Replacement Windows
Replacement windows are designed to provide a relatively quick solution to the problem of window heat loss. Replacement can reduce heat loss if the installation is done carefully. Tightfitting, double- or triple-pane windows can increase comfort and reduce energy costs for homeowners with single-pane steel or aluminum windows or very badly deteriorated wood windows. Because of the cost involved in replacing windows, the homeowner should consider whether repairing, weatherstripping, caulking, or adding a storm window to existing windows could provide the same reduction in heat loss.

REPLACEMENT WINDOW SYSTEMS

There are two ways to install replacement windows. The type of replacement window selected will depend, to some extent, on the existing windows. Windows duplicating the muntin arrangement of the existing windows help maintain the architectural integrity of the house. Most replacement systems, especially if they have insulated glass, use snap-in muntins that are removable for cleaning; however, wood windows with fixed muntins and insulated glass can be obtained.

Sash Replacement

With this replacement system, the existing window sash and all the window stops are removed. The old window frame and all exterior and interior trim are left in place. Then a new jamb (or jamb liner) and sash slip into the old frame.

Many window companies measure the old opening and make the replacement unit to fit the opening. Other companies use stock window units and make up the difference between the opening and the replacement window with filler strips. Windows made to fit the opening look better and are more effective in reducing heat loss.

Sash replacement is the least disruptive window replacement system. Replacing the sash can be done quickly. Because none of the window trim is removed, there is no need to repaint woodwork or adjacent walls. Sash replacement can be used where wood windows are very badly deteriorated.

Old steel or aluminum windows transmit cold through the frame. If only the sash is replaced, the window still feels cold. Moisture continues to condense on the frame.

Old wood windows often used sash cords, pulleys, and weights to counterbalance double-hung windows and hold them in place when the windows were raised. The large, hollow weight boxes on either side of the window can be insulated before the replacement windows are installed.

Windows with steel or aluminum frames must use a different replacement system. Simply replacing the sash will not solve the problem of heat loss. The window will still lose heat because the metal frame is a very effective conductor. Old metal windows had no thermal breaks, non-conducting materials used to stop the flow of heat through the metal. With old aluminum or steel windows, the metal frame must be entirely removed, and an entirely new window unit must be installed in the rough opening. If the metal frame is not removed, the goal of conserving energy is being defeated.

Window sizes vary from manufacturer to manufacturer. These dimensions show where measurements are taken.
With the sash and stops removed, this window is ready for new sash and window channel. Notice all the trim is left in place.

New sash with double pane glass and new window channel slide into the existing frame.

Window Removal

A second window replacement system removes the whole window unit. All jambs, sills and sash are taken out. This allows the new window unit (again these can be custom-sized) to retain the original glass size. It also allows the installer to insulate around the window frame before replacing window trim. This method is messier; and, it takes longer. Plaster or drywall around the opening may need to be repaired or replaced. Some window trim may split during removal. Repainting the wall adjacent to the opening may be necessary. However, if the goal is an energy efficient opening, this is the more effective method.

If the new window is to be larger than the existing opening, a contractor or carpenter would be needed to reframe the rough opening.

When replacing the entire window unit, the new window can be custom-sized to fit the rough opening, or stock window units can be used. When a stock window unit is used, the opening must often be made slightly smaller by additional blocking or furring strips.

The replacement unit will have different trim, requiring some patching. Cavities next to the window can be insulated.

Materials

A major factor in the homeowners' desire to replace existing windows may be the need to reduce maintenance. Replacement windows are often viewed as maintenance free. In fact, there are a number of materials and window systems that did not even exist a few years ago.

Wave-Length Selective Glass. In addition to using double or triple glazing, thermal performance of windows can be improved by the use of reflective coatings or films. Embedded between panes of glass, the coating or film can enhance or diminish the amount of sunlight streaming through the windows. The most commonly used films reduce incoming sunlight by reflecting the rays back toward their source. This reduces the need for summer cooling.
Wood windows can use vinyl or aluminum cladding to reduce exterior maintenance.

Wood Windows. Wood windows are used where the owner wants the look of wood on the inside of the house. Inside, the windows can be varnished, stained, or painted. Outside, the wood can be clad in aluminum or coated with vinyl, thus eliminating the need for exterior repainting. All existing exterior trim can be covered with aluminum. Trim covers can be custom-made to match the profile of exterior molding on historic buildings.

For painted exteriors, windows can be factory-primed. Because they can be painted, wood windows are a popular choice for homeowners who want their windows to match the exterior trim of the house.

Double-hung wood window units no longer use window cords and weights. Spring-loaded window channel both weatherstrips and holds sash in place. Some windows use spring-loaded sash balances so sash can be tipped into the room for cleaning. When windows are large, however, the modern sash balance may not be strong enough to support the increased weight of a double- or triple-pane window.

Additional features in some wood windows include: Vinyl gaskets that hold the glass; sun-screen glass; and double weatherstripping around the operable sash. Weatherstripping may compress to reduce air leakage to near zero. Condensation is less likely to form on wood windows than on aluminum windows, unless the aluminum windows are provided with a good thermal break.

Aluminum Windows. For a time, low-cost aluminum windows were a means of reducing initial construction cost and long-term maintenance. As energy costs increased, single-pane aluminum windows, with deteriorated weatherstripping and loose frames, became prime candidates for replacement.

Good quality aluminum windows, with thermal breaks to prevent heat loss by conduction, offer a 26 to 38 percent improvement over single-pane aluminum windows. Thermally improved windows separate the inside and outside of the frame with a material that does not conduct heat, such as wood, polyvinyl chloride (PVC), or rigid foam insert.
foam. The non-conducting material retards the flow of heat and brings window performance in line with that of a good quality wood window.

In climates where extremes of hot and cold are common, aluminum window frames will experience seasonal expansion and contraction. Aluminum windows with a wood thermal barrier or a rigid PVC, non-structural thermal barrier perform best under these conditions. In the latter system, the rigid polyvinyl chloride (PVC) connects an inner and outer aluminum frame. This type of thermal barrier allows the inner and outer frames to expand and contract independently. This prevents weakening of the frame and sash.

Even with a good thermal barrier, aluminum-framed windows generally have higher conductivity than wood or vinyl windows. Before purchasing an aluminum window in a cold climate, the buyer should check the CRF (Condensation Resistance Factor) rating to make sure moisture will not condense on the frame in winter. (See Circular F11.1, Selecting Windows.)

Aluminum windows can be made with factory-applied, colored finishes of baked acrylic or enamel. The colors are applied to the surface of the windows and are expected to last ten to twenty years.

Thermally improved aluminum windows that use a bridging device to join inner and outer frames have greater structural stability in extreme climates. An insulating material prevents metal-to-metal contact.

Some replacement windows tip into the room for easy cleaning.

Aluminum windows can also have the plain mill finish or an anodized finish. The mill finish is the color of aluminum. In an anodized finish, a thin, adherent layer of oxide is bonded to the aluminum and provides a permanent color to the aluminum. Many shades of bronze, brown, gold, and black are available. The anodized finish is a more permanent finish than the acrylic or enamel finish.

Most storm windows are made of aluminum. If the main, or prime, windows can be thoroughly weatherstripped, the addition of outside storm windows may be the most economical way to improve the energy performance of the windows.

The use of triple-track aluminum storm windows, with self-storing screens, eliminates the yearly task of exchanging wooden storms and screens, but triple-track windows vary in tightness. When triple-track windows are loose, they will not be as effective in stopping infiltration of cold, outside air.
Vinyl Windows. Many windows made for the replacement market have plastic frames and sash. This plastic is a polyvinyl chloride (PVC), extruded into hollow sections that can be easily cut and fabricated into window units. Metal reinforcement is sometimes added in the hollow sections for strength. PVC is a good insulating material. Also, it is virtually maintenance free. It cannot rot or rust, and it never needs repainting. Vinyl windows come in two colors, white and brown.

Vinyl replacement windows often have frames reinforced with metal. By itself, vinyl is a poor conductor of heat.

Spiral springs are used to balance the window sash. Sash usually tip out for easy cleaning; however, if the sash is disengaged from the spring, it can be very difficult to reattach. Cam action sash locks and lifts pull the sash tight against the meeting rail to provide a good weather seal. Burglar prevention hardware on the window should not give the consumer a false sense of security — a determined thief could still break the window glass.

Vinyl windows vary in quality. The less expensive models use thinner plastic extrusions (1.5mm compared to 2.3mm in better windows.) Also, some of the detailing (corners held by screws or inserted corner pieces, careless weatherstripping, and sagging screens) makes the windows less attractive than they might be. Vinyl windows with welded, mitred corners and thicker extrusions make more durable units.

Vinyl windows using European design concepts have a heavier profile and operate differently than double-hung or casement windows. These windows are tilt-turn windows. If the window handle is turned in one direction, the window will tilt out at the top to provide ventilation. Closing the window and turning the handle in the opposite direction allows the window to swing into the room, like a casement window, for easy washing. Heavy duty hardware pulls the window tight in several places, almost eliminating infiltration. Because these windows open into the room, they may not be compatible with traverse rod drapery.
Tilt-turn windows often use roll-down shutters on the outside to provide privacy. The shutters reduce heat loss on winter nights and daytime heat gain in the summer. The shutters can be partially opened during the day for ventilation, or they can be closed to provide total security. A slight curvature to the shutter slats allows them to roll into a box built into the top of the window.

Climates where there are extremes of heat or cold might not be suitable locations for some vinyl windows. In very hot climates, vinyl expands much more than wood. Some vinyl windows are anchored in the middle of the frame and allowed to move at the corners. This permits seasonal expansion and contraction. Where the weather is extremely cold, vinyl window channel can become brittle, lose elasticity, and split. New forms of vinyl that resist thermal movement are being developed. However, for now, wood or aluminum windows would be the best choice in extreme climates.

**THERMAL PERFORMANCE**

The term *R-value* is often used to describe insulation, but it can also be applied to the thermal performance of a window. The R-value is a measure of resistance to heat flow. The larger the R-value, the better the insulating properties of the material. The R-value of a single-pane window is close to 1.0. For convenience, a value of R-1 is used as a basis of comparison with other constructions. Table 1 shows approximate R-values for the common window constructions.

To improve window performance, the homeowner can install an inside or outside storm window or a replacement window. If the home has existing wood windows, Table 1 shows that the addition of a storm window can equal, or be greater than, the R-value for a double-pane window. This is because the trapped air between the panes of glass is responsible for the improved R-value. The distance between the storm and prime window is greater than the distance between the two panes in a double-pane window. A storm window also slightly reduces infiltration.

**TABLE 1**

<table>
<thead>
<tr>
<th>Glazing</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glazing</td>
<td>0.89-1.01</td>
</tr>
<tr>
<td>Double glazing sealed</td>
<td>1.47-1.79</td>
</tr>
<tr>
<td>glass unit</td>
<td>1.79-2.22</td>
</tr>
<tr>
<td>prime + storm</td>
<td></td>
</tr>
<tr>
<td>Triple glazing sealed</td>
<td>1.70-2.70</td>
</tr>
<tr>
<td>triple unit</td>
<td></td>
</tr>
<tr>
<td>prime (sealed double) + storm</td>
<td>2.33-2.78</td>
</tr>
</tbody>
</table>

*Wind blowing against the house causes *infiltration* through cracks around windows. On the opposite side of the house, in the wind shadow, the arrows are reversed, as heated air *exfiltrates*.*

**Estimating Energy Savings**

The use of double-pane windows will reduce heat loss through the glass by about one-half. How does this affect the total energy bill? Usually the heat lost through the windows is only a portion of the total heat loss, which also includes heat losses through walls, ceilings, foundations, and by infiltration. Therefore, even if the heat loss from every window were halved by changing from single-glazing to double-glazing, the total heat loss of the building would not be cut in half.

**Infiltration Heat Loss**

*Infiltration* of cold outside air and *exfiltration* of heated indoor air account for a substantial percentage of window heat loss. Infiltration occurs from cracks between the window frame and the wall, from weight-box cavities, and from cracks between the window sash and the window frame.

Caulking can reduce the amount of heat lost by infiltration. For example, exterior caulking of a wood window in a masonry wall reduces the heat loss by 75%, if the window is tight in other respects. Simple caulking, however, does not take the place of insulating the large, hidden openings behind the window trim, such as the cavities provided for double-hung window weights. Sash
Replacement substitutes tighter-fitting windows for loose, rattling windows. While this reduces infiltration at the top, middle, and bottom of the window, replacement does not eliminate heat loss around the window unit. Ideally, heat loss through the weight boxes or between the window unit and the rough framing should also be eliminated.

Insulation can be installed when windows are replaced. Weight box cavities can be insulated by blowing in fill insulations, such as rock wool, cellulose, or granular fill. In cases where the opening between the rough framing and the window jamb is too narrow to accept blown insulation, infiltration can be reduced by caulking. The only way to insulate this space is to remove the interior trim and install a fiberglass or expanding foam insulation.

To reduce potential problems with condensation, the insulation should be covered with a vapor retarder, such as a strip of polyethylene stapled or caulked to the window frame and overlapping the rough opening. The use of a vapor retarder is important in cold climates. In cold weather, warm, humid house air can migrate into the cavity and condense on the back side of exterior trim. This condensation can damage the insulation and trim. The vapor retarder is used to keep moisture-carrying indoor air away from areas where condensation can occur.

For those interested in estimating the reduction in energy consumption by changing windows to double- or triple-glazing, the pre-calculated tables in Circular A1.61, "Savings by Insulating Doors and Windows" should be consulted. Actual dollar savings are difficult to predict. The relative cost of fuel varies widely. With more expensive fuels, efforts to conserve heat will have a more rapid payback.

The use of replacement windows as an energy-saving strategy must be weighed against the benefits of improving insulation, improving the efficiency of the furnace, adding storm windows, or caulking and weatherstripping. Generally, the less expensive strategies (such as caulking, weatherstripping, or adding storm windows) will have the most rapid payback. This is because heat is not just lost through the glass area of a window. To really improve the energy efficiency of a window, extra steps must be taken to reduce window infiltration.