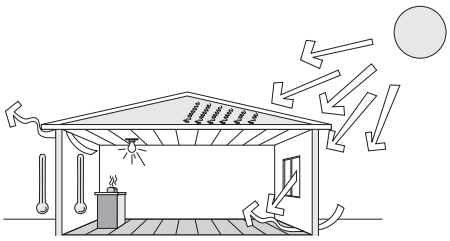
Percent of Total Heat Gain for Components



Component	Low	High
Solar Gains – Windows	15%	35%
Solar Gains – Roof	10%	30%
Solar Gains – Walls	3%	8%
Internal Gains – Heat	10%	25%
Internal Gains – Humidity	5%	15%
Air Leakage – Heat	10%	20%
Air Leakage – Humidity	5%	25%

Every home and homesite has a different distribution of heat gains. For example, homes with little shade have high solar gains while shaded homes have lower solar gains. Homes in humid climates have large humidity heat gains while those in dry climates don't. Homes with awnings have low window solar gain.

Reflectivity

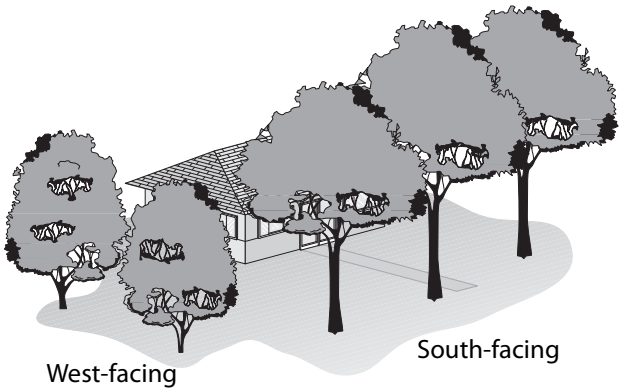
Solar energy falling on the roof and coming through the windows accounts for most of the solar heat accumulating indoors. Walls are less important as a source of solar heat.

Just as insulation levels (R-values) are the most important characteristic for low-energy heating, a well-shaded or reflective home enables low-energy cooling.

The most important places to use shading and reflectivity are on the roof and windows. Energy conservation measures that block the sun before it strikes the roof or windows are the most effective. Trees and other plants that provide shade are the best long-term investment for reducing cooling costs.

See "Temperature and Heat" on page 30 , "Sensible and Latent Heat" on page 30, and "Radiation" on page 35 for principles involved in heat gain.

Energy-Saving Landscaping



Landscaping is the best long-term cooling investment for residences. Southern exposures need taller trees to block the higher angle of the sun from the south. East and west vegetation should block the lower-angle sun from entering windows during the summer.

Cooling with Landscaping

A well-planned landscaping program can reduce an unshaded home's summer air-conditioning costs by 15% to 50%.

You may have noticed the coolness of parks and forests when compared to nearby city streets. This is because trees and shrubs create a cool microclimate, reducing the shaded area's temperature and absorbed solar heat.

A tree can produce daily cooling effects similar to five average-sized air conditioners running 20 hours per day. Shading and *evapotranspiration* (the process by which a plant releases water vapor) from trees can reduce air temperatures as much as 9°F compared to unshaded areas. Since cool air falls toward the ground, temperatures directly under trees can be up to 25°F cooler than air temperatures above nearby blacktop.

Studies by the Lawrence Berkeley Laboratory found summer daytime air temperatures 3°F to 6°F lower in neighborhoods with mature tree canopies compared to newly developed areas with no trees. Large urban parks are up to 7°F cooler than surrounding neighborhoods. A 25% increase in tree cover will decrease a city's average mid-after-

noon July temperature by 6°F to 10°F according to U.S. Department of Energy simulations for Sacramento, California.

Planting trees is ten times more cost-effective than building new power plants for summer cooling. Lawrence Berkeley Laboratory (LBL) estimates that increasing peak-load electrical supplies costs an average of $1.00 per kW-hour, while planting trees decreases peak-load consumption and is estimated to cost ratepayers only $0.10 per kW-hour.

Homeowners can reap big dividends from their landscaping. Studies by real estate agents and professional foresters estimate that the presence of trees raises a home's resale value 7% to 20%.

Shading Windows

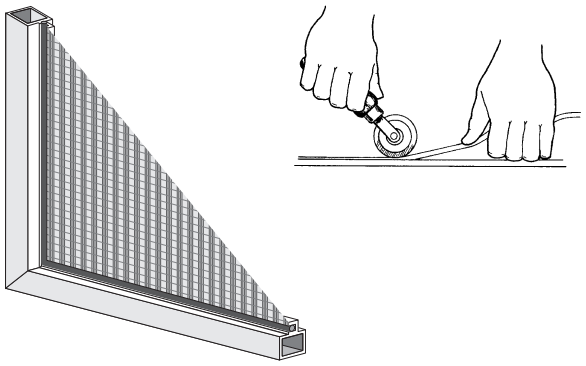
Single-pane, unshaded windows transmit about 85% of the solar heat striking them. This can account for up to 40% of a home's accumulated heat.

Consider these factors when deciding which windows to shade:

- Direction the windows face. South windows transmit the most solar heat. West windows contribute solar heat in the afternoon, just when you want it least. East windows begin heating the home early in the morning, causing more hours of discomfort.
- Location of natural shade from trees, overhangs, and other objects. If windows are already shaded by trees, nearby buildings, or large overhangs, additional shading is unnecessary.
- Total surface area of your windows. Shading devices for larger windows are generally more cost-effective than for smaller windows.

After considering these factors, utilize the following options to block 60% to 90% of the solar heat that currently enters your windows.

Sun Screens



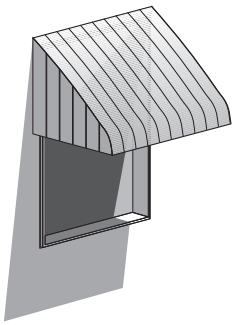
Sun screens are a very economical exterior window-shading device. Sun screen fabric is attached to an aluminum frame using a spline and roller.

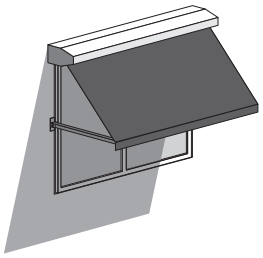
Sun screens — Sun screens are often the least expensive window-shading option to retain a view through the window. A sun screen is fabric stretched over an aluminum frame and resembles an insect screen. The fabric absorbs 65% to 70% of the solar heat before it enters the home.

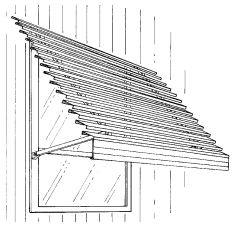
Sun screens must be installed on the exterior of a window to be effective. Therefore, they are not practical for outwardly opening windows, such as awning or casement windows, unless attached to the movable sash.

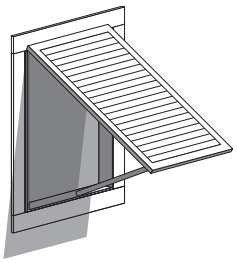
Reflective films — Metallized plastic window films (similar to those applied to automotive windows) can block 50% to 75% of the solar heat on single-pane glass. A microscopic layer of metal on the film repels solar radiation. Installed on the interior side of single-pane glass, reflective window films repel solar heat, cut glare, and reduce fading. To be most effective, the film must look like a mirror when viewed from outdoors during the daytime. Tinted films that merely color the glass are not as effective in blocking the sun as metallized films.

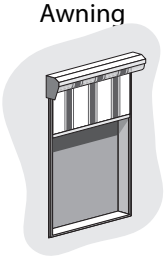
Exterior Window Shading Devices

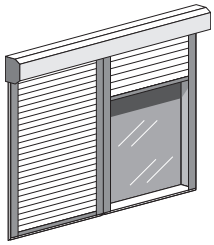

Custom Aluminum Awning

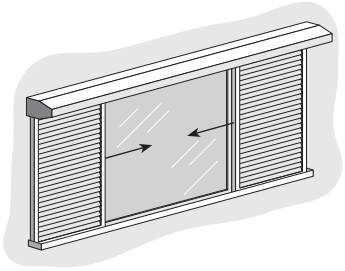

Retractable Awning

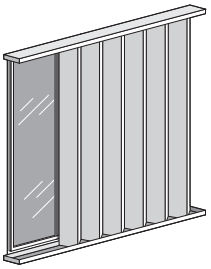

Slatted Awning


Bahama Shutter


Exterior Rolling Shade


Exterior Rolling Shutter


Sliding Shutters


Accordion Shutters

Consumer acceptance of reflective window films has been slow because they block daylight in addition to solar heat. Newer films, recently introduced to the marketplace, transmit more light, while blocking most of the heat.

Installing reflective window film is a moderately difficult do-it-yourself project. These films—manufactured with removable protective layers—require careful installation to an absolutely dirt-free glass surface. Unlike sun screens and awnings, reflective window films do not obstruct the operation of any kind of window.

Awnings — Awnings are popular in hot, sunny climates, since they intercept solar heat before it gets to the window. In general, however, awnings are not as good an investment as trees, sun screens, and window films because they are more expensive.

The most important considerations in selecting and designing awnings are:

- Amount of shade desired. The shade an awning produces is closely related to how far the awning drops down over the window. This distance is known as the "drop" of the awning.
- Importance of maintaining a view out the window. Depending on their drop, awnings can cut off a significant portion of a window's view.
- Cost of the awning. Custom-made aluminum or canvas awnings are more expensive than do-it-yourself awning kits or mass-produced awnings.

Awnings on a home's south side need a drop measuring 45% to 60% of the window height to block solar radiation from high in the sky. Awnings on the east and west need to drop 60% to 75% to block solar radiation emanating from lower in the sky in the morning and afternoon, respectively.

Interior window treatments — Interior window treatments with reflective surfaces—metallized or bright white—can block solar heat effectively. An opaque roller shade, with a white surface facing the exterior, rejects about 80% of the solar heat entering the window. Roller shades block most of the light and all the view. White

venetian blinds and white slim shades (a smaller-scale venetian blind) reject 40% to 60%. Venetian blinds and slim shades block most of the light and view.

If you want to retain some light or view, install roller shades made with metallized plastic window film. Like reflective films applied directly to glass, metallized plastic roller shades can preserve the view and transmit some light, while blocking most of the heat.

Exterior shutters and shades — Exterior shutters are not as popular as the window treatments described previously and are generally more expensive. But they can provide security and storm protection in addition to solar control.

Bahama shutters hinge at the top of the window. Sliding shutters slide horizontally to cover the window during the heat of the day. The traditional vertically hinged shutters—popular all over Europe—can also be used to block solar heat. Inexpensive exterior bamboo rolling shades are also popular in some warmer regions.

These movable exterior shading methods require a greater daily commitment by the owner than other window-shading devices. Exterior rolling shutters and shades, controlled indoors by motors or manually, are very expensive, but offer very good security and convenience.

Replacement windows — Replacement windows are not a cost-effective measure for reducing cooling costs. But if the windows are being replaced for other reasons, the added cost of low-e insulated glass is well worth the price in almost all U.S. climates. Multifamily buildings in southern climates should have reflective glass and/or architectural shading features, like overhangs and built-in solar screens.

The most important window glass characteristics for cooling are:

- *Solar Heat Gain Coefficient (SHGC)* is the ratio of solar heat passing through the glass to solar heat falling on the glass at a 90° angle. SHGC includes radiant heat transmitted, and also the solar heat absorbed and reradiated indoors. Single pane glass has a SHGC of 0.87.
- *Visible transmittance* measures how much visible light is admitted by the window glass. Visible transmittance is important because the window's main job is to give view and admit light. Special coatings—some of which cut visible light to 30%—may be unacceptable in some applications, such as when windows are small and few in number.
- *Shading coefficient* is a decimal number, like 0.55, that compares the transmittance of a window glass with clear glass. Clear glass has a shading coefficient of 1.00. A reflective glass window with a 0.55 shading coefficient would transmit 55% of the solar energy of clear glass.

See "Windows and Doors" on page 125 for a complete discussion of windows.

Conservation Measures for Roofs

Homes with reflective roof coatings, at least R-19 insulation, and good attic ventilation, may experience two-thirds less solar heat gain than those homes with darker roofs, little insulation, and poor ventilation. Homes with shaded, reflective, insulated, and ventilated roofs will absorb minimum solar energy.

The most effective measures for blocking solar heat through roofs are shading the roof with trees and giving the roof a reflective coating. Either trees or a reflective surface can block most of the solar heat streaming toward the roof and reduce cooling costs 10% to 40%, depending on climate and R-value of attic insulation.

Compared to poorly ventilated roofs, good roof ventilation helps to keep attic temperatures lower. But expect less savings from improving attic ventilation compared to radiant barriers and other sun-blocking measures, because attic heat gain is dominated by heat radiation.