performance in general—and especially windows. In what scenarios would you be involved in that decision?
- a) [If unclear: when are those products selected?]
- Q11. Is this different for different types of builders? (For example, is the opportunity different for custom or spec homes vs. with production builders?)
- Q12. When you are asked to rate a home’s energy performance what is a “typical” window performance you see? (Interviewer note: ask them to describe this in U-Factor, SHGC, low-e coating, triple panes, frame material.)
- a) When is it better than that?
- b) When is it worse?
- c) Do you typically check performance by climate zone? What do you find?
- Q13. How common is it to find ENERGY STAR qualified windows in new homes? Over the past 5 years or so, about what portion of the homes you rated had ENERGY STAR or better windows?

If needed:

ESTAR V6 (Current Specification)

Climate zone	U-Factor	SHGC	
Northern	≤0.27	Any	Prescriptive
	=0.28	≥0.32	Equivalent Energy Performance
	=0.29	≥0.37	
	=0.30	≥42	

- a) Has that changed over time?
- Q14. Are you aware of the updated ENERGY STAR specification, Version 7, which will take effect in October?

If needed:

The ENERGY STAR specifications for windows have been updated to version 7.0, which will go into effect in October of this year.

Read: ENERGY STAR V7 (Northern Climate) requires a U-Factor of 0.22 or less and SHGC of greater than 0.17. There is a provision allowing for tradeoff between these criteria, where windows with higher SHGC can have a higher U-factor to qualify.

ESTAR V7 (New Specification, as of October 2023)

Northern Climate Zone Tradeoffs (only for interviewer reference)	U-Factor	SHGC
	= 0.23	≥0.35
	=0.24	≥0.35
	=0.25	≥0.40
	=0.26	≥0.40

- Q15. How important are the Northern Climate Zone Tradeoffs? Do you have concerns about high solar heat gain coefficient allowances?
- Q16. What have you heard about the new ENERGY STAR spec from the builders you work with?
- Q17. How do you think the programs you work with will adapt to this new spec? Will they require the new specification? [Probe to understand if that is expected to change over time.]
- Q18. How important is window performance for homes striving to meet other performance thresholds, or qualify for incentives or labels?
- Q19. Are there programs or labels in which window performance is more critical?
- Q20. What do you think would encourage the adoption of windows meeting the updated ENERGY STAR V7 criteria?
- Q21. What prevents these windows from being installed now?
- Q22. Where do you turn for information or training on new products or practices likely to improve the energy performance of new homes?
- Q23. What do you expect we will see in the window market over the next 5-10 years? Who is most likely to adopt the new ENERGY STAR V7 specification? Who will be slowest?

Thank you! Those are all of my questions.

Residential New Construction Interviews: Single Family Builders

Outreach

Phone

Hi, my name is ____ and I'm calling from Cadeo, an Energy Efficiency research firm. We are calling on behalf of Center for Energy and Environment as part of a research project focused on understanding the single-family new construction market in Minnesota. We are talking to builders about window selection and window performance. Your perspective is very important for helping us understand this market.

Are you involved in constructing or developing new single-family or multifamily construction in Minnesota? **[IF NO, THANK AND TERMINATE].**

If yes: We are offering \$100 gift card for each completed interview, and we would love to talk with you about your experience building new homes. My questions should take about 20 minutes. Is this a good time, or should we schedule a follow up call?

[If referred to a different contact, collect their name/email/number and release contact.]

Thank you for your time today—do you have any questions for me before we get started?

Introduction

Thanks again for taking the time to speak with us. Our questions today should take about 15 minutes. All information you provide is voluntary and confidential and will not be shared beyond the team working on this research. Do you have any questions for me before we get started?

We also like to record these calls to help the research team with notetaking. Is it okay with you if we record this call?

Screening Questions **[ASK ALL]**

First, I'd like to ask a few questions about your work in Minnesota over the past two years.

Q1. About how many homes did your firm construct in Minnesota over the past two years?
Approximate estimate is fine.

[IF NONE, THANK AND TERMINATE?]

Q2. Are these all single-family detached homes, or do you also work on multifamily properties?

Q3. Where do you turn for information or training on new products or practices likely to improve the energy performance of new homes?

Q4. Do you ever work with home energy raters? [If yes: In what scenarios? At what point in construction are the raters integrated?]

Q5. We are trying to understand the process through which building shell decisions are made. How are window products selected for your homes or developments?

Follow up questions (as appropriate)

- a. Are they specified by an architect?
- b. What features are typically specified? (performance (U-value, SHGC, frame material etc.)
- c. Are you responsible for selecting windows, or how is this decision made??
- d. When are windows selected in the building process?
- e. How would you characterize the window you use most often?

Shifting to window procurement -

- f. How do you work with window suppliers?
- g. Do you ever order directly from manufacturers?
- h. How does the overall process differ for custom homes vs. spec homes or larger scale housing developments? **[If they work on MF: What about multifamily projects?]**
- i. Is this window procurement process updated regularly with new suppliers or options to compare pricing? How does that work? (Is there a specific time of year?)

Q6. About what portion of the new homes you worked on over the past two years had ENERGY STAR windows installed?

Q7. Do you work with any certification or labeling programs, like ENERGY STAR, LEED for homes, Zero Ready, or utility programs?

- a. [If yes] How do those programs affect the decisions made on window selection or shell performance generally?

Q8. How important is the efficiency of windows to new home buyers?

Q9. A new ENERGY STAR specification will be in place in October. Have you heard about this new spec? **[Interviewer note: If no, read information below.]** If yes, what have you heard about it?

If needed: The ENERGY STAR specifications for windows have been updated to version 7.0, which will go into effect in October.

Read: ENERGY STAR V7 (Northern Climate) requires a U-Factor of 0.22 or less.

ESTAR V7 (New Specification, as of October 2023)

Northern Climate Zone Tradeoffs (only for interviewer reference)	U-Factor	SHGC
	= 0.23	≥0.35
	=0.24	≥0.35
	=0.25	≥0.40

	=0.26	≥0.40
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Q10. Do you think this Energy Star change will influence you or your customers selection of windows?

- Q11. What types of homes will be most likely to install these new ENERGY STAR V7 windows?
- Q12. This new ENERGY STAR spec has a tradeoff that allows for higher U-Factor with higher SHGC (.35 or higher). Do you think you will consider this tradeoff in selecting windows after October? Are there risks for homes with high SHGC windows? Are there benefits?
- Q13. Are you aware of "thin triple" paned windows? These windows use thinner glass to reduce the weight and width compared to traditional triples. Have you seen these? Have you ever had them installed in a new home?

Q14. What changes do you expect we will see in the window market over the next 5-10 years?

Thank you! Those are all my questions.

Residential New Construction Interviews: Architects

Outreach

Phone

Hi, my name is ____ and I'm calling from Cadeo, an Energy Efficiency research firm. We are calling on behalf of Center for Energy and Environment as part of a research project focused on understanding the multifamily new construction market in Minnesota and how design teams approach window selection and window performance. Your perspective is very important for helping us understand this market.

Does your work include designing new multifamily buildings in Minnesota? **[IF NO, ASK IF THERE IS SOMEONE ELSE AT THEIR FIRM THAT SPECIALIZES IN MULTIFAMILY BUILDINGS. IF NOT, THANK AND TERMINATE].**

If yes: Great, we would love to talk with you about those buildings. My questions should take about 20 minutes. Is this a good time, or should we schedule a follow up call?

[If referred to a different contact, collect their name/email/number and release contact.]

Thank you for your time today—do you have any questions for me before we get started?

Introduction

Thank you for taking the time to speak with us. Our questions today should take about 15-20 minutes. All information you provide is voluntary and confidential and will not be shared beyond the team working on this research. Do you have any questions for me before we get started?

We also like to record these calls so the research team can review any notes we may miss during the discussion today. Is it okay with you if we record this call?

Screening Questions **[ASK ALL]**

First, I'd like to ask a few questions about the multifamily projects you have worked on in Minnesota over the past five years.

Q1. About how many newly construction multifamily buildings would you estimate you worked on in the past five years? (Alternative measures: number of units, total floor area.)

[IF NONE, THANK AND TERMINATE?]

Q2. How would you describe these projects, are they typically low rise? High-rise (four stories or higher)? Do you also work on low-income projects?

Q3. What is your role in these projects?

- Q4. We are trying to understand the process through which building shell performance is established and how window products are specified in new multifamily buildings. Can you talk me through how that typically works?
- Q5. Do you typically look for commercial glazing or residential window products when you are working on multifamily buildings?
- Q6. How does the selection process and performance expectation vary by building type (for example, 5+ stories, or townhouse type construction vs. low-rise?)
- Q7. What about by project design approach... how does this change if a project is design+build vs. plan+spec?
- Q8. Do you typically establish performance thresholds for window and glazing systems or do you specify actual products?
- Q9. When do you specify above code windows? Is this for a typical customer or building type?
- Q10. Who decides on the product that is ultimately selected?
- Q11. How does value engineering affect this process?
- Q12. Have you been involved in multifamily building design that involved other programs promoting high performance buildings, like LEED, Zero Ready, ENERGY STAR, utility programs, or other multifamily performance programs? [If yes: about how many buildings over the past five years? And how did the windows selected for these projects differ?]

We have some questions about specific window characteristics, and we'd like to understand your perspective on each.

- Q13. Let's start with ENERGY STAR-certified windows (V6, the spec that has been in place for some time now). Do you specify this level of performance? Why/why not? Is there resistance to this? In what scenarios?

If needed:

ESTAR V6 (Current Specification)

Climate zone	U-Factor	SHGC	
Northern	≤ 0.27	Any	Prescriptive
	$= 0.28$	≥ 0.32	Equivalent Energy Performance
	$= 0.29$	≥ 0.37	
	$= 0.30$	≥ 42	

- Q14. What about the NEW ENERGY STAR specification (V7, which will be in place in October)? Have you heard about this new spec? If no, read information below. If yes, what have you heard about it? Are you likely to include this level of performance in your plans after October?

If needed The ENERGY STAR specifications for windows have been updated to version 7.0, which will go into effect in October of this year.:

Read: ENERGY STAR V7 (Northern Climate) requires a U-Factor of 0.22 or less and SHGC of greater than 0.17. There is a provision allowing for tradeoff between these criteria, where windows with higher SHGC can have a higher U-factor to qualify.

ESTAR V7 (New Specification, as of October 2023)

Northern Climate Zone Tradeoffs (only for interviewer reference)	U-Factor	SHGC
	= 0.23	≥0.35
	=0.24	≥0.35
	=0.25	≥0.40
	=0.26	≥0.40

- Q15. Note that this new ENERGY STAR spec has a tradeoff element that allows for higher U-Factor with higher SHGC. How important is solar heat gain coefficient in multifamily buildings in Minnesota? What kind of tradeoffs do you consider when specifying SHG in multifamily?
- Q16. What other factors are important to the project developers or owners you work with when it comes to windows? (Probe to understand relative importance of price, appearance, sound transmittance, blast/riot proof glass, confidence in overall occupant comfort.)
- Q17. What prevents low U-Factor, high performance windows from being specified and installed in new multifamily buildings? (Are there factors other than cost?)
- Q18. What would encourage broader adoption of low U-Factor, high performance windows? Are there benefits that should be emphasized or promoted?
- Q19. Are you aware of "thin triple" paned windows, which use a very thin center pane of glass to achieve very high efficiency without added weight or thickness? Have you seen these? Used them in a project?
- Q20. Where do you turn for information or training on new products or practices likely to improve the energy performance of multifamily buildings? What about windows specifically, where would you recommend architects or design professionals go to learn about new window advancements?
- Q21. What do you expect we will see in the window market over the next 5-10 years? What types of projects are most likely to adopt the new ENERGY STAR V7 specification? Which will be slowest?

Thank you! Those are all my questions.