High Performance Glazing

Overview

Windows are usually a dominant feature of the building's exterior appearance. The energy lost through inefficient residential windows accounts for approximately 10% of total residential energy consumption. Because energy efficiency is a crucial component of sustainable design, energy-efficient windows can greatly impact the environmental performance of a building.

Few building systems affect the overall value of a building as much as glazing does. The building attributes that glazing can affect include:

- Exterior aesthetics,
- Indoor views,
- Occupant visual comfort,
- Occupant thermal comfort,
- Annual energy costs,
- The size and form of HVAC systems.

Product Comparisons

High Performance Windows	Conventional Windows
• Higher upfront cost, but lower operating costs	• Lower upfront cost, but higher operating costs
• Increased comfort in summer and winter	• Less comfort in summer and winter
• Potential to downsize or eliminate heating and cooling systems	• Greater dependence on costly mechanical systems
• Quieter rooms and less fading from UV light	• High noise transmission and fabric fading

Glazing Factors

The characteristics of effectively efficient glazing systems are typically expressed using the following technical terms:

- Visual transmittance (Tv) is a measure of the proportion of visible light that passes through a glazing system. Glazing systems with high values of Tv (0.7 to 0.9) provide lots of natural light and good vision, but they can also be a source of unwanted glare if not properly controlled. Systems with lower values of Tv (less than 0.4) can be visually distorting and quite gloomy on cloudy days.
- Solar heat gain coefficient (SHGC) is the sum of the solar radiation transmitted through the glazing and the portion of absorbed energy that ends up supplying heat inside. Glazing systems with high SHGCs (0.7 to 0.9) provide substantial solar gain, whereas those with low values (0.2 to 0.4) provide little solar gain.
- The light-to-solar-gain (LSG) ratio is simply Tv divided by SHGC. The LSG ratio is a useful index to compare how much light (and visibility) a glazing system provides in proportion to how much solar gain it produces. Systems with an LSG ratio greater than 1 provide more light than heat.
- U-value (also known as U-factor) expresses how much energy a glazing system transfers by conduction and convection. The lower the U-value, the more resistance a glazing system poses to heat transfer. Single-glazed units are worst-case; their U-values are typically higher than 1.0 Btu/hr–ft2–°F (~5.6 W/m^2.°K), whereas double-glazed units with well-designed frames might have U-values of less than 0.5 Btu/hr–ft2–°F ((~2.8 W/m^2.°K).

Energy Performance

Glazing may be clear, tinted, coated, or filmed—or some combination of these options. Windows may be single or multiple-paned, and the multiple-paned units can be filled with air or inert gas. Thermal breaks that improve the performance of the windows at their edges are also available. The materials, the techniques used, and the degree to which various treatments are applied ultimately determine the key characteristics of each glazing unit.

- **Tinted Glazing.** Tinting is achieved by adding materials when glass is in the molten state. Tinted glass can get quite hot because it absorbs a high percentage of the sunlight that strikes it. Old-style tinted glass tends to absorb across the spectrum, making it quite inefficient. Contemporary tinted glass performs much better.
- **Coated Glazing.** By firing thin layers of metallic oxides or other materials onto clear or tinted glass, a wide range of optical and thermal effects can be achieved. One type of coated glazing, “reflective glass,” acts like a partial mirror in both the visible and infrared regions of the spectrum. The best performance is obtained with the reflective coating on the outside surface. A reflective coating can be combined with an efficient tinted glass to limit visible transmittance even more—a design option that can help combat the effects of low-angle sunshine on east or west facades. Some coated glasses, known as “spectrally selective,” “low-emissivity,” and “low-e,” have the ability to reflect much of the infrared portion of the solar spectrum while transmitting most of the visible. A typical pane of single glass might have a U-value of about 1.0 Btu/hr–ft2–°F (~5.6 W/m^2.°K), whereas low-e glass might have a U-value of 0.63 Btu/hr–ft2–°F (~3.5 W/m^2.°K).
- **Films.** Thin films made of material that filter light of various wavelengths are used in two ways in new commercial buildings:
  - To provide dead air spaces and spectrally selective filtering when suspended between a pair of glass panes. This lowers the overall U-value of the glazing system while also delivering more favorable thermal and optical performance.

- To form laminated glass—a sandwich of two glass plates with a thin film of polyvinyl butyrate (PVB) in between, this option is usually reserved for buildings in cool climates with large heating loads (mountains & inland plateaus).
  Laminated glass is useful in commercial glazing applications. Clear laminated glass transmits quite well in the visible spectrum, but it has a very sharp cutoff in the ultraviolet region. This quality helps to keep fine art, furniture, and carpets from suffering UV-caused fading.

- **Multiple Panes.** Multiple panes offer more insulation from conductive and convective heat transfer than single panes. By adding a second pane, the insulating value of the window glass alone is doubled (the U-factor is reduced by half). As expected, adding a third or fourth pane of glass further increases the insulating value of the window, but with diminishing effect.
  Such insulation is not always wanted, however. For example, in warmer climates, buildings with HVAC systems that are frequently in cooling mode when the outdoor temperature is lower than the indoor air temperature may gain little benefit from installing insulated glass. However, a similar building in a cooler climate where significant amounts of heating energy are required probably would benefit from insulated glass. In hot climate (Lebanon coastal zone), a low-e coating could be applied to the back of the outside pane to reflect the heat from absorbed solar radiation back outdoors. In colder climates (mountains & Bekaa Valley), the low-e surface could be applied to the outside face of the indoor pane, where it would help retain indoor heat. In both cases, the combination of dead air space and the clear inside pane of the insulated glass unit raises overall energy efficiency and improves comfort.
- **Inert Gas Filling.** Installing low conductivity gases between the panes of glass such as argon or krypton in place of air can also improve the efficiency of the window. This lowers U-values by 25 to 30 percent when the spacing between panes is quite small (around 1/4 inch or 6mm).
- **Thermal Breaks.** The thermal performance of insulated glazing units typically drops off abruptly at the edges of the glazing because both the spacer that holds the panes apart and the window frame itself are commonly made from highly conductive aluminum (thermal bridge). Materials considerations for frame, sashes, and glazing spacers can have significant bearing on the overall energy efficiency of a window as well, though thermal break components can improve efficiency. Better materials include time-tested classics such as wood, as well as new composite materials, aluminum-clad wood, and fiberglass.
- Windows Orientation & Day-lighting Controls. Proper glazing orientation can significantly improve the benefits of day-lighting. Although the size and location of windows is important, to get the most out of free natural light, carefully consider window placement in the home, as that can dramatically affect overall energy performance. East- and west-facing windows will promote heat gain. For buildings that are located in the north hemisphere, southern windows will transmit desired light and heat in the winter, yet will also transmit excessive heat in the summer unless they are properly shaded. Northern windows will receive some light but will lose heat or cold throughout the year.

Conclusion & Tips:

- Multiple glazing layers (multiple panes that are spaced apart) increase the insulating and sound reduction properties of a window.
- Low conductivity gases (Krypton, Argon...) between the panes of glass can improve the efficiency of a window.
- Contemporary tinted glass performs much better than old-style tinted glass.
- Reflective Coated Glazing or low-Emissivity (low-E) can help combat the effects of low-angle sunshine on east or west façade.
  - Use low-e coating to the back of the outside pane in hot climate (coastal zone).
  - Use low-e coating to the outside face of the indoor pane in colder climates (mountains...).
- Make good attention to avoid thermal bridges.
- Laminated Glass is usually reserved for buildings in cool climates with large heating loads (mountains and inland plateau) and helps to keep fine arts, furniture, and carpets from suffering UV-caused fading.
- Size & orientation of windows is important:
  - East and West-facing windows will promote heat gain.
  - Southern windows will receive light and heat.
  - Northern windows will receive some lights but will lose heat or cold throughout the year.