THE ENERGY OBSERVER

Energy Efficiency Information for the Facility Manager

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Choosing and Optimizing Energy Efficient Windows

The Energy Observer summarizes published material on proven energy technologies and practices, and encourages users to share experiences with generic energy products and services. This quarterly bulletin also identifies informational sources and energy training for facility managers and staff. ***The Energy Observer*** is a service of the **Energy Office, Michigan Department of Labor & Economic Growth.**

Windows are critical to the utility and comfort of any building. Windows provide light, view, ventilation and egress, each of which can influence the well-being and productivity of building occupants. Properly placed windows can also aid in energy savings. At the same time they create breaks in the buildings wall mass, insulation and air flow, with significant influence on the building' s climate controls. As a result, if placed incorrectly, windows can lead to higher energy consumption, decreased occupant comfort and distractions due to glare.

Such problems can be avoided with consideration of window placement and purpose. An analysis of architectural and mechanical design, surrounding environment, building materials and window construction will help you to understand the interaction of windows with your building' s performance.

This Energy Observer will discuss where to place windows, their primary or combined functions, and what types of windows fit the space.

Balance Your Needs

During the design phase, it is important to determine the specific needs in each area of the building. Following are different areas of consideration for planning the location and type of windows to install in your building.

- If designed with all building systems in mind, windows can often lead to ***energy conservation***. Properly utilized windows can lead to electrical demand reduction, heating season solar gains, reduced HVAC equipment sizes and reduction of lighting requirements.

- Providing an ***outside view*** is essential in areas where staff and students will be working for prolonged periods. View windows provide relaxing views of natural landscape and provide information about weather conditions and time of day. View windows also promote mental stimulation and relaxation for eye muscles.

- ***Natural light*** or daylight provides the highest quality of light for visual tasks. By enhancing colors and visual appearance of objects, the eyes can better focus on smaller details.

- Using operable windows to provide natural ***ventilation*** can reduce the need for mechanical ventilation and improve the indoor air quality.

- View windows are often located at a level in which a seated person can see out. First Floor view windows create ideal locations for points of ***building egress*** in the event of an emergency.

Window Basics

There are three main types of energy flow through a window – non-solar heat losses and gains, solar heat gains, and air infiltration. Understanding these types of energy flow will help you in choosing the most appropriate type of window.

Non-solar heat flow through a window occurs when there is a difference between the interior and exterior surfaces of the window assembly. This is measured by the U-factor. The resistance to heat

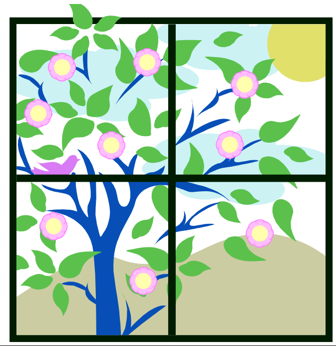

Table 1: Representative Window U-Factors

Glazing Type	Aluminum Frame w/o Thermal Break	Aluminum Frame with Thermal Break	Wood or Vinyl Frame with Insulated Spacer
	U-Factor (BTU/hr-ft^2-°F)		
Single Glass	1.30	1.07	(n/a)
Double Glass, ½-inch air space	0.81	0.62	0.48
Double Glass, E=0.20*, ½-inch air space	0.70	0.52	0.39
Double Glass, E=0.10*, ½-inch air space	0.67	0.49	0.37
Double Glass, E=0.10*, ½-inch argon space	0.64	0.46	0.34
Triple Glass, E=0.10 on two panes*, ½-inch argon spaces	0.53	0.36	0.23
Quadruple glass, E=0.10 on two panes*, ¼-inch krypton spaces	(n/a)	(n/a)	0.22

**E is the emittance of the low-e coated surface.*

Based on 3-ft-by-5-ft windows. U-factors vary somewhat with window size.

Source: 1993 ASHRAE Handbook: Fundamentals

flow, or R-factor, is the inverse of the U-factor. The R-factor can also be used to represent non-solar heat flow. *A lower U-factor results in a lower rate of heat loss and heating energy consumption. Higher R-factors mean greater resistance to heat flow.* See Table 1 for a listing of representative U-factors.

Another consideration is the insulating factor of a window, which is determined by the ability of the window to limit the flow of non-solar heat through the window assembly. Increasing the insulating factor of a window will affect the heating and cooling loads of the building and reduce the U-factor of the window. The insulating and U-factors can be affected by the addition of a gas-filler between the glass panes or a low-emittance (low-e) coating.

The frame of a window will also affect the U-factor. There are many options available, however wood, vinyl and fiberglass insulate far better than metal options. Naturally, composite frames of two different materials will have an insulating factor between the values of the individual products. When using metal frames be sure they include thermal breaks for good performance.

To control **solar heat gain,** window orientation and glazing can be modified to reduce the solar heat gain coefficient (SHGC). Low-e coatings can be engineered to reject some of the incident solar radiation. See Table 2 for a listing of representative Solar Heat Gain Coefficients.

You would most often select a SHGC based on the orientation of the windows. South facing windows that are to provide beneficial solar gain in the heating season require a higher SHGC. North facing windows are exposed to very little solar heat gain and, therefore, do not require investment in windows with high SHGC. East and west facing windows would benefit from a lower SHGC because of high solar heat gains during the cooling season.

Air infiltration can account for 5% to 30% of the energy use in a building. The quality of construction and installation of a window will dictate the amount of air leakage through the window area. Use the air leakage rating to compare the air tightness of different windows.

Remember to regularly check all existing window seals and surrounding areas for damage. Repair all window seals and fill or seal all cracks in foundations or wall surfaces.

Strategies For Success

Proper placement of windows is critical. Just as windows can provide many benefits, they can also cause problems such as glare, occupant discomfort, security and safety concerns. Each of the following areas should be evaluated during the design and incorporation of windows.

Whole Building Simulation:
Consider all aspects of the windows' impact on building use, including solar gains, HVAC equipment sizes, and reduced lighting loads. Using an energy-estimating program will help you understand the interaction between all of the building systems. Examples are DOE-2, BLAST and EnergyPlus.

Lighting and Daylighting Simulation:
Computer simulations of lighting and daylighting in a space will give information about the distribution of lighting in areas that may be affected by windows or skylights. Designing lighting distribution with daylighting in mind will help reduce the electrical lighting load. Proper use of photocell and timer technologies will also help reduce the lighting electrical load and maximize the daylighting potential.

Orientation: Windows should be placed toward the North or South or within 15° from true North and South. This will help to reduce low-angle east/west sunlight and the resultant glare.

Shading devices: These devices should be used to reduce the amount of glare and direct sunlight into the space. Reducing the contrast between the bright window and interior lighting will also reduce strain on the eye. Shading devices can be permanent devices such as overhangs, fins and landscaping or removable options such as shade screens, blinds or drapes.

Reflectance: Use splayed walls, or mullions along with reflective paint to indirectly add sunlight to a room. Placing windows adjacent to perpendicular surfaces such as walls provide the best lighting atmosphere.

Outside Reflective Surfaces: Cars parked outside of a window or light colored ground surfaces may create glare. Planting trees or hedges near the window area can block potential glare from outdoor sources. If glare is not a concern, these obstacles can create giant light shelves bringing in a lot of daylight.

Thermal comfort: Window surfaces that are considerably above or below the temperature of other room surfaces will feel uncomfortable. Use a minimum of double-glazing with low-e coating to maximize comfort.

View: Orient view windows based on needs. Classroom and office windows should look out onto natural or "passive" scenery. Administrative windows should look out on to building entry areas or other areas of security concerns.

Computer Screen Location: Computers should be located at a 45° angle from view windows to avoid glare or reflections of the window on the computer screen.

Durability: Choose sturdy mechanisms for all operable windows and shading devices. When selecting windows with glazing, keep in mind the following, aging (UV degradation or yellowing), structural strength, scratch resistance, breaking and fire resistance and replacement costs.

Table 2: Representative Window Solar Heat Gain Coefficients

Glazing Type	Solar Heat Gain Coefficient (SHGC)
Single Glass, clear	0.67
Single Glass, bronze tint	0.56
Single Glass, green tint	0.56
Double Glass, clear, ½-inch air space	0.60
Double Glass, bronze tint outer pane, ½-inch air space	0.49
Double Glass, green tint outer pane, ½-inch air space	0.48
Double Glass, E=0.15*, ½-inch air space	0.50
Double Glass, spectrally selective, E=0.04*, ½-inch argon space	0.33
Triple Glass, clear, E=0.15 on two panes*, ¼-inch air spaces	0.40

**E is the emittance of the low-e coated surface.*

Based on 3-ft-by-5-ft windows with wood or vinyl frames and aluminum spacers. Solar Heat Gain Coefficients vary somewhat with window size.

Source: WINDOW 4.1, Lawrence Berkley Laboratory, Berkeley, CA.

Accessibility: Make sure all windows easily accessible for maintenance and operation.

Security: Provide interior shades or tinted glass for ground level rooms that contain large amounts of computer equipment or other valuables.

Noise Transmission: If outdoor noise is particularly high in an area due to aircraft or heavy traffic, double glazed windows may be the best option. Standard double paned windows, with only a ¼" or ½" airspace are not very effective for blocking noise. At least one pane of laminated glass, possibly thicker along with a 2" to 3" air space will help to reduce the noise.

Resources

National Fenestration Rating Council (NFRC) Window rating system visit: www.nfrc.org

WINDOW 5.0 a window thermal performance estimating software http://windows.lbl.gov/Default.htm

DOE-2 building simulation software visit: www.eere.energy.gov

Glossary of Terms

Air Leakage Rate: (cfm/ft or cfm/ft^2) A measure of infiltration around a window. A lower air leakage rate indicates a better air tightness.

Infiltration: The inadvertent flow of air into a building through breaks in the exterior surfaces of the building.

Low-emittance (low-e) coating: Microscopically thin, virtually invisible, metal or metallic oxide layer deposited on a window glazing surface to reduce the U-factor or solar heat gain coefficient by suppressing radiative heat flow through the window.

Mullions: A vertical or horizontal, non-structural member, that divides a window or other opening into two or more panes. May be used to reflect or deflect light.

R-value: A measure of a material or assembly's resistance to heat flow. It is the inverse of the U-factor (R=1/U) and is expressed in units of hr-ft^2-°F/BTU. A higher R-value means greater resistance to heat flow and a higher insulating value.

Shading Coefficient: A measure of the ability of a window to transmit solar heat. It is equal to the SHGC multiplied by 1.15 and is expressed as a number, without units, between 0 and 1. The lower a window's shading coefficient, the less solar heat it transmits, and the greater its shading ability.

Solar Heat Gain Coefficient (SHGC): The fraction of solar radiation admitted through a window, both directly transmitted, absorbed and released inward. The SHGC is used as the standard indicator of a window's shading ability. Expressed as a number, without units, between 0 and 1. A lower SHGC means less solar heat transmitted and a greater shading ability.

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-ft^2-°F. The lower a window's U-factor, the greater are its resistance to heat flow and its insulating value.

FOR MORE INFORMATION…

Rebuild America offers free tools and publications for evaluating equipment efficiency and building performance. www.rebuild.org. Publication: *National Best Practices Manual for Building High Performance Schools*

ASHRAE offers information about state of the art HVAC&R technologies, publishes standards, and establishes guidelines. www.ashrae.org Publication: *2003 Applications Handbook*

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more information/registration:
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