Choosing Replacement Windows For Your Home[1]

Mark Pierce

In the Fall 2002 issue of HHE News I examined reasons for, and against, replacing older windows with new, energy efficient windows. That article illustrated that purchasing replacement windows gives a much lower return on investment in terms of increased energy efficiency than most other efficiency up-grades. Air sealing, increased insulation levels, and heating system up-dates are much more cost effective than window replacements in terms of cuttting heating costs. However, there are other reasons for replacing the windows in your home. For example, the existing windows in your home may be worn out, or you may want to update the appearance of your home by installing new siding and windows. This article presents information to help you make an informed decision when purchasing replacement windows.

Window Unit Components

A window unit consists of three main components: the frame, the sash, and the trim. And the trim includes both interior and exterior trim (see Figure 1 on page 2 for illustrations of these components).

- **Sash:** This is typically the moveable portion of the window, although sash can also be fixed (non-moveable). It includes the glass with a narrow frame of wood, vinyl, fiberglass or aluminum that holds the glass in place. The glass portion of a window is often referred to as **glazing**.

- **Frame:** The window frame consists of the sill, two side jambs and the head jamb. Attached to the side jambs are stops, which serve to hold the sash into the window frame. The window frame is installed in a **rough opening** that was built into the wall framing when the house was initially constructed.

- **Trim:** A window has both interior and exterior trim. The trim covers the opening between the window frame and the rough opening in the wall. Most window units are manufactured with exterior trim attached to the frame. After the window is placed into the rough opening and interior wall finishes have been completed, the interior window trim is installed.

Window Replacement Methods

Replacement windows, as the name implies, are meant to replace older windows initially installed when the home was built. There are three basic replacement methods:

1) Replacement Sash Kit:
The old window sash are removed from the existing window frame and replaced with new sash that contain insulating glass. Sometimes new window track liners are also installed over the older window stops. This is the least labor-intensive method for window replacement.

2) Replacement Insert:
This is a new window frame fitted within the old window frame. The old window sash and stops are removed leaving an opening into which a new, smaller window frame is installed. The advantage is that it provides a high performance window up-grade with little disturbance to interior and exterior wall surfaces. However, the new window sash will be smaller than the original sash, since they must fit into a smaller frame.

3) Replacement of Entire Window Unit:
This requires removal of the existing window frame which involves removing the window trim. This is a labor-intensive process, and therefor the most expensive of the replacement options. This option is necessary if the existing window frames cannot be used - if they are rotted for example.

Energy Efficiency and Replacement Windows

The overall energy efficiency of a replacement window unit is related to how well the glass and window frame components resist the flow of heat. The airtightness of

[1] This article orginally appeared in the Winter 2004 issue of Housing and Home Environment News

the window and how well the window is installed are also important factors (see side bar on page 3 for more information about how heat escapes through a window) Manufacturers use several methods to increase the energy efficiency of windows.

Multiple layers of glazing (glass)

Going from one to two layers of glass doubles the insulating value of a window. For example, a single pane window has a U-factor of approximately 1 while the same sized window with a double layer of glass has a U-factor of .49. U-Factor measures how well a window prevents heat from escaping. The lower the U-factor, the better the window is at resisting heat loss. Adding a third, and even fourth layer of glass further increases the insulating value, but not to the same extent as going from 1 to 2 layers. A triple glazed window has a U-factor only 25% better than a double pane window. Windows with three and four layers of glass also tend to be much more expensive than doulble pane windows. And extra layers of glass also reduce the *visible light transmittance* (VLT) of the window. VLT is the amount of light the window lets into the house. A typical single pane aluminum window has a VLT of .70, meaning 70% of the light hitting the window will get through . The exact same window with double glazing has a VLT of .62., and a triple glazed window has a VLT of .50.

Gas fills between the layers of glass

In older double glazed window units air was used as the gas fill between sealed panes of glass. Argon and krypton gas fills are now used because they are better insulators than air.

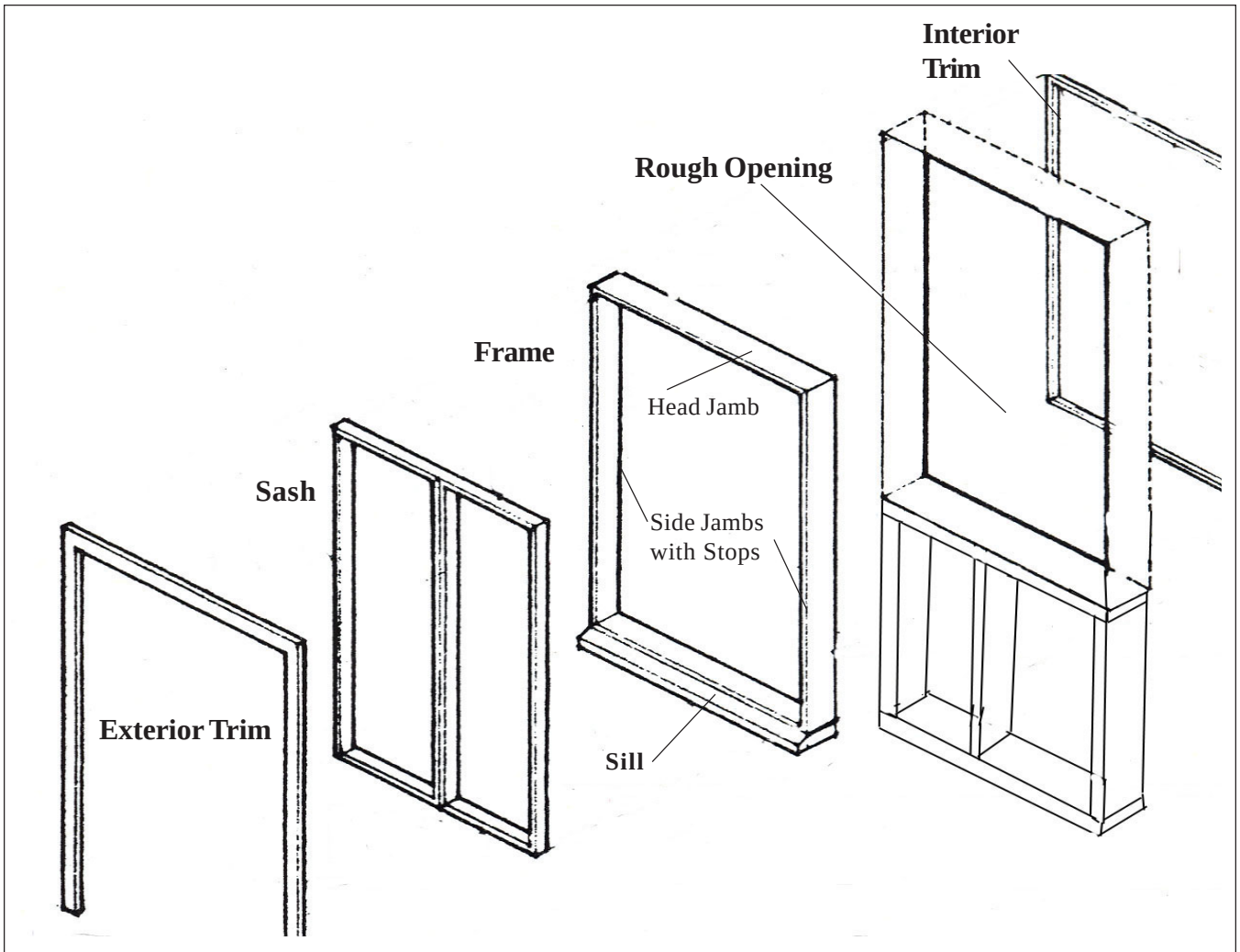


Figure 1: Components of a Typical Window

Low-emittance (low-e) coatings

This is a microscopically thin, virtually invisible metallic coating placed on one or more of the glass surfaces. It reduces radiant heat flow through the glass portion of the window (see side bar on this page for an explanation of radiant heat flow).

Use of "warm-edge" technologies

When a window has more than one layer of glass, edge spacers must be used to separate the layers. Traditionally, metal edge spacers have been used in multiple glazed windows. But metal increases conductive heat loss around the perimeter of the glass (see side bar on this page for more information about conductive heat loss through windows). To address this issue many manufacturers are now using metal spacers with a thermal break. A thermal break is obtained by separating interior and exterior metal frame components with a material better able to resist heat loss. Some are even using non-metal spacers to further reduce conductive heat loss around the window perimeter.

Use of non-heat conducting window frame and sash material

Aluminum and steel window frames and sash have very high heat conductivity properties, making them poor choices for energy efficient windows. Wood, hollow vinyl and fiberglass all have good resistance to conductive heat losses. The most energy efficient sash and frames are vinyl or fiberglass filled with polyurethane foam insulation.

Airtightness

The amount of air that leaks through cracks between window components is primarily a function of the tightness of the unit's weather stripping seals, and the air pressure differences between indoors and outdoors. A 25 mile an hour wind creates a constant air pressure on a window of 1.56 pounds per square foot. A window can have excellent thermal insulating qualities, but if it lets significant amounts of cold outdoor air into the house it will not be energy efficient.

Window Frames

Vinyl, wood and aluminum are the three most commonly used materials for replacement window frames. Fiberglass is another option that is gaining market share.

Aluminum conducts cold easily, so while it is a very durable material, it is a poor choice for window frames in a heating climate.

Heat Loss Through Windows

Conduction, convection, radiation and air leakage are the four primary ways that heat is lost through windows. A brief description of these heat flow mechanisms is listed below.

Conduction

This is the flow of heat through solid objects and between objects touching each other. An example of conduction would be a coffee pot settting on a hot wood stove. The heat from the hot stove surface conducts to the coffee pot.

Convection

Convection is the flow of heat by a moving fluid such as air. Most convection heat flows occur between a fluid and a surface. A cold winter wind blowing across your face is an example of a convective heat loss. Cold window glass cools air near its surface.

Radiation

Radiant heat travels through space from warm objects to cooler objects. Feeling the warmth of the sun on your face is an example of radiant heat flow. When inside your house on a winter night, radiant heat flow causes the cold glass surfaces of windows to pull heat from your body .

Air Leakage (unintentional air flow)

Excessive air leakage through windows reduces comfort and energy efficiency. Air leakage through windows occurs from cracks between window components and between the window frame and rough opening. Air leakage through components of quality replacement windows is minimal. But even the best window can have severe air leakage problems if it is not properly installed. Careful, high quality installation is extremely important if the full energy saving benefits of replacement windows are to be realized.

Wood frames provide good thermal performance and high durability. But exterior portions require a lot of maintenanace. Manufacturers overcome this problem by producing vinyl or aluminum clad wood windows. Typically the cladding is applied only to the exterior of the wood frame and sash, leaving the wood on interior portions of the window exposed. This creates a durable, long lasting window while displaying the attractiveness of natural wood on the home's interior. But wood replacement windows are typically the most expensive.

About 60% of replacement windows sold annually in the United States are vinyl. They are relatively inexpensive and never need to be painted. Well- built vinyl windows are also highly durable. But as with any product, quality often varies from manufacturer to manufacturer and even from model to model. Fortunately, identifying well-made vinyl windows is not difficult. Just look for an American Architectural Manufacturers Association (AAMA) sticker on the window. The AAMA sets minimum quality standards for vinyl windows. Manufacturers that want the AAMA sticker on their windows must submit sample units to independent laboratories. These labs test the windows for corner joint strength, resistance to forced entry, impact resistance, color retention and several other factors. If the windows pass, the manufacturer is allowed to place the AAMA sticker on their window units.

Fiberglass window frames are very strong and durable. Fiberglass windows tend to be less expensive than wood, and more expensive than vinyl windows.

The National Fenestration Rating Council

With hundreds of window manufacturers using various combinations of materials and technologies, making a replacement window purchasing decision can seem like a monumental challenge. Fortunately, the information you need to make an informed decision is listed on the National Fenestration Rating Council (NFRC) label found on all high-quality windows (see page 5 for an example label).

The NFRC is a non-profit public/private collaboration that provides contractors and homeowners with standardized, unbiased methods so that an apples-to-apples comparison of various window brands and product types can be made. Always look for the NFRC label on windows. If a window does not carry the label it is extremely difficult to determine the actual energy efficiency of that window.

Window Durability

Long warranties from the window manufacturers indicate sound window construction and long-term durability. And while most manufacturers provide some type of warranty, be aware that the time period covered and the warranty offered apply to only specific components of the window unit. For example, manufacturer X may warranty the seal between glass layers for 20 years and all other window components for 10 years. While manufacturer Y may warranty window hardware for life, other components for 2 years and the glass seal for 5 years. So read and compare warranties carefully, and select windows with long warranty periods on all components. Note also that manufacturer warranties seldom cover the cost of labor for replacing a unit if it should fail.

Installation

Even though you spend thousands of dollars to purchase high quality energy efficient replacement windows, you will not realize energy savings unless the windows are installed correctly. For the highest quality installation, hire a contractor that has received training and accreditation from a professional organization such as the Building Performance Institute (BPI).

If you are a capable, experienced do-it-yourselfer you can probably do the work yourself. Many manufacturers supply training videos or booklets that give detailed information about how to install their products. Make certain you obtain all the information required and know exactly how to install the particular units you purchase before proceeding. If you are uncertain about any aspect of the job, it is best to seek out the services of a professional installer.

The National Fenestration Rating Council (NFRC) Label

The NFRC energy performance label can help you determine how well a window, door or skylight will keep heat in your building in the winter, and out during the summer. This label will assist you in making apples-to-apples comparisons between various products.

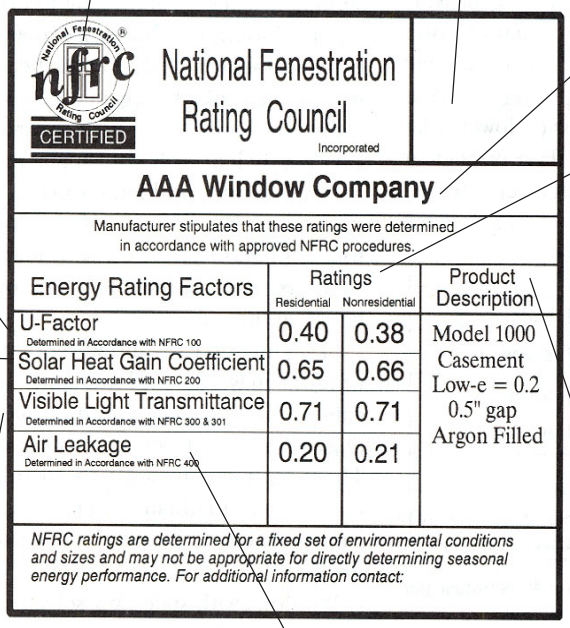
Below is an example of an NFRC label. All parts of the label are described. The U-factor and Solar Heat Gain Coefficient, which rate the efficiency of the entire window (glass and frame), are the most important in choosing the most energy efficient window.

U-Factor
U-Factor measures how well a window prevents heat from escaping. The lower the U-factor, the better the window is at resisting heat loss. U-factors listed for NFRC rated windows are for the *total* window unit, accounting for heat losses from the window frame, the edge of the glass and the glass itself. In our cold, mostly heating climate look for a U-Factor of .35 or lower.

Solar heat gain coefficient (SHGC)
This is a measure of how much solar heat gets transferred through a window. A SHGC of .65 indicates that 65% of the solar heat that strikes a window gets through it. In a heating climate such as ours, a high SHGC may be desirable if the house is constructed using passive solar techniques.

The **NFRC Insignia** is your assurance that this window has been independently rated.

This box contains the name of the **Independent Certification and Inspection Agency** selected by the window manufacturer



Name of the **window manufacturer**

The NFRC rates all products in two standard sizes so that consumers and others can be sure they are comparing products of the same size. On the label, these two sizes are listed as "Res" and Non-Res"

Description of the particular **product** to which this label is attached

Visible light transmittance (VLT)
This is a measure of how much visible light comes through the entire window. There often is a trade-off between high-energy performance and VLT. Multiple layers of glazing and low-e coatings can reduce the amount of light that gets through the window. Use this measure to help you determine how much light you will sacrifice for various levels of energy performance.

Air Leakage
Air leakage (AL) is measured as the amount of cubic feet of air passing through each square foot of window, per minute (cfm/sq. ft.). The lower the AL, the more energy efficient the window.

Final Recommendations:

- When shopping for new windows look for the National Fenestration Rating Council (NFRC) label. The NFRC label allows you to make accurate comparisons about the energy efficiency of different makes and models of windows. Remember that the lower the U-value, the more efficient the window. Look for windows with a U-value no higher than .35.

- Select windows with an air leakage rating at or below .20 Cubic Feet per Minute per Square foot of window (CFM/Sq.Ft.)

- Choose windows with long term warranties. The air/gas seal between glass layers is probably the most important component to have warranted. If the seal is lost fogging occurs between the layers and much of the insulation value of the window is lost.

- If you are hiring the work done be certain to obtain the services of a trained individual that has been certified by a professional organization such as the Building Performance Institute. If you will be doing your own work, make sure you do careful, high quality installations.

References

Carmody, J., Selkowitz, S., & Heschong, L. (1996). *Residential Windows, A Guide to New Technologies and Energy Performance* New York: Norton.

Krigger, J., (2000) *Residential Energy, Cost Savings and Comfort for Existing Buildings.* Helena, Montana: Saturn Resource Management.

United States Department of Energy. (1997) *Selecting Windows for Energy Efficiency* Publication 788. Copy on world wide web at:

Hymes, S. (1998). Selecting replacement windows. *Journal of Light Construction.* Vol. 16, February, 1998.