George Washington University's South Hall.

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Considerations When

Upgrading AND Renovating Window Systems

By Steve Gille

Today's educational facilities managers face many challenges. As stewards of their campus' physical assets, these professionals are charged with improving students' learning environments, saving money, and maintaining the historical and aesthetic integrity of their buildings.

For schools and universities that have not replaced their windows in many years, a window systems upgrade can help meet these challenges by creating facilities that are more comfortable, energy efficient, and conducive to learning.

Many windows systems found in older institutions are leaky, single-glazed with conductive framing systems. They can be difficult or even dangerous to operate, promote unhealthy condensation, mold or mildew formation, and require occupants to keep away from exterior walls to avoid glare, drafts, and noise.

University of Notre Dame's historic Farley Hall renovation. The existing window frames were left in place and encapsulated with aluminum interior trim to preserve and restore the campus' architectural legacy.

U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®), and the U.S. Department of Energy's (DOE) ENERGY STAR® for Buildings. Criteria from these programs often are part of a campus' architectural and sustainability initiatives helping conserve natural resources and increase efficient use. For example, George Washington University's Foggy Bottom Campus Plan guided the design of the school's South Hall residence. The plan's "Grow Up, Not Out" approach allows the Washington, D.C.-based university to meet its academic and housing space within its existing campus boundaries.

Helping compare energy costs related to existing windows with new windows, the DOE and Lawrence Berkeley National Laboratory offer publicly available software. When these tools' calculations are integrated with a whole building design approach, they also provide valuable information on reducing HVAC capacity and costs. These benefits may be enhanced by modeling windows and daylighting devices' positioning to optimize buildings' energy savings of passive ventilation with operable windows and to optimize occupants' productivity by managing glare, temperature, and outside views.

These attributes and performance objectives are supported by a window system's orientation, style, framing material choices, and glass selection.

Climate and Orientation

Local climate, site selection, and building orientation should be among the first considerations when choosing a window system. The window's direction determines the potential for unwanted solar heat gain and disruptive glare. East and west facing windows warrant special attention for solar control, especially in warmer climates. Although a south orientation typically provides the most natural light throughout the day, the indirect and ambient light offered by north-facing windows can be significant. In cold weather climates, south-facing windows provide the best potential for passive solar heating.

Even in colder climates, operable windows provide a seasonal opportunity for natural ventilation. Not only can these help reduce demands on the HVAC system, but they also can assist with emergency venting and egress requirements.

ENERGY EFFICIENCY

The greatest gain from replacing or upgrading educational facilities' windows systems may be the savings from improved energy efficiency. Heat loss and heat gain through windows impact heating and cooling demand. Maximizing the daylight in classrooms also can lessen the demand and cost for electrical lighting.

Energy-efficient replacement windows play an important role in achieving green building recognition by such programs as the

Window Style

Options available for colleges and universities' retrofit and replacement projects include:

- Fixed
- Single-hung
- Double-hung
- Horizontal-rolling (sliding)

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Whether selecting operating or fixed windows, the type and configuration of these units influence the glazing and framing options.

- Framing
- A range of framing materials is available for windows:
- Wood
- Wood/polymer composites
- Vinyl
- Fiberglass
- Steel
- Aluminum

The type of material selected for window frames impacts a window systems' performance. Due to its durability, low maintenance and ability to provide great structural strength, aluminum often is the material of choice for college and university projects. Supporting campuses' green building goals, aluminum framing for window systems can be fabricated with secondary billet. This material should be free from contaminants and may exceed 40 percent recycled content from combined pre- and post-consumer sources.

Glass Selection

Aluminum framing systems may be manufactured with a thermal barrier to aid in its energy efficiency. This thermal improvement inserts a physical barrier between the window unit's glass lites for added performance. With the use of Low-E glass, these high-performance, insulating glazing units minimize unwanted heat loss and heat gain, reduce glare, block ultraviolet (UV) radiation and increase occupants' comfort. Multiple glazing options are appropriate for educational institutions.

- Low-E coatings – increase the insulating properties of a window by reducing the amount of heat transferred through the glazing
- Spectrally-selective, Low-E coatings – reflect the infrared rays that generate heat, while admitting the visible light spectrum associated with natural lighting
- Reflective coatings – provide greater glare and solar heat gain reduction; also restrict the amount of daylight entering a room
- Electrochromic or "smart" glazing – reacts to solar heat gain and glare by changing from clear to tinted; actively managing lighting and cooling through smart glazing could reduce peak electric loads by 20 to 30 percent in many buildings[1]
- Laminated glazing – consists of a tough plastic interlayer that is bonded between two panes of glass under heat and pressure; offers increased protection for campuses prone to hurricanes or earthquakes.

ACOUSTICAL PERFORMANCE

Laminated glazing frequently is preferred when upgrading windows to improve the acoustical performance of a classroom by reducing exterior noise. This can be important for campuses located in high-traffic areas and close to airports. Quiet learning environments contribute to increased attention and concentration, which enhances student achievement.

WELLNESS AND COMFORT

In addition to avoiding noise pollution, access to natural light positively impacts student performance and test scores, reduces absenteeism, and boosts staff morale and job satisfaction. A California study showed that students who had access to natural daylight progressed faster in both math and reading, and had higher test scores.[2] Negative factors such as glare, temperature extremes, and stuffy air can offset the positive affects of daylight.

Students and staff work best in a space with a comfortable air temperature and humidity level, air movement, and daylight. Drafts near windows can be a major source of discomfort, especially in cold climates. Drafts are caused not only by windows

Several ratings can help determine which window systems are right for the project.

The American Architectural Manufacturers Association (AAMA) and the National Window & Door Manufacturers Association (WDMA) developed voluntary specifications for aluminum, vinyl, and wood windows. These specifications have made it easier to select windows for air, water, structure, and thermal performance. AAMA/WDMA also have defined window categories from residential to architectural grade. Windows selected for college and universities should be AAMA commercial (CW) or architectural (AW) grades.

National Fenestration Rating Council (NFRC) Energy Ratings account for the performance of the whole window system. In U.S. jurisdictions, building energy codes require that windows bear the NFRC label to verify energy rating code compliance.

The energy ratings included on the NFRC label are:

- U-Factor – measures the level of insulation; the lower the U-Factor, the better the window insulates.
- Visible Light Transmittance (VT) – indicates the amount visible light that passes through glazing; the higher the VT, the more light.
- Solar Heat Gain Coefficient (SHGC) – expresses the solar heat gain transmitted through the glazing; the lower the SHGC, the less solar heat the window transmits.
- Air Leakage (AL) and Condensation Resistance (CR) are optional – AL ratings indicate the amount of air leaking through closed windows in the presence of a specific pressure difference; a lower AL value indicates less air leakage. CR measures how well the window resists water build-up; the higher the condensation resistance factor, the less build-up the window allows.

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with significant air leakage, but also by poorly insulated windows, which allow cold air to pool next to windows. This cold air circulates throughout the classroom through the building's ventilation system, causing uneven temperatures as the warmer air rises and the colder air sinks. When the interior surface temperature of marginally performing glass falls below interior room air temperature, the Mean Radiant Temperature (MRT) is reduced. This MRT effect can cause students near windows to feel chilled, even if the room air temperature is comfortable.

Controlling glare is a major consideration when upgrading or replacing window systems. Whether it occurs in a classroom, library, or other learning environment, glare from windows can cause discomfort, and headaches, and can impact learning. Several glazing options, including reflective, electrochromic, and Low-E coating, will help lessen or eliminate glare, as will traditional window treatments and blinds.

AESTHETIC AFFECTS

Maintaining a campus' look and feel is paramount in many window systems upgrade and replacement projects. Most window manufacturers offer a range of operating window types that can replicate a building's original profiles and sightlines with modern performance and materials.

If a campus is located in a historical district, replicating the original window profiles and sightlines may be mandatory. While local regulations and building codes directly impact the criteria established for the window systems in some cities and designated historic districts, the exterior appearance of proposed replacement windows can require redevelopment authority approvals. While sometimes viewed as a roadblock, such approvals can serve the valuable purpose of maintaining period and neighborhood ambience, which can help preserve both property values and community values.

For example, simulated double-hung windows are a popular choice for schools. These mimic the look of traditional double-hung windows with offset glass planes and matching sightlines, while offering the reliability and affordability of project-in hopper vents, project-out awning vents, and casements. The compression seals and ease of operation that characterize projected and casement windows may improve functionality of replacement windows, versus replacing "in kind" with double-hung sash. Facilities managers can request these products with extended warranties and accelerated delivery schedules to support their renovation project needs.

Panning vs. Tear-Out

A key, logistical decision on an historic property is whether to leave existing window frames in place, or do a complete "tear-out" and start again.

Removal of existing operable sash, while leaving existing framing in place, usually makes for faster installation and minimizes disruption. The existing frames are used as anchorage points, and an extruded aluminum sub-frame or "panning" system lines the opening.

If a tear-out of existing frames is the option, perimeter protection often is required in occupied spaces and the process is slowed considerably. Caution must be exercised in determining what concealed wall materials may be disturbed, including asbestos.

MAINTENANCE AND DURABILITY

Maintenance, durability, and life-cycle costing all play a part in selecting products for educational facilities window upgrades. Several factors also can contribute to a project's longevity:

- Integral blinds, installed between the glass panes by the manufacturer, require no cleaning and are protected from damage or vandalism
- Hermetically-sealed, double- or triple-insulating glass units that have been certified by American Architectural Manufacturers Association (AAMA) or the Insulated Glass Manufacturers Alliance (IGMA) ensure long-term resistance to between-glass fogging
- Anodized aluminum finishes offer an ever-expanding color palette of abrasion-resistant, UV-stable surfaces that resist corrosion and are easy to maintain
- Architectural (AW) class windows are life-cycle tested for up to 4,000 operating cycles, and must pass the most stringent performance tests

Regardless of which type of window system is selected, using materials that are successfully tested to meet stringent industry standards and are backed with a comprehensive warranty will help minimize maintenance and repair costs.

VENDOR RELATIONSHIPS

Window system upgrades frequently occur during the summer months when school is not in session. In some cases, replacement continues into the academic year, and extra effort must be employed to minimize disruption to occupants. Regardless of the time of year, a good relationship with the contracting team, including a specialty-glazing contractor, is essential to a smooth process. Involving the team early and communicating clearly will contribute to keeping the project on budget and on time.

Whether planning a learning institution's window systems upgrade or retrofit, energy efficiency, acoustical performance, occupant comfort and wellness, historic and aesthetic integrity, and maintenance and durability should all be considered to ensure a successful project.

NOTES

1. The Efficient Windows Collaborative Tools for Schools, 2008.
2. Heschong Mahone Group. "Daylighting in Schools," Pacific Gas and Electric Company on behalf on the California Board for Energy Efficiency Third Party Program, August 1999.

Steve Gille is education market manager for Wausau Window and Wall Systems, Wausau, WI; he can be reached at *sgille@wausauwindow.com*. This is his first article for *Facilities Manager*.

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