

## Design Guidance for New Windows in a Hot Climate

### Introduction

The energy impact due to windows in a home depends on several design decisions—climate, window orientation, window area, shading conditions, and window (frame and glazing) type. Homeowners and designers need to know the answers to the following questions. What is the best window type to reduce energy use in a particular location? Does window area and orientation affect energy use? Are shading devices effective in saving energy?

Unfortunately, the answers to these questions are not quite as simple as they seem. For example, there is a general perception that homes with larger window areas use more energy than homes with smaller window areas. This may be true for windows with conventional clear glazing, however, with high performance windows, a home with a large window area can use the same amount of energy or even less energy than a space with a small window area. The best option is not always obvious, so it is important for homeowners and designers to be aware of the available advanced technologies and to use calculation tools to optimize design choices for energy-efficient performance.

To provide guidance, the following pages examine the energy use impacts due to orientation, window area, and shading strategies for homes in Phoenix, Arizona. The energy use was calculated for many window design variations including 5 orientations, 3 glazing areas, 5 shading types, and 20 window

### Key Issues

**Orientation:** Homes with windows facing predominately north use less energy than homes facing east, south, or west. With high-performance windows and shading strategies, these differences can be considerably less.

**Window Area:** Energy use increases with window area using windows with clear and high-solar-gain glazing. With high-performance windows, energy use may not increase at all when using a larger window area.

**Shading Condition:** On north-facing homes, shading devices will have little impact. On south-facing homes, overhangs can be effective to block the hot summer sun. Shading devices have less impact when using high-performance windows with low-solar-gain glazing.

types. The assumptions for these variations are shown on the next page. All simulations were performed using RESFEN and analysis was done using the Window Selection Tool. To determine actual impact of window design variations on a specific project, use the Window Selection Tool or [download RESFEN](#).

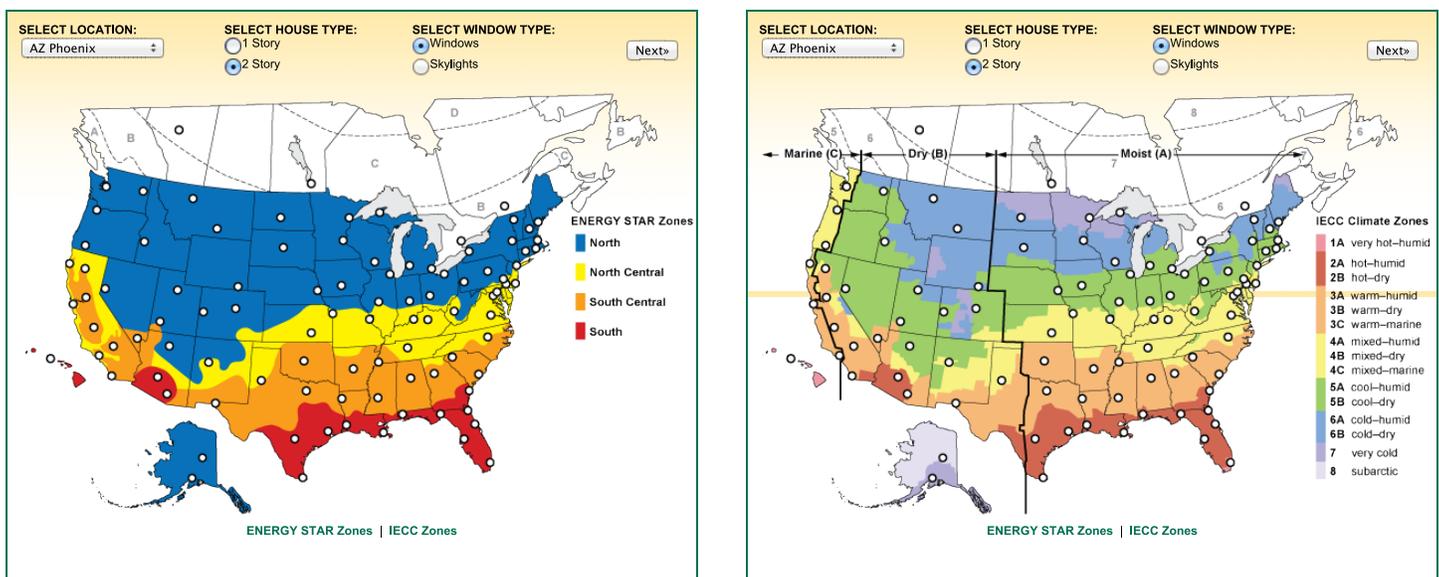


Figure 1. Opening screen of the Window Selection Tool showing the cities, house type, and window type available for selection. You can choose to see the map with the ENERGY STAR® zones or the IECC zones. The tool has options for new or replacement windows, 98 cities, 1- or 2-story home, and windows or skylights.

## Assumptions

The following assumptions are used in the Window Selection Tool for all energy use calculations presented in this design guide. The annual energy performance figures were generated with **RESFEN6** provided by Lawrence Berkeley National Laboratory. The annual costs are for space heating and space cooling only and thus will be less than total utility bills. Costs for lights, appliances, hot water, cooking, and other uses are not included. Natural gas prices are based on state-specific average natural gas retail price data for the heating season (November–March) for the years 2009–2011. Electricity prices are based on average state-specific electricity retail price data for the cooling seasons (May–September) of 2009–2011. All price data is from the **Energy Information Administration** (EIA).

### The House

The house used in the simulations for this guide is a 2600 square foot, two-story new house. The mechanical system uses a gas furnace for heating and electric air conditioning for cooling. The foundation is slab on grade. The building envelope consists of R13 walls and R30 roof.

### House Orientation

Orientation of the windows of the house are available in equal, where the windows are equally distributed on all 4 sides, and north, east, south and west where 55% of the window area is on the dominant orientation with 15% on remaining 3 orientations.

### Window-to-Floor Ratio

Window sizes were modeled with a fenestration window-to-floor area ratio (which includes the area of the whole window with frame). Window-to-floor ratios include 10%, 15%, and 20%.

### Shading Systems

Overhangs were mounted directly above the window frame with a 2-foot projection. The overhang extends the entire width of the window. Interior Venetian blinds were simulated so that the slats would have a seasonal SHGC multiplier (summer=0.80, winter=0.90). Typical shading represents a statistically average solar gain reduction which includes interior shades, 1-foot overhang, adjacent buildings 20 feet away, and other sources of heat gain reduction such as insect screens and trees. Maximum shading takes into account interior shades, 2-foot overhangs and obstructions that represent adjacent buildings.

### Window System

There are hundreds of glazing systems available in the market today, with varying combinations of glass panes, special coatings, and tints. The Window Selection Tool models the performance of 20 window systems, representative of the breadth of options available. U-factor and SHGC are for the total window including frame. For ease of comparing the performance of glass features, all high-performance glazing systems in the Window Selection Tool are modeled with an argon fill.

## Window Types Used in Energy Calculations

Products Simulated				Center of Glass			Whole Window		
ID	Layers	Description-	Frame	U-factor	SHGC	Tvis	U-factor	SHGC	Tvis
1	1	Clear	Metal	1.04	0.86	0.90	1.29	0.73	0.69
2	2	Clear	Metal	0.48	0.76	0.81	0.83	0.65	0.63
3	2	Tinted	Metal	0.48	0.63	0.61	0.83	0.54	0.47
4	2	Low-E, Hi SHGC	Metal	0.26	0.67	0.78	0.65	0.58	0.61
5	2	Low-E, Med SHGC	Metal	0.25	0.42	0.72	0.64	0.38	0.56
6	2	Low-E, Lo SHGC	Metal, Thermal Break	0.24	0.26	0.64	0.63	0.26	0.49
7	2	Clear	Metal, Thermal Break	0.48	0.76	0.81	0.60	0.62	0.63
8	2	Tinted	Metal, Thermal Break	0.48	0.63	0.61	0.60	0.51	0.47
9	2	Low-E, Hi SHGC	Metal, Thermal Break	0.26	0.67	0.78	0.42	0.55	0.61
10	2	Low-E, Med SHGC	Metal, Thermal Break	0.25	0.42	0.72	0.42	0.35	0.56
11	2	Low-E, Lo SHGC	Metal, Thermal Break	0.24	0.26	0.64	0.41	0.23	0.49
12	1	Clear	Non-metal	1.04	0.86	0.90	0.88	0.64	0.65
13	2	Clear	Non-metal	0.48	0.76	0.81	0.52	0.57	0.59
14	2	Tinted	Non-metal	0.48	0.63	0.61	0.52	0.47	0.44
15	2	Low-E, Hi SHGC	Non-metal, Thermally Improved	0.26	0.67	0.78	0.29	0.50	0.57
16	2	Low-E, Med SHGC	Non-metal, Thermally Improved	0.25	0.42	0.72	0.28	0.31	0.52
17	2	Low-E, Lo SHGC	Non-metal, Thermally Improved	0.24	0.26	0.64	0.27	0.20	0.46
18	3	Low-E Hi SHGC	Non-metal, Thermally Improved	0.16	0.55	0.69	0.20	0.41	0.50
19	3	Low-E, Med SHGC	Non-metal, Thermally Improved	0.15	0.38	0.63	0.19	0.28	0.45
20	3	Low-E, Lo SHGC	Non-metal, Thermally Improved	0.15	0.24	0.51	0.19	0.18	0.37

## Orientation

Figure 2 shows the range of possible annual energy costs for the design variations grouped by orientation. This figure shows:

- The impact of orientation on energy use is not the same for all windows.
- The lower ends of the bars show that under certain conditions, very low energy use can be achieved with any orientation.
- West-facing designs use the most energy.
- North-facing designs use the least energy.
- Orientation has a reduced impact on energy performance when high-performance windows are used.

In the past, windows had little capability in reducing solar heat gain, so the design of energy-efficient houses in hot climates evolved to protect windows from significant solar gain. In warm to hot climates strategies include facing most windows north, where there is little direct exposure, or to the south where overhangs can be designed to keep out most of the hot summer sun. West windows are subject to the full force of the strong afternoon sun, at a time of day when temperatures generally climb to their peak. East windows have the same problem in the morning hours, but air temperatures tend to be cooler.

In spite of energy concerns, a house may have a spectacular view or other amenity to the east or west. Fortunately, the traditional patterns of avoiding east- and west-facing windows are not as critical when high-performance windows are used. Figure 3 illustrates the impact of 5 different window orientations on annual energy costs in Phoenix, Arizona. In all cases, the

windows have typical shading. As expected, orientation has a negative impact when clear, single-glazed windows are used. The use of double glazing shows little improvement. When high-performance windows with a low-solar-gain low-E coatings are used, the window orientation has a diminished impact on energy use—nearly all the glazing can face west with less energy use than the conventional glazings facing north.

Impact of Window Orientation

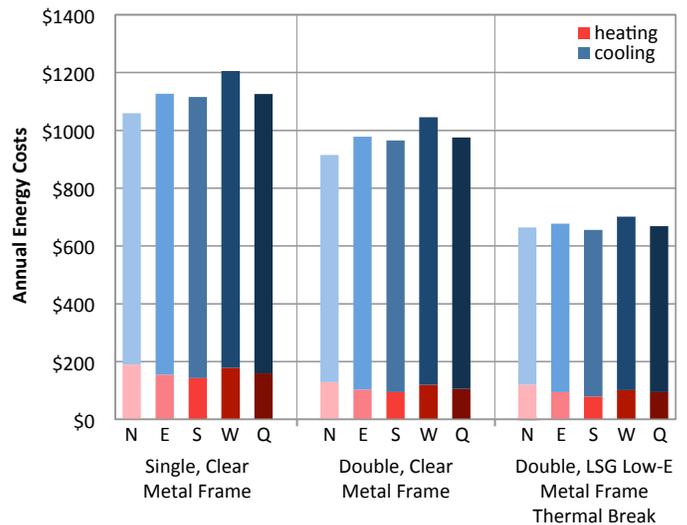


Figure 3. Impact of orientation for 3 windows in Phoenix, AZ. The results are for 15% window area with typical shading.

Range of Performance by Orientation

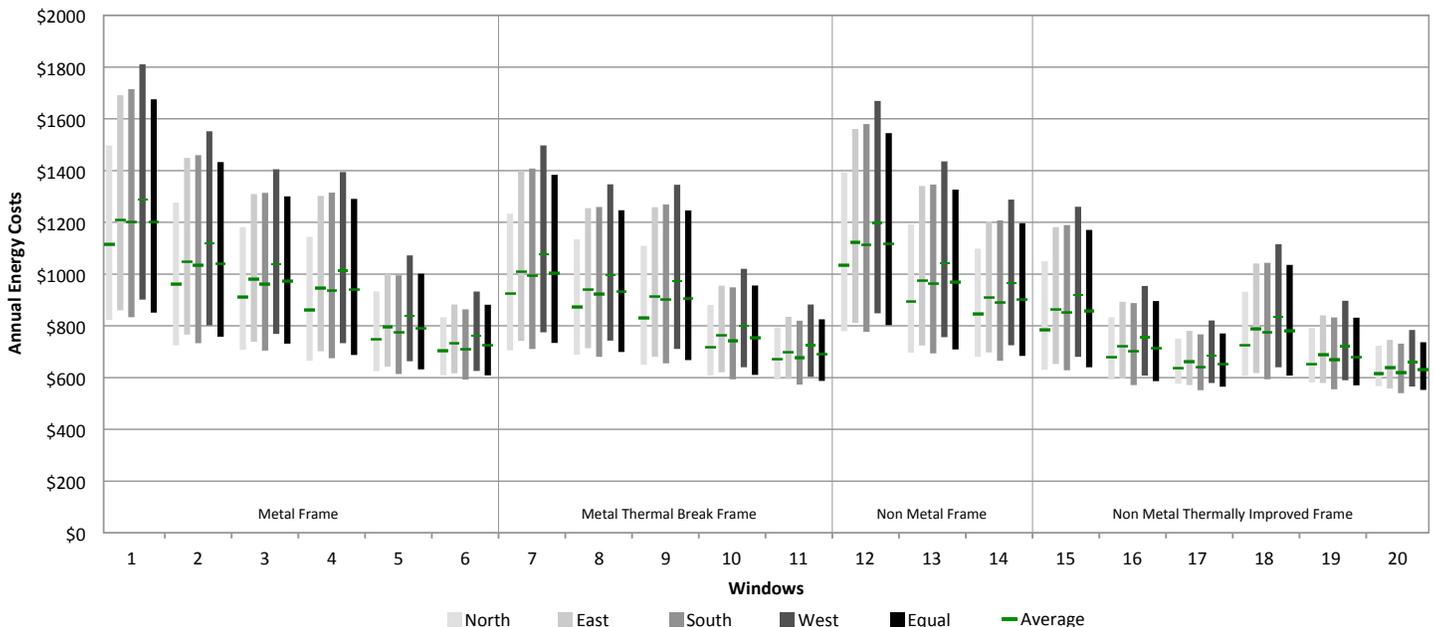


Figure 2. Annual energy costs (heating & cooling) for all window design variations by orientation in Phoenix, AZ.

## Window Area

Figure 4 shows the range of possible annual energy costs for the design variations grouped by window area. This figure shows:

- The impact of window area on energy use is not the same for all windows.
- The lower ends of the bars show that under certain conditions, very low energy use can be achieved with any window area when using windows with moderate- or low-solar gain glazing.
- The higher ends of the bars show that larger window areas can have much worse performance when using windows with clear or high-solar gain glazing.
- When larger windows are desired, the combination of high-performance windows plus appropriate exterior and/or interior shading strategies can reduce the cooling impact to that equal or better than a smaller, unshaded window.

Another traditional guideline to reduce solar heat gain is to reduce the home's total glazing area. This can be effective with any type of window, but it is particularly important when less efficient windows are used. Because of the need for daylighting, views, and natural ventilation, significantly reducing window area may not be a realistic or desirable strategy. Figure 5 illustrates the impact of 3 different glazing areas (small-10%, moderate-15%, large-20%) on the annual energy costs for a

house in Phoenix, Arizona. In all cases, the windows are equally distributed on the four orientations with typical shading. With single or double clear glazing, increasing the glazing area has a very significant impact on the cooling load. The annual energy use for a house with low-solar-gain low-E glazing exhibits the same pattern of increasing cooling load as the window area increases, but the differences are minimal.

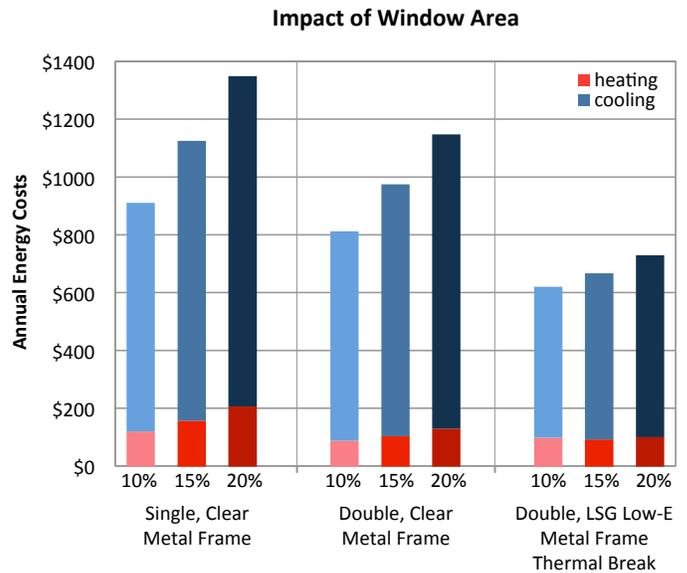


Figure 5. Impact of window for 3 windows in Phoenix, AZ. The results are for equal orientation with typical shading.

## Range of Performance by Window Area

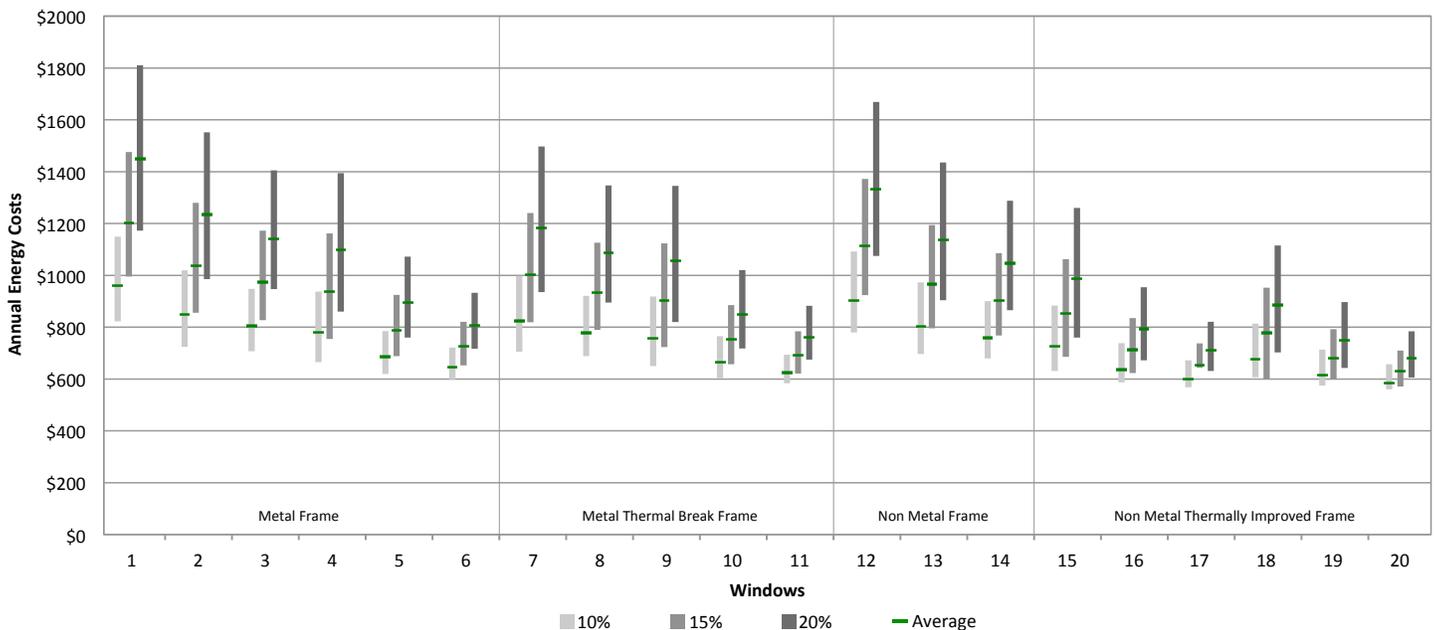


Figure 4. Annual energy costs (heating & cooling) for all window design variations by window area in Phoenix, AZ.

## Shading

Figure 6 shows the range of possible energy costs for the design variations grouped by shading condition. This figure shows:

- The impact of shading strategies on energy use is not the same for all windows.
- The lower ends of the bars show that under certain conditions, very low energy use can be achieved with any shading strategy on any orientation.
- The higher ends of the bars show that windows with no shading and with overhangs perform the worst.
- The impact of shading strategies is reduced when using high-performance windows.

Any effort to shade traditional windows has had great benefits in terms of comfort and energy use. The best place to shade a window is on the outside, before the sun strikes the window. Exterior shading devices have long been considered the most effective way to reduce solar heat gain into a home. The most common approach is the fixed overhang. For south-facing windows, overhangs can be sized to block out much of the summer sun. Overhangs have the advantage of reducing heat gain and glare without diminishing the view. Other exterior devices include grills, awnings, shutters, roll-down shades/shutters, and canopies. The choice of shading strategy is often distinctly regional, based on local traditions. The drawback of some shading devices is that they block light and view.

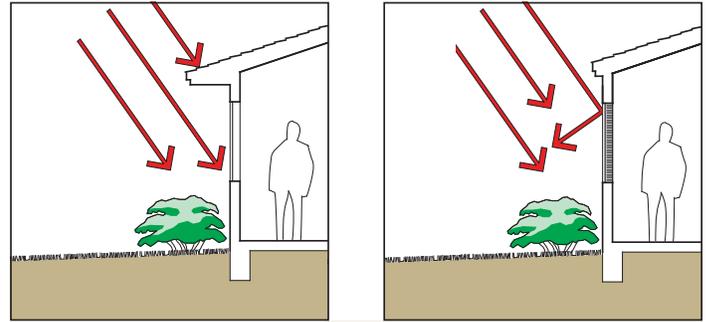


Figure 7. Shading strategies can reduce the solar heat gain that enters through the window.

Most homeowners use some form of interior window treatment such as drapes, blinds, or shades on their windows. In addition to their decorative aspects, drapes and curtains are used by homeowners to control privacy and daylight, provide protection from overheating, and reduce the fading of fabrics. To most effectively reduce solar heat gain, the drapery used to block the sunlight should have high reflectance and low transmittance. The impact of drapery on the solar heat gain is proportionally lessened as the window is shaded by other methods, such as exterior shading or tinted glass. The main disadvantage of drapes and other interior devices as solar control measures is that once the solar energy has entered the room through a window, a large

Range of Performance by Shading Type

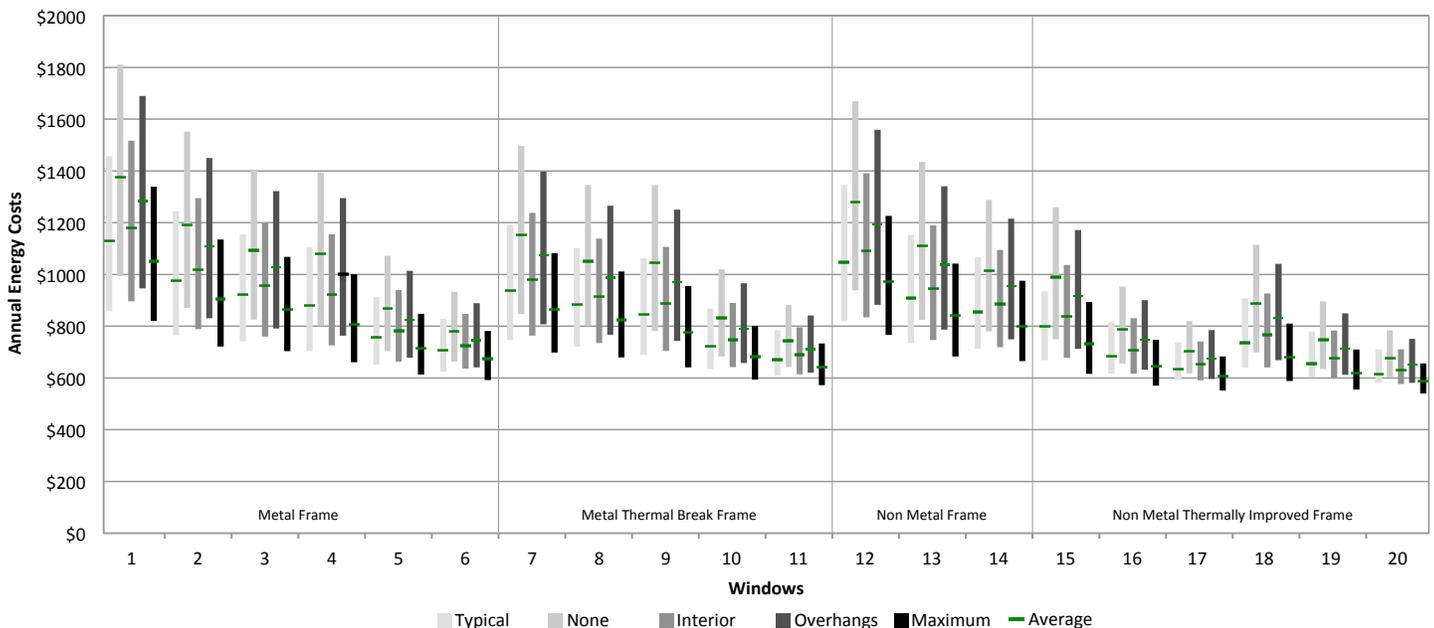


Figure 6. Annual energy costs (heating & cooling) for all window design variations by shading type in Phoenix, AZ.

proportion of the energy absorbed by the shading system will remain inside the house as heat gain.

Blinds and shades primarily provide light and privacy control but they also can have an impact on controlling solar heat gain. These include horizontal Venetian blinds, miniblinds, vertical slatted blinds, pleated and honeycomb shades, and roll-down shades—all of which can be made of various materials. Unlike other strategies to reduce heat gain, such as overhangs, interior shades generally require consistent, active operation by the occupant. Unfortunately, when shades are down, daylight and view are diminished or excluded completely. It is unlikely that anyone would operate all shades in a consistent, optimal pattern as they are often assumed to be operated in computer simulations. Motorized and automated shading systems are widely available to solve these operational problems. The control systems can be automated using sensors, time clocks, or a home automation system. They can also be directly controlled by the occupants.

By using high-performance windows to provide the necessary solar control, there are two important benefits: there is less need for operating the shades, and the window is covered less of the time, resulting in increased daylight and unobstructed views. If your goal is to minimize cooling energy use, or you live in a house without air-conditioning in a hot climate, then the combination of good shade management with low SHGC windows will be the best strategy.

A broad-leafed tree is good at providing cool shade in the summer. In addition to shading the building from direct sun, trees have been found to reduce the temperature of air immediately around them by as much as 10°F (5°C) below the temperature of the surrounding air due to evaporation of moisture. A window shaded with vegetation can have full shade in the summer, while enhancing the view and perhaps the ventilation. Trees and bushes can provide strategic shade from low east or west sun angles that are extremely difficult to shade architecturally.

Figure 8 illustrates the impact of 5 different shading strategies (typical, none, interior blinds, overhangs, maximum) on the annual energy costs for a house in Phoenix, Arizona. In all cases, the windows are equally distributed on the four orientations with a moderate window area. With single or double clear glazing, using no shading or overhangs significant impacts the cooling load. Overhangs are much less effective against the lower angles of the east and west sun, but can be quite effective on the south orientation. Reliance on any form of shading is not nearly as important, however, when windows with low-solar-heat-gain coefficient are used.

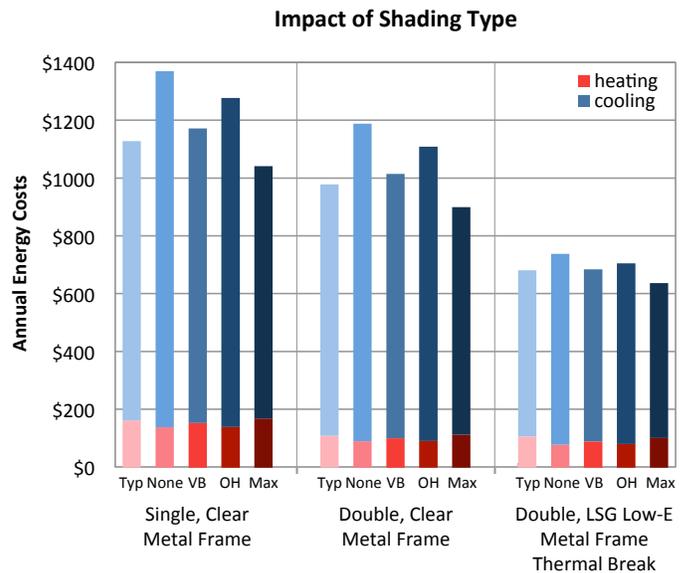


Figure 8. Impact of window for 3 windows in Phoenix, AZ. The results are for equal orientation with typical shading.

### For More Information

Visit the **Efficient Windows Collaborative** (EWC) for more information. The EWC web site provides unbiased information on:

- benefits of efficient windows;
- how windows work;
- how to select an efficient window;
- Window Selection Tool; and
- EWC members that provide efficient windows.

The EWC is a coalition of window, door, skylight, and component manufacturers; research organizations; federal, state and local government agencies; and others interested in expanding the market for energy-efficient fenestration products.