# ENERGY Answers for Business

# WINDOWS AND WINDOW TREATMENTS

Windows have an important effect on your building's interior lighting, interior and exterior aesthetics, energy efficiency and comfort. Cooling requirements dominate indoor comfort conditions in the Phoenix area, so window selection is a process of maximizing daylighting while minimizing summer heat gain. This fact sheet focuses on the energy performance characteristics of windows and other building elements associated with them. Your window choices can result in significant energy savings.

## Types of Windows

Windows are commonly described according to their number of panes of glass and whether any type of tint or coating is applied to the glass to alter its performance. High performance windows include heat-absorbing, reflective and spectrally selective glazings.

**Glazing options** – A wide variety of glazing options are available to satisfy different types of design conditions and performance requirements. Glazing can be single, double or triple pane. It can be clear, tinted, reflective or have spectrally selective coatings such as low-emissivity (low-e) coatings. The space between panes of glass can be filled with an inert gas (typically Argon) that doesn't allow heat to pass readily. Common glazing options include:

- **Clear glazing** – The familiar standard without any type of tint or coating designed to alter the visibility or energy performance of the glass.
- **Tinted glazing –** Tinted glass is often specified as an inexpensive way to reduce solar heat gain through windows. Often referred to as "heat-absorbing" glass, tinted glazings block solar heat by actually absorbing it in the glass itself. However, while this does reduce the direct solar heat gain, it also causes the temperature of the glass to rise. The most common colors are bronze, gray and green and they all block solar heat gain in about the same proportion. Black tint is the worst choice for cooling load reduction since it absorbs much more visible energy than heat energy.
- **Spectrally selective glazing** – Spectrally selective glazings are designed specifically to admit a higher level of visible light while still controlling solar heat. They do so by responding differently to different wavelengths of solar energy allowing for much clearer glass with good solar control. Spectrally selective glazings are available with a range of performance characteristics. This provides a high level of design flexibility as different coatings and performance characteristics can be selected for each orientation providing optimal solar control while maintaining a uniform appearance. Popular "low-emissivity" or "low-e" glazings are a type of spectrally selective glazing that is typically selected to provide enhanced insulation value, good visible transmittance and good solar control. Some low-e windows, however, can allow more solar heat to penetrate than others so it is important to evaluate glazing options against all of a project's design criteria.
- **Reflective glazing** – Semitransparent metallic coatings are applied to clear or tinted glass to provide a high level of solar heat control. However, they reduce cooling loads at the expense of daylight transmittance. They can also cause glare problems in the surroundings and unintended heat gain in surrounding buildings.

**Window performance ratings** – Window systems are rated using several performance parameters that allow designers to select a glazing option that satisfies a project's aesthetic, comfort, daylighting and energy efficiency criteria. Several important window performance ratings are discussed below, and the following table compares typical ratings for different types of windows.



APS

- **U-Value –** The rate of heat flow through a window assembly due to the temperature difference between the two sides of the window. The lower the U-value, the greater the insulating value of the window.
- **Shading Coefficient (SC) –** The ability of glazing to block the sun's radiant heat. The SC is the ratio of solar heat gain of a window compared to single-pane 1/8" clear glass. The lower the SC, the lower the solar heat gain through the window.
- **Solar Heat Gain Coefficient (SHGC) –** The fraction of solar radiation passing through a window as heat compared to the amount of solar radiation striking the window. The SHGC is becoming a standard performance metric and is becoming more common in the performance ratings of manufacturers. It is similar to the shading coefficient in that the lower the SHGC, the lower the solar heat gain.
- **Visible Light Transmittance (VLT) --** The percentage of visible light that passes through the window assembly. A high VLT indicates a greater fraction of incident natural light passing through the window. Reducing cooling loads by specifying lower SC and SHGC ratings needs to be considered in conjunction with the visible light transmittance of the glazing choice to achieve a balance between cooling load reduction and the desired natural light environment.
- **Ultraviolet Transmittance –** An indication of the percentage of ultraviolet radiation striking the glazing that passes through it. Many energy-efficient glazings also reduce UV transmission.
- **Sound Transmission –** Sound transmission properties are expressed as the "outdoor-to-indoor-transmission class (OITC)." The higher the OITC, the better its sound insulation properties.

## Typical Window Performance Values

| Glazing Type | U-Value Of Glazing | Shading Coefficient | Solar Heat Gain Coefficient | Visible Light Transmittance |
|---|---|---|---|---|
| Single-pane, clear | 0.88 | 1.00 | 0.86 | 90% |
| Double–pane, clear | 0.48 | 0.87 | 0.75 | 81% |
| Double – pane, clear, low-e | 0.32 | 0.70 | 0.60 | 73% |
| Double–pane, tinted (bronze) | 0.48 | 0.59 | 0.50 | 48% |
| Double – pane, tinted (green), low-e | 0.32 | 0.48 | 0.42 | 61% |
| Double–pane, reflective | 0.48 | 0.26 | 0.22 | 18% |

**Selecting a glazing** – About half of the sun's energy is in a form that is visible to the human eye and the rest is in a form that contributes only heat to the interior of a building. When selecting a glazing option a good rule-of-thumb is to choose an option that maximizes daylighting and occupant comfort, minimizes energy use, and still meets the project's design and aesthetic criteria. As the chart shows, glazing options are available that meet a wide range of performance criteria. Here are a few glazing selection considerations:

- Double-pane windows, while more expensive initially than single-pane, offer better insulating qualities and comfort in perimeter zones, greater design flexibility, improved sound attenuation, and reduced cooling loads.
- For the Arizona desert climate, the ideal window choice is often a spectrally selective window that transmits as much of the sun's visible energy as possible (high VLT) and rejects as much solar heat as possible (low SC or SHGC).
- For maximum solar control and reduction of cooling load, it is particularly important to use glazing with low a SC or SHGC on the east, west, and to a lesser extent, the south sides of a building.
- Don't assume that dark glass is the best solar control. Many dark glazings block more light than heat and thus only minimally reduce cooling load over other choices.
- The larger the window area, the greater the need for better insulating qualities, lower SC or SHGC, and lower VLT to reduce glare.

## Window Films

For existing buildings, many of the solar control benefits of tinted, reflective and low-e glass are available by applying window films to existing windows. Window films are typically thin layers of polyester film that can either be clear, tinted or reflective. Some films use thin coatings similar to those used in low-e windows. Films can reduce solar heat gain by as much as two thirds, and some films will provide good solar control while allowing good visible light transmission. Quality films also reduce fading of fabrics and provide some safety from broken glass. Most manufacturers offer guarantees that the film will last for at least five years. The following table presents several examples of the performance characteristics of window films applied to clear glass. Films are available from manufacturers that can meet a wide range of solar control and visible light design criteria.

### Example Performance of Clear Glass With and Without Window Films

| Glazing Type | Shading Coefficient | Solar Heat Gain Coefficient | Visible Light Transmittance |
|---|---|---|---|
| **Single-pane ¼" glazing** | | | |
| Clear glass | 1.00 | 0.86 | 90% |
| Clear with tinted film | 0.50 | 0.43 | 48% |
| Clear with reflective film | 0.29 | 0.25 | 15% |
| Clear with spectrally selective film | 0.51 | 0.44 | 69% |
| **Double-pane ¼" glazing** | | | |
| Clear glass | 0.87 | 0.75 | 81% |
| Clear with tinted film | 0.56 | 0.48 | 43% |
| Clear with reflective film | 0.42 | 0.36 | 16% |
| Clear with spectrally selective film | 0.58 | 0.50 | 62% |

The amount of radiant solar energy that enters a building depends on the type of glazing, any surface treatments of the glass, the window's orientation and exterior or interior shading. For all of these reasons, cooling load reduction and energy savings will vary significantly depending on the specific application. Manufacturers of window films often have computer programs available to help estimate savings for specific cases. In general, clear east and west windows will gain the most heat in the summer. In the winter, the south windows will gain the most. If your building has unshaded clear glazing on the east, west or south sides, you may want to consider adding window film. In order to take advantage of natural daylight, consider using film that allows plenty of natural light to enter (high VLT). For reducing cooling costs, priority should be given to west or east facing windows. South facing windows are the second priority. North windows are the lowest priority from an energy and comfort point of view, although it may be necessary to include north windows in a window film retrofit for aesthetic and appearance reasons.

## Window Shading

Shading for windows can reduce cooling costs and increase comfort while providing pleasant ambient day lighting. Shading can be produced by interior or exterior means.

- **Overhangs and awnings –** These devices reduce cooling costs and improve comfort while maintaining good natural day lighting. They are most effective on south-facing windows and can be effective on east and west windows with proper design.
- **Exterior shade screens –** Shade screens can be mounted directly on the exterior of the windows. Because they reduce the amount of sunlight and radiant heat hitting the glass, they are very effective in reducing cooling costs. Screens are available with shading coefficients from 0.20 to 0.80, although screens with SC's of 0.3 to 0.4 are the most common in Arizona.

- **Exterior louvered shades –** Some exterior louvered shade systems are adjustable so the degree of shading can be changed. Some are adjusted with motors that can be actuated with switches, timers or sun sensors.
- **Interior blinds, curtains and drapes –** Light colored or reflective blinds, drapes and curtains can reflect sunlight back out of a window before it heats the space. To be effective, they must be regularly closed during the day. If they are closed consistently, they can produce significant savings. A tightly closed white venetian blind can reduce the solar heat gain through a single pane of normal glass by 25 to 30 percent.[1]

## How Do Windows Affect a Building's Heating and Cooling Costs?

The following table presents a comparison of annual heating and cooling costs for a typical 10,000 square foot office building with a few selected types of windows. This example is for a building with electric heating and cooling in the Phoenix area.

**Annual Heating and Cooling Costs with Different Window Types for a Typical 10,000 Square Foot Office Building in the Phoenix Area**

| Window Type | Annual Heating and Cooling Costs |
|---|---|
| Single-pane, clear | $5450 |
| Double-pane, clear | $5180 |
| Double-pane, clear, with shade screen (SC = 0.35) | $4360 |
| Double-pane, tint (SC = 0.50), low-e | $4860 |
| Double-pane, reflective (SC = 0.20), low-e | $4020 |

## For More Information On Energy-efficient Windows and Window Treatments

Contact the Web sites of the National Fenestration Rating Council (NFRC), the International Window Film Association, the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), the U.S. Department of Energy's Energy Efficiency and Renewable Energy Network, and the U.S. Environmental Protection Agency's Energy Star Buildings Program.

For general information regarding electric service for your business, call the APS Business Center at 602-371-6767 or 1-800-253-9407. For an on line analysis of your business energy use visit the APS Web site and take the Energy Survey at http://www.aps.com/aps_services/energysurvey/Default_BUSRES.html?type=b.

[1] ASHRAE Fundamentals, 1997.