

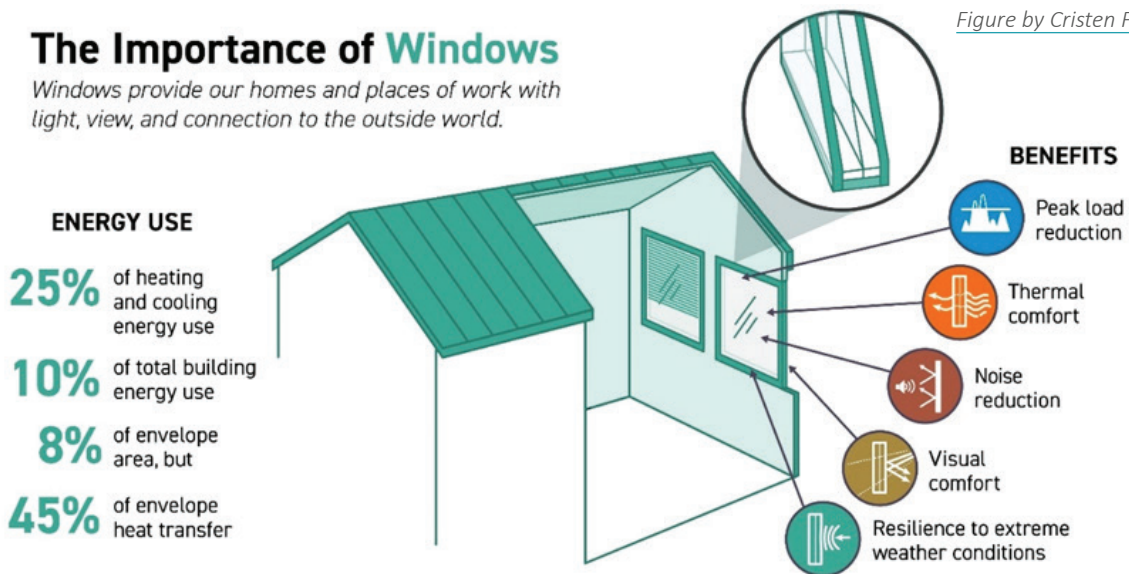


## The Opportunity of Windows

Windows are an immensely important part of every building, residential and commercial, shaping our experience of daylight and ventilation. Unfortunately, they can also be the source of huge leaks in the building envelope's air sealing, which means more energy than necessary is required to maintain comfortable temperatures through heating and cooling systems. State programs for energy-efficiency upgrades of all buildings should include provisions for window improvements.

- Replacing windows with higher-performing ones can greatly improve the building envelope, which improves energy efficiency as well as non-energy benefits.
- Improved comfort and decreased energy cost burden result in decreased health hazards and financial burdens.
- This brief offers considerations for program design and example programs that states can reference. A BPS can be implemented at any level of government including federal, state, county, and municipal.

As the NREL graphic below shows, even though windows are, on average, only 8 percent of the building envelope area, they account for 45 percent of envelope heat transfer. Consequently, the choice of a higher-performing window can provide major energy and cost savings.



This graphic also illustrates that a better window—triple-paned instead of double-paned, the current industry standard—can provide a series of other benefits, including thermal comfort, noise reduction, and resilience to extreme weather.



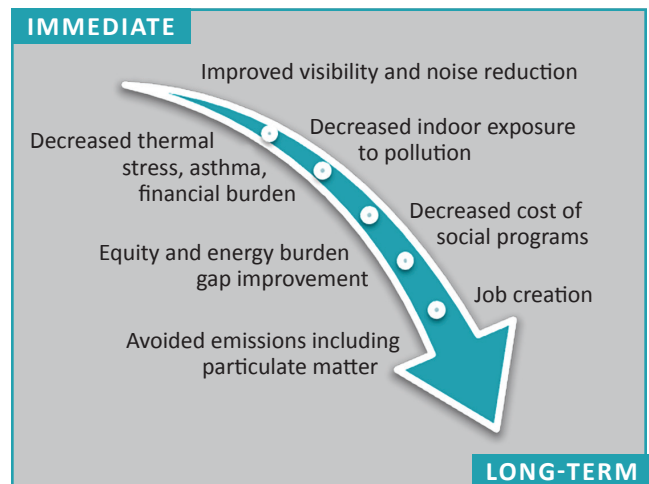
Windows technology remained more or less in a steady state for literally thousands of years. Only relatively recently have manufacturers started to design windows to achieve better energy performance and to yield greater health benefits. The oldest glass windows used by the Romans, around 100 CE, were single-paned, installed with attention to controlling the internal experience of daylight and ventilation. Starting in the 1970s, building regulations called for window upgrades to address increased concern about energy efficiency due to the oil crisis. Single-panes became glazed and double-paned, with a layer of inert gas such as argon trapped between the panes to act as additional insulation. Nowadays, [triple-panes](#) provide the most energy and non-energy benefits. However, standard high-R triple-panes are expensive, too heavy and wide for some retrofit applications, and therefore are not seeing much market uptake.

Below, NEEP explores the benefits that triple-panes can provide and new innovations in the market to lower their costs and make installing them more accessible.

## Non-Energy Impacts from Residential Upgrades

Upgrading one's windows drastically improves insulation, increasing indoor temperature in the winter, which also leads to better comfort. The next graphic illustrates numerous benefits of a new triple-pane window, from temperature control to decreased exposure to outdoor air pollution. Insulation is also good for noise reduction, decreasing perceived sound by about half. As shown, [further benefits](#) are experienced over a longer timescale.

- Better air sealing means outdoor pollutants don't enter the house through the windows, which is more important in congested cities and other overburdened communities. This is increasingly important as climate change results in more wildfires and as wildfire smoke becomes an increasingly common health hazard in the U.S.
- Decreasing financial energy burden by improving energy efficiency in the home can also free up residents' savings to afford food, medicine, and rent. In turn, this decreases the burden on social systems like energy and food assistance programs, and decreases rates of eviction.
- On a larger social scale, expanding window programs can lead to [job creation](#); there are further opportunities to increase equity if disadvantaged communities are targeted for training, recruitment, and upskilling. Per the [Bureau of Labor Statistics](#), glaziers are employed across the nation, typically requiring only a high school diploma or less before starting on-the-job training as apprentices.
- Globally, all forms of weatherization and energy efficiency improvement result in environmental benefits such as [avoided emissions](#), including particulate matter. The [ENERGY STAR Home Upgrade](#) lists a set of six high-impact energy-efficiency improvements, including high performing windows.





Programs delivering home upgrades should prioritize deploying high-performance windows in low- and middle-income and environmental justice communities to reduce energy burden and to optimize other, non-energy benefits. These populations are more likely to both have inefficient appliances and be unable to afford expensive window replacements, contributing factors to the [energy burden gap](#). Additionally, serving historically marginalized communities by improving the environment and health outcomes can improve social cohesion, perceptions of discrimination and equity, rates of incarceration, childhood development and early schooling, poverty rates, and housing stability. Focusing on these communities is one way to begin to deliver justice.

## Barriers in Window Deployment

Two primary barriers have prevented adoption of efficient windows in the past, affordability and ease of replacement. However, recent advancements address these barriers head on.

- **Affordable high-quality windows will increase market uptake.** Pacific Northwest National Laboratory (PNNL) [cited price](#) as a primary reason that customers were not adopting triple-panes. They indicate, however, that affordable building materials do exist. PNNL found that incremental costs for triple-panes are only [\\$6 per square foot over](#) standard ENERGY STAR windows.
- **New technology in the market has made it easier to replace windows.** In the past, replacing low-performing windows with thicker triple-paned windows was more complicated, time-consuming and expensive than using standard double-panes, because triple-panes were wider and heavier. Current replacement practices require contractors to remove and replace an existing window, often having to modify the frames and other structures around the windows to accommodate the bigger size. This increases the time for replacement, cost of materials, and skillset required of the contractor. Newer triple-panes allow for direct replacement, or **drop-in replacement**, which means that the window frames don't need to be taken out of the wall, which can lead to other concerns such as needing to replace siding.

## Window Program Examples

To increase market adoption and access to these benefits, states can take a few steps:

- Standardizing energy-efficiency windows and adopting energy-efficiency programs that include window rebates.
- Creating a standard for energy efficient windows creates a signal to the market that the state will be requiring more of certain types of products and thereby drives adoption. Below are two resources states can use to set a standard.
  - [A National Fenestration Rating Council](#) (NFRC) label gives windows energy performance ratings like U-factor (a measure of how the window conducts energy—the lower the better), solar heat gain coefficient (the percentage of heat from the sun that gets through the glass), and a brief description of the window. NFRC is an independent organization that rates the energy performance of windows but does not rank them for energy efficiency.



- [The ENERGY STAR Version 7 Residential Window, Door, and Skylight specification](#) came into effect October 2023. It provides a significant jump in efficiency and savings and will recognize a good selection of types and styles of products offered by a variety of manufacturers at a range of price points.
- Adding windows as a measure for a state’s energy-efficiency or weatherization programs can grow adoption through existing networks. For example, [Con Edison](#) has a windows program, within its New York affordable multifamily energy-efficiency program, that provides a \$200 incentive per MMBtu saved by window replacement as part of its non-comprehensive gas savings pathway. Below are some resources states can reference in adopting their own window program.
  - [The Partnership for Advanced Window Solutions](#) (PAWS) was launched by the U.S. Department of Energy along with regional energy-efficiency organizations (like NEEP) and national labs. PAWS partners with vendors of high-performance windows, utilities, trade allies, window manufacturers, glass makers, and home builders to create demand for advanced window solutions. PAWS will support utility programs and assist in developing consumer incentive programs for advanced window solutions.
  - The [Building America Solution Center](#), under the U.S. DOE, provides guidance documents on window improvements and installation, among other types of home improvement. Guides related to windows include complete window and frame replacement, replacement of windows, of storm windows, of window sashes, and more.

## Conclusion

Windows, though not a great entry point into a building, can be a great entry point to improving the building envelope, and therefore the experiences of those inside. This brief illustrates ways in which window replacement is an important step, considerations for program design, and a few existing programs that can aid in implementation. Through using this tool, states can start to grow this market and increase adoption of windows and the numerous benefits that stem from them.