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Sizing Up Skylights

by Jeffrey L. Warner

Sunlight from above can enliven a house dramatically. Designers, builders, and homeowners who understand the energy aspects of skylights can best select them for comfort as well as appearance.

Skylights, like windows, are distinctive features of homes that greatly influence their aesthetics. Consequently, consumers may neglect some important energy considerations when selecting skylights. But the energy concerns that apply to vertical windows—heat losses and gains, solar gains, and infiltration and ventilation—apply even more strongly to skylights. The "U-factor" and the "shading coefficient" or "solar heat gain coefficient," should be on every skylight shopper's checklist. (For some basics on windows and energy, see "Consumer Guide to Energy Saving Windows," *HE*, Jul/Aug '90, p.17.) Unfortunately, rating skylights for their energy efficiency can be a complicated matter, making them even more difficult to select than windows.

Heat Loss Problems

Skylight glazings can be made of glass or a variety of plastics. While glass is more durable, it is limited to a planar shape. Plastic glazings, on the other hand, can be molded into a wide variety of shapes (see Figure 1). While dome- and ridge-shaped skylights are aesthetically pleasing, they have significant drawbacks in terms of energy. Because of the way they are molded and sealed, they cannot incorporate the energy efficiency options—*low-E* or *spectrally selective coatings* and gas fills—often used in skylights with flat glazings to lower their *U-factors* and boost their energy performances (see "Skylight Energy Glossary"). Shaped skylights also have larger surface areas, resulting in greater heat losses for a given opening size.

Installed skylights typically have higher effective U-factors (lower *R-values*) than windows of the same materials,

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Skylight Energy Glossary

Conduction. The flow of heat through a solid material, such as glass or wood, from particle to particle in the material.

Convection. The flow of heat through a circulating gas or liquid, such as air in a room or between skylight panes.

Infiltration. The inadvertent flow of air through breaks in the exterior surfaces of buildings. It can occur through spaces between skylight frames and glazing.

Low-emittance (low-E) coating. A microscopically thin, virtually invisible, metal or metallic oxide layer deposited on a skylight glazing surface to reduce the skylight U-factor or shading coefficient by suppressing radiative heat flow through the skylight.

Radiation. The transfer of heat in the form of waves from one separate body to another. Energy from the sun reaches the earth by radiation, and a person's body can lose heat to a cold skylight surface in a similar way.

R-value. A measure of the resistance of a material or assembly to heat flow. It is the inverse of the U-factor (R=1/U) and is expressed in units of hr-ft²-°F/Btu. The higher a skylight's R-value, the greater is its resistance to heat flow, and the greater is its insulating value.

Shading coefficient. A measure of the ability of a skylight to transmit solar heat, relative to that ability for ⅛ in. clear, double-strength, single glass. It is expressed as a number without units between 0 and 1. The lower a skylight's shading coefficient, the less solar heat it transmits, and the greater is its shading ability.

Solar heat gain coefficient. The portion of solar radiation admitted through a skylight, both directly transmitted and absorbed and subsequently released inward. The *solar heat gain coefficient* will probably replace the *shading coefficient* as the standard indicator of a skylight's shading ability in the near future.

Spectrally selective coating. A low-E coating that blocks out much of the sun's heat while transmitting substantial daylight.

U-factor (U-value). A measure of the rate of heat flow through a material or assembly. It is expressed in units of Btu/hr-ft²-°F. Skylight manufacturers and engineers commonly use the U-factor to describe the rate of non-solar heat loss or gain through a skylight. The higher a skylight's U-factor, the lower is its resistance to heat flow, and the lower is its insulating value.

Visible transmittance. The portion of visible light transmitted by a skylight.

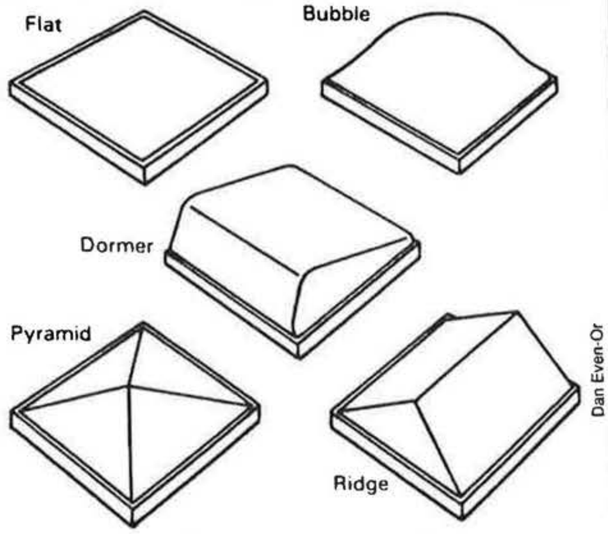
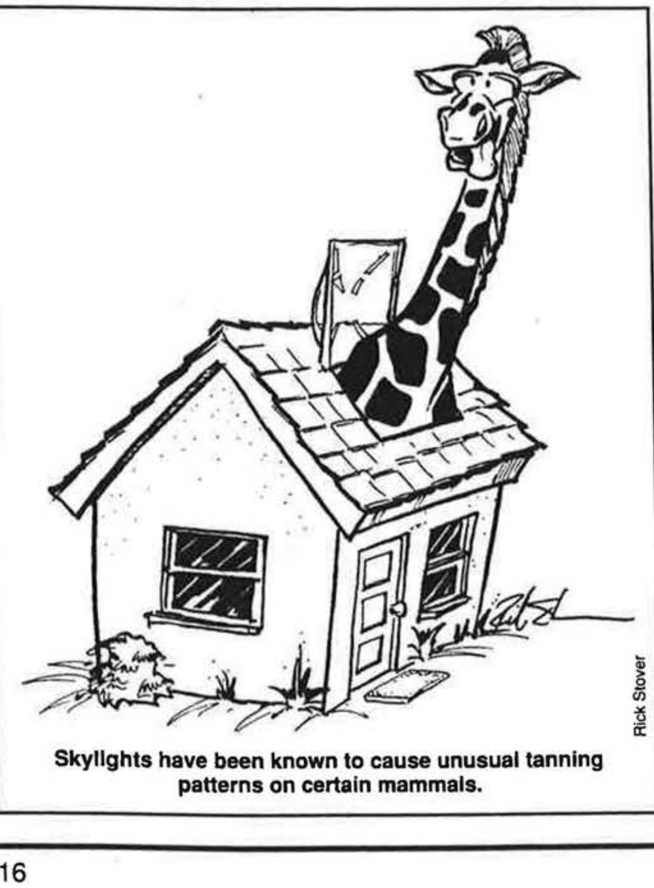


Figure 1. A sampling of available skylight shapes.

construction, and size, resulting in 35%–45% greater heat losses during cold weather. This occurs for several reasons.

Convection

Skylights tend to lose more heat by *convection* than do vertical windows for two reasons. First, in skylights incorporating more than one glazing, warm air between the panes rises upward, the same direction as the primary heat flow through the skylight. The warm air adjacent to the colder upper glazing is cooled and falls, to be replaced repeatedly by more warm air from below. Spaces of more than about ¼ in. between panes permit greater air circulation and tend to increase this problem.



Skylights have been known to cause unusual tanning patterns on certain mammals.

Similarly, the warm air in a house rises toward the ceiling, where it comes in contact with the cold surface of the skylight. The air is cooled and falls, forming a large draft loop in the house and decreasing comfort. The more nearly horizontal a skylight is, the more significant these effects are. Convective losses through vertical windows are less pronounced because the primary heat flow direction through them is horizontal and because they are not generally placed near the ceiling.

Radiation

While windows are often sheltered by exterior shutters, overhangs, or shrubs, skylights are exposed to the cold night sky. They can lose substantial heat by *radiation* to the sky, decreasing their energy performances. Heat losses through skylights can be remedied by selecting skylights with low-E coatings and gas fills, and by further insulating skylights using manually or automatically movable insulating devices.

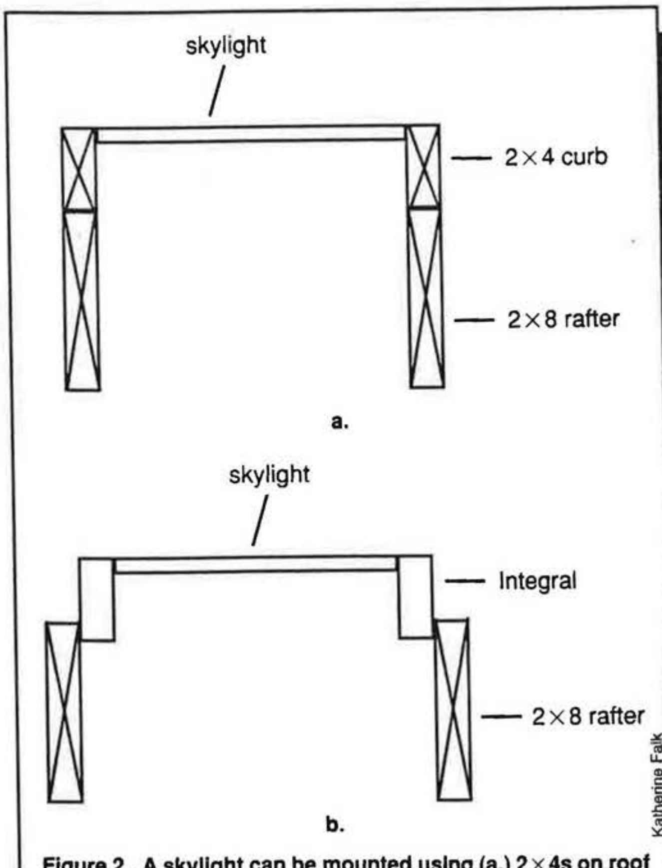


Figure 2. A skylight can be mounted using (a.) 2×4s on roof rafters or (b.) an integral curb between rafters.

The "Curb"

A window installer must add a twist when mounting a skylight. The skylight must have a curb, or supporting frame, that fits on top of or between roof rafters. A skylight without an integral curb, is supported by 2×4s, 2×6s, or special insulating curb material set on top of the rafters (see Figure 2a). If the skylight has an integral curb, it is typically mounted between rafters (see Figure 2b). In either case, the curb increases the total surface area and the potential for heat loss through the skylight. To counter this, the curb should be insulated, fit snugly, and be caulked at the joints.

Handling the Sun

Skylights are typically much more exposed to the high summer sun than are vertical windows. This results in greater solar heat transmission through a comparable glazing area at inopportune times. Selecting smaller skylights with low *shading coefficients*, or low *solar heat gain coefficients*, helps to alleviate this problem.

On the other hand, skylights do not need to be large to admit substantial daylight, enhancing the appearance and comfort of a home. A properly selected and well-positioned skylight can illuminate a room with a floor area twenty times the skylight's area. If the skylight is located in a roof with an attic rather than a vaulted ceiling, the walls of the skylight well should be splayed to admit more sunlight and distribute it more evenly in the room (see Figure 3).

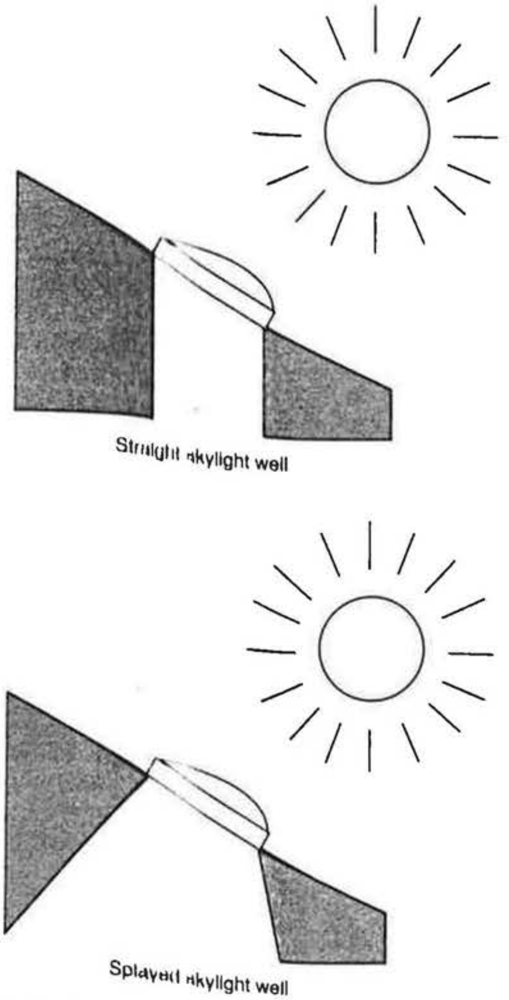
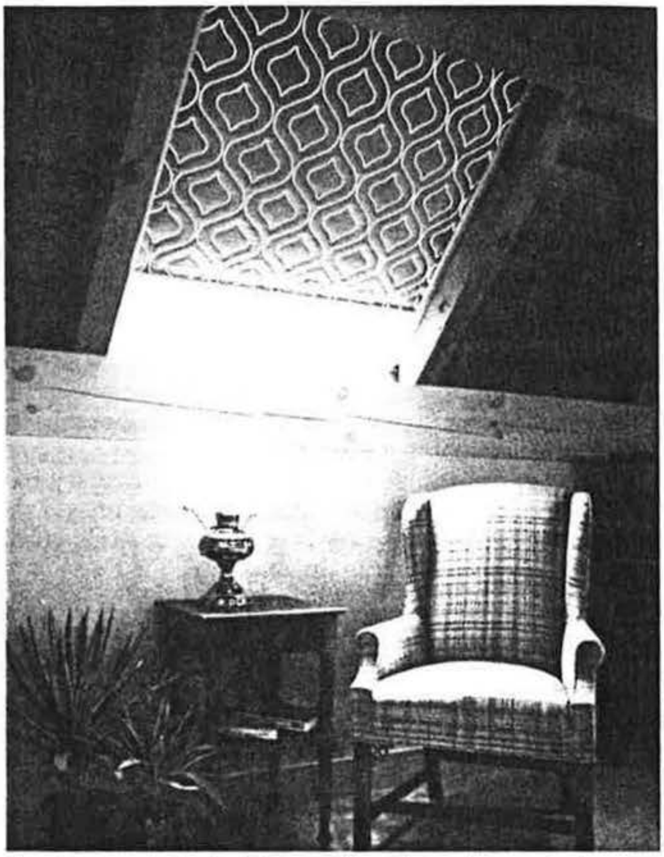


Figure 3. A splayed skylight well provides better illumination.

WINDOWS



Courtesy of Window Quilt

The Window Quilt skylight covering shown here cuts down on energy losses at night.

Free Ventilation

Skylights are especially susceptible to *infiltration* through spaces between their frames and glazings because of the way they are mounted, as noted above. High quality, tightly constructed skylights should be selected, carefully installed, and caulked at the joints between components.

As previously explained, cold skylight surfaces can cool the warm air that rises to them, making occupants uncomfortable. If a skylight can be opened, this drawback can be turned into an advantage during warm periods. Warm air rising toward the ceiling can escape, resulting in natural cooling and ventilation at no cost.

Next—Skylight Ratings

The characteristics of skylights discussed here make it difficult to rate them for energy efficiency. Standard window test equipment can be used to determine U-factors for flat skylights in a vertical position. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has adjusted these values for skylights mounted 20° from the horizontal (see Table 1). The U-factors of sloped skylights are much higher, and the energy performances much lower, than those of vertical windows that are otherwise similar. However, more glazing panes,

Comparison of Skylight and Window U-Factors

	U-Factor[1] Skylight (at 20° slope)	U-Factor[1] Window (vertical)
Single glazing, aluminum frame, metal spacer	1.9	1.1
Single glazing, wood frame, metal spacer	1.5	0.9
Double glazing, ½ in. air space, aluminum frame, insulated spacer	1.1	0.6
Double glazing, ½ in. air space, wood frame, insulated spacer	0.8	0.5
Double glazing, E = 0.2, ½ in. argon space, wood frame, insulated spacer[2]	0.7	0.4
Triple glazing, E = 0.1 on two panes, ½ in. argon spaces, wood frame, insulated spacer[2]	0.4	0.2

1. U-factor is expressed in units of Btu/hr-ft^2-°F.
2. "E" is the emittance of the low-E coated surface.

Source: *1993 ASHRAE Handbook: Fundamentals*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

low-E coatings, gas fills, and better insulating frames and spacers clearly improve skylight energy performance.

It is very difficult to determine U-factors for skylights with molded glazings. They do not fit into the plane of standard window test equipment, which is suited to flat glazings. Nor can their U-factors be easily calculated using computer programs since heat is conducted through them in many directions, and since air flow and convection are complex at their unusually shaped surfaces. Energy performance is also hard to predict for various types of curbs or supporting frames, which substantially influence the overall U-factors of skylights, but the details of which may not be known until installation.

The National Fenestration Rating Council (NFRC), a broad-based non-profit group formed to develop a national energy rating system for windows and skylights, recently proposed procedures for determining U-factors for windows. But similar procedures for skylights, which are more complex, are not yet available. (The NFRC's ultimate goal is to establish testing and rating procedures for insulating value, shading ability, and airtightness for all types of windows and skylights.)

Skylight Savvy

Properly selected and installed skylights can add to the beauty, comfort, and value of a home. Here's what to look for:

- Skylights with low U-factors to minimize heat losses—and, for additional protection, movable insulating devices.
- Small skylights with low shading coefficients or low solar heat gain coefficients to moderate the sun's heat.
- Well-constructed skylights that are sealed properly in the roof opening to reduce infiltration. ■