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Energy Efficient Windows

W. Ted Haskell

Windows are among the most important features of any house, and they deserve at least as much thought and planning as any other part of your house, old or new. Their impact on energy costs means that window choices will make a big difference in the long-term cost of home ownership.

The good news

Light. Glass windows were one of the most important historical developments in building construction. Openings with glass could allow daylight indoors without letting in cold air. This is still one of the most important functions of windows.

Ventilation. Windows that open allow you to let in fresh air. Before the advent of mechanical ventilation this was more important, but even today opening windows can increase comfort during mild weather.

Cooling. During hot weather, you can open windows to create cooling air currents.

Heating. During the winter, unshaded south-facing windows often let more heat into the house during the day than they lose during the night. Even homes not designed specifically as “solar homes” can benefit from sunlight through south-facing glass.

Views. Windows allow views for beauty and security.

Design. Windows have always been important architectural design elements. Recent design trends have increased the emphasis on windows as part of what makes a house “look good.”

The bad news

Energy costs. Windows have less resistance to heat loss than other parts of the house. In fact 1/3 or more of the heat loss in a typical house is through the windows. This means that 1/3 of your heating bill could be going out your windows!

Comfort. Because windows are usually the coldest part of your house, they can cause you to be uncomfortable.

Overheating. Large windows, particularly those on the east and west sides of a house, or large areas of overhead glass, can cause too much heat gain from mid-spring through late fall. This causes high air conditioning bills or uncomfortable indoor temperatures.

How do I minimize the bad news?

That’s what this publication is all about. Energy efficient windows, carefully installed and used in moderation, can give you all the important benefits of windows, while maintaining comfort and low home heating costs.

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W. Ted Haskell, Extension agent, energy, Oregon State University.
Designing with Windows

Even when you use energy efficient windows, they are still likely to be the biggest heat loser in your new home, addition, or remodel. So it makes sense to plan their use carefully. With thoughtful planning you can have lots of natural light, attractive views, and plenty of summertime ventilation without high heating bills.

Consider windows versus walls. Even in new, energy efficient houses and additions, windows lose heat five to ten times as fast as the walls per square foot. It really pays to keep window areas moderate, since every place you use wall instead of window you save energy. Of course unshaded south-facing glass is an exception—by letting sunlight in during the winter, these windows help heat the house.

Other than high heating bills, what’s wrong with lots of glass?

Cost. Large windows cost much more than smaller ones, and windows are more expensive than walls. The window treatments (shades, drapes, blinds) also are more expensive. If the windows come within 18 inches of the floor, they must be made with safety glazing, adding greatly to your window cost.

Comfort. Even when they're energy efficient, windows will have the lowest temperature in the house during the winter. That can lead to drafts of cool air, and they'll make anyone next to them cold. When large window areas face east or west, they'll cause overheating from late spring through early fall.

Glare. When one wall of a room has a large glass area, it will be much brighter than the rest of the room. Your eyes have a hard time adjusting to this contrast, and find it tiring.
Maintaining your views
People often overestimate how much window area they need in order to enjoy a view. Compared to a wall of glass, a smaller window often "frames" a view—eliminating unwanted clutter such as parked cars, roads, and neighbors' roofs.

There's rarely a benefit in a sill height of less than 3 feet. A lower height does little to enhance your view and makes furniture placement difficult.

Stock house plans often have more windows than they need. Since the designer doesn't know about the lot the house will be built on, windows are often included in case there's a view in that direction. When you're using a stock plan, identify windows that don't have a function for your particular location and eliminate them or make them smaller. Keep in mind though, that building codes have minimum window areas for some rooms to meet emergency exit and ventilation requirements.

Letting in light
Western Oregon is notorious for cloudiness, so it's especially important for windows to be designed to let light into the house during the day. But even in western Oregon, you don't need a lot of window area to provide plenty of light. Window locations and indoor colors are much more important.

Use light colors for walls and ceilings to reflect light throughout the interior of your house. Light-colored flooring and furnishings also help. Don't underestimate the importance of using light colors. In addition to reflecting light deep into rooms, light colors also reduce the contrast between bright windows and darker interiors. This contrast causes unpleasant eye strain.

When a room has two outside walls, put smaller windows on each wall rather than large windows on just one wall. By spreading out the light sources over more than one wall, you can get light further into the room.

You can get light into hard-to-reach areas by using small skylights. A 2- by 3-foot skylight provides a lot of light and can direct it to places that a large window can't. Paint the skylight well a light color so it doesn't absorb the light before it gets into the room.
Summer and winter sun strike windows differently.

It's important to keep in mind that if the area of south-facing windows exceeds 8 percent of the total floor area (120 sq. ft. in a 1,500 sq. ft. home), you'll need some way to store the solar energy that's coming in, or you'll overheat. This is done using "thermal mass" such as concrete, rock, brick, tile, or water. See "For Further Reading" on page 19 for books on solar house design.

**Overhead glazing**

Using glass in place of some roof areas is a great way to get sunlight into areas of the house that windows just can't reach. You may be tempted to use large areas of overhead glazing, but drawbacks include the following.

**Cost.** The risk of breakage from overhead glazing is of great concern to building codes. To reduce the risk of falling glass, most codes require overhead glass to be tempered on the top layer and laminated on the bottom layer. This adds to the expense of overhead glazing.

**Heat loss.** Overhead glass loses heat even faster than regular windows. Even in energy efficient houses and additions, skylights will lose heat ten to twenty times as fast as insulated ceilings per square foot.

**Heat gain.** Glass with typical roof slopes is oriented so that summer sun shines through it directly. Large areas of overhead glass may make your summers uncomfortable.

**Water leakage.** Large areas of overhead glazing are often built on site rather than by a skylight manufacturer. Quality control is more difficult under these circumstances, so the likelihood of water leakage is greater. It is often difficult and expensive to repair these leaks.

Use moderation when it comes to skylight areas. Place small, high-quality skylights so they direct light exactly where you want it.
Parts of a window

The names for various parts of windows can be confusing, because not everyone uses the same terms to describe the same parts. We'll use the following terms and definitions.

Frame. The frame is stationary and holds the glazing or sash to the house. It may be made of metal, wood, plastic, or fiberglass.

Glazing. Glazing usually refers to the clear materials that make up most of the window area. Glazing is usually made of glass, although plastic glazing is becoming more common. Glazing also means the act of installing glazing materials, but we won't use it that way in this publication. People sometimes call the materials that hold the glass in the window “glazing.” These materials should be called “glazing compounds” or “glazing systems.”

Sash. An openable section of a window, or the frame of an openable section of window. This section can slide or swing to open. The sash frame may be made of metal, wood, or plastic.

Spacer. The spacer holds layers of glazing apart to create an air space between panes.

Stop. The wood, metal, or plastic piece that holds the glazing in the window, or that holds a sash in the window frame.

Weatherstripping. Materials used to prevent air leakage between openable sashes and the main window frame.
Heat loss through windows is one of the main causes of high heating bills. Windows can lose heat five to twenty times as fast (per square foot) as other parts of the house. Windows lose heat in three ways.

**Air leakage**
Air leaks around window frames and openable sashes—even when windows are closed. Whenever there is wind or a temperature difference between inside or outside, air can leak through windows.

**Conduction**
Heat is lost directly through the glass and window frame. Conduction passes heat from molecule to molecule right through solid materials. In winter, for example, heat is conducted from the warmer inside surface of the glass to the colder outside surface.

**Radiation**
Heat energy is emitted from all objects in the form of infrared radiation. Infrared travels like light: in one's sight without requiring a medium to carry it. Whenever an object can “see” colder objects, it will lose heat to the colder objects. Radiant heat is lost through windows directly, and by window materials themselves radiate heat to colder outside objects (even a cold night sky is a “cold object”) during the winter.

### Table 1. Cost of heat loss through windows (approximate $ per year of heat loss per square foot of window not including air leakage).

<table>
<thead>
<tr>
<th>Location</th>
<th>Oil at $1.00/gal</th>
<th>Oil at $1.50/gal</th>
<th>Nat gas at $3.50/therm</th>
<th>Nat gas at $4.00/therm</th>
<th>Elect at $.045/kwh</th>
<th>Elect at $.07/kwh</th>
<th>Heat pump at $.045/kwh</th>
<th>Heat pump at $.07/kwh</th>
<th>Wood at $90/cord</th>
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<tbody>
<tr>
<td><strong>Portland</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Single pane window</td>
<td>$1.07</td>
<td>$1.47</td>
<td>$1.20</td>
<td>$1.38</td>
<td>$2.15</td>
<td>$0.77</td>
<td>$1.19</td>
<td>$1.35</td>
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<tr>
<td>Med eff double pane (U=.5)</td>
<td>$0.53</td>
<td>$0.70</td>
<td>$0.39</td>
<td>$0.39</td>
<td>$0.71</td>
<td>$0.25</td>
<td>$0.39</td>
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<tr>
<td>High eff (U=.33)</td>
<td>$0.37</td>
<td>$0.52</td>
<td>$0.22</td>
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<tr>
<td>Super eff (U=.25)</td>
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<td>$0.37</td>
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<tr>
<td>Med eff double pane (U=.5)</td>
<td>$0.80</td>
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<td>High eff (U=.33)</td>
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<td>$0.59</td>
<td>$0.33</td>
<td>$0.44</td>
<td>$0.51</td>
<td>$0.79</td>
<td>$0.28</td>
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<td>$0.49</td>
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<tr>
<td>Super eff (U=.25)</td>
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<td>$0.25</td>
<td>$0.33</td>
<td>$0.38</td>
<td>$0.60</td>
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</tr>
<tr>
<td>Single pane window</td>
<td>$1.53</td>
<td>$2.00</td>
<td>$1.12</td>
<td>$1.49</td>
<td>$1.72</td>
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<td>$0.96</td>
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<tr>
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<tr>
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<td>$0.32</td>
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<td>$0.55</td>
</tr>
<tr>
<td>Super eff (U=.25)</td>
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<td>$0.50</td>
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<td>$0.43</td>
<td>$0.67</td>
<td>$0.24</td>
<td>$0.37</td>
<td>$0.42</td>
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</table>

Note: These figures assume the following heating efficiencies: oil or gas furnace system efficiency—70 percent (82 percent furnace eff., 15 percent duct losses); electric heating system efficiency—100 percent (assumes in-room heaters such as baseboard—electric furnace will be lower efficiency); heat pump system efficiency—180 percent; wood system efficiency—50 percent. These efficiencies include assumed duct losses. There are wide variations in efficiency that will change the cost of energy lost through windows.

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How much does this cost?

The cost of heat loss through windows depends on the efficiency of the window (its "U-value"), its leakiness, the severity of the winter climate, and the cost of energy used to heat the home. Table 1 will give you an idea of what the heat loss through windows costs. You can pick the climate that is closest to where you live. Then find the fuel you use and the cost that is closest to yours. After that find the cost of the heat loss through the type of window you have, or are interested in.

For example, if you live in Portland, heat with natural gas at 58 cents per therm, and have an old house with single pane windows, you lose 90 cents for each square foot of window during an average winter. If you are considering highly efficient windows to replace your old ones, you can see that they would only lose 30 cents per square foot per year. That's a savings of 60 cents per square foot. If you have 300 square feet of windows, you'd save $180 per year. Note that Table 1 doesn't include the cost of heat due to air leaks.

Windows and comfort

Windows can cause discomfort in two ways. First, they can cause drafts. A leaky window will allow cold drafts of outside air to blow on people inside, making them cold. But even a tightly sealed window can cause drafts by cooling the air right next to it. Cold air is heavier than warm air, so it can fall down the interior surface of a window and circulate into the room.

Our bodies also radiate heat to windows. Windows make us cold even when we're not touching them. This radiant heat loss is important—typically over 40 percent of our body heat loss is radiant loss to cold objects around us, such as windows.

By installing energy efficient windows, we can reduce drafts and radiant heat loss, greatly improving comfort. Some people think that new, energy efficient windows are the best home investment they've ever made—not only because of lower heating bills, but also because they are now much more comfortable.

Typically over 40 percent of our body heat loss is radiant loss to cold objects around us, such as windows.

Window heat loss causes discomfort.
Testing for Energy Efficiency

Later, we'll discuss features that go into energy efficient windows. While it's useful to understand these features, you can't accurately predict the efficiency of a window just by listing its features. A more accurate way to assess efficiency is to look for tested energy performance. Once you find the tested performance of windows, you can spend the rest of your time shopping for other important features like style, hardware, and operating convenience. Tests measure and rate two aspects of windows' efficiency: U-value and air leakage.

**U-value**

U-value is a rate of heat transfer. Low U-value means low heat loss. So look for low U-values when you shop for windows. Window U-values range from slightly over 1.1 to below .25. When you're reading literature about specific windows, look for tested U-values, not calculated values. Two windows with the same calculated value may have different tested values.

The non-glass part of a window has a large effect on the overall efficiency of the window. Make sure the U-value rating is for the entire window—glazing, frame, and sash.

U-value testing should be done by an independent testing laboratory, and it should be done according to industry test standards. The two most widely accepted standards are AAMA 1503.1 and ASTM C236 or C976. If these standards are not cited in the literature, assume that the U-values listed are calculated. Ask for the tested U-value.

You may already be familiar with the term “R-value.” It refers to resistance to heat flow and is used to rate insulation efficiency. Since window ratings are almost always expressed in U-values, we'll use them most of the time. If you'd like to convert a U-value into an R-value, just divide 1 by the U-value. For example, if a window's U-value is 0.38, its R-value is 1/0.38 = 2.63.

While we recommend that you compare tested U-values, a computer program called Window 3.0, produced by the Lawrence Berkeley Laboratory, appears to predict U-values accurately. If you are unable to find a tested U-value for a particular window, a U-value calculated by Window 3.0 is a good substitute. As in testing U-values, the results of Window 3.0 may be more reliable when done by an independent organization rather than by the window manufacturer.

**Air leakage**

Air leakage tests provide results that are expressed in “CFM” (cubic feet per minute) per foot of openable sash. The lower the CFM rating, the less air leakage and the more efficient the window. Look for a window with a test result lower than .2 CFM.

The test standard for window air leakage is ANSI ASTM E283-73. This standard allows testing at a range of simulated wind speeds, so make sure when you're comparing test results that the wind speed was the same for both tests. Look for tests based on a 25 MPH wind speed.

**NFRC Rating**

A national, uniform rating system for windows is expected to be in place beginning in 1992. The rating system is being developed by the National Fenestration Rating Council (NFRC). It will be based on a standard U-value test procedure, and is expected to make comparing window performance easier for consumers, builders, and designers.

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Energy Efficient Features

It used to be that all you'd look for in energy efficiency was "double glazing." Now we know that there's more to look for than two layers of glass.

Energy efficient glazing
The usual way to improve performance of the glazing portion of the window has been to add more layers. The glazing itself, whether glass or plastic, doesn't add much insulation. Rather, it's the still air films on either surface of the glazing that provide insulation.

Storm windows were the original way to add insulation to single pane windows. They have the added benefit of reducing air leakage around the sashes of openable windows. A well-installed storm window can cut heat loss through a single pane window by over half.

You won't find tested U-values for storm windows since they're applied over a wide variety of window types. However, you can sometimes find tested air leakage rates.

Old storm windows had one disadvantage—they had to be removed before windows could be opened for fresh air. In many new storm windows, this problem is solved by installing the storm window in a sliding track. This makes cleaning easier.

Double pane insulated glass. This is now the most popular method of adding another layer of glass with insulating air films. The air space is permanently sealed between the two layers of glass so the windows can be cleaned and opened like a single pane window. The edges of the glass must be completely sealed, so moisture and dirt can't leak into the air space. If the edges leak, moisture and dirt can cause a film to build up on the inside surfaces of the glass which can't be cleaned. The only way to restore clarity is to replace the unit—a costly remedy if not covered by a warranty.

For best energy performance, the air space separating the two layers of glazing should be from 1/2- to 3/4-inch thick. Some manufacturers list the overall thickness of their glazing including the glass itself, others list the thickness of the air space alone.

Look for a long guarantee on the edge seal on windows you are considering. The industry "standard" is 5 years, but some manufacturers offer 10 years and longer. Most guarantees don't cover labor, and some pay less as the window gets older.

In general, "double seal" insulated glass can be expected to outlast "single seal." Double seals use two types of sealant at the edges. One is primarily designed to make the edges air tight, the other provides some structural reinforcement in addition to preventing air leakage.
Stops should overlap the entire spacer that holds glass layers apart.

One construction detail to look for is stops that overlap the entire spacer that holds the glass layers apart. This overlapping shades the edge sealant from the damaging direct rays of the sun and holds the glazing in the frame firmly.

The larger a window is, the more stress it puts on the edge seals. If you have plans for a large window (over 16 square feet), you may instead want to divide the area into several smaller panes of glass. This is even more important if your house is in a windy area.

Triple pane windows. These windows add yet another layer of glazing, bringing the U-value down to as low as 0.32 (R-3.2), compared to 0.49 (R-2) for the best standard double-glazing. This reduction in heat loss is 33 percent. Triple pane windows can be manufactured as sealed units, but a more popular approach has been to combine a sealed insulated glass unit with a storm window.

With the advent of more efficient, triple pane windows have been far less popular due to higher manufacturing costs and heavier weight.

Low-e (low emissivity) glazings. These glazings are usually sealed, double glazed units with a coating that gives them efficiencies comparable to triple glazing. U-values can be below 0.34 (R-2.9)—nearly as low as the best triple-glazing. The manufacturing cost is lower than triple glazing. By the mid 1990s, low-e glazing is expected to be the most common glazing system in new windows.

There is a minor change in color and a slight reduction in light transmission when compared to uncoated double-glazed windows. These changes are not noticeable most of the time. New low-e coatings just coming on the market further minimize the slight changes in tint and light transmission caused by the low-e coating.

Another advantage is that low-e coatings block out most ultraviolet light, the wave length of sunlight that causes fabrics to fade and weaken.

There are several types of low-e glazing. The U-values vary, so be sure to look for tested U-values. Some low-e coatings are combined with tints that are designed to prevent unwanted light (and overheating). If you’re planning to use south-facing windows for winter solar heat gain, make sure you don’t buy a window with a coating designed to prevent heat gain.

Gas-filled insulated glass units. These units are usually manufactured with argon gas between the panes instead of air. Argon doesn’t conduct heat as fast as air does, so the energy efficiency is improved. The savings from using...
argon depends on the mixture of gas and air between the panes—the more argon, the better. Since different manufacturers use different amounts, be sure to use tested U-values for comparing different windows. Also keep in mind that these tests will be for the window when it is new, and the window will gradually lose some argon. Luckily this takes a long time, so you will have saved a lot of money before the amount of argon is significantly reduced. Uncoated insulated glass windows with argon fill can have U-values below .45 (R-2.2)—with low-e coatings, argon-filled units can have U-values below .32 (R-3.1).

Manufacturers are beginning to use other high efficiency gases as well, such as krypton.

Suspended plastic film. Another way to add efficiency is to suspend one or two thin layers of clear plastic film in the airspace between two layers of glass. Each layer of film adds the insulating value of two additional air films.

Heat Mirror uses one or two layers of plastic film with a low-e coating. A new window on the market incorporates two layers of low-e coated plastic film and high efficiency gases between the panes. Windows with Heat Mirror glazings can have U-values as low as .25 (R-4).

Other glazing products. Other products show promise for further improvements. We do not know when these materials will become available. One promising technology is to evacuate the air from between the panes of glass to create a "soft" or "hard" vacuum (soft and "hard" refer to how complete a vacuum is—no air at all would be a very hard vacuum). The potential U-value of this technology may be as low as .1 (R-10).

Another new technology being investigated is installing a clear insulation, called aerogel, between two panes of glass. This system may be comparable to the vacuum systems in energy efficiency.

There are some problems to overcome before these products can be used in homes, but they have great potential to dramatically reduce energy loss through windows.

Comparing glazing costs
Low-e double pane glazing appears to be cost effective in new construction and when replacing existing windows as long as the added cost does not exceed $7.00 per square foot (typical costs range from $1.00 to $2.50). Energy savings over uncoated double pane windows in western Oregon can be expected to be approximately $.15 to $.25 per square foot, so your investment in low-e can return from 20 to 25 percent annually. In eastern Oregon, your savings will be greater.

Energy costs as of summer 1992.
Filling the air space with argon typically saves about half as much energy as a low-e coating, so would only justify half as much added cost. In most cases, argon gas fill is cost effective. The combination of low-e coating and argon gas is often available for about $2 per square foot added cost in Oregon and is well worth that amount.

**Improved spacers**

The spacers that hold glazing layers apart are usually made of aluminum. Since aluminum conducts heat rapidly, the edges of most glazing units are much less efficient than the center of the unit. As the glazing units get more efficient, the spacers become a more important cause of heat loss. New materials are being introduced to reduce this "edge effect." They are usually plastic, which conducts heat much more slowly than aluminum. In addition to saving energy, they reduce the chances that condensation will form at the edge of the window. As of summer 1992, they are just coming onto the market so you may have difficulty finding these products.

**Energy efficient frames**

The frame and sash of a window typically make up 10 to 30 percent of the total window area. The type of material in the frame has an important effect on the heat loss rate of the window. The table in page 15 shows typical U-values for insulated windows. When you compare the performance of windows with the same glazing, but different frames, you can see how important the frame is in determining energy performance. Windows with similar frame and glazing combinations have a large range of U-values, so don’t use this list to compare specific windows. Use tested U-values.

**Metal window frames.** These frames are popular because of their low cost and low maintenance, but they conduct heat faster than other window frames. This not only causes higher rates of heat loss, but it also increases the chances for water to condense on the frames and the glazing.

Water condensing on windows can be more than an annoyance—it can cause window sills to rot, leading to expensive repairs. Solid metal window frames should not be used in new homes or window replacements.

**Thermal break metal windows.** These windows reduce the heat loss through the frames by separating the outside metal frame from the inside metal frame using a plastic insert. This provides enough insulation to greatly reduce heat loss and chances for condensation.

When shopping for thermal break windows, make sure the main window frame, all sashes, and all frame members are thermally broken.

**Wood frames.** These are still the standard by which other windows are measured when it comes to energy performance. Wood windows conduct heat much more slowly than metal. Some wood windows are available with aluminum or vinyl cladding, which eliminates the need to paint the outside of the frame.

**Vinyl frames.** These frames have recently become very popular in the Northwest. Their energy performance is comparable to wood, but they don’t require as much maintenance. Vinyl expands and contracts as temperature changes. Since light colors absorb less heat, choose light colored frames when you’re using vinyl windows.
Fiberglass frames. These frames haven't been marketed extensively in the U.S. yet, although there are plans to do so. They are expected to have comparable energy performance to vinyl and wood frames and should require little maintenance.

Ventilating frames. In the past decade building scientists have recognized the importance of proper ventilation systems in homes. One part of any ventilation system is the fresh air intake(s). Since an open window is too large an intake during the winter, some window manufacturers have added small intake vents in their window frames. The advantage of using vented window frames (usually one vent per bedroom and one for every 300 square feet of other living space) is that you can install the vent at the same time you install the window, saving labor. Remember two things:

1. Place the vented window where it will be least likely to cause cold drafts during the winter.
2. The window vent is only one part of a ventilation system. Don't bother with the window vent if you're not installing the rest of the system. There are three other parts: a building shell built to minimize uncontrolled air leakage; a quiet, properly sized exhaust fan; and a control system to provide the right amount of ventilation at the right time.

Weatherstripping

For a window to open and close, there must be a gap between the window sash and the frame. To reduce air leakage through this gap, manufacturers install weatherstripping. It can be difficult to evaluate how well a manufacturer has weatherstripped its windows, so try to get tested air leakage information for the windows you're considering.

Weatherstripping will wear over time and must need to be replaced. When you compare windows, ask if replacement weatherstripping is available and if you can replace it yourself. Since the weatherstripping on sliding windows wears out faster than on hinged windows, ease of replacement is even more important.

The hardware that closes the windows is also important. Try to find an installed window of the type you're considering so you can see how well it opens and closes. (Many window dealers have sample windows set up in their showrooms.) Does the weatherstripping seal tightly when the window is latched shut?

### Table 2. Typical energy ratings of windows (typical U-values and R-values).

<table>
<thead>
<tr>
<th>Type of frame</th>
<th>Glazing type</th>
<th>Air space between glazing layers</th>
<th>U-value</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal, no thermal break</td>
<td>Single, clear</td>
<td>1/4&quot;</td>
<td>1.21</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Double, clear</td>
<td>1/4&quot;</td>
<td>0.67</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>Double, clear</td>
<td>1/8&quot;</td>
<td>0.56</td>
<td>1.39</td>
</tr>
<tr>
<td></td>
<td>Double-storm</td>
<td>1/4&quot;</td>
<td>0.55</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/4&quot;</td>
<td>0.59</td>
<td>1.69</td>
</tr>
<tr>
<td>Metal, thermal break</td>
<td>Single, clear</td>
<td>1/4&quot;</td>
<td>1.10</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Double, clear</td>
<td>1/4&quot;</td>
<td>0.67</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>Double, clear</td>
<td>1/8&quot;</td>
<td>0.56</td>
<td>1.79</td>
</tr>
<tr>
<td></td>
<td>Double-storm</td>
<td>1/4&quot;</td>
<td>0.49</td>
<td>2.27</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/4&quot;</td>
<td>0.49</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/2&quot;</td>
<td>0.39</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Double, low-e</td>
<td>1/2&quot;</td>
<td>0.44</td>
<td>2.27</td>
</tr>
<tr>
<td>Wood or vinyl</td>
<td>Single, clear</td>
<td>1/4&quot;</td>
<td>0.99</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>Double, clear</td>
<td>1/2&quot;</td>
<td>0.58</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>Double-storm</td>
<td>1/4&quot;</td>
<td>0.49</td>
<td>2.05</td>
</tr>
<tr>
<td></td>
<td>Double-storm</td>
<td>1/2&quot;</td>
<td>0.35</td>
<td>2.86</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/4&quot;</td>
<td>0.32</td>
<td>3.13</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/2&quot;</td>
<td>0.39</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Triple, clear</td>
<td>1/2&quot;</td>
<td>0.31</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td>Double, low-e</td>
<td>1/2&quot;</td>
<td>0.38</td>
<td>2.63</td>
</tr>
</tbody>
</table>

Note: The values in this table represent fairly typical U and R values. Windows of types shown in the table have been tested and the results differ in varying degrees from the values shown in this table. Some windows perform better, others perform worse. OSU Extension Service recommends that you look for tested values from independent testing laboratories that test according to one of the following standards: AAMA 1503.1-1980, ASTM C236 or C976, or NFRC.
Installing Windows in New Homes

Window installation has an important effect on air leakage through and around windows. Windows should be installed so they stay square. If they aren't square, the window frame will be distorted, and when the sash is closed, the weatherstripping may not be able to seal the gaps. An out-of-square installation also may make the window difficult to open and close. It can put stress on the glazing, which can make the edge seals fail.

Square installation

To check whether a window is square, take the measurements of the two diagonals. If the window is square, the diagonal measurements will be the same. Also check to see if the space between the sash and frame (sometimes called the "reveal") is the same all the way around the sash. If it is, then the weatherstripping will seal equally well all around the window, and operation should be smooth.

Sealing

Sealing between the window and the framing of the house is crucial to prevent air from leaking around the window. After all, you don't want to invest in a high-quality window only to have cold air leak in around it (or warm air leak out). You can seal this gap in a number of ways, as follows.

Fiberglass. Stuffing fiberglass insulation into the gap is not enough. Fiberglass by itself allows air to leak through, but if you caulk over the fiberglass you can stop the air movement.

Backer rod. Another good way to seal is to use polyethylene "backer rod" (sometimes called "caulk backer"), which can be stuffed into the gap. This foam material will stop most air leaks (it will be even more effective if it is caulked over).

Polyurethane foam. Expanding polyurethane foam (foam in a can) is often used, especially by people who use it often enough so they are good at it. There are a couple of warnings though. First, as the foam expands, it can cause the window frame to bow, which can jam the window closed. Don't fill the crack all at once—if you don't put enough in the first time, you can add more later. Second,* there are low-expansion foams that are easier to control.

* These are low expansion foams that are easier to control.

Out-of-square windows can cause edge seals to fail.
some polyurethane foams set up hard. If yours is this type (you can tell after doing the sides and bottom of the window), don’t use it to fill the crack at the top of the window.

Rigid foam can transfer building loads onto the top of the window, and windows are not designed to carry any weight. Some foams remain flexible after they cure and should be all right to use in this location, but be careful not to overfill.

Some vinyl windows and most metal windows have a “nailing fin” around the outside of the frame. This fin should be sealed to the rough frame or sheathing of the house using caulk. This will reduce air leakage and the chances of water leakage. However, it’s still important to seal between the frame and the rough opening to stop air leakage even when the fin has been caulked to the sheathing or rough frame.

Most manufacturers have specific installation procedures they recommend (or require for their warranties to be valid). Be sure you have a copy of their procedures and follow them carefully.

Seal the nailing fin to reduce air and water leakage.
Replacing Old Windows

The principles for replacing old windows are the same as those for installing windows in new homes, so read that section first. However, you also have a choice of products specifically designed for the replacement market.

If your window frames are still in good shape, but you need to replace the sashes, you can buy them separately. These sash replacements are readily available for older wood single- and double-hung windows. Replacing only the wood sashes is much easier than replacing the entire frame, since you don’t need to remove the old frame and trim. If you’re replacing the whole window and doing the job yourself, you may find it easier to install windows designed specifically for replacing existing windows. These usually don’t have nailing fins since the fins require either siding removal or modification of the opening to install properly. Be sure to follow the manufacturer’s instructions carefully. You’ll need these instructions before you order the windows so you can take the correct measurements for your new windows.

Storm windows
If you have single-pane windows that are in good shape, it may not make economic sense to replace them with high performance windows if energy savings is your only objective. Installing storm windows is usually more cost effective since they cost less and require much less labor.

If you’re replacing the whole window and doing the job yourself, you may find it easier to install windows designed specifically for replacing existing windows.

Exterior storm windows. These are the most widely used. The most popular are aluminum-framed double or triple-track systems. The tracks allow you to slide the windows open so you don’t need to remove the storm windows to get you want ventilation. When you’re considering this type of window, ask the contractor if you can see a 1- or 2-year-old installation so you can find out how well the windows operate after they’ve been in service for a while.

If your existing windows have aluminum frames, make sure that the storm window is installed so that there is no contact between the storm and main window frames. This direct contact greatly increases heat loss through the frame and the likelihood of moisture condensation.

Interior storm windows. These windows are installed inside your existing windows. The advantages are ease of access and lack of change in the exterior appearance of the house. The disadvantages are loss of sill space and a slight change in appearance of the inside of the house. Energy performance should be equal to exterior storms given equal care in installation. Interior storms can be installed as sliding windows to allow easy opening for ventilation. Some are installed as easily removed panels which are stored during the season when you want to open windows.

You can create do-it-yourself storm windows from various types of clear plastic held in place with tape or homemade frames. Kits are available at most hardware or home improvement stores or you can buy the glazing and frame materials separately. See “For Further Reading” on page 19 for an Extension publication on building storm windows.
For Further Reading

Books listed below are available through the OSU Bookstore or at libraries.


Oregon State University Extension publications
In July 1992 the OSU Extension Service publications warehouse was destroyed by fire. We are replacing our supplies. The publications listed may be available in the office of the OSU Extension Service that serves your county. Check with that office for current prices.

You also may call Agricultural Communications at Oregon State University, (503) 737-2513, to learn the availability and current price of the publications.

—EC 1240, How to Build Storm Windows, no charge
—EC 1405, Energy Efficient Windows, $1.50

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