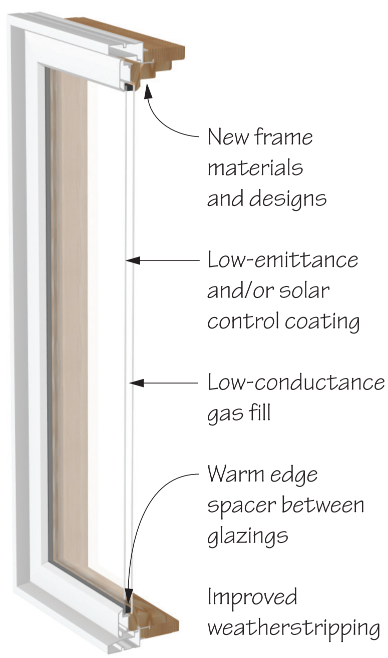
Efficient Windows Collaborative

The Efficient Windows Collaborative Builder Toolkit

www.efficientwindows.org October 2009

Energy-efficient windows are integral components of high quality homes and help homeowners save heating and cooling costs. With efficient windows, homes can more easily meet energy code requirements, achieve ENERGY STAR® homes recognition, or meet utility incentive requirements. In many cases, using efficient windows allows builders to reduce home energy demand while increasing the amount of glazed area—and marketing studies have shown that larger glazed areas appeal to prospective buyers.



Technological advances have significantly improved window energy performance. Many of these advances are invisible, but the ENERGY STAR® label designates high-performance products and the NFRC label provides reliable information about the performance details (see page 8).

Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient windows.

Builder Toolkit Contents

Why Energy Efficient Windows?

How to Finance Energy Efficient Windows in New Homes

Energy-efficient windows increase the value and comfort of a house, but they also raise a cost issue. Windows are an expensive part of the building envelope, and although higher energy performance is more than offset by long-term energy cost savings, it may add to the upfront cost.

How to Make the Most of Energy Efficient Windows

Builders can provide the best indoor comfort and energy performance by selecting windows that are best suited for a home's climate and orientation.

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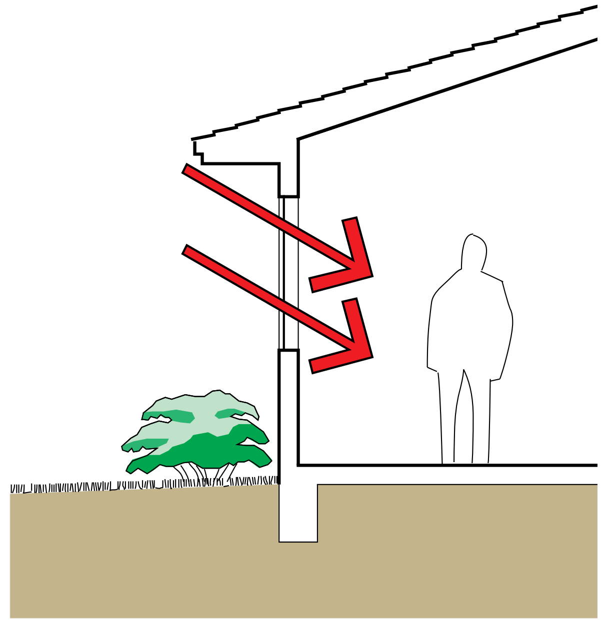
Residential Windows Book
Carmody, J., S. Selkowitz, D. Arasteh, and L. Heschong. Residential Windows: New Technologies and Energy Performance, 3rd ed. New York, NY: W.W. Norton & Company, 2007.

Why Energy Efficient Windows?

Energy and Cost Savings

Energy efficient windows are designed so that heat is kept inside the home in the winter and outside the home in the summer. This reduces heating and cooling costs, minimizes energy consumption that impacts the environment and limits the size of the HVAC equipment required for keeping the home comfortable.



Cooling Season Savings

In climates that mainly require cooling, windows have represented a major source of unwanted heat gain. In recent years, windows have undergone a technological revolution. It is now possible to significantly reduce solar heat gain and improve comfort while providing clear views and daylight. This means that high performance windows can face into the sun if desired without great energy penalties—although shading techniques remain important.

The graph below illustrates the significant savings in cooling season costs associated with improved windows. Installing low-solar-gain low-E windows instead of traditional dual-pane windows in a typical 2,000 square foot house in Phoenix, Arizona would reduce the air conditioner peak load from 4.5 tons to 3.5 tons. The low-E coating would avoid the up-front cost of one ton of air conditioning and save the homeowner about 19% of cooling costs.

Downsize HVAC systems

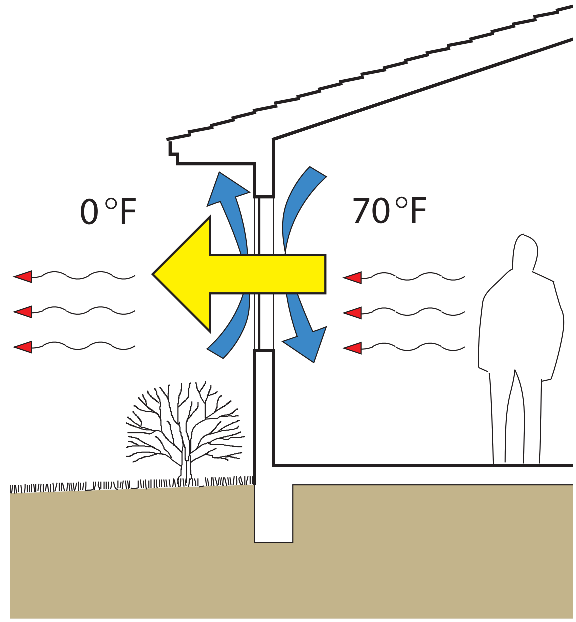
High-performance windows not only provide reduced annual heating and cooling bills; they reduce the peak heating and cooling loads as well. This means that smaller HVAC systems (including the furnace, heat pump, air conditioner, and fans) may be installed in energy efficient homes. Smaller HVAC systems cost less, consume less energy and are just as effective as larger systems if energy efficient windows keep peak demand low.

Annual Cooling Energy Cost for a Typical House in Phoenix, AZ

*Compared to the same 2000 sf house with clear, doubl glazing in a wood/vinyl frame.

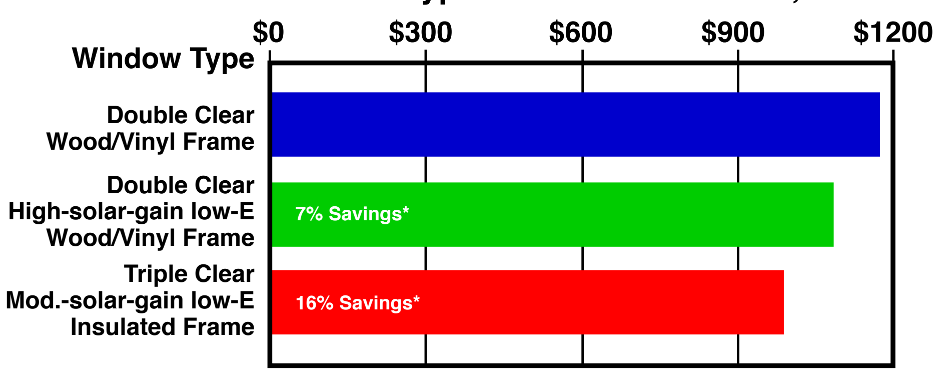
Heating Season Savings

In climates with a significant heating season, windows have represented a major source of unwanted heat loss, discomfort, and condensation problems. With modern windows, it is now possible to have lower heat loss, less air leakage, and warmer window surfaces that improve comfort and minimize condensation. This means that windows do not any longer have to be an energy loser to be avoided—increasing glazing area with high performance windows can have little or no affect on total energy use.



The graph below illustrates the significant savings in heating season costs associated with energy efficient windows for a house in a heating-dominated climate. For a typical 2,000 square foot house in Boston, Massachusetts, double-glazed low-E windows instead of conventional double-pane windows reduce heating costs by 7%. Triple-pane low-E windows with insulated frames would save as much as 16%.

Annual Heating Energy Cost for a Typical House in Boston, MA



*Compared to the same 2000 sf house with clear, double glazing in a wood/vinyl frame.

Improved Comfort

Improved Winter Comfort

Energy-efficient windows improve comfort within homes by providing a warmer interior surface during the cold winter months, preventing the living space near windows from getting uncomfortably cold. Air adjacent to inefficient windows is cooled and floats to the ground. This feels like a cold draft, even though the windows may not be leaky at all.

Improved Summer Comfort

By reducing the need for air conditioning, windows that control solar heat gain also reduce the risk of possible health effects from air conditioning—for instance, the overuse of air conditioning can cause headaches or aggravate the effects of arthritis and neuritis.

Less Condensation

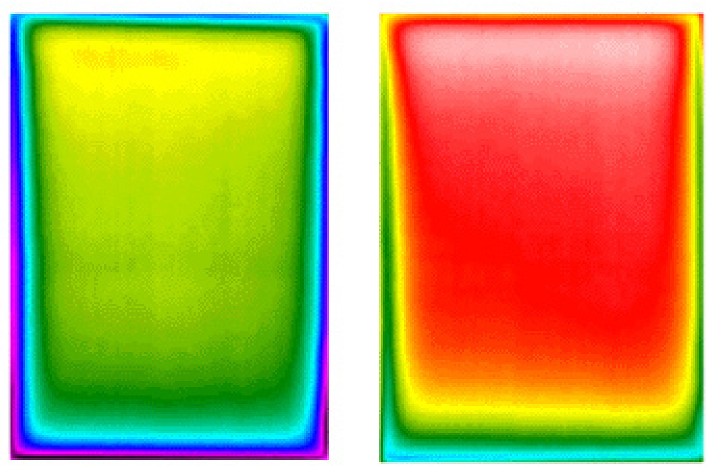
High-performance windows with warm edge technology and insulating frames have warmer interior surfaces, so that the likelihood of condensation is significantly reduced under all climate and humidity conditions.

Impact of Low-E Glass and Insulating Spacers on Condensation

The adjacent images show interior surface temperature patterns of a clear double-glazed unit (left) and an energy-efficient low-E insulated glazing unit with an improved spacer (see illustration below).

Under typical winter conditions, (i.e. 20°F outside), condensation on the glass under typical humidity levels is shown by purple and blue. With a conventional clear double glazing (left), condensation occurs in a band a couple inches wide along the edge of the sightline, with more condensation along the bottom than at the top. With the energy-efficient low-E insulated glass unit (right), condensation will be greatly reduced (a small strip less then 1 inch high along the bottom).

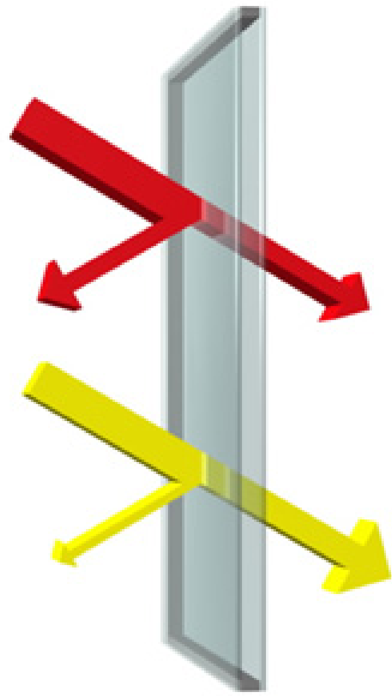
Under extreme winter conditions (i.e. 0°F outside), condensation is shown by purple, blue and green. With clear double glazing, there is condensation over the entire unit. With energy-efficient low-E glazing, there is only condensation on a band along the bottom and up along the edges.



Source: Lawrence Berkeley National Laboratory

Increased Light and View

Daylight and view are two fundamental attributes of a window. Unfortunately, windows are also the source of significant solar heat gain during times when it is unwanted. Traditional solutions to reducing solar heat gain, such as tinted glazing or shades, mean that the amount of light is reduced as well. New glazings with low-solar-gain low-E (spectrally selective) coatings can provide better solar heat gain reduction than tinted glass, with a minimal loss of visible light. This also means that views can be clearer and unobstructed.



Greater Protection from UV Fading

Many organic materials, such as carpet, fabrics, paper, artwork, paints, and wood may fade upon exposure to sunlight. Window selection can influence the type and intensity of transmitted radiation. The most harmful radiation in sunlight are ultraviolet (UV) rays, which are the most likely to break chemical bonds, leading to fading and degradation. Glass blocks all UV radiation below 300 nm, but transmits UV from 300–380 nm. Coatings on glass can reduce the transmission of UV radiation by up to 75%. UV absorbers can also be incorporated into thin plastic films in multilayer windows or as an interlayer in laminated glass. In both cases, the UV transmission can be reduced to less than 1%. However, it is important to note that the remaining visible light that is transmitted can still cause fading in some materials. But low-E coated glass or plastic films reduce fading to a minimum for many modern interior furnishings.

How to Finance Energy Efficient Windows in New Homes

Energy-efficient windows can raise a cost issue. Windows are an expensive part of the building envelope, and although the extra cost of energy-efficient windows will be more than offset by energy cost savings, higher energy performance adds a premium to the upfront cost. There are options to deal with this upfront cost if funds are limited.

Make Windows a Priority

Many other home improvements can be made later on, once a house has been completed and the homeowner has more funds available. Windows, however, should always be installed in the best available quality in order to prevent later regrets. To replace windows later results in extra cost that is avoidable if the right decisions are made while the home is first constructed. Homebuilders can point out to homebuyers that windows should be a priority—the garden decoration can be added later.

Energy Efficient Mortgages

Energy efficient mortgages (EEM) promote the design, construction, and purchase of more energy-efficient homes. With EEMs, homeowners' qualifying ratios for higher loans increase if energy efficiency features, such as high-performance windows, are added to their homes. EEMs make sense because homeowners that save on heating and cooling or other energy expenses can repay loans far easier than the owners of less efficient homes. Energy efficient mortgages are one tool that allows homeowners to offset the financial constraints that might otherwise prevent them from considering the best quality windows in their new home.

Energy Efficient Mortgages

Energy efficient mortgages are offered through several different programs in the secondary mortgage market. Fannie Mae, Freddie Mac, the Department of Housing and Urban Development, Federal Housing Administration, and the Veteran's Administration offer programs to increase energy efficiency through EEMs. The number of banks offering this type of mortgage has grown significantly in recent years.

More information on EEMs can be found at:

- www.energystar.gov/index.cfm?c=bldrs_lenders_raters.energy_efficient_mortgage
- www.natresnet.org/ratings/default.htm
- www.hud.gov/offices/hsg/sfh/eem/energy-r.cfm
- www.ase.org/section/_audience/consumers/refinanceremodel/refinancing/

Tax Credits

Provisions in the Federal Energy Policy Act of 2005 allow home builders to claim a tax credit of $2000 for qualifying energy-efficient homes. The qualification criterion is the estimated heating and cooling energy consumption of the home. It must be at least 50% below the heating and cooling consumption of a comparable home that meets the standards of the 2004 supplement to the 2003 International Energy Conservation Code (IECC). Energy-efficient windows are crucial for achieving such low consumption of heating and cooling energy.

The credit goes directly to the home builder. In order to claim the credit, a builder must have the home's energy performance estimated and certified by an independent certifier that is accredited by the Residential Energy Service Network (RESNET).

Currently, the tax can be claimed for homes placed in service until December 31, 2009. Renewal of the tax credit is pending in Congress. For more information, view www.energytaxincentives.org/builders/new_homes.php.

How to Make the Most of Energy Efficient Windows

Builders can provide the best indoor comfort and energy performance by selecting windows that are suited for a home's climate and orientation. .

Most windows and skylights now have labels that display energy ratings to help builders and homeowners choose energy-efficient products. These labels have been developed by the National Fenestration Rating Council (NFRC), a not-for-profit organization that administers the only uniform, independent rating and labeling system for the energy performance of fenestration products (windows, doors, skylights and attachment products). The most important rating criteria for heat loss and gain are U-Factor and Solar Heat Gain Coefficient (SHGC).

NFRC
National Fenestration Rating Council®
CERTIFIED

World's Best Window Co.
Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low E
Product Type: **Vertical Slider**

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	**0.32**
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
0.51	**0.2**
Condensation Resistance	
51	—

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.
www.nfrc.org

The U-factor measures the rate a window conducts non-solar heat flow, representing the performance of the entire window, including the frame and spacer materials. The lower the U-factor a window has, the more energy efficient it is. Window U-factors generally range from 0.15 for high-performance triple-pane units to 1.20 for older single-pane units.

A window with a high solar heat gain coefficient (SHGC) is collects more solar heat, which is beneficial during the winter but can increase cooling demand if no shading is provided. A window with a low SHGC more effectively controls cooling loads but limits the potential for free winter heating from the sun. SHGCs range between 0 and 1.

What is the difference between R-value and U-factor?

The R-value is used for most parts of the building envelope in order to indicate insulating performance. The U-factor is used to express the insulation value of windows. R-value and U-factor are similar in measuring non-solar heat flow. But the term R-value is usually used for wall or ceiling insulating value and does not translate well to windows and other fenestration products. Therefore, the U-factor is used for fenestration products. It is important to note that these ratings relate to each other inversely: A higher R-value means better insulated walls and ceilings, while a lower U-factor indicates better performing windows.

To determine the R-value equivalent of a window U-factor, divide 1 by the U-factor number.
E.g.: a 0.25 U-factor equals a 1/0.25 = 4 R-value.

Low or High Solar Heat Gain?

In climates with a clear dominance of either cooling or heating energy use, the decision of whether to choose windows with a higher or a lower SHGC is relatively straightforward. A low SHGC helps reduce cooling loads, whereas more solar heat gain reduces winter heating needs. In most U.S. climates, however both heating and cooling needs can be significant, so the question of the optimum SHGC is not as easy to answer. It depends on the design of the house and the specific climate of its location. Here are some rules of thumb for mixed climates:

- A higher SHGC (above 0.40) can be considered for south-facing windows if overhangs provide shading in the summer. South-facing windows are a good source of passive winter heat gain.
- East- and west-facing windows should provide good solar control because they are a source of much unwanted summer heat gain unless well shaded, e.g. by trees (overhangs don't work well against the low morning and evening sun).
- • Ideal windows have a low U-factor. This keeps the home warm in the winter, even if the SHGC is low to keep the summer heat out.
- The Efficient Window Collaborative's Window Selection Tool helps you choose suitable window types for specific climatic conditions. Also, Lawrence Berkeley National Laboratory provides a computer program to calculate energy use based on window selection. The name of the program is RESFEN and can be download at windows.lbl.gov/software.

Window Orientation can Greatly Influence the Energy Efficiency of a Home.

Orientation in a northern climate (mostly heating)

It is generally accepted that orienting the majority of windows to the south in a heating-dominated climate will result in greater solar gain and less heating energy use. This is a very important consideration if less efficient windows with a higher U-factor are used. On the other hand, by using high-performance windows, the impact of window orientation on heating energy use is diminished. For example, north-facing windows with triple glazing and low-E perform about as well in keeping heating use low as south-facing windows with clear double glazing. With a greater window area, the difference between less efficient and more efficient windows as well as the difference between north-facing and south-facing windows becomes greater.

Orientation in a mixed climate (heating and cooling)

Orienting windows to the south will result in greater solar gain in winter while overhangs can be designed to reduce summer solar gain.

East and west window are more difficult to shade. Their glazing area should either be kept at a minimum or consist of highly energy-efficient windows with a low SHGC.

North facing windows perform the best in summer but are worse in providing winter heat gain. However, well-insulated windows with a low U-factor prevent heat loss and even in winter provide for energy efficient north-facing glazing.
The difference between orientations is diminished when higher-performance windows with lower U-factors and SHGCs are used. The less external shading and the greater the window area, the greater the difference in energy costs between less efficient and more efficient windows, and between different window orientations.

Orientation in a southern climate (mostly cooling)

In predominantly cooling climates, the goal is to face most windows north, where there is little direct exposure, or to the south, where they can be designed with overhangs that will keep out most of the hot summer sun. Overhangs are much less effective against the lower angles of the east and west sun. Therefore, simply reducing the size and number of east and west windows can be the best strategy.

The orientation of windows has a significant impact when typical clear-glazed windows are used. Note that high-solar-gain low-E windows perform worse than low-solar-gain low-E windows. When higher-performance windows with low-solar-gain low-E coatings are used, window orientation and the size of the glazing area have a greatly diminished impact on energy use. Shading provided by overhangs or trees, however, should always be considered as an additional means of reducing cooling loads.