upgrading windows

REPAIR, REFURBISH, OR RETROFIT?

BY C.C. SULLIVAN AND BARBARA HORWITZ-BENNETT,
CONTRIBUTING EDITORS

The U.S. Environmental Protection Agency reports that inefficient windows can account for 25% of a typical building's heating load in cold weather and 50% of the cooling load in warm months. That's one reason that even cash-strapped property owners are planning building envelope upgrades that include new window installation.

Thanks to today's high-performance fenestration products and systems, well-designed and properly installed window retrofits deliver predictable and calculable operations benefits. However, Building Teams must focus on a number of key decisions in order to arrive at the optimal solution: Repair the windows in place? Remove and refurbish them? Opt for full replacement? Which types of materials and window profiles and styles are best suited for a retrofit application? How do aesthetics factor into the equation?

Drawing from years of experience, a select group of expert organizations and Building Team leaders, including architects and contractors, share insights that have helped sort out these problems on recent major projects.

DECISION #1: REPAIR OR REPLACE?

To determine whether the repair of an existing window system will be sufficient to boost performance, the first step is to inspect the window for *three key performance factors:* 1) structural integrity, 2) air penetration, and 3) water penetration. If any of these performance factors is compromised to the extent where the window cannot be easily repaired by caulking or weather stripping, replacement is most likely the best option, according to Jacob Johnston, Project Manager, Alliance to Save Energy (www.ase.org), an energy-efficiency advocacy organization.

However, there are other reasons that might justify replacement, says Dean Lewis, Educational and Technical Information Manager, American Architectural Manufacturers Association (www.aamanet.org). These include the windows' *acoustics*, *appearance* (due to aging), and *maintenance requirements*. Another often overlooked factor: the *compatibility* of existing windows and doors with a repurposed building space or a new occupancy type.

David Bell, AIA, LEED AP BD+C, Principal of Bell Architects (www.bellarc.com) and a specialist in historic preservation and adaptive reuse, says Building Teams should also consider the remaining useful life of a window's components, its "historic element," and its ease of operation.


HALKIN MASON PHOTOGRAPHY

For an 1893 academic building in the Collegiate Gothic style at Bryn Mawr (Pa.) College, architect MGA Partners reworked the original windows and added a new, glass-enclosed stair tower. The original building's emphasis on ventilation systems and window placement is typical of college laboratories built in the 1880s, influenced by industrial practices and hospital design.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ DESCRIBE the assessment considerations for replacing or repairing existing fenestration systems, with particular attention to occupant health and comfort.
+ EXPLAIN the relative benefits and tradeoffs, including energy savings and indoor environmental quality, of material specifications for replacement window and door products.
+ LIST three or more requirements for evaluating replacement windows, doors, and other fenestration, depending on the historical styles or aesthetic criteria of the subject building.
+ DISCUSS the materials and systems attributes that affect a window system's energy efficiency, including thermal bridging.

With so many advances in window design and manufacture in recent years, "replacement often is the best approach," even for windows that are only 15-20 years old, says Kenneth M. Lies, AIA, Principal of the structural engineering and architectural service firm Raths Raths & Johnson (www.rrj.com). There are, however, projects where the best course of action is repair—for instance, a project with existing windows of a more recent vintage and known manufacturer, for which warranties can be called upon for necessary repair parts, says Lies.

Another possibility for many typical commercial and institutional fenestration systems is partial replacement or augmentation, such as installing new hardware, glass within the existing sashes, new sashes within the existing window unit, or the addition of storm windows.

"Oftentimes, drainable window systems are converted to barrier systems as part of a repair effort," says Kevin A. Kalata, RA, SE, Associate Principal, Wiss, Janney, Elstner Associates (www.wje.com). Barrier-type repairs may consist of new silicone cap beading or preformed silicone frame joint seals, which can result in significant cost savings over full replacement. Kalata warns, however, that they are "highly dependent on the quality of the repairs and can require frequent and diligent maintenance."

Sometimes the decision is determined by the building code. Rick De La Guardia, President/Founder, DLG Engineering (www.dlgengineering.com), says that the building code in Florida, where he is based, allows

COURTESY J.E. BERKOWITZ

After adding two lites of high-performance low-e glass to the existing interior window surface on 651 windows at the Kevon Office Center, Pennsauken, N.J., originally built in 1971, the new insulating glass units are delivering a solar heat gain coefficient as low as 0.27, a winter U-value of 0.15, and an R-value of 6.67.

for repair work to bring the window up to substantial compliance with the code at the time the building was originally built. However, if the needed repairs exceed a specified threshold, then the repairs, including the windows, must comply with current code, which usually means replacement.

Often the decision boils down to the availability of new parts, the cost of labor to install them, and the extent to which building performance will be enhanced with new windows, says Burt Andrews, Principal, Larson & Darby Group (www.larsondarby.com).

A related question is whether to *preserve the existing trim*. Generally speaking, says Bell, if the trim is in good condition, is considered integral

8 TIPS FOR AVOIDING thermal bridges

Thermal bridging has a huge effect on energy efficiency in windows. Designers typically try to specify thermally broken or thermally improved window frames, only to be forced by budget constraints to settle for standard frames.

The determination of the age and make of a window should provide some idea as to whether the frame has a thermal break, says George M. Blackburn III, AIA, NCARB, who chairs the Dallas Building Enclosure Council and serves on the national board of the Building Enclosure Technology & Environment Council. A visual inspection of the window is often sufficient to determine the condition and degree of any deterioration, defects, or damage, and whether the glass is single pane or insulated, he says.

Many existing steel and aluminum sashes were not originally configured with a thermal break. Furthermore, says Jonathan A. Morris, AIA, of Carmine Wood Morris. it's "nearly impossible" to add thermal breaks into an existing framing system, as the area of cold aluminum is so small in relation to the glass area. When full replacement is not an option, you'll have to settle for insulating the glass.

In the case of fixed-glass commercial windows, there are companies that can custom manufacture a retrofit glazing insert over the existing window that will provide a thermal break and insulating air space between the existing glass, says Blackburn. This can be installed on either the interior or exterior and is less expensive than a complete replacement of the existing window.

Kevin Kalata, with Wiss, Janney, Elstner Associates, offers these tips to control thermal bridging:

1. **Align the thermal breaks** in the frames with the insulating glass unit.
2. **For storefronts, use thermally broken subsill members.** Subsills are required at the base of storefront systems for drainage of water that penetrates into the system. Thermally improved subsills may use vinyl or other low-conductive materials for subsill end dams when thermally broken dams are not available.
3. **For curtain walls, maximize the thermal separation distance** between the aluminum pressure plate and structural mullion. Where higher thermal performance is needed, consider using fiberglass or vinyl pressure plates and spacers in lieu of aluminum plates.
4. **Use insulated glass units** for both vision and spandrel areas. Stainless steel or thermally broken "warm-edge" spacers are often used as a means of reducing thermal bridging effects between the glass lites. Other options for improved thermal performance include triple-glazed window units or vacuum-insulated glass. Spandrel glazing options for higher thermal performance also include the use of vacuum-insulated panels that are sandwiched between the exterior glass lite and the interior metal facer.
5. **Align the thermal break** in the window system as closely as possible with the insulation in the surrounding wall assembly. Offsets between insulation layers and thermal breaks in windows can provide a heat flow path or thermal bridge. Give careful consideration to the placement of the window within the opening in order to minimize thermal bridging effects.
6. **Provide adequate separation** between perimeter claddings and the window system to minimize direct heat loss. Attachment clips or angles should be located on the inboard side of the thermal break as well as the inboard side of the perimeter wall construction insulating layer, where possible. Never extend clip supports across the thermal break.
7. **Provide thermal breaks** in all perimeter flashings or trim that surround the window. Flashings and trim should not extend beyond the thermal break in the window system. Flashing extensions are often created by preformed silicone sheets or membrane flashings.
8. **Apply an air barrier** at the perimeter of the window system that is integrated with the surrounding wall system. Air flow around the frames from the exterior or from cavities within the wall system that are vented to the exterior can reduce the performance benefit of thermal breaks.

to the architectural style, or is historically significant, it should be retained. However, if the windows are being replaced to create a continuous air barrier and drainage plane, or to improve flashing, or to add insulation, "then we would consider replacing or modifying the trim," says Bell.

A number of new products are available to assist in historic building projects, such as injecting deteriorated wood trim with resins or epoxy to restore its appearance for continued function use, says George M. Blackburn III, AIA, NCARB, General Manager, Construction Consulting International (www.sunited.com). This is particularly helpful with arched trim, which can be difficult and expensive to replicate, he says.

AAMA's Lewis points out that the time and labor required to remove, refinish, and repair interior facings and stools can easily overrun the cost of replacement millwork or extrusions. As an alternative, designers can turn to a wide variety of brick mold. And, with the exception of stone or masonry outdoor trim, old millwork can usually be replicated fairly easily.

DECISION #2: HOW TO CHOOSE THE RIGHT MATERIALS FOR THE JOB

If the windows are being replaced, designers must choose between a variety of materials, including wood, aluminum, steel, vinyl, and fiberglass, and weigh the benefits and drawbacks of each.

Wood: Warm and wonderful. Although wood is much more common in residential and historic building applications, wood windows can be used in renovation and high-end commercial projects when a certain aesthetic is desired. "There are building owners who will settle for nothing less than the traditional and warm appearance of a wood window," says Lewis.

On the other hand, wood has its own maintenance requirements and is susceptible to moisture and water damage. However, the latest finishes and preservatives, coupled with better installation, materials, and procedures, are effectively minimizing water penetration. Mark A. Magrino, AIA, TBS Services (www.tbsservices.com), says he often clads the wood frame exterior and sash with vinyl or aluminum to minimize maintenance and leakage concerns.

Replacing broken glass in wood windows can be tricky. With other framing types, it is sometimes possible to deglaze the window and then replace the glass, but wood frames often require a new window unit, says Mike Palmer, Project Manager, Knutson Construction Services (www.knutsonconstruction.com).

Aluminum: Colorful, storm-resistant. A popular choice for commercial buildings, aluminum frames are available in a wide range of colors and profiles and can be adjusted for any opening size, says Palmer. In addition, missing glass can be replaced from the inside or the outside of the building.

In the past, aluminum's high strength-to-weight ratio and narrow sightlines meant low thermal conductivity, says Lewis, but the advent of thermal isolation materials has improved thermal performance. "We typically see steel and aluminum windows in institutional buildings because of their durability, longevity, and scale, allowing for larger panes," says Bell.

In terms of durability, De La Guardia, who does a lot of hurricane-related work, appreciates aluminum's ability to handle rain and salt water, in addition to high wind loads. Jonathan H. Morris, AIA, Principal, Carmina Wood Morris (www.cwm-ae.com), is a strong believer in aluminum-clad exteriors in place of painted wood exteriors for the sake of weatherability.

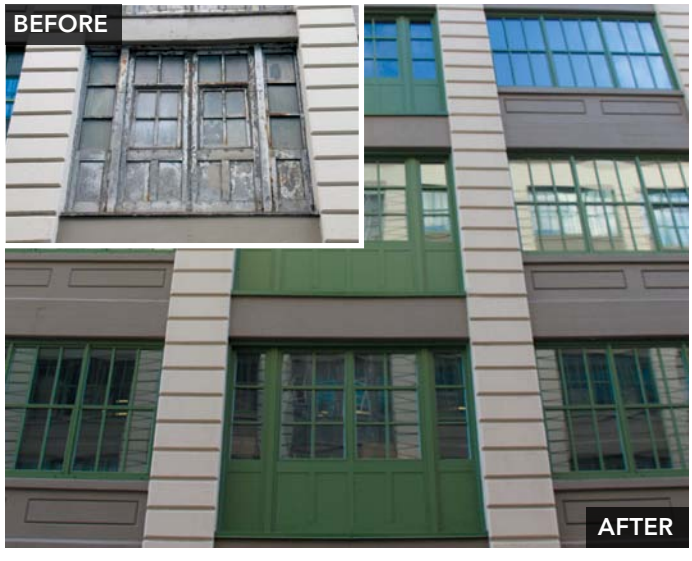
One aspect of aluminum to keep an eye on is its vulnerability to staining, discoloration, and scratching during the construction process. Knutson Construction's Palmer advises Building Teams to handle the installation and cleaning of aluminum windows with care, especially when washing the exterior of a masonry structure.

Steel: Opening up design options. While steel does lend versatility in design and a nice narrow line aesthetic, steel frames come with their own set of maintenance requirements, nor do they deliver good insulation in cold climates. Consequently, a good thermal break is essential, says Palmer.

Steel also has to compete with aluminum, which often has the edge when it comes to metal frame selection. "We have renovated some former factory buildings that had large industrial steel sash windows," says Morris. "We designed new aluminum windows that feature insulated glass and thermal breaks while duplicating all of the original window's sight lines and proportions within a half-inch of the original's dimensions."

Vinyl: Easy maintenance. Known for its thermal performance and low maintenance, as well as a wide range of colors and finishes, vinyl is commonly used in residential and light commercial applications. In the past, sash size was limited, particularly for outward designs such as casements, but with advances in internal reinforcement, vinyl windows have overcome this limitation.

Palmer cautions, however, that vinyl (and fiberglass, too) must be carefully installed so that the jambs, head, and sill are plumb and level. If this is not done accurately, he says, the operable unit may



COURTESY KEYMARK CORP. / NORTHERN BUILDING PRODUCTS

As shown in this before-and-after sequence, the installation of 263,000 customized window systems at Brooklyn's former Bush Terminal has maintained the historic integrity of this former shipping, manufacturing, and warehousing center while turning it into a modern commercial space.

not set right, operate properly, or seal correctly. "We have had existing vinyl windows where the frame joinery has failed, allowing water to the interior or the balancing system within the window, which fails again usually as a result of the initial quality of the construction or miscellaneous part," says Magrino, Past Chair of the Philadelphia Building Enclosure Council.

Fiberglass: Strong to last long. Fiberglass offers greater strength than vinyl and is comparable to aluminum in this regard. It does come with a higher production cost, but fiberglass's ability to reduce heat transfer while maintaining structural integrity makes it a good alternative to aluminum, says Johnston.

RENOVATING OLDER BUILDINGS IN STYLE

When updating windows in older properties, notably historic buildings, any reuse, restoration, or renovation usually must follow strict codes and guidelines. In most cases, Building Teams will opt to match the existing look of the fenestration, either with new matching windows or by removing, refurbishing, and reinstalling the original windows.

For instance, many State Historic Preservation Offices and the National Park Service may require Building Teams to replicate the building's original window style, no matter the cost. This usually requires referencing historic photos and inspecting partial windows where the original windows are missing, says Michael D. Binette, AIA, Principal, The Architectural Team (www.architecturalteam.com).

However, for nonhistoric projects, such factors as how the spaces function, user expectations, security, daylighting and views, and the extent to which the windows will be used for passive ventilation, may factor into the decision.

For example, daylighting requirements may dictate larger window size and a greater degree of fenestration on the south-facing wall. "This is especially the case where the interior of the building is being completely remodeled, and the opportunity to install a light shelf presents itself," says Lewis.

In a similar vein, you may want to use glass films, tint, or frit. "Structural silicone glazing options may also be considered due to their superior thermal performance over exposed mullion conditions," says Kalata.

Another major concern is *aesthetics,* which can swing the pendulum both ways. On the one hand, there may be a strong directive to maintain the façade's original look. "People are often creatures of habit when it comes to the existing window type," says RRJ's Lies. However, there are options, such as replicating a double-hung window with a casement using a "simulated divided lite" horizontal check rail bar. This gives the appearance of a double-hung with the functionality of a casement window, says Lies. Still, there is a point where some window styles simply become outdated and should be replaced.

Practicality is yet another important factor. For example, jalousie and awning windows cannot sustain hurricane-force winds in hurricane zones and need to be replaced with a different style of window, such as a single-hung or horizontal rolling window, says De La Guardia.

In cases where the original façade requires preservation, customized energy-efficient replacement windows or the addition of interior storm windows can help update performance. Newer products and technologies are also enabling architects to specify high-quality windows, even when program requirements are tight. For example, new materials and designs can provide the necessary narrow sightlines and unobtrusive hardware when an owner is being required to retain the appearance of hung windows in a building located in a historic district with tight preservation ordinances, says Lewis.

ENERGY EFFICIENCY, PLUS AESTHETICS

The reviews are mixed as to whether replacement windows can deliver both high performance and top aesthetics. For instance, highly energy-efficient windows require insulated glass lites that create a "chunky" look, says Magrino. Similarly, muntins, which lend an attractive, traditional look, may compromise performance.

"Every time you add a muntin or mullion into a window opening, you risk maintaining the exterior enclosure of the building," says Palmer. "The architectural and manufacturer details require careful review. Quality control is a must, as well as verifying that the installer maintains the thermal break."

Moreover, in specific regions such as coastal Florida, strict building codes and testing and certification requirements guide product selection, leaving little room for aesthetics, says De La Guardia. "Designers must choose from a list of approved windows which do not allow much deviation from the tested specimen," he says. "This consideration has almost totally eliminated the use of true muntins or colonial-type windows and doors due to their inability to sustain the impact forces required by code." He notes, however, that false or applied muntins are an option.

For building projects that are not subject to hurricane-zone requirements, energy efficiency does not have to come at the expense of aesthetics. "Muntins, for example, do not have to contact surface two or surface three of an insulating glass unit," says Lewis. "They

HOACHLANDER DAVIS PHOTOGRAPHY / COURTESY BELL ARCHITECTS

The rehabilitation and adaptive reuse of the Old Naval Hospital, Washington, D.C., has turned the national award-winning building into a vibrant cultural center. With updated windows, doors, trim repair, and new air, vapor, and thermal barriers, the LEED Silver building's measured energy use index savings is an impressive 67%.

BILL BRIGGS/COURTESY KNUTSON CONSTRUCTION

Skilled laborers replaced 2,300 windows and 1,006 patio doors at Riverside Plaza, Minneapolis (right), where exorbitant utility bills, caused in part by 40 years' worth of air and moisture leaks, have been reduced significantly.

can be properly clipped to the inside surfaces of the spacer to eliminate them as a thermal conduction path through the window."

With the availability of such products as solar-reflective paints, Lewis believes that designers can specify high-performance windows that also have an attractive appearance, style, and design. "Energy efficiency and aesthetics are not mutually exclusive," says Larson & Darby's Andrews. "Window manufacturers have been pretty responsive in producing windows that look good and are still efficient."

HISTORIC PRESERVATION: ADDING COMPLEXITY TO YOUR WINDOW PROJECT

Historic restoration projects can be especially difficult to navigate. At the earliest point in preplanning or schematic design, therefore, De La Guardia advises finding out if the project falls under the jurisdiction of the municipality's historic preservation board, which may have restrictions that directly contradict the local building code. Any conflicts will have to get sorted out, and submittals will have to be reviewed by all authorities having jurisdiction before proceeding further.

As far as the work itself, Building Teams should start by accurately measuring and photographing the existing windows, interior and exterior trim, rough openings, and wall thickness and composition. "There should be a plan for preserving items for reuse by careful removal and proper storage of all elements that are sound and can be reinstalled," advises Construction Consulting's Blackburn.

The survey should also verify if the old glass contains any tinting and should determine how the frames were installed. "Some old warehouse steel frames were set in place when the masonry walls were built," says Palmer. "In this case, the frames will have to be cut or ground out."

Windows and frames should be tested for hazardous materials. Older steel frames may contain lead paint, and older glazing materials may contain asbestos, says Palmer.

According to the Secretary of the Interior's Standards for the Treatment of Historic Properties, if the original windows still exist, they must be repaired and restored. Storm windows, additional weather stripping, or other changes that do not alter the original appearance of the windows can be applied to enhance performance, says Kenneth M. Itle, Senior Associate at Wiss, Janney, Elstner. In cases where the original windows no longer exist, the new windows should fit the original rough openings in the wall and match the style of operation, pattern of divided lights, and, if possible, the materials of the original windows, says Itle.

"One challenge with historic projects is the unknown," says Robert J. Verrier, FAIA, NCARB, Vice President and Managing Principal of The Architectural Team. Building Teams should make sure that the work contracts include contingency provisions. Verrier advises that a plan of action be created to address hazards that may crop up unexpectedly after construction has begun.

As AAMA's Dean Lewis notes, "Be careful where nails or screws are driven into the wall and how to go about demolishing both interior walls and the inside surfaces of exterior walls. Also, be cautious when using present-day materials and procedures with previous-era construction."

SECONDARY WINDOWS: ANOTHER ARROW IN YOUR FENESTRATION QUIVER

Secondary windows are second sets of windows installed on the interior side of existing windows. Architect David Bell specifies them for roughly a third of his firm's historic projects to gain energy performance, improve thermal comfort, and retain existing historic windows—such as single-glass, steel-framed windows—without altering the exterior.

More affordable than full window replacement, this approach can improve the windows' energy rating with less time disruption in the space. However, the windows can be difficult to clean and to open for ventilation, and they can sometimes be subject to moisture and dust infiltration through the existing sashes, says Bell. Adds Palmer, "Looking through two sets of windows may distort the view, and if some sort of airflow isn't maintained between the two window units, frost could build up on the exterior set during cold weather."

Furthermore, **secondary windows do not address the energy, air, water, or structural problems of the original window system.** "Though they may reduce energy and air/water infiltration, they do not eliminate or significantly reduce these problems the way a complete window system replacement would," says Johnston.

But they can save energy in historic buildings. According to a white paper (at: http://chicagowindowexpert.com/wp-content/uploads/2013/09/ENERGY-WHITE-PAPER.pdf) by building envelope consultant Mark Meshulam, supplemental window systems were modeled to reduce energy consumption in a 100,000-sf building with existing monolithic glass by 23-30%. The study found that supplemental window systems work best in cold climates with high local energy costs, but also perform well in temperate climates.

TECHNOLOGY KEEPS FORGING AHEAD

Recent advances in glazing technology can yield significant energy savings in window upgrades. These include:

- **Vacuum insulated glazing.** Delivering high R-values (approximately R12 per inch inside insulated glass units), the system removes air between the glass panes, thereby mitigating heat transfer through conduction and convection.
- **Vacuum insulated panels.** Offering thermal efficiencies of up to R30 per inch in a thin profile, so-called "VIPs" can be sandwiched between a glass lite and an interior metal facer so that they can be glazed into curtain wall assemblies, offering greater energy efficiency and possibly less condensation.
- **Warm edge spacers.** These products incorporate thermal breaks and metals or alloys that are less conductive than traditional aluminum, thereby reducing heat loss through edge effects.
- **Polyamide thermal breaks.** Thanks to the physical properties of polyamide materials, these thermal breaks perform better than conventional poured and debridged urethane thermal breaks.
- **Carbon fiber clips and pressure plates.** Currently offered in some curtain wall systems, these clips and plates deliver high thermal performance, translating into enhanced energy efficiency and reduced condensation potential.
- **Preformed silicone transition seals.** Typically installed at the perimeter of curtain wall frames, these seals effectively minimize air infiltration. They can be adhered to the surrounding wall system and attached and sealed to the curtain wall using manufactured extrusions, sealants, or special silicone shapes.

For use in hurricane zones, De La Guardia adds to the list special glass **interlayers**. These can maintain the integrity of the glass after it breaks. A structural silicone applied between the glass and frame enables the glass to remain connected to the frame.

REFINING THE WORK PROCESS

Beyond newer systems and technologies, Knutson Construction's Palmer stresses the importance of bringing in experienced building professionals to execute window retrofits. "Having a glass and glazing contractor and a project manager who understand the importance of the window system and how it interacts with the rest of the building envelope is key," he says.

Holding a **pre-installation meeting** with the architect, general contractor, and window contractor's installer should provide all parties with an understanding of how the system should ultimately perform, he adds.

Finally, **quality control** should be conducted to ensure that the installation is executed properly. To this end, Building Teams are using BIM-based virtual construction models to review construction-phase sequencing and assembly details. Construction services provider KBS (www.kbsgc.com) documented these steps in the retrofit of the Link Apartments Manchester project, a 187-unit, 180,809-sf multifamily residential project in Richmond, Va., which received National Green Building Standard certification.+

COURTESY J.E. BERKOWITZ

As part of the U.S. Department of Energy's Better Buildings Initiative and a DOE-funded window replacement study, 525 single-pane windows in a 40-year-old building in downtown Philadelphia were replaced with triple-glazed insulated glass units yielding more than 25% overall HVAC savings and up to 60% savings on the perimeter, depending upon the orientation.

WINDOW UPGRADES
yield proven performance

A U.S. Department of Energy Better Buildings Initiative project replaced 525 windows in a 40-year-old building in downtown Philadelphia and delivered DOE-measured HVAC savings of more than 25%.

The goal of this $1.6 million DOE-commissioned study, performed by Home Innovation Research Labs and Quanta Technologies, was to demonstrate the extent to which low-e retrofit glazing systems can improve energy efficiency in older commercial buildings. According to those involved, the project exceeded expectations.

"At more than 25%, the whole building's heating and cooling energy savings were significant and on par with what I expected, but frankly, I was surprised by how much the savings were in the perimeter offices—up to 60%, depending on orientation," says Thomas Culp, Project Manager, Birch Point Consulting, La Crosse, Wis.

For this 12-story, 20,000-sf office building, located at 400 Market Street, the old single-pane windows were replaced with triple-glazed insulating glass units. The building owner also qualified for a tax deduction of up to $.60/sf. The contractor succeeded in replacing 18,000 sf of glazing in just 50 working days. Because the building remained fully enclosed throughout the retrofit, work area disruption was minimal.

In order to quantify indoor comfort improvement in the study, one perimeter office facing east and one facing north was left untouched, while neighboring offices received window upgrades.

"The data showed that the surface temperatures of the retrofitted windows were typically 20°F warmer on winter days and 10-20°F cooler on summer days, substantially improving comfort and usability of the space," says Culp. Day-night temperature swings were reduced from 50°F to 20°F for east-facing windows, and from 20°F to 4°F for north-facing windows.

"As you can imagine, sitting next to inefficient glass can be cold in the winter and warm in the summer, potentially leading to discomfort and decreased productivity for whoever sits next to the window," says Carolyn Pfeiffer, Property Manager with Kaiserman Company, which owns 400 Market Street. "We've heard comments about how much more comfortable the building has been since the window replacement, and tenants on the lower floors have mentioned a decrease in street noise."

For more details on the DOE study, visit www.RBBwindows.com or go to: http://www.rbbwindow.com/wp-content/uploads/DOE_Performance_Comparison_400_Market_St_10_23_2013-Final.pdf.

> EDITOR'S NOTE

*This completes the reading for this course. To earn **1.0 AIA CES HSW learning units**, study the article carefully and take the 10-question exam posted at:*
www.BDCnetwork.com/UpgradingWindows