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In This Issue:

High-Performance Glazing: Making the Most of Today's Advanced Technologies

Today's designers can choose from an exciting array of high-performance glazing products. But with so many options available, selecting the right glazing for any given application is more complicated than ever.

If your glazing expertise needs a tune up, a good place to start is the Energy Design Resources design brief, *Glazing* (**www.energydesignresources.com/resource/20**). Another useful resource is the Web site *Windows for High Performance Commercial Buildings* (www.commercialwindows.umn.edu). Sponsored by the U.S. Department of Energy's Windows and Glazings Program, this Web site was developed jointly by the University of Minnesota and Lawrence Berkeley National Laboratory (LBNL).

Both publications emphasize that the best glazing selection for a particular application depends on many variables, including climate, building and window orientation, shading, and how the space will be used. With so many factors in play, it is impossible to provide one ideal glazing specification for all California buildings. Instead, designers should do a whole-building life-cycle analysis for each project that takes into account lifetime building energy consumption, daylighting utilization, and the value of cooling equipment displaced by more advanced glazing systems.

Interior view of the LBNL full-scale test facility with electrochromic windows at three different levels of transmittance: fully colored (left), colored partially (middle), and fully bleached (right). Photo courtesy of LBNL.

In many cases, selecting advanced glazing systems will create a cascade of benefits and savings. For example, glazing that reduces solar heat gain can lower air-conditioning costs. By lowering peak cooling loads, it may be possible to reduce the size of the mechanical system and its components. Smaller chillers, boilers, ducts, and fans could yield a notable reduction in capital costs.

If that advanced glazing also provides high visible transmittance (in combination with adequate glazing area), it can be used to illuminate interior

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Glazing and Title 24

California's Building Energy Efficiency Standards, commonly referred to as Title 24, sets minimum performance requirements for fenestration. In commercial buildings that follow the prescriptive approach to compliance, the 2005 Standards require that windows must have a U-factor no greater than either 0.47 or 0.77, depending on the climate zone.

The relative solar heat gain of the windows must be no greater than the values given in Tables 143-A, 143-B, or 143-C of the Standards. The relative solar heat gain values vary by climate zone, window-wall ratio, and window orientation. For details, download the Standards from **http://energy.ca.gov/title24/2005standards/index.html**.

The window performance data typically provided by glazing manufacturers are center-of-glass U-value and SHGC that do not include effects of the frame on overall window performance. Since 2001, however, Title 24 has required that window performance be evaluated as a whole, including the U-factor that includes frame effects. To help designers calculate the overall U-factor and SHGC of a window assembly, LBNL developed a software program, Window 5.2, which includes a current database of manufacturers' glazing data. It's available for free from **http://windows.lbl.gov/software/default.htm**. ■

spaces with daylighting. Automatic controls that switch or dim the electric lights in response to available daylight levels can potentially lower lighting energy use. The only way to thoroughly evaluate the interdependent effects of these measures is to conduct building energy performance simulations.

High-Performance Glazing Today

When it comes to glazing, the term "high performance" refers to a variety of technologies, as described below, that can be used alone or in combination to provide an array of benefits, including lower energy costs, enhanced daylighting opportunities, more comfortable spaces, increased productivity, improved durability, and better security.

Insulated Glazing, Edge Spacers, and Gas Fills

Insulated glazing units are constructed of multiple panes of glass with air spaces between them to improve the insulating value compared to single-pane glazing. Double-pane glazing has been in widespread use for many years; insulated glazing units with three or more panes are also available, and can be cost effective for commercial buildings in the hotter inland California climates.

Edge spacers hold the panes apart. A low-conductance, thermally improved spacer, also called a warm-edge spacer in cold climates, will help reduce heat losses and gains compared to traditional aluminum spacers.

The space between panes, normally filled with dry air, can be filled with a low-conductance gas such as argon or krypton to further reduce heat transfer. Gas fills are usually only justified for buildings that use large amounts of heating or cooling energy.

Low-E Coatings

Adding low-emittance (low-e) coatings can further reduce heat losses and gains in an insulating glass unit. The low-e coating is made by depositing very thin, transparent layers of metals or oxides on the glass. When a low-e coating is added to a conventional double-glazed unit, it provides thermal properties equivalent to triple glazing. Low U-value "superwindows," which are typically a combination of insulated glazing, low-e coatings, edge spacers, and fills, are traditionally used in cold climates but these windows can provide significant energy reduction and be cost effective in hot climates as well.

While conventional low-e coatings are primarily designed to reduce thermal transfer, spectrally selective low-e coatings also have the ability to reflect much of the infrared portion of the solar spectrum while transmitting most of the visible. A spectrally selective low-e glazing will let in more daylight than solar heat gain, and in cold climates has the added advantage of keeping warmth in the building in the winter.

New Options for Highly Insulating Glazings

Manufacturers are developing additional options for highly insulating glazings but most are not yet commercially available. Companies are now offering double-fiberglass glazing assemblies that are filled with a translucent insulation material such as aerogel. This foam-like substance consists of about 4 percent silica and 96 percent air. The microscopic cells entrap air, reducing heat conduction while allowing transmission of diffuse light. Other companies are working on transparent aerogel layers for use between glass layers. Researchers are also pursuing evacuated window technologies; these are insulating window units in which the space between the panes is a vacuum.

Framing Systems

Most glazing systems are held in place in the wall or façade with framing systems. Framing systems for curtain walls are typically aluminum. Aluminum alone is not a good insulator so thermal breaks can be added to the framing system to reduce energy transfer. Manufactured commercial windows have frames that are made of metal, wood, fiberglass, or hybrid designs.

Tinted Glazing

Traditional bronze and gray tinting have fallen from favor because although they slightly reduce solar gain, they greatly reduce visible transmittance, thereby diminishing daylighting opportunities. Today's high-performance tinted glass, which has a light blue or light green tint, offers both higher visible transmittance and a lower solar heat gain coefficient (SHGC). It can be combined with low-e coating to further improve performance.

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Events and Conferences

April 4–5, 2006

Ceres Conference 2006
Oakland, CA

Titled "Accelerating Sustainable Governance," this conference focuses on how sustainable governance builds shareholder value and promotes lasting prosperity.

www.ceres.org/events/conference

April 12–13, 2006

Green Construction 2006
San Jose, CA

Conference and exhibition focusing on the design and construction of environmentally friendly buildings.

www.greenconstruction2006.com

April 19–21, 2006

National Conference on Building Commissioning
San Francisco, CA

The commissioning industry's premier conference on how to make buildings work better.

www.peci.org/ncbc

Reflective Coatings

Reflective coatings are made by firing thin metallic or metal oxide layers onto clear or tinted glass. These coatings can provide the lowest solar heat gain, but as with tinted glazing, visible transmittance usually drops more than SHGC.

Plastic Films

As an alternative to triple- or quadruple-pane glass windows, which can be relatively thick and heavy, some manufacturers offer windows with a low-e coated, thin plastic film that is suspended between two panes of glass. This lowers the U-factor while providing favorable optical performance.

Laminated glazing is made by bonding a thin film of polyvinyl butyral (PVB) between two panes of glass to improve durability and safety. It is often used in applications where hurricanes, earthquakes, or bomb blasts are a concern.

Fritted Glazing

Fritted glazing has a baked-on ceramic coating that provides color and patterns. White is the most common color, but gray, black and metallic silver frits should be considered if reducing reflection is a concern. The darker frits can increase heat gain through absorption of solar gains.

Emerging Technologies

Researchers and manufacturers are developing a new generation of switchable glazings that hold out the promise of significant energy savings for commercial buildings. Often dubbed "smart windows," the optical properties of these dynamic glazing materials change as a result of changes in temperature, light, or voltage.

Electrochromic Windows

The most promising of these technologies for windows in commercial buildings seems to be electrochromic coatings, which have the ability to change from clear to a colored transparent state without degrading views. An electrochromic coating consists of multiple layers of very thin films, whose optical properties are controlled by applying a low voltage.

Electrochromic coatings can be used in combination with low-e coatings and insulating glass units to reduce heat transfer. Typical electrochromic windows have an upper visible transmittance range of 0.50 to 0.70, with a lower range of 0.02 to 0.25. The SHGC ranges from 0.10 to 0.50. Very low transmission levels (<0.001) are needed to provide full privacy and eliminate glare. High transmission levels can be used to allow in daylight during overcast periods.

Recently, LBNL completed an extensive field study on prototype electrochromic windows in a full-scale test facility at LBNL. "Electrochromic windows can play a significant role in reducing energy and peak demand in future buildings while delivering improved occupant comfort and amenity," says Eleanor Lee, co-principal investigator of the project, "as long as they are controlled and integrated properly with other building subsystems such as the electric lighting and mechanical systems."

High-performance glazing, as discussed above, can reduce solar heat gain and illuminate spaces with daylight. "Smart glazings," Lee says, "can optimize these interdependent effects in real-time under variable sun and sky conditions. The control algorithm is key to attaining a comfortable work environment and energy savings."

LBNL field data showed that if the electrochromic windows are controlled to maximize energy efficiency, average daily lighting energy savings ranged from about 10 to 45 percent, cooling load savings were 5 to 15 percent, and average peak cooling load reductions were about 20 percent compared to a more conventional but efficient system—a shaded, spectrally selective, low-e window with the same daylighting control system. Savings would be even larger if compared to a conventional code-compliant design. If the electrochromic windows are controlled for visual comfort as well as energy efficiency, these savings might decrease; the degree would depend on how one controls for visual comfort.

In the study, occupants judged the automated electrochromic window system

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as significantly more desirable than the reference window (a static high-transmittance window with manual Venetian blinds). Preferences were strongly related to perceived reductions in glare, reflections on the computer monitor, and window luminance. “Since occupants used blinds more frequently with the reference window,” says Lee, “the electrochromic system has the added advantage of providing views out for a larger percentage of the day.” Electrochromic windows, she notes, are expected to yield greatest energy efficiency and peak demand reductions in commercial buildings with large-area windows in hot inland regions of California.

Large-area electrochromic windows and skylights have just been introduced to the market and are available in sizes of up to 42 by 60 inches with on-off switching. Continuous modulation between the fully colored and bleached states is anticipated to be available shortly.

Other Smart Windows

Suspended particle devices are another type of variable-tint windows; however, their long-term durability is not yet proven. Other technologies in the works include photochromic windows that change transparency in response to light intensity, thermochromic windows that change transparency in response to temperature, and gasochromic glazing, which are darkened when diluted hydrogen is introduced into the window cavity. None of these emerging technologies have yet made it to market.

Another new technology is the liquid crystal device window, also known as switchable privacy glazing. In its unpowered state, the crystals are randomly oriented and block sunlight transmission and view; applying an electric field to the film aligns the particles and permits views out. Liquid crystal device windows are already on the market, although their SHGC remains high and considerable power must be used to keep them in their transparent state.

For more information about these advanced technologies, visit the Windows for High Performance Commercial Buildings Web site (**www.commercialwindows.umn.edu**).

Training Schedule

Partial list of upcoming classes. For a complete list, visit each utility’s website.

Date	Course	Time	Location	Units
Mar 7	*Building Commissioning*	8:30AM–12PM	ERC	3
Mar 9	*EnergyPro 4 Nonresidential Title 24 Updates*	9AM–3PM	San Diego	4.5
Mar 9	*Daylighting in Practice—Lessons from the Seattle Better Bricks Daylighting Lab*	9AM–4:30PM	PEC	6
Mar 9	*Basic Lighting for Commercial and Industrial Facilities*	8:30AM–12PM	Temecula	3.5
Mar 14	*Basic Lighting for Commercial and Industrial Facilities*	5:30–9:30PM	Yucaipa	3.5
Mar 14	*The Gas Company’s Energy Efficiency Expo 2006*	8AM–12PM	ERC	0
Mar 14	*Design Strategies for High Performance Glass*	9AM–12PM	CTAC	3
Mar 14	*Identifying and Assessing Common Retrocommissioning Opportunities*	9AM–4:30PM	PEC/ Internet	6
Mar 15	*Title 24 2005 New HVAC and Acceptance Test Requirements*	9AM–4:30PM	PEC/ Internet	6
Mar 16	*Basic Heating, Ventilation and Air Conditioning*	8:30AM–12PM	San Bernardino	0
Mar 23	*Basics of Photovoltaic (PV) Systems for Grid-Tied Applications*	9AM–4:30PM	Oakland	6
Mar 22	*Packaged Unit Heating, Ventilation and Air Conditioning*	8:30AM–4PM	CTAC	0
Mar 24	*Introduction to Life-Cycle Costing*	8:30AM–12:30PM	CTAC	0
Mar 29	*Energy 101*	8:30AM–12PM	Palm Desert	0
Mar 30	*Exceeding Title 24 for Schools*	9AM–1PM	PEC/ Internet	3.5

Training Locations

Location	Explanation	Phone	Website
CTAC	SCE’s Customer Technology Application Center, Irwindale	(626) 812-7537	www.sce.com/ctac
ERC	Southern California Gas Company’s Energy Resource Center, Downey	(562) 803-7500	http://seminars.socalgas.com
Oakland	Oakland City Hall	(415) 973-2277	www.pge.com/pec
Palm Desert	Palm Desert Chamber Building	(626) 812-7537	www.sce.com/ctac
PEC	PG&E’s Pacific Energy Center, San Francisco	(415) 973-2277	www.pge.com/pec
San Bernardino	San Bernardino County Business Resource Center	(626) 812-7537	www.sce.com/ctac
San Diego	SDG&E Century Park	(858) 636-5726	www.sdge.com/construction/ee_commercial_newconst_training.shtml
Temecula	Temecula Valley Chamber of Commerce	(626) 812-7537	www.sce.com/ctac
Yucaipa	Crafton Hills College	(626) 812-7537	www.sce.com/ctac