

## High Performance Windows

According to a study conducted by Lawrence Berkeley National Laboratory (<http://eetd.lbl.gov/BT.html>), the energy lost through inefficient residential windows accounts for 2% of total U.S. energy consumption or 9% of total residential energy consumption. Because energy efficiency is a crucial component of sustainable design, energy-efficient windows can greatly impact the environmental performance of a building. The ability to create buildings with superior energy performance has been due, in large part, to the many improvements in window technology made during the last thirty years. These technologies are widely available and relatively inexpensive for most commercial and residential applications.



### **PRODUCT COMPARISONS**

#### **High Performance Windows**

- Higher upfront cost and lower operating costs
- Increased comfort in summer and winter
- Potential to downsize or eliminate heating and cooling systems
- Quieter rooms and less fading from UV light

#### **Conventional Windows**

- Lower upfront cost and higher operating costs
- Less comfort in summer and winter
- Greater dependence on costly mechanical systems
- High noise transmission and fabric fading

### **LEED CREDITS**

Using this material potentially contributes to obtaining these credits in the US Green Building Council's LEED certification program:

#### **Energy and Atmosphere**

EA Credit 1 Optimize Energy Performance

#### **Materials and Resources**

MR Credit 7 Certified Wood (for windows certified by the Forest Stewardship Council)

LEED stands for Leadership in Energy and Environmental Design. To find out more about it, visit [www.leedbuilding.org](http://www.leedbuilding.org)

### **ENVIRONMENTAL ATTRIBUTES**

#### **Energy Performance**

Multiple glazing layers, or multiple panes of glass that are spaced apart, increase the insulating and sound reduction properties of a window. Low conductivity gases between the panes of glass



can also improve the efficiency of the window. This space may be filled with argon or krypton gas to boost the R-value of an air-filled window. Krypton is used in the highest energy performance windows made today. (Argon and other gases are generally not available in high-altitude locations, as the gas escapes through breather tubes required for shipping to or through high-altitude areas.)

Other energy saving features of new windows include low emissivity, or Low-E, coatings. Typically, a thin, transparent layer of tin or silver oxide is deposited on the surface of the glass. This coating allows light to pass through while blocking much of the heat. This is in contrast to tinted glass (common in commercial applications), which also blocks heat but does not admit as much light.

Materials considerations for frame, sashes, and glazing spacers can have significant bearing on the overall energy efficiency of a window as well. The use of aluminum or steel has lost popularity because they readily conduct heat and cold, though thermal break components can improve efficiency. Better materials include time-tested classics such as wood, as well as new composite materials, aluminum-clad wood, and fiberglass.

Energy performance of windows is measured in a number of different ways. For most applications, the most important numbers are the **U-factor**, which measures a window assembly's overall resistance to conductive and convective heat flow, and the Solar Heat Gain Coefficient (**SHGC**), which measures how much radiant heat is coming through the window. Look for windows that have an Energy Star label or, in the San Francisco Bay Area, have a U-factor of less than 0.40 (the lower the U-factor, the better it insulates) and an SHGC of less than 0.40 (the lower the SHGC, the less solar heat coming through). However, if utilizing passive solar design strategies, you may require a higher SHGC (more solar gain allowed) for southern windows. See the National Fenestration Rating Council (NFRC) at [www.nfrc.org](http://www.nfrc.org) and the Efficient Windows Collaborative (EWC) at [www.efficientwindows.org](http://www.efficientwindows.org) for further explanation of different measures of window performance.

ENERGY Performance			
<ul style="list-style-type: none"> <li>Energy savings will depend on your specific climate, house and lifestyle</li> <li>For more information, visit NFRC's website at <a href="http://www.nfrc.org">www.nfrc.org</a></li> </ul>			
Technical Information			
Res	U-Factor	Solar Heat Gain Coefficient	Visible Transmittance
	.46	.35	.56
Non-	.43	.36	.57

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product energy performance. NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes.



Finally, and very importantly, carefully consider window placement in the home, as that can dramatically affect overall energy performance. East- and west-facing windows will promote heat gain. Southern windows will transmit desired light and heat in the winter, yet will also transmit excessive heat in the summer unless they are properly shaded. Northern windows will receive some light but will lose heat or cold throughout the year. (See Passive Heating and Cooling Design Sheet.)

### Resource Impacts

Virtually all flat window glass is float glass, created when molten glass is spread out on top of a layer of molten tin and cooled. Post-consumer recycled glass is never used in this process, although the scrap glass accumulated during manufacture is routinely recycled to make new



windows. Because the amount of metals or polyesters used in low-e coatings is very small, the environmental impacts are negligible.

**Wood remains the most popular framing material**, both for its visual appeal and its relatively good energy efficiency. Because of the requirement for strength in window frame construction, only top quality, knot-free woods may be used. This kind of wood is both expensive and in short supply. Engineered wood is often used in non-visible parts, conserving scarce and expensive virgin wood resources. Recently, some manufacturers have begun to offer FSC certified woods, which may be the “greenest” option available for window frames. Wood frames are typically treated with fungicides and formaldehyde-based finishes. Some sort of exterior coating is needed for durability, and factory painted or stained wood windows are recommended as factories typically have equipment to control and/or capture airborne pollutants from paints. Wood windows are also available with vinyl or aluminum exterior cladding to offer a maintenance-free surface.

**Aluminum and steel frames** may contain high recycled content and are readily recyclable. However, the production of iron ore and bauxite (the mineral sources of steel and aluminum) can have severe environmental impacts on the surrounding area. Frames made of aluminum or steel should have thermal breaks, which incorporate other less conductive materials into the frame construction. Typically, these materials are petrochemical-based resins such as epoxy or vinyl.

**Vinyl or PVC** (polyvinyl chloride) makes up roughly one third of the market share of window frames and sashes. Vinyl is either used alone in extrusions or as cladding over wood window frames. It cannot be painted and easy to maintain. Vinyl is not very strong and thus requires more frame to hold the glass in place, reducing the glazing area and transmitted light. Vinyl’s tendency to expand and contract with normal temperature fluctuations can cause loosening of seals and corner cracks. However, the major problem with vinyl is not as much with its durability, but rather the production and incineration of PVC that creates significant toxins, including dioxin, one of the most toxic compounds known. For this reason, vinyl windows are often discouraged for “green” projects. For a well-referenced report on the dangers of PVC, see the Healthy Building Network-commissioned report at [www.healthybuilding.net/pvc/ThorntonPVCSummary.html](http://www.healthybuilding.net/pvc/ThorntonPVCSummary.html).

**Fiberglass** is usually a mix of polyester resin and glass fiber formed into window frame structures. Its high strength allows smaller frame components and therefore high glazing area and transmitted light. Wood-framed interiors are optional with some products. Fiberglass has excellent energy performance and a very low coefficient of expansion, so it holds paint well and is very durable and stable through time. However, air pollution emissions from fiberglass production dampen some of its environmental benefits.

**Composite wood and vinyl** windows are a relatively new product. Like fiberglass, they have excellent energy performance, are very strong and durable, and can be painted. Manufacturers sometimes use post-industrial wood and vinyl waste from other window manufacturing lines in the production of composite windows. While containing less vinyl than all-vinyl windows, the issues with PVC are still true for this product; read above to learn more about the environmental problems with PVC.

### **Health Considerations**

- Energy efficient windows promote less interior condensation, reducing the potential for some mold growth.
- Defective or improperly installed windows can allow rainwater to enter a structure and create adverse health impacts, including mold growth.



- Chemically sensitive individuals may have an adverse reaction to the fungicides used to treat wood windows. A better alternative are thermally-broken aluminum windows with a baked-on enamel finish.

## **FUNCTIONAL CONSIDERATIONS**

### **Cost**

Windows that combine many of the elements listed above—multiple glazings, Krypton gas interior, low-E coatings, well insulated frames, and tight seals—can add up to \$1000 to the cost of energy efficient windows in a new home project. However, if high performance windows are used, it may be possible to offset the higher initial cost by downsizing heating and cooling equipment. Thus, other upfront costs of the project may be lower, while operating costs can be considerably lower.

### **Installation**

Installation should be left to building professionals familiar with proper weather control and insulation details. High performance windows are installed the same way as standard windows. The issue of proper window flashing has been in debate the last few years, since so many wall systems are failing because of a lack of or incorrect installation of window flashing. For the latest information of proper flashing, visit Building Science Corporation’s website at [www.buildingscience.com](http://www.buildingscience.com).

### **Maintenance**

High performance windows are maintained the same way as standard windows. All windows and associated flashing and caulking should be inspected annually. Ensure the flashing system is still intact and shedding water and the caulking is soft, pliable, and not cracked.

## **RESOURCES**

High performance windows are available from most window manufacturers. For specific dealer or retail locations, visit the manufacturer’s website or search the Green Materials Database, [www.builditgreen.org/guide](http://www.builditgreen.org/guide).

### **Manufacturers: Fiberglass Windows**

<b>Name</b>	<b>Energy Saving Features</b>	<b>Manufacturer</b>
Accurate-Dorwin Pultruded Fiberglass Windows	Double or triple glazed. One or two low e coatings.	Accurate-Dorwin Winnipeg, Manitoba CANADA (888) 982-4640 <a href="http://www accuratedorwin.com">www accuratedorwin.com</a>
Integrity Pultruded Fiberglass Windows	Frame and sash components made from Ultrex(TM), a pultruded composite of fiberglass and polyester resin. Integrity’s glazing options are limited to low-e2 with argon insulating glass.	Integrity Windows and Doors Marvin Marketing Office Eagan, MN (800) 328-0268 <a href="http://www.integritywindows.com">www.integritywindows.com</a>
Milgard	Products include vinyl, thermally	Milgard Manufacturing, Inc.



Pultruded Fiberglass Windows	broken aluminum, pultruded fiberglass windows, and fiberglass-clad wood windows. Windows are custom-manufactured, and the company offers a wide range of glazing options.	Tacoma, WA (800) 645-4273 <a href="http://www.milgard.com">www.milgard.com</a>
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### Manufacturers: Wood Windows

Name	Energy Saving Features	Manufacturer
In Sol 8	Includes two Heat Mirror(TM)-coated films suspended between the panes of glass.	Hurd Millwork Company Medford, WI (800) 433-4873 <a href="http://www.hurd.com">www.hurd.com</a>
Heat Smart	Available in three versions: double-glazed with low-e coatings and argon gas-fill; triple-glazed with one low-e coating and one argon-filled cavity; and triple-glazed with two low-e coatings and two argon-filled cavities. Incorporate some FSC-certified wood.	Loewen Windows Steinbach, Manitoba CANADA (800) 563-9367 <a href="http://www.loewen.com">www.loewen.com</a>
High Performance Wood Windows	Includes triple glazing with two low-e coatings and argon or krypton gas-fill.	Marvin Windows and Doors Warroad, ND (888) 537-8268 <a href="http://www.marvin.com">www.marvin.com</a>
Designer Series Smart Sash	Made from ponderosa pine, eastern white pine, sugar pine, and some white fir. Available with an interior removable panel of glass and with an exterior panel of either single-pane or double-pane argon-filled, low-emissivity SmartSash glazing.	Pella Corporation Pella, IA (800) 847-3552 <a href="http://www.pella.com">www.pella.com</a>
High Performance Wood Windows	Offers a triple-glazed, argon-filled panel with two low-e surfaces. Commercial and Residential Products.	Weather Shield Manufacturing, Inc. Medford, WI (800) 477-6808 <a href="http://www.weathershield.com">www.weathershield.com</a>

### Manufacturers: Glazings

Name	Energy Saving Features	Manufacturer
Solera Translucent Insulation	Consists of two layers of glass separated by 2.5" of clear, acrylic, honeycomb-patterned film insulation. Overall transmissivity can be varied from 22% to 73%.	Advanced Glazings Ltd. Sydney, Nova Scotia CANADA (902) 794-2899 <a href="http://www.advancedglazings.com">www.advancedglazings.com</a>
Comfort E1, Comfort T2, and Solar Glass	Float glass and solar glass products. Product lines for residential and commercial markets and several specialized solar glass products for	AFG Industries, Inc. Kingsport, TN (800) 251-0441 <a href="http://www.afgglass.com">www.afgglass.com</a>



	PV, passive, and active solar applications.	
Heat Mirror Glass	Coated films suspended between two panes of glass filled with argon or krypton gas.	Alpen Glass Boulder, CO (800) 882-4466 <a href="http://www.alpeninc.com">www.alpeninc.com</a>
Lo E2	Soft-coat, low-e glazing Can be combined with clear glass in a double-pane unit for thermal heat reduction.	Cardinal IG Eden Prairie, MN (800) 843-1484
INE Neutral Low-E Glass	High-performance glazing that provides protection from solar heat gain in an almost clear glazing.	Interpane Clinton, NC (800) 334-1797
Pilkington Energy Advantage	Hard-coat (pyrolytic), low-e glass For use in passive solar buildings on southern orientations.	Pilkington NA Toledo, OH (800) 526-6557 <a href="http://www.pilkington.com">www.pilkington.com</a>
PPG High-Performance and Solar Control Glazings	Offers high solar transmission using a hard-coat (pyrolytic) low-e coating. Available in Clear or Tinted varieties.	PPG Industries, Inc. Glass Technology Center Pittsburgh, PA 15238 (800) 377-5267 <a href="http://www.ppgglazing.com">www.ppgglazing.com</a>
OKASOLAR Sun Control Glazing	Custom-made insulated glass units with built-in fixed louvers that reflect sunlight upward towards the ceiling.	Schott Corporation Technical Glass Division Yonkers, NY (914) 968-8900 <a href="http://www.schottglass.com">www.schottglass.com</a>
Superglass Quad with Heat Mirror	Incorporates two Heat Mirror suspended films and three gas-filled cavities between dual panes of glass.	Southwall Technologies Palo Alto, CA (800) 365-8794 <a href="http://www.southwall.com">www.southwall.com</a>

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