Windows: Pushing the Envelope on a Brighter Future

Isaac Smith, Center for Energy and Environment, Steven Sylvestre, Center for Energy and Environment, Josh Quinnell, Center for Energy and Environment, Tamara Anderson, Northwest Energy Efficiency Alliance

ABSTRACT

One of the first things homeowners ask energy auditors about are windows. The common practice is to steer them away from windows and toward insulation to improve their home's energy efficiency, and rightfully so. However, over 50 million windows are sold every year and when homeowners make costly investments in "energy efficient" windows, that is not always what they receive. NEEA and CEE seek to change this by launching market transformation programs that will accelerate the adoption of high-performance windows (HPW). It is critical that homeowners receive HPW when making this investment, because windows installed today will still be around in 2060 given their long lifetime (35–45 years). This is also an important technology peak load savings — results from a modeling study completed by CEE will highlight the outsized impact that windows have on peak heating and cooling loads. NEEA and CEE will also summarize the results from recently completed market research and interviews that highlight consumer demand and the barriers and biases in the market today. Additionally, NEEA and CEE will share their strategies and approaches for addressing these barriers, including results from a volume-builder and affordable housing pilot. This is the perfect time for energy efficiency programs to engage this market, as recent innovations in the window industry and updates to the ENERGY STAR® specification will help motivate a stagnant market. The strategies and approaches covered in this report can also be leveraged by others, so the impact of better windows can be felt across the country.

Introduction

While windows brighten our days and constitute only 8% of the surface area of a typical home, windows are poor energy performers. As the U.S. prioritizes net zero energy buildings, addresses carbon emissions, and confronts the challenges of decarbonizing the grid, there is a pressing need to dramatically increase the availability and use of highly efficient window products. Buildings are responsible for ~40% of U.S. energy use/emissions. Windows are responsible for about 4% of total societal energy use and greenhouse gas (GHG) emissions, or ~4Q of energy. This costs building owners and consumers ~$50 billion/year (PAWS. 2022).

Windows usually account for 30-40% of the heat loss in winter, and often add to cooling peaks and discomfort in summer. Switching from today's code-compliant window in a new home to new advanced solutions—a window with ~R5 insulating power —can save between 7-16% of a home's energy use, and even more in older homes.

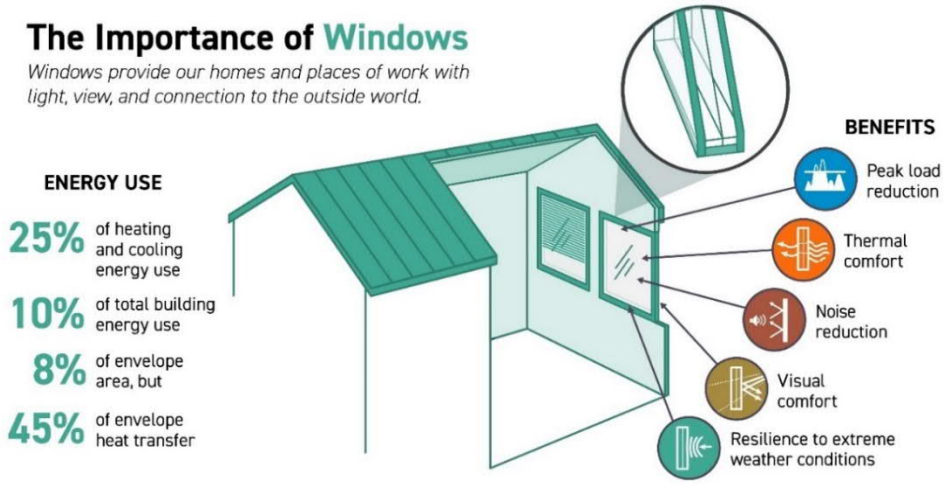

Figure 1. The Importance of Windows (PAWS. 2023)

The Northwest Energy Efficiency Alliance (NEEA) and Center for Energy Environment (CEE) plan to capture this opportunity with their market transformation programs. NEEA is a non-profit organization working to effect market transformation through the acceleration and adoption of energy-efficient products, services, and practices. CEE is a non-profit organization that implements Minnesota's Efficient Technology Accelerator (ETA), a statewide market transformation program that accelerates deployment and reduces the cost of emerging and innovative efficient technologies, bringing lower energy bills and environmental benefits to Minnesotans.

CEE and NEEA are each working to accelerate the adoption of HPW that meet the following criteria –

Performance Characteristics	Physical Characteristics
•U factor: ≤ 0.22 (area weighted). •Air Leakage: ≤ 0.3. •Condensation: ≥ 45. •SHGC: No spec.	•Fixed or operable windows. •Can be installed or retrofitted in an existing wall with 2x4 framing construction.

Figure 2. High Performance Window (HPW) definition

Market Research

Market research is a key pillar of market transformation programs, as it identifies market barriers and opportunities and deepens the understanding of the inter-workings of the market. CEE and NEEA each completed market research prior to launching their programs. This section covers some of the key findings.

Market Overview

There were an estimated 57.4 million residential windows sold annually in the US in 2022 (Bender, 2024) and roughly half of those windows are sold to new construction and the other half are sold to replacement markets in existing homes. This fluctuates with the new

construction industry and by region, with sales in existing homes outpacing new construction in regions with less construction and population growth. Data for the Northwest and MN are shown in Table 1, below.

Table 1. Regional window sales

Region	New Construction	Percentage	Existing Homes	Percentage	Total
Northwest – OR, WA, MT, ID	1,590,000	45%	1,975,000	55%	3,565,000
MN	508,000	50%	513,000	50%	1,021,000

CEE's market characterization study, completed by the Cadeo Group in 2022, found that the market dynamics within the replacement and new construction markets are complex but very different from each other. The new construction market is highly driven by first cost and will typically specify a code minimum window, unless the home is participating in an above-code program or energy efficiency is prioritized (e.g., passive house construction). The significant overall cost of window packages and the incremental cost between a code minimum package and a HPW package make windows an easy target for keeping costs down.

The replacement market is complex for homeowners to navigate, as they face several choices related to brand, product line, and contractor. They also need to decide on many factors outside of efficiency (e.g., type, aesthetic, etc.), all of which impact cost. Homeowners are more likely to request or prioritize ENERGY STAR products compared to builders, but they rely heavily on contractor opinions, making contractors a key influencer in the window replacement market.

Consumer Research

In 2022, NEEA contracted with the Cadeo Group to conduct a residential HPW market characterization study to identify what triggered homeowners to purchase windows, as well as to build an understanding of the windows supply chain more generally (including awareness of HPW throughout the supply chain). Cadeo's work revealed that, while air drafts, condensation, and poor aesthetics could cause homeowners to consider replacing windows, they often stalled in the decision-making process for years (Cadeo Group, 2022). Broken glass, however, caused homeowners to purchase a replacement window relatively quickly. Homeowners relied on online research and installer recommendations the most when making a decision to purchase, and were generally inhibited from purchasing HPW by the higher up-front costs (see Figure 3).

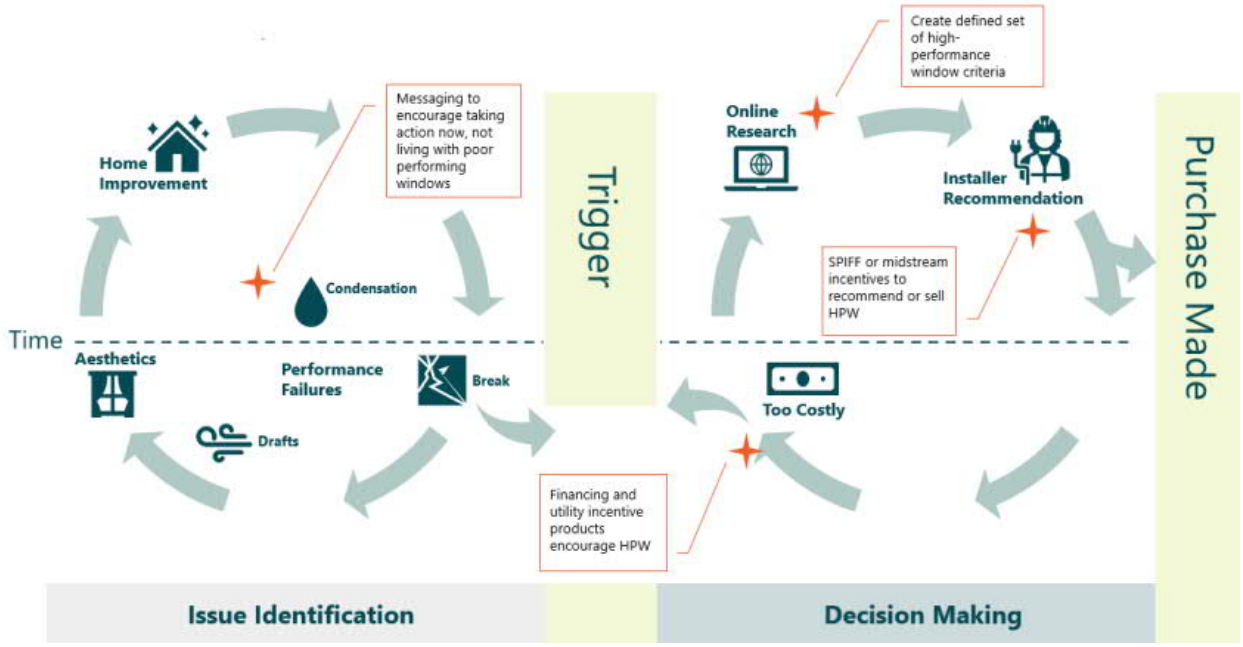

Figure 3: Path to Purchase Diagram, with Potential Influence Points (Cadeo Group, 2022).

However, a 2021 article published by the National Association of Home Builders (NAHB) provided evidence that new home purchasers are valuing the efficiency of their windows over many other attributes with 83% of homebuyers surveyed indicating that ENERGY STAR-rated windows are either essential or desirable (39% and 44%, respectively). Similarly, this survey showed that 71% of home buyers found triple-pane windows essential or desirable, indicating that home buyers want high performance windows.

Mystery Shopping

As part of NEEA's Market Characterization Study, the Cadeo Group conducted mystery shopping calls in early 2022 (Cadeo 2022). The mystery shopping analysis revealed several persistent barriers in the supply chain:

- Most suppliers viewed anything beyond double-pane as superfluous and appropriate only in extraordinary situations.
- Suppliers expected that customers will rely heavily on installer and vendor opinions.
- Double-pane, gas-filled windows met the current residential building codes, which contacts described as requiring high-efficiency windows.
- The relatively mild climate of the Northwest affected supplier recommendations. Some contacts noted that if they were based in Alaska or Arizona, a more efficient window might make sense.
- The number of options and features homeowners chose from could lead them to (1) rely even more heavily on the recommendations of an installer or vendor, or (2) reduce their decision burden by eliminating less-compelling options immediately.

Similarly, mystery shopping was completed as a part of CEE's Market Characterization study (ETA 2023). Here is an excerpt from the report the summarizes the experience –

> *"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."*

Key takeaways from mystery shopping.

- Shoppers first interaction is often with non-technical staff.
- Shoppers are faced with pervasive information asymmetry.
- Vendors offered mixed opinions on triple pane windows (weight, cost, best option)
- The range of project cost is substantial.

To further illustrate the final point, Figure 4 shows the variation in price received during mystery shopping. Pricing was typically delivered as a range of costs per window, which typically included labor for installation. As you can see the low end of the range varied from $1,000 to nearly $3,000 per window, while the high end of the range varied from $1,500 to $4,500. This illustrates some of complexity and information asymmetry that consumers face when shopping for windows. The next section provides further information and research on product cost.

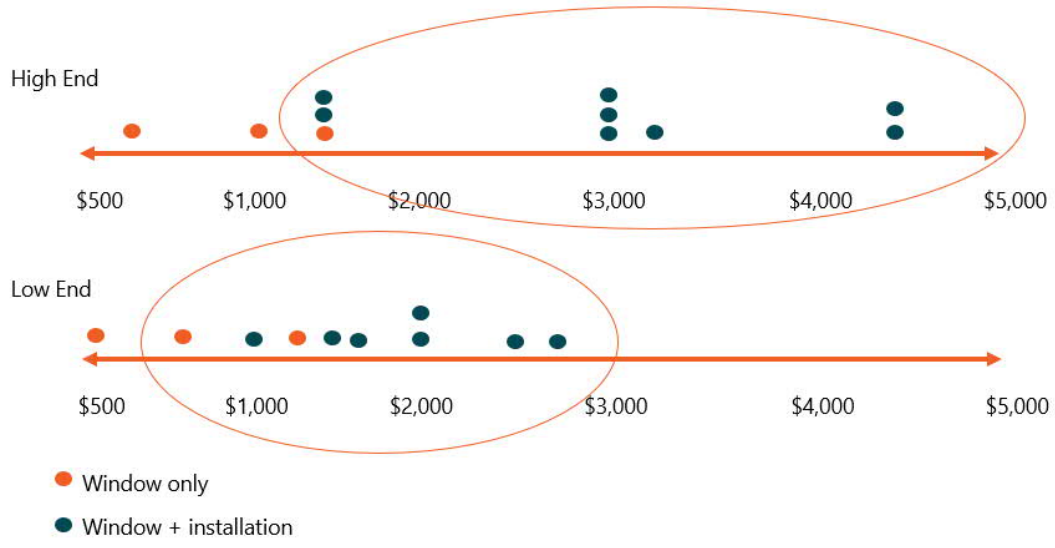

Figure 4. Results from mystery shopping for CEE's Market Characterization report (ETA 2023)

Product Cost

NEEA's market strategies often include coordinating with manufacturers to meet new energy efficiency requirements. In order to gain insights into how manufacturers might address the new ENERGY STAR® V7 rating, it was important to gather more information about different ways the new rating could be met and their relative incremental costs above current market leaders. NEEA contracted with Steve Selkowitz, formerly of Lawrence Berkeley National Laboratory (LBNL), to conduct a cost study of HPW to meet this need.

The study explored several technical pathways to make the required thermal improvements from an ENERGY STAR V6 window to a V7 and concluded that an upgrade to a thermally enhanced double-glazed window or a shift to a triple glazed window could be achieved at an incremental manufacturing cost of ~ $1.80 - $2.10/sf with volume production (Selkowitz 2023).

These relatively low incremental cost ($30 per 15 sq. ft. window) for manufacturing HPW is also verified by an analysis completed by the Environmental Protection Agency (EPA) as part of the ENERGY STAR v7 update. This research found that there was little correlation between window energy-performance and pricing (green trend line), as this is often driven by other factors like window type, style, finish, and hardware (Figure 5). When isolating the difference in energy performance, this study found that the incremental cost for v7 window compared to a code window was $54 (PAWS. 2023).

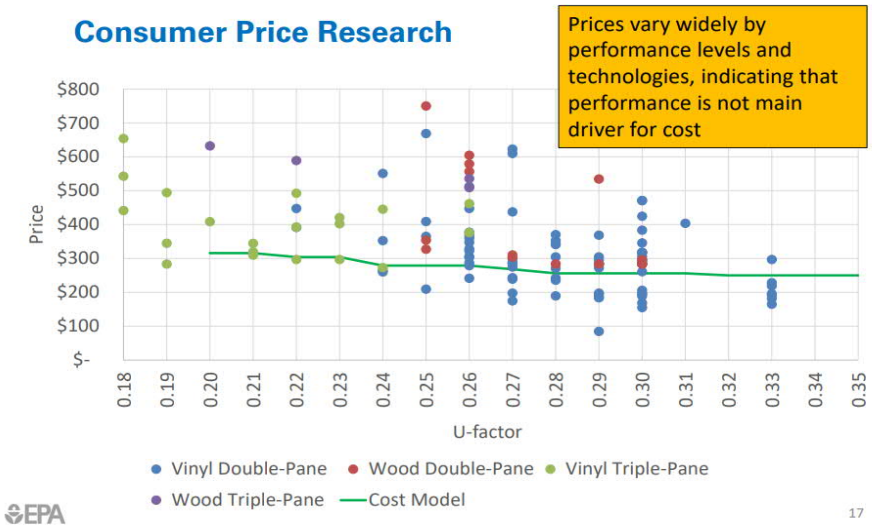

Figure 5. Results from consumer price research completed by EPA (EPA 2021)

Market Barriers

Lack of Awareness and Familiarity

Market interviews suggest that cost is a perceived barrier, although research on product cost indicates a difference between perceptions (e.g. "doubling in price") and cost findings (Figure 5). When asked about the barriers to recommending and bidding HPW, 3 of the 4 barriers found in the interviews were related to cost –

- Competitive market – potential to get ‘undercut’ by a different contractor
- Leads to a more expensive project – potentially doubling in price
- Time required to explain value and price difference isn’t worth it
- Sell window assemblies – often focused on other features, not just efficiency

This indicates that price is still a barrier that likely stems from lack of awareness and familiarity with HPW. The industry perception of triple pane windows was established when the only triple pane window options were thick, heavy products that utilize three panes at a standard thickness. These products were expensive and difficult to install due to their increased weight and frame size, so many builders and contractors avoided them and have maintained this negative perception even though new products have entered the market.

Builders and contractors discourage homeowners from installing triple pane windows due to their historical experiences and fear of being undercut on price by their competitors. Today, there is a lack of industry and consumer awareness of modern triple pane technology, such as hybrid triples and thin triples, which address many of the preexisting concerns associated with triple pane windows. Broad awareness and familiarity of with these modern paths to window performance will be needed to accelerate the adoption of HPW.

Product selection is complex, with many factors and features to navigate.

Many features are available to homeowners when purchasing windows including frame material, latching mechanism, operating method, etc., resulting in a wide range of price points of windows to consider. Aesthetics and operability are typically prioritized during project scoping, sometimes over efficiency, and each window feature impacts total product cost. Due to these considerations, and information asymmetry between manufacturers and customers, price does not always track proportionately with performance. Unless a customer specifically requests triple pane or high-efficiency windows, double-pane low-e products are generally offered as the efficient option.

Case Studies and Pilots Can Build Awareness with Key Market Partners.

Demonstrating the value proposition of HPW will be critical to drive demand and transform the window market. The window purchasers or customers that are primarily responsible for driving demand are most often homeowners, builders, and multifamily developers. It will be key to deploy several tactics to reach each of these target audiences and demonstrate the value that HPW. One method of demonstrating the HPW value proposition will be through field pilots. The pilots may take the form of one or more of the following approaches.

- Production builder pilot – Engage with a local production builder to share cost, price, and product availability data, and facilitate a bulk purchase of HPW for a new development. This tactic may include a cost-share approach to offset the incremental cost to the builder.
- Low-income single-family or multifamily developer pilot – Similarly, engage with a low-income developer, such as Habitat for Humanity, to ensure that the benefits of HPW are brought to these households.

The pilots will be used to develop case studies, training materials, and program resources that demonstrate the value and remove perceived barriers for HPW. NEEA has already started engaging the market in pilot activities, with completed case studies highlighted in the next section.

Market Opportunities

CEE's Market Characterization (ETA 2023) assessed market opportunities that could be leveraged to hasten technology adoption. The following key opportunities were identified and informed subsequently developed market engagement strategies.

ENERGY STAR Version 7.0

A new ENERGY STAR specification (Version 7.0) went into effect October 23, 2023. This specification creates an opportunity for national alignment on HPW product definition and can serve as a benchmark for utility programs and policies across the country. In addition, the updated specification has motivated manufacturers to consider product development and positioning of lower U-factor windows.

A variety of these higher-performance options are enabled by innovations in the window industry including: the strength and reduced cost of thin glass, and improvements to spacer, frame, and sash thermal performance through advancing designs. These and other advancements alleviate manufacturing concerns by providing multiple paths to performance and improve the business case for high-performance windows for a wider range of manufacturers.

Windows Provide Substantial Non-Energy Benefits.

Windows present a host of non-energy benefits (comfort, noise reduction, and health)to the consumer, which is unique compared to other energy efficiency measures. The health benefits of windows can be significant. Poor-performing windows can lead to indoor condensation due to a combination of low outdoor temperature and high indoor humidity, particularly in cold climates like Minnesota and wet climates like the Northwest. Condensation leads to mold, mildew, and rot, which can have serious impacts on the health of a home's occupants. In addition, windows provide a connection to the outdoors which has been shown to have noteworthy effects on the mental health of residents (Veitch 2012) These benefits can be leveraged to drive demand and awareness for HPW.

Builder Pilots and Case Studies

NEEA's HPW builder pilot focuses on assessing the barriers and opportunities for the widespread adoption of highly energy-efficient windows in the Northwest residential market. The objective was to create a demonstrated, repeatable value proposition for the marketplace when compared to typical practices in new construction homes, and to create a like-for-like replacement solution with triple pane windows for double-pane windows.

In 2021 - 2022, NEEA focused on early adopters, green and above-code builders. Builders who elected to participate in the pilot had a general interest in building energy efficient homes, seeing HPW as an additional opportunity to extend their construction practices above and beyond code.

It was assumed that the Oregon and Washington codes would act as a primary driver for builders in those states due to additional energy credits and allowable building envelope improvements that provide credit for low U-value windows. Because energy codes, tax credits, utility programs, and certifications all act as drivers, one early approach used by the pilot team was to show the approximate investment in HPW—on a per-home basis—relative to other measures that also help builders achieve similar levels of efficiency and savings.

Habitat for Humanity in Bend / Redmond

NEEA published the triple pane window flyer on BetterBuilt[NW] which included a table (Figure 6) that shows a comparative added cost for two different ways to build a more energy-efficient home, based on a 2,300 square foot home. Habitat for Humanity was motivated to install triple pane windows to help meet energy performance goals and above-code energy performance for cost equivalent trade-offs (BetterBuilt[NW] 2023).

	Option 1			Option 2
	Double-Pane Window	Rigid Foam	Furring Strips for Rain Screen	New Triple-Pane Window
Material Cost	$9,209/building	$1,971/building	$333/building	$11,554/building
Installation Costs	$6,000/building	$8,000/building		$6,000/building
Total Costs	$15,209/building	$10,304/building		$17,554/building
Grand Total	$25,513/building			$17,554/building

*Estimated $250/window installation cost

Figure 6: Comparison of added costs for two different energy efficient home builds (BetterBuilt[NW] 2023)

Grace Weger, the Bend/Redmond Habitat for Humanity affiliate, gave a presentation at the BuildRight conference in Portland, Oregon titled “Building for Net Zero Energy in Affordable Housing and the Case for High Performance Windows” alongside their rater, Earth Advantage. The conference was geared toward a builder audience (BuildRight 2023).

The keynote speaker and founder of Building Science Fight Club, Christine Williamson, at the BuildRight conference also echoed the importance of HPW for the home with a similar message (Acelab for Architects 2023).

NEEA documented the work at the Bend/Redmond Habitat for Humanity in their case study (BetterBuiltNW 2023). See Figure 7 for project image rendering.

Figure 7: Habitat for Humanity’s 27th St. Townhomes (BetterBuilt[NW] 2023)

Confederated Tribes of Grande Ronde

NEEA worked with the Confederated Tribes of Grande Ronde, and their contractor to install triple pane windows in their elder housing project at Creekside, near Grande Ronde, Oregon. Triple pane windows emerged as a central aspect of their net-zero strategy, because they could affordably provide a host of benefits—including enhanced thermal and auditory comfort, lower energy bills and easy installation—without requiring any changes to the rest of the building's design. Resiliency and meeting energy performance goals for their housing development were key motivating factors for the Tribes. Case studies and videos with further details on this project can be found on BetterBuilt^{NW}.

Energy Trust of Oregon also worked with the Tribes on this project. In an Oregon Public Broadcasting (OPB) article on how climate-friendly homes offer Grand Ronde's tribal elders affordability and comfort against climate change Ryan Webb, the Tribes' engineering and planning manager was quoted saying "A lot of the efficiencies we talk about are actually hidden that you don't even see," Some of those "hidden" efficiencies include triple pane windows that keep energy bills low in the summer and winter, as well as helping reduce traffic noise from the nearby busy highway (Samayoa 2023).

National Production Builder

In Washington, the state energy code, known as WSEC, makes it challenging for builders to meet code with a combustible fuel such as natural gas. Builders effectively need more energy efficiency investments (known as energy credits) in the new homes that they build if they choose to heat with natural gas.

In the current Washington state energy code, the 2018 WSEC, a builder of a typical medium size home is required to choose and install six energy credits beyond the code minimums known as the base code. However, if a builder chooses a combustion fuel like natural gas for the primary heat source instead of an approved electric heat pump, that builder will need to choose one additional energy credit. This is due to the Fuel Normalization Table which rewards primary heat sources based on their carbon emissions potential (Washington 2018).

Energy credit choices range from envelope enhancements to installing solar PV panels. Among the 27 choices for energy credits is the opportunity for a builder to install windows more efficient than the 0.27 base code minimum for window efficiency. HPW can contribute to either 0.5 or 1.0 energy credit depending on the efficiency of the HPW chosen. A 0.22 window package, which is the most common package chosen by our builder in the pilot, would receive 0.5 energy credits. Incorporating HPW into their gas heated homes has contributed to the effort by our national, production builder to exceed code and heat with natural gas, their preferential fuel.

Pilot Key Highlights & Takeaways

- Builders reported positive experiences sourcing triple pane windows from suppliers and manufacturers that they worked with historically.
- Delivery times for HPW were found to be identical to any other production window.
- Overall, the slight increase in weight did not decrease the likelihood of adoption HPW as standard practice.

- Two builders indicated that they would use triple pane windows as their standard offering moving forward.

Energy Savings

As outlined in the introduction, windows are a small but critical component of the building envelope. They are typically the weakest link (lowest R-value) and biggest contributor to homeowner comfort issues due to cold drafts and low glass temperatures. This is particularly true for homes that started with or have completed basic weatherization – R-11 walls, ~R-35 attic insulation and attic air-sealing – but still have windows that are 20 - 40 years old. To accomplish our energy efficiency and climate goals it will be critical to address these windows and put in the best possible option at the time of these replacements. The case studies outlined below highlight the impact that HPW can have.

Modeling Case Studies – Minneapolis, MN

The case studies outlined below are representative of common MN homes that could greatly benefit from window upgrades. They have completed basic envelope weatherization but still have older, in-efficient windows. To better understand the impact of upgrading their windows, CEE modeled the before and after energy use and how HPW would impact the heating design load, annual energy use, and peak impacts in the winter.

Table 2. Minneapolis Modeling Case Studies

	Case 1	Case 2
Year Built	1920s	1960s
Square Feet	2,800	2,700
Attic Insulation	R-40	R-35
Wall Insulation	R-11	R-11
Windows	Single-Pane plus Storm	Double-Pane Clear Glass

Figure 8 below shows the impact of upgrading to HPW as well as completing weatherization. In this case weatherization includes attic air-sealing and adding insulation to achieve R-50 (which is applied prior to window upgrades when modeling). Since these homes already had attic insulation, this did not lead to significant savings. However, the windows had a large impact, resulting in a 17% and 19% reduction in annual heating energy use, respectively. Including the energy savings from weatherization, the reduction was 23% and 26% reduction, respectively.

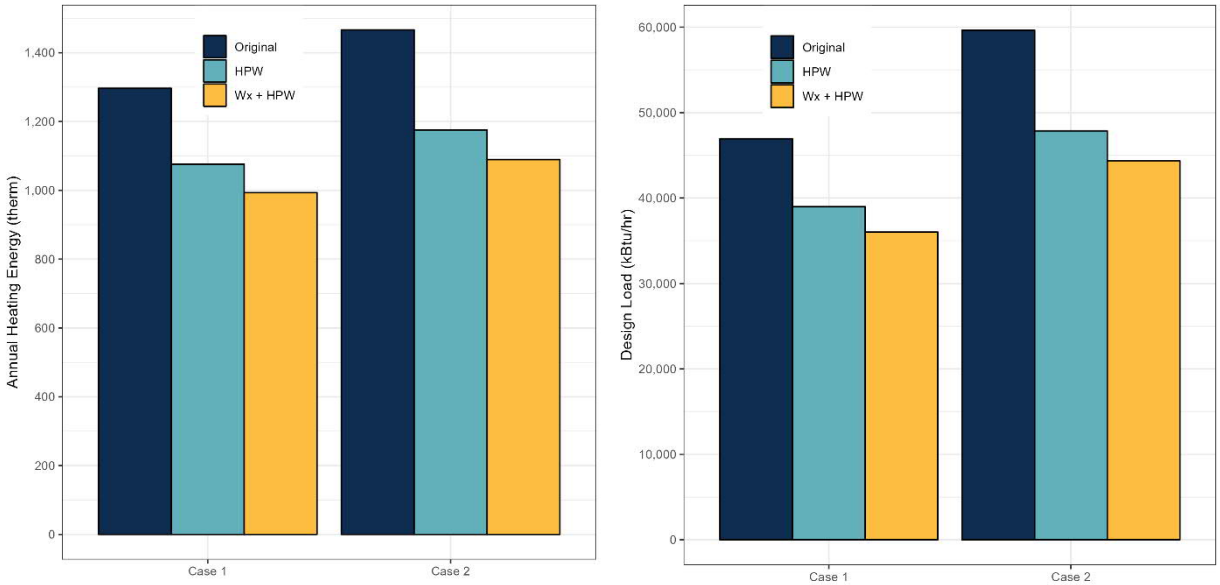

Figure 8. Annual heating energy use (left) and design load (right) impacts from HPW upgrades

There is a lot of momentum nationally for residential electrification via air-source heat pumps (ASHPs). This includes significant investment in the technology through federal and state programs offering large incentives to help accelerate adoption. These are valuable programs, but too little attention has been paid to the importance of envelope upgrades for these homes. As part of this modeling project CEE evaluated the outcomes from electrifying these homes with and without weatherization and window upgrades.

In MN, electric backup heat is needed even when installing a cold-climate ASHP. Figure 9 shows the peak demand (kW) for these homes at Minneapolis's design temperature (-10°F). For Case 1, on the left, peak demand would be reduced 3.2 kW if the windows were upgraded with the minimal weatherization upgrades described above. Similarly, the window upgrades with weatherization would reduce peak demand 4.5 kW for Case 2.

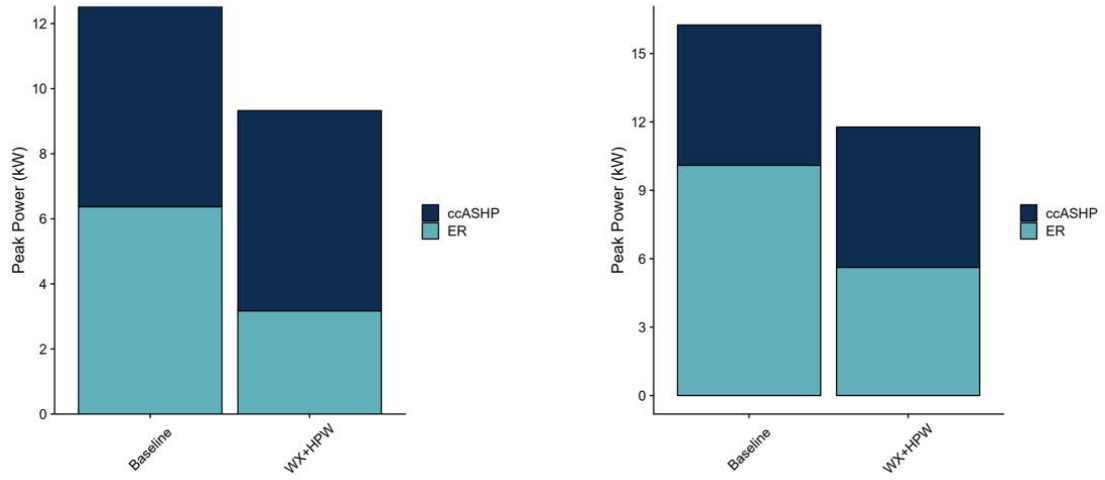

Figure 9. Case 1 (left graph) and Case 2 (right graph) peak impacts from heating electrification

These multi-kW reductions produce many benefits, starting with the panel requirements for the home and extending to the local distribution system. These window upgrades can reduce the electric resistance (ER) requirements by 2-3 kW, saving the homeowner money on equipment cost and reducing the needs for electric panel upgrades. As shown in Figure 8 above the design load is also reduced by 8,000 to 12,000 Btus, which results in a half ton or full ton reduction in the size of the heat pump, which could also saves homeowners money on equipment cost.

Windows Deliver Peak Energy Savings - Northwest Field Study from PNNL

As shown by the MN results, high performance windows are one of the best technologies for reducing peak load. This is also the case across the country, which was highlighted by a 2021 PNNL study that found thin triple pane windows could achieve 17% peak heating savings and 33% peak cooling savings when compared to baseline – double-pane clear glass - windows in PNNL's lab homes.

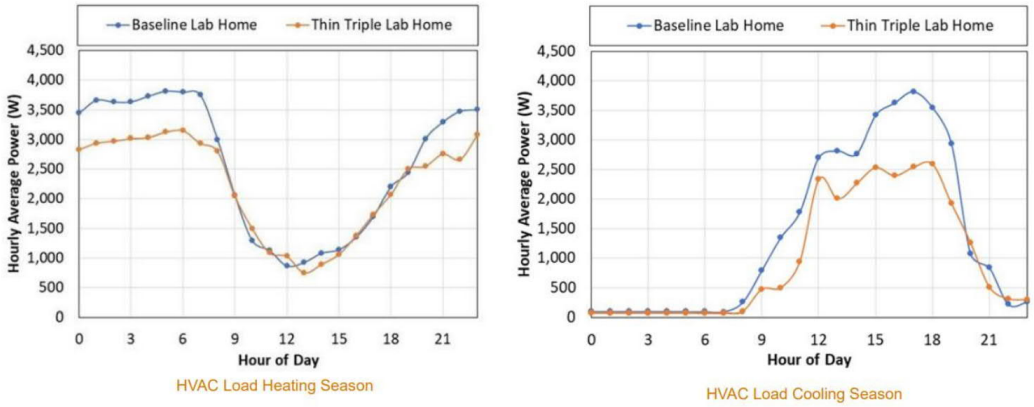

Figure 10: PNNL Lab homes testing load shapes during heating and cooling seasons (Cort.2021)

HPW are one of the best technologies for reducing peak load. In the summer, these products with lower SHGC and/or with effective shading, can minimize solar heat gain which reduces cooling costs and system peaks. In the winter, a better insulated building envelope prevents heat from leaking out of the building, reducing peak heating load. This will be particularly important for buildings with electric heat. As the lowest performing component of a building's envelope, windows should be prioritized when addressing winter peak load reduction. Higher performance windows also improve thermal comfort, in some cases allowing lower thermostat set points which will save additional energy.

Program Opportunities – Utilities, States, and Cities

Windows have historically been left out of energy efficiency programs because of challenges with cost-effectiveness. However, momentum toward electrification, recent advancements in window technology, and the release of ENERGY STAR version 7, have changed this paradigm, creating an opportunity to build cost-effective programs that are popular with customers and critical to achieving energy goals.

As illustrated in figure 11, windows are a crucial piece of the building envelope that needs to improve in order to advance the efficiency of buildings. Home A represents a typical new home with R-3 windows and R-20 walls, which produces a whole-wall average R-value of 10.8. Home B has an upgraded envelope design utilizing high performance windows (R-5) and walls (R-38), which achieves a whole-wall average R-value of 19. Home C demonstrates what happens if we try to achieve the same whole wall average R-value as Home B, without upgrading the windows. As shown in Figure 11, this would require R-330 wall insulation, which is not feasible. This illustrates how important windows are to improving envelope performance. Quite simply, there becomes a point when it is not feasible to achieve better performing homes, without better windows. (PAWS. 2023).

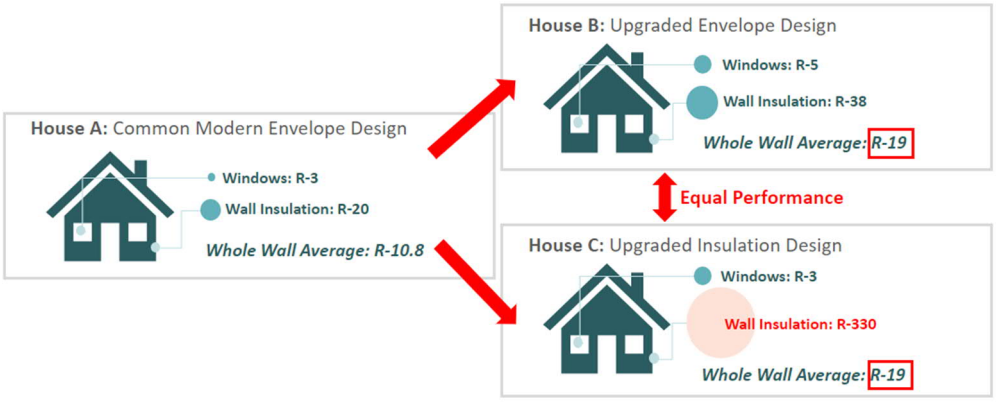

Figure 11. Three new home design scenarios exhibiting the importance of HPW (PAWS. 2023.)

Local programs, incentives, and policies are needed to drive adoption of HPW, and as Figure 11 illustrates, window programs will be critical to achieving energy goals. HPW improve the performance of the building envelope, which reduces peak energy demands, the size and cost of HVAC equipment, and improves customer comfort and health.

Programs are needed to build awareness by developing and distributing consumer awareness materials highlighting the value proposition of HPW. In addition, local cities and jurisdictions can implement programs or policies that require or motivate new construction buildings to include HPW, by requiring ENERGY STAR windows in their above-code programs.

As discussed, the energy efficiency landscape has changed and it is time to work together to build, align, and launch utility programs across the country. The update to ENERGY STAR provides a national specification that everyone can leverage, and the research EPA completed shows that the incremental cost for these windows is minimal - $54 per window (PAWS. 2023.). Window improvements are highly valued by homeowners and asked frequently asked about, so utility programs will be popular. The Partnership for Advanced Window Solutions (PAWS) has put together a utility playbook that provides further detail on how and what is needed to launch these programs.

National Collaboration – Partnership for Advanced Window Solutions

The partnership for advanced window solutions (PAWS) was developed to aggregate market demand, reduce product cost, quantify benefits, and accelerate the adoptions of HPW and

window attachments. The partnership engages with manufacturers, utilities, and other key stakeholders to disseminate information and conduct research to support the development of HPW products and initiatives across the country. This national collaborative is a key resource for anyone interested in HPW and can help support stakeholders in a variety of ways, including –

- TRM Support: We recognize the importance of integrating these measures into state TRM's and can provide support by providing savings analysis and white papers.
- Region Specific Savings Analysis: Utilizing ENERGY STAR V7 modeling data, the PAWS group can provide tailored savings analysis
- Program Design: PAWS can support in the design and early implementation of window programs and pilots.
- Manufacturer Engagement: PAWS has developed relationships with several manufacturers and can facilitate connections for interested utilities.
- Online Resources: As we move forward, resources like this one will be uploaded to the PAWS website – PAWS.energy

Conclusion

HPW are available and recent technology advancements have removed previous barriers to adopting triple-pane and high-performance windows. This includes product cost, which does not directly relate to energy performance in the window market. As shown by the ENERGY STAR analysis, HPW only cost $54 more window when compared to code windows (EPA 2023). However, we need to work together to drive demand and build awareness of HPW. With the update to ENERGY STAR, this is the perfect time for energy efficiency programs to engage in this market and the strategies and approaches covered in this report can be leveraged by others. PAWS is also a resource for anyone interested in advancing windows and launching programs to build awareness of the many benefits of HPW. HPW are an essential envelope measure as buildings decarbonize, which highlights the importance of collaborating on efforts to transform this market.

References

Acelab for Architects. "Christine Williamson: Why Glazing Matters So Much More Than Insulation." YouTube Video, 8:58. June 3, 2022. www.youtube.com/watch?v=zJRsmiaqh6A&t=36s

BetterBuilt^{NW}. 2023. "Triple-Pane Windows with a U-Factor of 0.22 - A Better Builder Value?" betterbuiltnw.com/assets/uploads/resources/FINAL_Triple-Pane-Windows-Flyer_2023-06.pdf

———2023. "Habitat For Humanity" betterbuiltnw.com/assets/uploads/resources/FINAL_NEEA_HPW_HFH_Handout_Digital.pdf

———. 2023. "Net-Zero Comfort for the Heart of a Tribal Community?" betterbuiltnw.com/resources/net-zero-comfort-for-the-heart-of-a-tribal-community-triple-pane-windows

BuildRight. 2023. “Grace Weger.” Grace Weger « BuildRight Conference (buildrightpdx.com)

Cort, Katherine. 2021, Evaluation of Thin Triple- Pane Windows in the PNNL Lab Homes.

Environmental Protection Agency (EPA). 2021. Draft 1 Version 7 Stakeholder Webinar. https://www.energystar.gov/sites/default/files/asset/document/V7_Stakeholder%20Meeting_7-27-2021_final.pdf

ETA. 2023. “High Performance Windows: Market Characterization” https://www.etamn.org/high-performance-windows-market-characterizationSamayoa, Monica. OPB “Climate-friendly homes offer Grand Ronde’s tribal elders affordability and comfort against climate change.” Jan 17, 2024. www.opb.org/article/2024/01/17/climate-friendly-homes-offer-grand-ronde-tribal-elders-affordability-comfort-against-climate-change/

Bender, Rhett, Syed, Kaif, and Delonis, Courtny.“High-Performance Residential Window Market Share Study.” Ducker Carlisle. 2024. neea.org/resources/high-performance-residential-windows-market-share-study

Kah, Jaclyn, Moran, Dulane, Suzuki, Jun. “High-performance Windows Market Characterization study” Cadeo Group, 2022. neea.org/img/documents/High-Performance-Windows-Market-Characterization-Study.pdf

Partnership for Advanced Window Solutions (PAWS). 2022. Why Windows Matter. s40446.pcdn.co/wp-content/uploads/2022/04/PAWS-WWM_handout_04.07.2022-2.pdf

Partnership for Advanced Window Solutions (PAWS). 2023. Utility Program Playbook. paws.energy/wp-content/uploads/2022/06/PAWS-Utility-Program-Playbook-.pdf

Selkowitz, Steve. “Study of High-Performance Windows incremental Manufacturing Cost.” Stephen Selkowtiz Consultants, 2023. neea.org/resources/study-of-high-performance-windows-incremental-manufacturing-cost

Veitch, J.A., A.D. Galasiu. 2012. “The Physiological and Psychological Effects of Windows, Daylight, and View at Home” https://nrc-publications.canada.ca/eng/view/ft/?id=06e1364d-71f3-4766-8ac8-f91da5576358

Washington State Building Code Council. *Washington State Energy Code- Residential 2018 Edition Chapter 51-11c WAC.* Washington, 2018. 2018 WSEC_R Final package2.pdf (wa.gov)