

# **The Launch of the Partnership for Advanced Window Solutions: Give the People What They Want, Great Window Solutions!**

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## **ABSTRACT**

Windows account for 25% of residential HVAC energy use and 45% of building envelope heat transfer, despite only making up 8% of the surface area. To meet carbon reduction targets, the nation needs to substantially reduce building energy use, which requires improving window performance in both new and existing buildings. However, efficient window products have been slow to advance despite technological innovations. In response, the U.S. Department of Energy (DOE) has joined forces with regional energy-efficiency alliances and national labs to launch the Partnership for Advanced Window Solutions (PAWS), a national collaborative focused on transforming the windows market with a broad, aggressive set of strategies to adapt, replicate, and widely deploy a full range of advanced glazing, window, and window attachment solutions. The collaborative builds on previous market transformation programs to aggregate market demand and reduce product costs, with a strong focus on sector-wide collaboration to achieve aggressive goals. This paper outlines recent PAWS efforts to develop new utility and regional market transformation programs, refine energy ratings, ENERGY STAR<sup>®</sup> specifications, and building energy codes. It provides updates on emerging window technologies and recent findings from field demonstrations focused on novel highly insulated windows. This paper also outlines future PAWS efforts to replicate success and scale these window solutions to meet national carbon reduction goals, and via retrofits, enhance the viability and cost effectiveness of regional decarbonization programs. Through technology, policy, and partnerships, the PAWS collaborative is emerging as a central hub for a national windows market transformation.

## **Introduction**

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. At the national, state, and local level, public and private organizations are now laying out a series of aggressive targets and goals over the next 10-30 years for the performance of new and existing buildings, in terms of energy use and carbon emissions. A more recent overlay of these efforts adds the priority to decarbonize the grid, with a predominant focus on building performance, since more than 70% of electricity is used in residential and commercial buildings. Given that 75% of the projected 2050 building stock exists today, achieving these goals will require a new focus on deep retrofits of

existing buildings, while simultaneously requiring that we strive for dramatic reductions in energy use in all new construction.

Do windows matter as we begin to address these complex energy and carbon challenges? How should we address the challenge of window performance in new construction and retrofit? At the macro level, the annual and cumulative energy and carbon impacts of inefficient windows are significant. Nationally, windows account for ~4 Quads of energy use each year, about 10% of all building energy use (Hart et al. 2019). This represents ~200Mt of CO<sub>2</sub> and costs building owners more than \$50 billion each year. At the individual building level, windows are essential to the wellbeing and day-to-day living of occupants, yet most existing windows are poor energy performers. In homes and commercial buildings, windows are typically the weakest link in a building's envelope.

In a typical new home, windows constitute only 8-10 percent of the surface area, yet account for 40-45 percent of the peak heat loss in winter and add to cooling peaks and discomfort in summer. Switching from code compliant, double-pane Low-emissivity (Low-e) windows in a new home to new R5 window solutions can save 7-16 percent of a home's energy use, depending on climate. In older homes, retrofitting single-glazed windows with R5 windows can provide much larger energy savings. In commercial buildings, the iconic image of a highly glazed office building façade often comes with high energy bills, large peak-cooling loads, glare, and thermal discomfort. Ben Evans, federal legislative director at the U.S. Green Building Council, which runs the Leadership in Energy and Environmental Design Program (LEED), recently explained that “Buildings are responsible for 40% of carbon emissions in the U.S. We’re not going to meet our climate goals unless we do more about buildings.” Figure 1 below shows the oversized energy impact poor performing windows have on the energy use of a home, along with the multitude of benefits that accrue when high-performance window solutions are used.

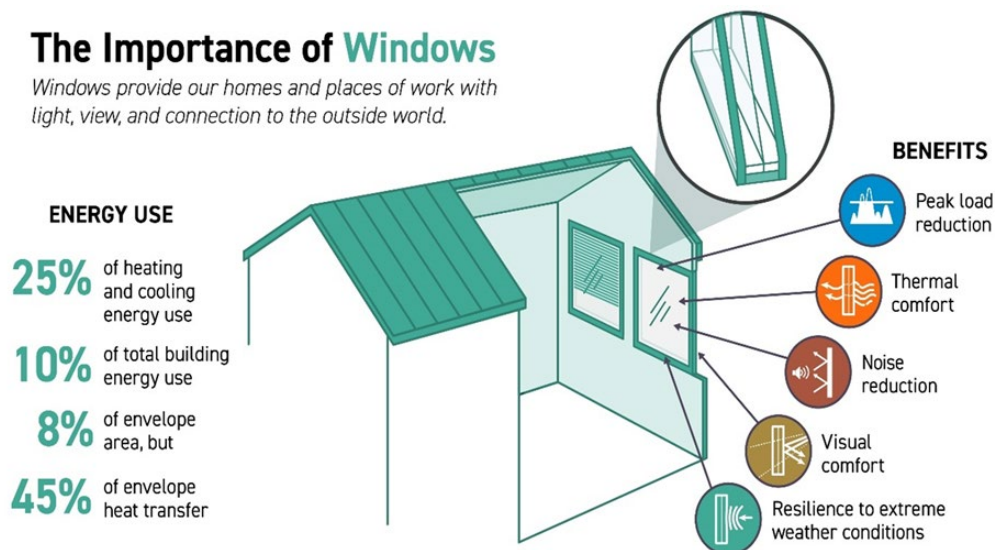


Figure 1. The Importance of Windows in Typical New Home (Source: Berkeley Lab)

Homeowners and building owners recognize the importance of their windows. They want quality windows that enhance their comfort, connect them to the outdoors, and help reduce their energy bills and carbon emissions. In 2021, a window-replacement job was among the top five home projects in terms of return-on-investment, according to national estimates by Remodeling Magazine. Many building owners are also unaware of or do not understand the oversized impact poor performing windows can have on the energy use of a building's HVAC system, and overall comfort and wellbeing of occupants. Moreover, in the world of energy efficiency, high-performance windows and attachment products have long been a neglected tool in the energy-efficiency toolbox as the technology has lagged far behind other solutions to improve building-energy performance. In addition, utilities have been more focused on shorter-term energy paybacks. Some new high-performance window options—e.g., thin triple windows—are available as niche, low volume, and therefore expensive products. Improved window attachments can reduce window heating and cooling loads and improve comfort. However, consumers and architects remain unaware of these advances and the potential to improve the comfort and energy savings of their homes and buildings. Builders typically select code minimum for new homes to minimize first-cost and few high-performance products are installed in retrofit applications. Policymakers often raise the concern of high first-cost for window replacement thus, less funding resources are allocated to window programs, including limited utility incentives. Yet, 7.1 million households get some quantity of new windows or doors per year due to high consumer interest and old dysfunctional windows long past their useful life. This large market share is a ripe opportunity to promote high-performance windows that can be highly cost effective for their increased marginal cost and get consumers to replace more windows.

Windows do matter to building occupants and as an element in national energy policy. So what can be done to change current practice? Given this background of slow technological advances and demand for new policies for reduced carbon emissions from buildings, the newly formed national market transformation collaborative, the Partnership for Advanced Window Solutions (PAWS) intends to address this complex challenge. The mission of PAWS is to be the “nerve center” between existing efforts and launch new ones where needed. Through collaborative research and programs, PAWS aims to aggregate market demand, reduce product cost, quantify benefits, and accelerate the adoption of advanced windows and window attachments. Transforming window markets will support advanced building codes in new construction and promote retrofit strategies necessary to achieve aggressive carbon reduction and net zero energy building goals. It will also help building owners make the right investments at the right time. Figure 2 demonstrates that if HVAC systems are addressed before a building's envelope, the HVAC systems are often oversized. Investments should be sequenced with building-envelope measures addressed first—which then results in reduced HVAC needs.

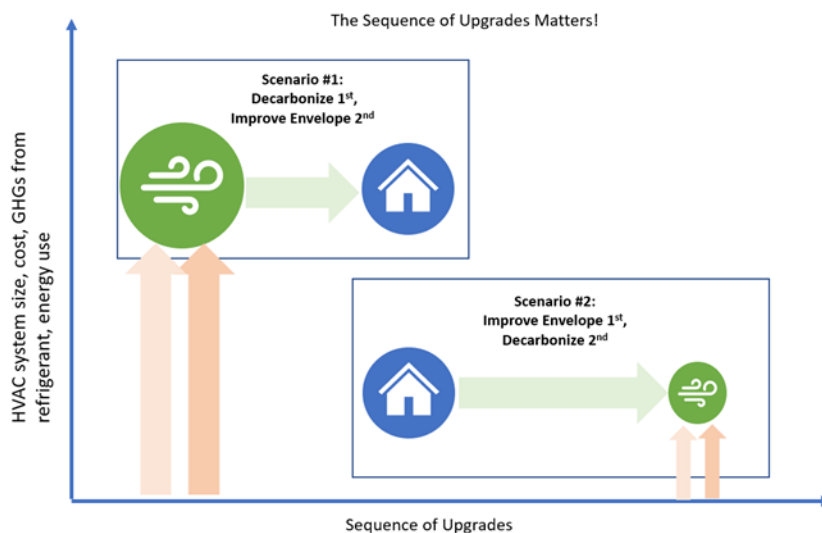


Figure 2. The importance of the building-upgrade sequence

PAWS builds on previous market transformation programs to aggregate market demand and reduce product costs, with a strong focus on sector-wide collaboration to achieve aggressive goals. At the 2018 ACEEE Summer Study on Efficiency in Buildings, Selkowitz, et. al. presented a preliminary market transformation strategy, which employs a technology push with demand-side and supply-side measures for the market introduction and adoption of the highly insulating “thin-triple” glass product. At the 2020 ACEEE Summer Study, Hart et. al, reported on progress toward implementing this supply push/demand-pull strategy, including field demonstrations and collaborative partnerships focused on leveraging these efforts to scale up market transformation efforts. Now that the collaborative is fully launched, PAWS intends to try to orchestrate and guide a broad range of market transformation activities that provide opportunity and momentum to push the market for high-performance window solutions across the valley of death and into high volume, mainstream market applications.

## PAWS Builds on Technology Solutions and Market Resources Already Within the Windows Market

### Ongoing Investments in RD&D

For many years, research by the national labs supported by DOE’s Building Technologies Office (BTO) focused on reducing energy intensity and costs for window technologies, while maintaining or enhancing occupant comfort, productivity, and product performance. Several national labs have conducted research, development, and design on advanced windows and their components, and tested the installation, performance, and builder/owner acceptance of these technologies. Table 1 summarizes a sampling of recent DOE and national lab-led field-validation research efforts that demonstrate advanced performance for a range of window and window-

attachment technologies (e.g., High-r windows, Low-e storm windows, secondary commercial glazing, insulated shades, and exterior shades). These advanced window solutions have been demonstrated for a broad range of applications and climate zones, also shown in Table 1.

**Table 1: Summary of RD&D Conducted by National Labs on Window Solutions**

| Technology                                                                                                                                                                                                                 | Study                                                                                                               | Baseline Description                                                                    | Findings                                                                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High-R Window Replacement Energy-Saving Potential                                                                                                                                                                          | LBNL study of energy simulated savings potential of thin triple glazing (Hart et al. 2019)                          | Typical windows based on NFRC-certified products                                        | <ul style="list-style-type: none"> <li>• 16% annual savings in heating-dominated climates</li> <li>• 12% annual savings in mixed climates</li> <li>• 7% annual savings in cooling-dominated climates</li> </ul>                              |
| High-R Thin Glass Triple-Pane Window Replacement                                                                                                                                                                           | PNNL Lab Homes side-by-side triple-pane study (Widder et al. 2012)                                                  | Double-pane, clear-glass, aluminum-framed windows                                       | <ul style="list-style-type: none"> <li>• 12% annual savings in Richland, Washington</li> <li>• 11.6% heating savings/18.4% cooling savings</li> </ul>                                                                                        |
| Highly insulating Triple-Pane Window Replacement                                                                                                                                                                           | PNNL Lab Homes side-by-side triple-pane study (Hunt et al. 2021)                                                    | Double-pane, clear-glass, aluminum-framed windows                                       | <ul style="list-style-type: none"> <li>• 18% annual savings in Richland, Washington</li> <li>• 12% heating savings/28% cooling savings</li> </ul>                                                                                            |
| Exterior and Interior Low-e Storm Panels                                                                                                                                                                                   | PNNL Lab Homes: Exterior and Interior Low-e Storm Panels (Knox and Widder 2014; Petersen et al. 2015)               | Double-pane, clear-glass, aluminum-framed windows                                       | <ul style="list-style-type: none"> <li>• Annual average savings percentage of</li> <li>• 10.1±1.4</li> <li>• Annual average savings percentage of 7.8±1.5 (covering 74% window area)</li> </ul>                                              |
| Exterior Low-e Storm Windows                                                                                                                                                                                               | Chicago case study with LBNL (Drumheller et al. 2007)                                                               | Six low-income homes; single-pane wood-framed windows                                   | Low-e storm windows showed: <ul style="list-style-type: none"> <li>• 21% reduction in overall home heating load</li> <li>• 7% reduction in overall home air infiltration</li> <li>• Simple payback of 4 to 5 years</li> </ul>                |
| Exterior Shades                                                                                                                                                                                                            | PNNL Lab Homes side-by-side triple-pane study (Hunt and Cort 2020)                                                  | Double-pane, clear-glass, aluminum-framed windows and compared to interior vinyl blinds | <ul style="list-style-type: none"> <li>• 10% cooling savings when compared to interior vinyl blinds</li> <li>• 20% cooling savings when compared to home with no shading on same windows</li> </ul>                                          |
| Interior Insulated Shades                                                                                                                                                                                                  | PNNL Lab Homes: Double- and triple-cell cellular shades (Cort et al. 2018)/ (Peterson et al. 2016)                  | Double-pane clear glass windows with vinyl blinds                                       | <ul style="list-style-type: none"> <li>• Cooling HVAC = 10-25% savings</li> <li>• Heating HVAC = 7-18% savings</li> </ul>                                                                                                                    |
| Interior Insulated Shades                                                                                                                                                                                                  | ORNL Test Home: Single- and double-cell cellular shades (Bhandari et al.)                                           | Vinyl venetian shades over code window                                                  | <ul style="list-style-type: none"> <li>• HVAC Energy Savings (heating) ranging from 9-23% in room-by-room comparison</li> </ul>                                                                                                              |
| Commercial Secondary Glazing                                                                                                                                                                                               | NREL Test of single- and double-pane secondary glazing for commercial buildings (Kiatreungwattana and Simpson 2021) | Single-pane windows in Federal building                                                 | Energy Savings by percentage U-value and HVAC capacity reduction (Denver, CO study area) <ul style="list-style-type: none"> <li>• 17- 30% lower U-value</li> <li>• 5 -16% lower SHGC</li> <li>• 10-19% heating capacity reduction</li> </ul> |
| LBNL = Lawrence Berkeley National Laboratory; NFRC = National Fenestration Rating Council; NREL = National Renewable Energy Laboratory; ORNL = Oak Ridge National Laboratory; PNNL = Pacific Northwest National Laboratory |                                                                                                                     |                                                                                         |                                                                                                                                                                                                                                              |

## Advances in Window Solution Technologies

This market transformation effort is aided by the technological improvements across all window categories that enhance the comfort and energy efficiency of homes and buildings, and deliver these enhancements with lower costs and greater durability. In particular, there has been innovation in the primary and secondary window markets in recent years, enabled—in some cases—by technology advancements and volume production practices from other industries. Manufacturers are designing products that meet high-performance criteria, and PAWS is working with them to grow the marketplace for these products. There are currently 138 manufacturers in the U.S. that have certified product lines that meet the proposed ENERGY STAR Version 7.0 specifications. Technology advances in recent years have allowed manufacturers to achieve higher performing products in many ways. Most high-performance products harness one, or a combination of, the following components:

- **Room Side Low-e Coating.** Historically, higher performing window products use a Low-e coating on the window exterior to block ultraviolet and infrared light yet allow visible light to pass through. Newer high-performance windows use the same coating on all four glass surfaces of the window, including the interior. This approach typically reduces the U-factor of a window by 0.04.
- **Third Insulated Glass Unit (IGU):** Triple glazing has been around for a while, but at higher costs. Traditional triple glazing previously required redesign of the window frame due to the heavier, wider IGUs. As a consequence, builders and manufacturers avoided mass adoption of these products, which have remained a niche product. Recent technology advances allowed manufacturers to develop thinner, lighter triple-pane products. One new variant of the traditional triple-glazed window is designed as a drop-in replacement for R3 windows. These units are called “thin-triple IGUs” and result in an R-8 IGU. When used as a drop-in replacement for an R3, the window’s overall performance will increase to about R5 without any redesign of the window frame. A key feature of this design is how it uses a thin layer of glass that floats within a ¾" - 1" IGU. Most IGU manufacturing equipment can process 1.6mm glass with simple equipment tuning and as thin as 0.7mm with more significant modifications. The availability of the thin glass down to 1.6mm is common in the U.S. Availability of glass down to 1.0mm has recently increased because of its use in TVs and computer monitors, making this emerging technology more affordable and feasible for window manufacturers.
- **Improved Spacers:** Window spacers are strips of plastic, metal, or foam that separate glass panes in a window. Older windows typically have metal spacers with poor insulating properties. Improved non-metal spacer designs have hit the market in recent years and are designed to improve the overall efficiency of window products by reducing heat loss at a window’s perimeter.
- **Thermally Improved Foam-Filled Frames:** Some manufacturers have found success by insulating their window products’ frame with either spray foam or push-in foam. Like improved spacers, this approach enhances the product’s thermal efficiency by reducing heat loss at the window perimeter.

- **Gas Fill:** Gas-filled windows provide an additional layer of insulation and increase its overall efficiency. Manufacturers use either krypton or argon for gas fills. Argon is a relatively inexpensive gas-fill option commonly used in efficient window technologies. Krypton is a better insulator, but its cost has proven to be volatile in recent years, making it a less attractive option for manufacturers.

### Advances in Window-Solution Costs

The cost of windows is a function of all the above features but, even as high-performance windows remain more expensive than lower performing windows, affordable options do exist today. As noted by EPA in the ENERGY STAR Version 7.0 specification proposal and shown in Figure 3, performance—as measured by U-factor "...is not a main driver for cost" and many vinyl triple-pane windows lines achieving U-0.22 or lower are available at prices comparable to far less efficient vinyl double-pane windows. These data indicate that delivering economical high-performance windows to market is not dependent upon additional scientific and engineering breakthroughs, but is more dependent upon sustained demand and volume production.

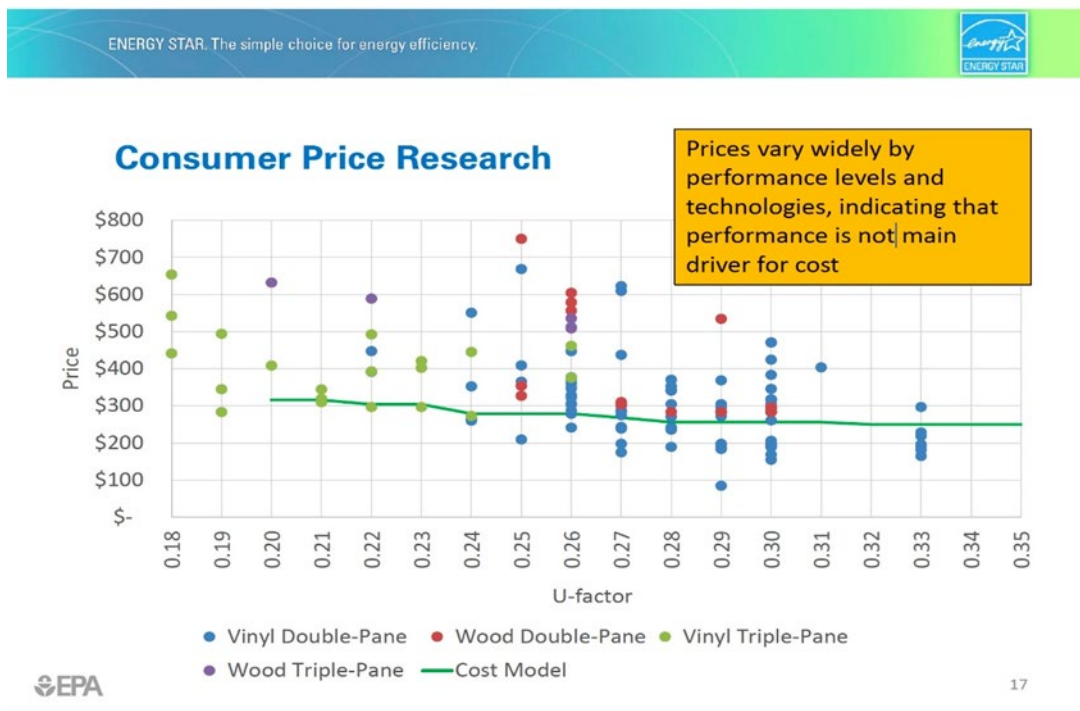


Figure 3: ENERGY STAR Version 7.0 Specification Proposal - Windows Price Research

## **Market Infrastructure Components in Place**

### **ENERGY STAR – Market Differentiation**

Key infrastructure components necessary to growing this market are also well established and primed to support the adoption of higher performing window products. For residential and multifamily markets, the ENERGY STAR specification plays a key role in helping consumers and builders choose a higher performing product. Version 6.0 has been in place since January 2015, and combined with the effect of code changes, has a market share of close to 90%. The Version 7.0 specification, referenced in the introduction, is being finalized and will likely be adopted in summer 2022, with expected implementation in mid-2023. The new specification sets the bar at a 0.22 U-value in the Northern zone as a prescriptive value and offers energy-equivalent tradeoffs with variations in Solar Heat Gain Coefficient (SHGC). Other regions have less dramatic changes proposed for U-values but include shifts in SHGC. Exhaustive research and analysis by the EPA and national labs indicate better performing products are available, offering consumers increased resiliency against extreme weather events and significant energy savings from energy use reductions. Despite challenges presented by the pandemic and supply chain issues, many manufacturers, suppliers, and other market actors are preparing for the specification change to ensure qualified products are available. The change in the specification is a significant improvement for efficiency and the market. Utilities and regional energy-efficiency organizations will need to pivot quickly to help consumers realize these gains and stay ahead of codes.

### **Ratings and Certification – Market Differentiation**

Selecting an energy-efficient window best suited for building type, climate, orientation, space function, thermal and visual comfort, appearance, and budget can be a challenge. It is critical that accurate, credible rating and certification procedures be available in the right format to user groups (e.g., homeowners, contractors, architects, and engineers), to help differentiate these critical performance attributes. PAWS works with existing partners to promote and extend existing rating and certifications where they meet market needs, and help improve tools and databases where they are insufficient.

The windows market also already has two well-established, robust rating organizations for primary and secondary windows: the National Fenestration and Ratings Council (NFRC), and the Attachments Energy Rating Council (AERC) for attachment products. NFRC-certified products are independently tested, certified, and labeled to help consumers make purchasing decisions and compare properties of different products. NFRC calculation procedures—particularly the International Glazing Data Base (IGDB), maintained and updated in partnership with Lawrence Berkeley National Laboratory (LBNL)—are widely used in the commercial glazing industry although rating and certification procedures have not had the same impact in commercial construction as in residential applications. NFRC is also beginning the re-launch of a windows selection tool on the Efficient Windows Collaborative website, providing accessible guidance to promote selection of more efficient window products for new and retrofit applications. PAWS plans to partner further with NFRC to build new connections between manufacturers and the energy-efficiency community that help increase consumer awareness about the role efficient windows play in comfort and saving energy.

AERC serves the window attachments market for commercial and residential products. They offer a comprehensive rating, labeling, and certification program for a variety of products, including commercial secondary windows, Low-e storm windows, blinds, cellular shades, shutters, and awnings. They also support the development of utility programs targeting these products and work to include window-attachment measures in state technical resource manuals (TRMs). These manuals feature listing and savings rates typically required for utility programs to include as program measures. This connection to utilities is important to successfully educate consumers about the impacts of window attachments and other high-performance window products in their homes and buildings. PAWS actively works to further connect with utilities on high-performance window offerings and with AERC's ongoing marketing support to increase consumer awareness about the benefits of these products.

### **Growth in mandatory decarbonization policies increase need for cost-effective solutions for low carbon buildings**

Growth of net zero and Passive House certifications continues to grow along with local and state policies which mandate building-carbon reductions and increased consumer awareness. Increasingly, builders and owners are looking for ways to meet these new, aggressive targets with affordable products and a supply chain that can deliver in a timely fashion. Currently, many builders find it easier and cheaper to order triple-pane windows from Europe because advanced products are very difficult to source and buy in the U.S. With building codes advancing across the country, improved windows are becoming a crucial component in decarbonization policy and in reaching aggressive goals that are driving those codes.

### **Utilities are looking for new efficiency opportunities**

The changing utility landscape offers the windows market new opportunities as a technology for targeted incentives. As lighting savings wane, many utilities are looking for new products and innovative program designs that help reach aggressive energy-saving targets to their customers. For new construction, some utilities and efficiency programs are testing thin triple-pane windows with production builders as a means for them to reach better-than-code program targets and access federal tax credits more easily. The value proposition for builders includes an easier install compared to heavier, traditional triple-pane windows, and more efficient windows that allow for possible trade-offs with opaque wall-insulation requirements. For homeowners, thin triple windows offer a quiet, more comfortable home, reduces their energy costs, and provides high resale value.

Historically, window programs have been challenging for utilities to implement because of their high upfront cost—despite frequent requests from customers for window rebates. As technology advances and costs come down for higher performing window products, the cost-effectiveness equation becomes more favorable. Utilities previously unable to support window programs are recognizing the potential for expanding their portfolio to include these products and achieve savings in a previously untapped product category. High-performance window products can be integrated into low-income weatherization programs or coupled with air source

heat pump (ASHP) retrofits to tighten a home's envelope and allow for smaller HVAC system installs. As mentioned, new homes programs are well suited to include incremental window rebates for higher tiers of performance, and upstream program models can provide discounts at the distributor level to influence the retrofit market which is generally more challenging to target.

A few utilities are having success with window retrofit programs. Energy Trust of Oregon has long invested in retrofit windows for homeowners. Eversource has developed a successful multifamily program that bundles a window rebate with other building owner engagement. Regionally, market transformation programs in the Northwest, Illinois, and Minnesota are in the development phase. These programs will build on work by Northwest Energy Efficiency Alliance and Center for Energy and the Environment which work upstream in the market with production builders, manufacturers and their supply chains, and aim to leverage the upcoming ENERGY STAR Version 7.0 specification to help accelerate homeowner and builder adoption.

Utilities and state regulators are beginning to acknowledge the necessity and value in quantifying non-energy benefits for energy-efficiency measures. This presents a significant opportunity for windows. Customers value window products for numerous reasons beyond energy efficiency and often upgrade their windows because of them. Noise reduction, increased comfort, and condensation concerns are all important selling points for high-performance windows, and there is growing scientific evidence of the importance of light on human health and wellbeing. By quantifying non-energy benefits, utilities can use a much more appealing cost-effectiveness equation and provide more generous rebates to their customers. Similarly, windows can play an important role in climate resiliency. High-performance windows deliver greater resiliency and thermal comfort during demand response events, which result in greater customer retention in Distributed Energy Resources programs. As managing climate risk becomes a higher priority for consumers, utilities can emphasize the benefits window retrofits present to minimize vulnerability, adding to the long list of non-energy benefits.

## Why Aren't High-Performance Window Solutions Taking Off Yet?

Despite significant research and development, window product technical innovations, market infrastructure advances, and customer desire for quality windows, the market for higher performing windows solutions has been slow to grow. **The problem appears to be a very fragmented market despite pockets of innovation and activity.**

- Manufacturers require higher demand before they invest in scaled production that leads to subsequent price reductions.
- To date, prices for these products remain high, and due to limited production, high-performance windows are difficult to source—even for builders and consumers that can afford them.
- For new construction, supply chain uncertainty has many builders reluctant to broadly shift to high-performance windows, even as they acknowledge buyers appreciate the benefits.

- Many utilities can't run programs until prices decline because of cost effectiveness requirements.

There are many organizations that play a role in the adoption of high-performance windows and attachments, but they are not aligned.

## **Launching the PAWS Solution to Reinvigorate Market Transformation**

### **DOE and Efficiency Organizations Support a New National Window Initiative**

The U.S. DOE BTO continues to fund energy-efficient windows research and development that previously resulted in new window and attachment products, and new design tools to support decision making. In an expanded market transformation effort, DOE supports and collaborates with various organizations to launch the national PAWS collaborative, including the national labs, windows industry, supporting trade groups, energy advocates, utilities, and market transformation organizations to accelerate the availability of these products and increase their adoption. Through PAWS, DOE and its partners are taking the next step, building upon the foundational technical work already completed, to create a more streamlined and efficient channel for market adoption of high-performance window solutions.

Because the high-performance windows market and its players are fragmented—and in some cases misaligned—PAWS works to realign and build awareness of existing work, and find pathways to socialize and adapt tools, resources, and programs for other regions and partners. PAWS will also identify missing components of high-performance windows market transformation efforts, and additional market barriers that have not been addressed. PAWS serves as a centralized point of collaboration—a high-performance windows market nerve center—to build resources across multiple organizations to help bridge the market gap.

To accelerate the program scope and impacts, the PAWS collaborative builds on lessons learned from past market transformation programs. PAWS also targets a multitude of windows market obstacles, including:

- Market-related obstacles such as cost or supply chain issues. Builders want to purchase an efficient product but cannot procure those product options from the existing supply chain.
- Technical obstacles such as uncertainties in product performance or durability.
- Supply-and-demand obstacles. A company will invest in developing a new efficient product, but the education and awareness to build market demand is not there.

PAWS will function as a partner, broker, and advocate to identify each of these market obstacles and work with collaborators to create market-viable solutions. PAWS is partnering with utilities, state and local government, builders, manufacturers, regional energy-efficiency offices, and NGOs with a building efficiency mission. Partners and programs will be driven by market needs, funding availability, partner engagement levels, and their ability to replicate programs. As the PAWS mission states:

*Through collaborative research and programs, PAWS aims to aggregate market demand, reduce product cost, quantify benefits, and accelerate the adoption of advanced windows and window attachments. Transforming window markets will support advanced building codes in new construction and promote retrofit strategies necessary to achieve carbon reduction and net zero energy building goals.*

## **PAWS Opportunities**

Three priority technology opportunities are initially being addressed by PAWS and its partners:

1. Increase demand for R5 insulating windows for residential markets, new construction and renovation/replacement. The initial market focus is residential but will be expanded to commercial building applications.
2. Storm windows and insulating panels for residential and commercial retrofits where window replacement isn't affordable or practical.
3. Solar control solutions with shades and blinds to reduce cooling energy use and peak cooling loads, enhance thermal comfort, and provide resilience during power failures. Automation options that can link shading deployment to smart building and electric grid initiatives will be explored and promoted.

To move this work forward, PAWS has organized the collaborative's activities into five key areas and Working Groups that will allow members to focus on progress in each area.

**Table 2: Summary of PAWS Key Areas/Working Groups**

|                                                |                                                                                                                                                                                                                                               |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Ratings, Codes &amp; Certifications</b>     | <ul style="list-style-type: none"> <li>• ENERGY STAR specification support</li> <li>• Field-performance validation</li> <li>• Building-code body coordination</li> </ul>                                                                      |
| <b>Utility &amp; Program Collaborations</b>    | <ul style="list-style-type: none"> <li>• Working with utilities on windows programs <ul style="list-style-type: none"> <li>○ Residential and commercial</li> <li>○ New and retrofit</li> <li>○ Attachments and windows</li> </ul> </li> </ul> |
| <b>Stakeholder Campaigns &amp; Initiatives</b> | <ul style="list-style-type: none"> <li>• Ongoing support to DOE technology campaigns</li> <li>• Coordination with manufacturers/technical support</li> <li>• Public awareness campaigns/consumer outreach</li> </ul>                          |
| <b>Data &amp; Tools</b>                        | <ul style="list-style-type: none"> <li>• Energy-savings tools</li> <li>• Financial program tools to support investment</li> <li>• Document comfort, resilience</li> <li>• Training programs</li> </ul>                                        |
| <b>Incentives, Rebates &amp; Tax Credits</b>   | <ul style="list-style-type: none"> <li>• Policy support</li> <li>• Program design</li> </ul>                                                                                                                                                  |

Each focus area has a set of opportunities and resources to leverage and build upon, and near-term strategies and deliverables that will ultimately be used by other Working Group members to drive adoption. One example includes the Ratings, Codes and Standards Working Group, which is initially focused on gaining support and momentum for the upcoming ENERGY STAR Version 7.0 window specification change, a critical market infrastructure piece for primary windows, doors, and skylights. This Working Group has served as an efficient way to gather and share key information, centralize stakeholder comments, and increase support for the specification change. In turn, the Utility and Program Collaboration Working Group will use the new specification momentum and resources developed by PAWS members in the Ratings, Codes and Standards Workgroup to collaborate with utilities and regional market transformation programs. The goal of this Workgroup is to launch awareness programs and provide consumers with incentives that drive adoption of more efficient windows. PAWS collaborators will also develop a bank of resources with regional metrics to assist utilities in the design and implementation of window programs.

A parallel example exists for window attachments. AERC invests in the analysis and work associated with ensuring that window attachment products are included in state TRMs. AERC has a utility workgroup that helps build programs targeting attachments products. Utilities have resources in both areas to help think through the development of programs targeting primary and secondary window products. PAWS and AERC's work also gives program designers access to other utility program managers with experience running programs and can help them adapt a program for their territory. The goal is to create a hub of resources and experience that can be more easily and quickly deployed, easing greater market adoption for high performance window solutions.

## **Conclusion**

Because the U.S. building construction and window industry is a mature market with significant inertia where fundamental changes take time, a market transformation-driven effort is needed to accelerate the change to meet national and regional carbon-reduction policies and goals. PAWS is one such effort. There is a significant breadth of activities PAWS is focused on and a growing number of national and regional partners that will collaborate to make it happen, including:

- Utility programs
- Manufacturers
- Builders
- Market transformation partners

PAWS invites more market transformation organizations and players active in the building envelope and windows markets to work together to drive market advancement for high-performance windows. Through technology, policy, and partnership efforts, the PAWS collaborative is emerging as a central hub for a national windows market transformation.

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