

## **Industrial Revolution**

*Every home makes compromises among different and often competing goals: comfort, convenience, durability, energy consumption, maintenance, construction costs, appearance, strength, community acceptance, and resale value. Often consumers and developers making the tradeoffs among these goals do so with incomplete information, increasing the risks and slowing the adoption of innovative products and processes. This slow diffusion negatively affects productivity, quality, performance, and value. This department of Cityscape presents, in graphic form, a few promising technological improvements to the U.S. housing stock. If you have an idea for a future department feature, please send your diagram or photograph, along with a few, well-chosen words, to [elizabeth.a.cocke@hud.gov](mailto:elizabeth.a.cocke@hud.gov).*

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# **High-Efficiency Windows: The Frontier of High- Performance Construction**

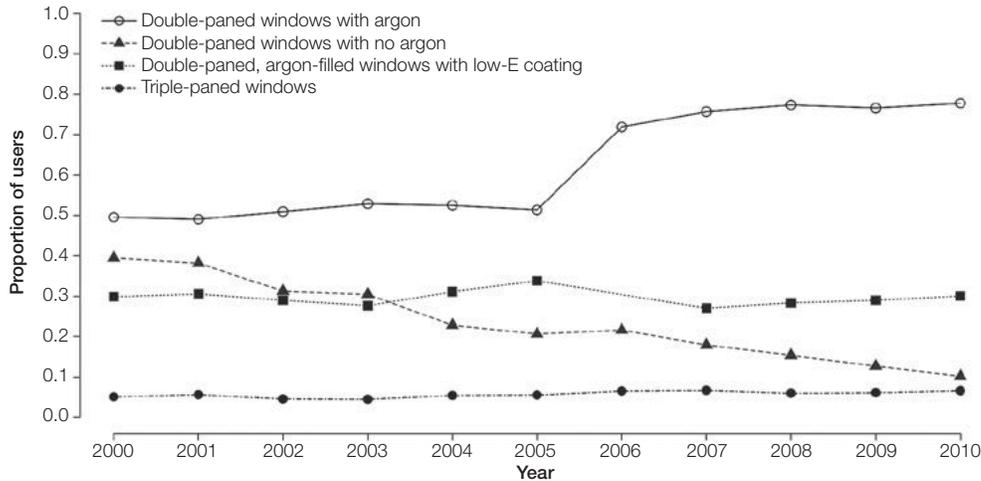
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New generations of high-efficiency windows (HEWs) protect residents from harmful radiation, conserve and resist energy flows (thermal efficiency), and are increasingly specific to the needs of the homeowner and the unit.

Windows not only serve to let in light and air, but they are also critical in controlling conduction and radiation as a result of the light and air. In high-performance home construction, where tightness of construction (air leakage) and efficiency of walls (resisting heat transfer) are critical, the performance of HEW units becomes a key factor in ensuring efficiency for the building's envelope (builder) and operation (homeowner).

Technological innovation in the window market has been very active over the past 20 years. The typical American home before the 1990s contained single-paned glass units or double-paned units with little thermal efficiency. By the late 1980s, double-paned windows began benefiting from the inclusion of low-emissivity coatings, or low-E coatings, that manufacturers apply to one side of the glass, which reduces energy flow through the glass. Low-E coatings remained the innovative choice in the 1990s, because the cost of manufacturing these units became less over time. Since the mid-1990s, manufacturers have developed gas-filled glazing to ensure performance in windows. This innovation resulted from manufacturers introducing a dense gas (typically inert, such as argon), between two panes of glass, which insulates against thermal conductance. Exhibit 1 illustrates the

**Exhibit 1****Use of High-Efficiency Windows, 2000 Through 2010**

*low-E = low-emissivity.*

high-efficiency window cluster options since 2000 that have rapidly displaced the lower efficiency alternative (listed second in exhibit 1 as double-paned windows with no argon), which dropped from 40- to 10-percent market share.

## Typical High-Efficiency Windows

Traditional window products include single- and double-paned windows without the use of energy-efficient technologies. HEWs are those outside the traditional technology that include energy-efficient technologies. Although they come in many versions, materials, and types, a basic classification of current HEW off-the-shelf options is as follows—

- Double-paned windows with argon.
- Double-paned, argon-filled windows with low-E coating.
- Triple-paned windows.

Double-paned windows come in many sizes and types, many of which can be purchased locally. Some common types of windows are fixed (nonopening), awning (hinging up), casement (hinging left or right), single- or double-hung (separate sections that move up and down independently), and slider (separate sections that move side to side independently). Placing windows will vary in difficulty depending on the size, type, and connection detail; for example, some windows are manufactured with a flange that allows for easy connection to the framing of the home. Triple-paned windows are being used outside the United States with success, but they still remain a custom option that is expensive in the U.S. market.

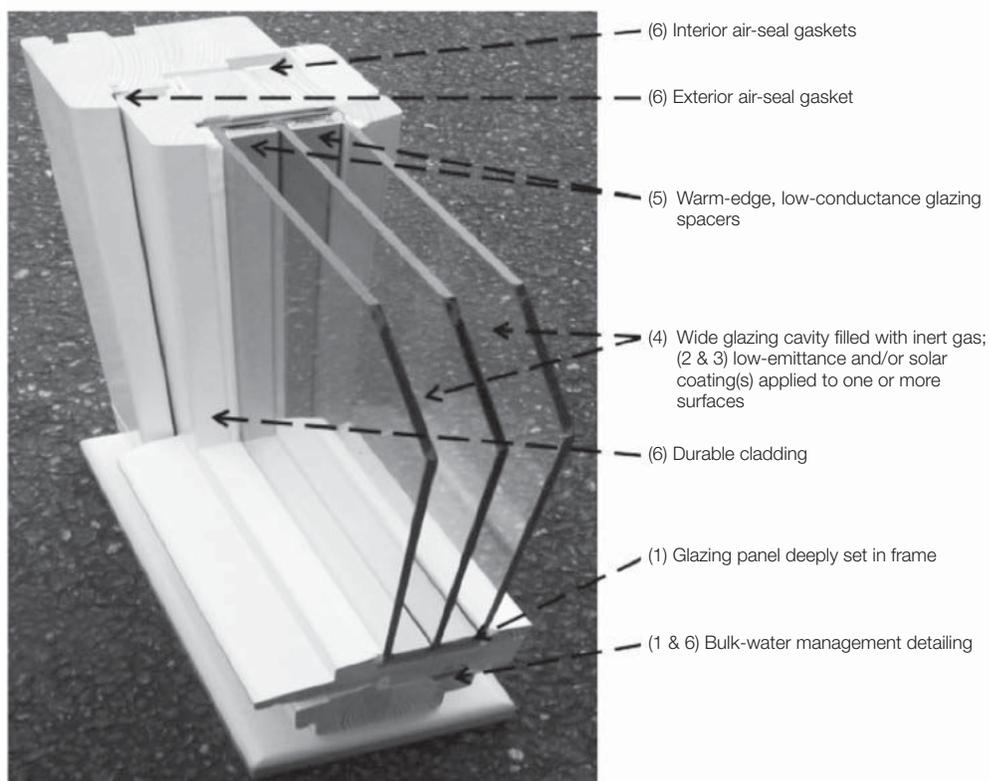
The National Fenestration Rating Council's (NFRC's) classification system helps consumers understand the benefits of the different window options. The NFRC rating information is a label that the manufacturer pastes onto each product. The consumer can use the label to determine the product's basic thermal and optical properties.

- U-value (thermal resistance; the lower, the better).
- Solar heat-gain coefficient (amount of solar radiation that passes through).
- Visible transmittance (amount of light in the visible portion of the spectrum that passes through).
- Air-infiltration rate (amount of air that leaks through cracks in and around the window).

When selecting an HEW option, consumers will find many recent technological improvements, such as glazing unit structure; low-emittance (also called low-emissivity, or low-E) coatings; solar-control glazings and coatings; low-conductance gas fills; warm-edge spacers; and thermally improved sash, frame, and weather stripping. Exhibit 2 shows a sectional view (cross-cut image) of a triple-paned, argon-filled, low-E HEW that includes these technological innovations.

## Exhibit 2

### Anatomy of a High-Efficiency Window (sectional view)



Note: Numbers indicate technological improvements as follows: (1) glazing unit structure; (2) low-emittance (also called low-emissivity, or low-E) coatings; (3) solar-control glazings and coatings; (4) low-conductance gas fills; (5) warm-edge spacers; and (6) thermally improved sash, frame, and weather stripping.

## Benefits of High-Efficiency Windows

Please refer to the numbers in the note of exhibit 2 for the explanation that follows. The benefits of using these technologies are various.

- Current glazing unit structures (1) are required to be more durable to physically support the glass and technologies surrounding energy-efficient options. As an example, the window structure and hardware that contain a single pane required major changes in design and durability when adding the weight of more panes.
- Glazings with low solar heat gain coatings (2 and/or 3) have minimal loss of visible light, which could obscure view.
- Coatings (2 and/or 3) reduce fading from ultraviolet light and can significantly reduce winter heat loss and summer heat gain.
- Heating and air-conditioning systems can be smaller due to heating and cooling load reduction (4).
- Similarly, improved general comfort from reduced “hot” or “cold” spots (4), in turn, enables residents to make lower demands on their heating and cooling systems.
- Frame materials and coatings (5 and/or 6) resist conduction and reduce condensation, also requiring less airflow across them.

## Acknowledgments

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## Additional Information

Many websites offer extensive information on the specifications and use of HEWs. Also, the PATH (Partnership for Advancing Technology in Housing) Technology Inventory on the [www.toolbase.org](http://www.toolbase.org) website provides additional information.