CODES AND COSTS PUSH TEAMS TOWARD sustainable enclosures

COURTESY PETER CHIPCHASE / ARUP

The new Abu Dhabi Investment Council Headquarters is housed in two 29-story towers clad with a dynamic exterior shading system, arguably the world's largest intelligent shading skin.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ DESCRIBE how stricter building codes and standards are affecting the design of building enclosures, enhancing energy efficiency and indoor environmental quality.
+ DISCUSS how window-to-wall ratios influence decisions for building enclosure design, with implications for sustainability and occupant well-being.
+ EXPLAIN net-zero building approaches and their implications for enclosure design, energy efficiency, and occupant health.
+ LIST types of façade products and active façade technologies and be able to describe potential costs and environmental benefits to Building Teams, owners, and end-users.

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

Stricter codes and standards, the net-zero energy movement, and responsive façade systems are driving change in building envelope design and detailing. Enclosures—the preferred term for exterior walls, roofs, and foundations as a system—are receiving an unprecedented level of attention.

Concerns about global climate change, building energy use, and operating costs have coalesced in new construction codes. Façades and fenestration have a major impact on heating, cooling, and lighting loads, which account for 57% of combined total energy use in commercial buildings, according to the California Energy Commission. Better enclosure design is one of the most significant ways to boost a building's energy efficiency. Façade consultants, building science researchers, and activist government jurisdictions are adding momentum to the quest for improved performance.

CODES IMPOSE INSULATION IMPROVEMENTS

With every revision cycle, codes and standards kick energy requirements up a notch, says Sarah K. Flock, AIA Associate, Senior Architect with architectural, structural engineering, and building science consultancy Raths, Raths & Johnson (www.rrj.com). "Changes in energy codes and standards continue to dramatically affect enclosure design," says Flock. "Specifically, ASHRAE 90.1 and the International Energy Conservation Code, or IECC, have increased thermal resistance requirements, lowered U-values for fenestration products, and included more developed provisions related to air tightness."

As with U-values, which describe the rate of heat loss for enclosure assemblies and materials, demands for reducing thermal transfer have steadily become stricter. For example, in 2009, the IECC added a continuous insulation requirement—abbreviated as CI or c.i. in some industry documents—for walls in climate Zones 3 and 4, a temperate band of states across the southern half of the U.S. Existing CI values for the more northerly Zones 5 and 6 were increased in the same revision.

As recently as 2009, ASHRAE 90.1 "Energy Standard for Buildings Except Low-Rise Residential Buildings" and the IECC both required minimum R-20 roof insulation in climate Zone 4. Last year, that spec was bumped to R-25, and 2012 updates also require continuous insulation on walls with light-gauge metal framing for most climates.

"The increased insulation requirements for walls and roofs mean that architects must rethink systems that have worked in the past," says Jonathan Baron, AIA, LEED AP, Associate, Shepley Bulfinch (www.shepleybulfinch.com). (The U.S. Department of Energy offers a helpful analysis of nuances in both ASHRAE 90-1.2010 and the 2012 IECC at: http://1.usa.gov/XlSivr.)

Faced with tougher insulation rules, some owners may contemplate a relatively easy approach: placing a new layer of rigid foam plastic insulation (such as expanded polystyrene) directly over the sheathing underlayment, in addition to the typical batt insulation faced with a vapor barrier. Not so fast, cautions David W. Altenhofen, AIA, East Coast Director with The Façade Group (www.facadegroup.com): "This creates a double vapor barrier and may trap moisture in wall assemblies, with unforeseen consequences."

Adding foam insulation also triggers the applicability of NFPA 285, "Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components." This important fire-safety check requires that exterior construction assemblies that could catch fire—including foam insulation boards—demonstrate their ability to limit vertical and lateral flame propagation.

MORE INSULATION CAN LEAD TO MORE COMPLEXITY

Demands for more insulation are chipping away at the concept of the "perfect wall," where an air and vapor barrier is installed on the sheathing, there is no insulation in the stud cavity, and all the insulation outboard of the sheathing is located in a cavity behind the cladding. "The increased levels of insulation required have led to architects putting insulation back into the stud cavity, with the consequent risk of condensation on the inside of the sheathing, unless there is a vapor barrier on the inside of the wall," says Richard Keleher, AIA, CSI, LEED AP, Senior Architect, The Thompson & Lichtner Co. (www.thompsonlichtner.com).

However, Keleher says, "The installation of an interior vapor barrier would lead to two vapor barriers, which should be avoided. Consequently, hygrothermal studies need to be done to assess the proper way to design this more complicated wall."

NFPA 285 not only applies to insulation boards but also to water-resistive barriers. Components must be tested for fire resistance as a full assembly, and many wall types have not undergone testing—except for systems from certain product manufacturers—because the test is costly and time-consuming. "These requirements are limiting the choice of materials, and making some of our old standby products obsolete," says Altenhofen.

According to Keleher, some assemblies that pass NFPA muster may include elements that are not desirable from a weatherproofing standpoint: namely, unreliable membranes and metal fire deflectors that disrupt the membrane flashings. Other assemblies may use inappropriate or less effective insulation "to avoid the need to comply with this test," says Keleher.

The use of low R-value insulation (some as low as R-3.5) obviously increases energy costs. Substitute insulation materials may be further compromised because they are air- and moisture-permeable, whereas some types of foam plastic insulation have an R-value of 5 and are both airtight and watertight.

Despite the difficulties, national and local standards and codes will undoubtedly continue to demand better enclosure performance, with the likely addition of new rules for measurement and verification of energy savings. This trend is already being seen in the latest generation of building certification programs.

"M&V will hold designers more accountable, so there will be more of an incentive to get the massing and orientation of a building optimized from the very start," says Matt Williams, Associate Principal and Façades Practice Leader with Arup (www.arup.com). "It will also encourage teams to select the right glazing and façade systems to minimize heating and cooling loads."

Some jurisdictions are making concessions that acknowledge the complexities of adding insulation, and providing incentives for compliance. A recent example is New York City, which has updated zoning regulations to allow owners to add up to eight inches to exterior walls, as long the project adds R-value, without including the additional square footage when calculating the building's maximum footprint or floor area ratio.

Codes and regulations are undeniably powerful, but operating costs and sustainability certification programs could be an even greater goad for owners of commercial and institutional properties. The most progressive owner-developers and Building Teams tend to view the relevant codes as a foundation rather than an upper limit.

"Although these transformations in building codes will improve building energy performance beyond today's standards, they are only part of a larger picture," says green building advocate Blaine E. Brownell, Assistant Professor in the School of Architecture at the University of Minnesota, Minneapolis. "After all, codes can only do so much, and we must not only seek incremental improvements, but also better holistic design thinking."

WINDOW-TO-WALL RATIOS UNDER SCRUTINY

Window-to-wall ratios are another subject of recent code changes, all of which tend to limit the use of exterior glazing. ASHRAE 90.1-2010's prescriptive requirements allow up to 40% WWR and 5% skylights as a percentage of the roof area. The 2012 IECC specifies an even more restrictive 30% WWR, and just 3% for skylights.

Experts note that these ratios are not a rigid rule. Building Teams can pursue a performance-based approach to enable larger proportions of fenestration. In these cases, teams must use modeling or calculations to show that their designs reduce whole-building energy consumption as much as a prescriptive approach.

"The prescriptive method can simplify the design process, but it may also offer less flexibility than other compliance options," notes Raths, Raths & Johnson's Flock, who chairs Chicago's Building Enclosure Council (BEC) group. (The BEC is an initiative of the National Institute of Building Sciences; 26 chapters exist nationwide, organized by local climate and market.)

Despite code changes, the architectural profession's love affair with the all-glass enclosure appears as strong as ever. To keep this choice viable, products like high-performance insulating glass units and materials such as low-emissivity glass are becoming standard. The Façade Group's Altenhofen, who chairs the Building Enclosure Council—National, says, "We rarely see anything but IGUs specified, and they almost always have a low-e coating of some sort. More projects are using high-tech low-e products, and sometimes double low-e coatings on both the number two and three surfaces of the IGU."

Altenhofen predicts further technological advances. "We've seen huge improvements over single glazing and even over IGUs of 20 years ago, but we still need better performance by utilizing triple glazing, electrochromic glass, and insulating translucent products such as nanogel-filled glazing."

Building Teams can take advantage of additional thermal-management strategies, including sunshades, light shelves, glass tinting, building orientation, and fritting and silk screening of IGUs. Arup often mixes glazing systems with more opaque, insulated elements, according to Williams. When shadowboxes are used with thermally broken frames and external shading, the façade can retain a glass-wall appearance with a lower WWR.

Client preferences are also morphing in specific market sectors. High WWR ratios are still common for office towers and residential high-rises. Owner-operated facilities such as institutions and public buildings are trending toward lower WWRs, coupled with more sophisticated façade designs and daylighting strategies, according to Susan Hayes, PEng, LEED AP, BD+C, Senior Project Engineer with RDH Building Engineering (www.rdhbe.com).

Flock points out that today's highest-performing glass still offers only a quarter of the insulating value provided by a well-designed opaque wall. Nevertheless, many building owners believe natural light is worth the effort and investment, since it plays such a prominent role in keeping employees happy and productive. According to Sue Klawans, Director of Operational Excellence and Planning, Gilbane Building Company (www.gilbaneco.com), "The key is to use a site-specific approach and not a one-size-fits-all mentality."

NET-ZERO MOVEMENT PROMPTS TECHNICAL ADVANCEMENTS

In tandem with stricter codes and standards, a growing focus on net-zero energy buildings will undoubtedly improve enclosure design. Shepley Bulfinch's Baron, who co-chairs Boston's BEC chapter under the auspices of the Boston Society of Architects, says, "Net-zero will

THERMAL MASS: An unsung hero of energy efficiency

With an increased focus on the R-value of building enclosures, it's important to not get caught up in an insulation metric and lose sight of overall thermal performance. Thermal mass, when properly exploited, can significantly boost energy efficiency due to thermal lag time: the structure's ability to absorb and store significant amounts of thermal energy.

Some wall designs, such as those using *insulated concrete forms* (ICF), don't fully leverage the potential of thermal mass, because the insulation's placement prevents the thermal mass from being exposed to the building's interior. On the other hand, high-performing insulated thermal mass can be achieved by using an insulated concrete block product with a continuous *expanded polystyrene* (EPS) insert separating the block's interior from its exterior, as opposed to a core-stuffed block.

A recent study by the Oak Ridge National Laboratory found that this insulation configuration is significantly more energy-efficient than conventional interior-insulated walls and ICF systems. The study (http://1.usa.gov/UXTdFA) tested six exterior wall configurations of concrete and insulating foam, finished with gypsum board and stucco, by modeling performance for six U.S. climate zones, measuring annual heating loads, annual cooling loads, and total annual energy demand. The difference between the least effective configuration (with all the insulation on the inside) and the most effective (all the insulation on the exterior) ran as much as 11% in some climates.

Structures built with insulated concrete block have been documented to yield HVAC energy savings of more than 60% compared with conventional wall systems, because the block significantly reduces natural temperature fluctuations inside the space.

An example of the importance of thermal mass can be found in a convenience store in Genesee, Pa., which installed continuously insulated concrete block in 1994. The owner is able to heat and cool the space for $0.31/sf.

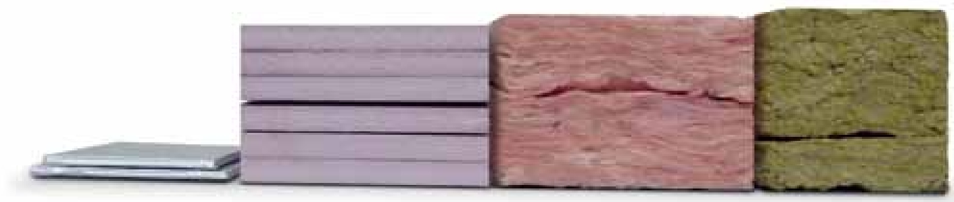
COURTESY NRG INSULATED BLOCK

Insulated concrete block with continuous insulation leverages thermal mass to achieve a high level of thermal performance. Such a system exploits the thermal properties of the building materials, resulting in significant energy savings.

The same building, theoretically built to LEED 3.0 standards with R-54 walls—10 inches of concrete and 10 inches of rigid EPS insulation exposed to the interior—was modeled to yield heating and cooling costs of $0.53/sf.

The moral of the story? R-value is not necessarily the best determinant of thermal effectiveness, and insulated thermal mass plays a significant role in driving thermal performance.

COURTESY SCHÖCK



COURTESY PANASONIC

New technologies for advanced enclosures, which can be particularly useful for net-zero energy buildings, include balcony thermal breaks (left) and super-insulating vacuum insulated panels (at the left in photo above). By reducing thermal and energy loss through the balcony, balcony thermal breaks can significantly improve building enclosure performance. The vacuum insulated panels are a fraction of the size of conventional insulation materials and offer extremely low conductivity.

be a huge push to make building enclosures better performing, since the enclosure design is a critical component of energy performance."

Essentially, net-zero design involves two steps: 1) reducing a building's inherent energy demand through design, and 2) generating efficient power so demand and supply reach perfect equilibrium. Because on-site energy generation and storage often come with a hefty price tag, restraining demand is a crucial and potentially more cost-effective strategy. "Building envelope design can make or break a net-zero project," says RDH's Hayes, who specializes in mechanical and electrical efficiency.

A net-zero building must be properly sited and oriented, and designed with compact massing, says Altenhofen. The next step is controlling heat gain and loss through well-deployed insulation and a carefully air-sealed enclosure. R-values for walls in net-zero buildings may exceed 60, with roofs approaching an R-value of 100.

To meet such extreme specs, Building Teams usually opt for windows and doors with very low air-infiltration rates, plus triple-glazed fenestration. "Unfortunately, there are not many U.S. window manufacturers that meet these requirements, so in some cases imported products are needed," says Altenhofen.

COURTESY CASCADIA WINDOWS

Fiberglass thermal clips installed on stud walls work to thermally isolate the cladding from the structure, significantly reducing insulation losses caused by thermal bridging and improving energy performance.

More domestic vendors are gearing up to create appropriate systems. In particular, Hayes is impressed with super-insulating vacuum insulated panels, balcony thermal breaks, and thermal clips for exterior walls. "Super-insulating panels are a modern type of insulation that have very low conductivity, which makes them great thermal insulators," says Hayes. "They typically consist of a low-conductivity core—like a honeycomb—wrapped in a protective barrier, with the air vacuumed out." Touted as achieving thermal performance values up to 38 times greater than glass wool and about 20 times greater than hard urethane foam, some super-insulating products are claiming R-values of up to 60.

Balcony thermal breaks extend from the floor slab to serve as a bridge to the wall's insulation. Normally, balconies increase heating demand by about 9%, according to a recent RDH study involving high-rise residential buildings in cold climates. Thermal breaks can minimize thermal outflow and energy loss through the balcony slab, and reduce the risk of condensation and mold formation.

Another source of thermal loss occurs through z-girts, which are commonly used to attach exterior wall assemblies to the structure. By bridging the insulation, conductive fasteners can actually lower the walls' stated R-value by more than 50%, according to Hayes. As an alternative, designers can specify nonconductive spacers, or thermal clips, made from fiberglass or similar materials to thermally isolate the cladding from the structure. These products significantly reduce thermal bridging.

ACTIVE FAÇADES BLEND FUNCTION, APPEAL

Building Teams that want to create sustainable enclosures have numerous new products to choose from choices, adding exciting options but also complexity. Components of emerging active façade systems include motorized and automated solar shades, hoppers for venting, and media walls that display entertainment or information.

As an example, the University of Minnesota's Brownell points to the SolPix media wall system, designed by German architect Simone Giostra. "His latest version integrates a variety of new technologies, such as photovoltaics, LEDs, light sensors, and sun-shading capabilities, to create a true high-performance enclosure system," says Brownell.

Giostra's most prominent project, the SolPix/GreenPix Zero-Energy Media Wall at Beijing's Xicui Entertainment Complex, is an energy-efficient curtain wall that combines solar power generation, sun shading, and a dynamic digital screen. The wall can display videos, interactive performances, and live and user-generated content. It is billed as the "world's largest LED color display," with 2,292 RGB LEDs lighting up a 24,000-sf surface.

Together with Arup, Giostra's team developed a new technology to laminate polycrystalline photovoltaic cells into the glass curtain wall. Strategically placed with varying densities on the building skin, the PV cells function as a shading element and use solar energy to help power the media wall. The enclosure also benefits from a high-performance thermal management system.

Intra-panel sensors measure atmospheric conditions such as wind pressure and solar variation, which are translated into what Giostra calls "animatronic reactivity." The resulting display offers "real-time interactive animations that transform the building façade into a responsive environment."

Another Arup active façade project, in collaboration with the international architecture firm Aedas, is the recently completed Al Bahar Towers, headquarters of the Abu Dhabi Investment Council. The 29-story twin towers feature a dynamic intelligent shading system, which provides a striking aesthetic element. Translucent geometric shade panels cover the south, west, and east elevations, forming decorative patterns as they open and close. The design echoes a *mashrabiya*, a traditional element of Arabic architecture consisting of a projecting oriel bay window covered with carved wooden latticework.

The intelligent shading system, with each panel driven by a linear actuator, is so effective that the Building Team was able to specify clear, rather than tinted, glass. Because solar conditions are highly predictable in Abu Dhabi, each shading unit is programmed to open and close at set times.

"The sequencing of opening and closing is calculated to limit the solar energy on the façade to predetermined values," says Peter Chipchase, MEng, CEng, MICE, MIStructE, PE, Associate Director with Arup. "This is to achieve target reductions in overall cooling loads and energy consumption."

Overall, the assembly reduces solar heat gain by 50%, cuts carbon emissions by 40%, and significantly reduces cooling plant capital costs. The Council on Tall Buildings and Urban Habitat gave the sunscreen its Innovation Award last year.

Creating active façades is a daunting task, says Williams. "Success requires an understanding of complex forms through three-dimensional analysis, an understanding of the uses and limitations of potential cladding materials, and an understanding of cladding systems and their integration with the other building systems to ensure that these systems can be documented and reliably delivered wherever that building may be located."

Not all projects are so massive, however. Small-scale smart shading systems are showing up on public, institutional, and corporate buildings around the U.S. For the Carle Heart and Vascular Institute, under construction in

Navigating the treacherous GREEN BUILDING PRODUCT WATERS

Building Teams striving to create sustainable enclosures can take advantage of many new product options coming to market, regardless of whether they are trying to meet a specific sustainability standard. "Even if it is not a project's goal to be a LEED-certified building, our clients, construction managers, engineers, and architectural teams often determine together, for example, to save energy and costs for the manufacturing and shipping of cladding materials by choosing locally manufactured materials," explains Jane Galli, AIA, LEED AP, Associate, Shepley Bulfinch.

Demand is also creating more competition and, ultimately, more sustainable products. However, the smorgasbord of green, high-performance products can also be confusing. "The increase in number of products does create more of a challenge to industry professionals and owners making decisions due to the lack of a single certifying or regulatory body," says Susan Hayes, Senior Project Engineer, RDH Building Engineering.

"Making proper product selections is very difficult," agrees David W. Altenhofen, East Coast Director with The Façade Group. "There are so many product rating and certifying programs that it is nearly impossible to know whom to trust. We are trying to focus on rating programs that emphasize maximum reduction of operational energy, compared to embodied energy. Others have differing and valid criteria, such as chemical sensitivity and pollution during manufacturing."

Blaine E. Brownell, Assistant Professor in the School of Architecture at the University of Minnesota, and a respected scholar of advanced materials for architecture, sees materials and enclosure design dovetailing for greener facilities. For the best building performance, teams must find ways to synthesize energy assessments of the enclosure design and analyses of products' material characteristics. "Currently these areas are treated separately for the sake of simplicity, but they will increasingly intersect," says Brownell, a BD+C "40 Under 40" honoree.

In addition to a plethora of product choices, new certification programs, such as the Certified Sustainable Building Advisor, are coming to the fore. "The movement is evolving. It's not only about LEED anymore," says Sue Klawans, Director of Operational Excellence and Planning, Gilbane Building Company. "We are focusing on the life cycle of the building and reasonable facility operating costs."

Brownell predicts that the industry will eventually move to a performance-based model, rather than fixating on LEED and some other environmental checklist systems that are predominantly prescriptive. "Then, the design team will have more freedom to devise its own ways to meet important energy and material benchmarks."

Urbana, Ill., Shepley Bulfinch designed a system that adjusts interior shading devices in a double-height lobby. The technology works with roof-mounted radiometers that monitor sky conditions and trigger the appropriate shading response.

Active façade design is still in the formative stages, with Building Teams working to balance benefits and costs. Ironically, some venerable design strategies may prove just as important as high-tech solutions.

Altenhofen is a fan of giving end-users more control so they can "intelligently" operate their own buildings. "These days, we are looking at going back to the oldest and simplest solution: operable windows controlled by the occupants," he explains. "We are trying to use email and text-messaging to suggest to the occupants when it would be good to open or close their windows in response to the current outdoor conditions. I think this is a more realistic approach and reflects a general trend away from hermetically sealed and mechanically controlled buildings."

In fact, façade design must balance a wide range of integrated, multidisciplinary skill sets to truly provide a holistic solution, says Williams. Though energy codes and sustainably minded building owners may push for the highest performing façade solutions, practical concerns are always part of the mix.

COURTESY SIMONE GIOSTRA & PARTNERS ARCHITECTS

Combining a high-performance curtain wall, photovoltaics, LEDs, light sensors, and sun shading, the SolPix/GreenPix Zero-Energy Media Wall at Beijing's Xicui Entertainment Complex is also a dynamic digital screen capable of playing videos and other themed content. Some images offer a graphic interpretation of real-time climate conditions.

Minnesota project combines FAÇADE TECHNOLOGIES

The new Anderson University Center at Hamline University, St. Paul, Minn., incorporates a high-performance envelope, using Old World materials in a modern context. The façade is primarily terra cotta, plus a secondary zinc metal panel system, an insulated backup wall, and a curtain wall system. With an R-22 wall assembly, an R-37 roof assembly, neutral low-e insulating glass, and a window-to-wall ratio of 29%, the high-performance design cost an additional $93,391. The investment was offset by a utility rebate of $23,240 and annual energy performance savings of $35,429, for a relatively quick, two-year payback.

The bright red-orange terra cotta tiles, at 30 inches by 9 inches, were easily installed and offer low maintenance and durability. "The resulting façade has open joints that operate as part of a pressure-equalized rainscreen system," says Design Architect Luke Voiland, AIA, Shepley Bulfinch. "This eliminates the maintenance required by brick systems—for example, tuckpointing, washing—or the resealing required with barrier systems like precast and some metal panel systems."

Completing the façade are nine-inch horizontal zinc panels, which lend a modern metallic look and serve as the outer layer of the rainscreen system. Because zinc is highly reactive with a number of common building materials, Shepley Bulfinch worked closely with the contractors and zinc manufacturer to understand which materials could and could not be in contact with the zinc.

The backup wall incorporates two types of insulation, in response to the harsh climate. Outside the vapor barrier is a 2.5-inch layer of mineral fiber, and within the stud space, there is an additional layer of spray foam insulation. According to Voiland, Shepley used THERM to evaluate thermal bridging and WUFI analysis to ensure no condensation would form in the wall.

Although the curtain wall system is curved, the design team worked diligently to create radiuses that could be achieved by a standard catalog of glass shapes, holding the line on costs. Similarly, the architects selected a standard five-foot-wide-panel, simplifying purchasing and construction.

The Building Team took advantage of a local rebate program that provided free energy modeling and analysis in exchange for hitting energy-use benchmarks. "This resulted in several modifications to the building, including slightly higher window sills, enhanced lighting, and mechanical systems," says Voiland.

Another notable feature of the enclosure is a solar panel array on the south elevation and roof. For aesthetic and functional reasons, the architects proposed a vertical array, which ultimately required close collaboration with the PV manufacturer to achieve a cost-effective mounting strategy.

COURTESY SHEPLEY BULFINCH

A curved curtain wall, terra cotta cladding, and a zinc metal panel system adorn the façade of Anderson University Center at Hamline University in St. Paul, Minn.

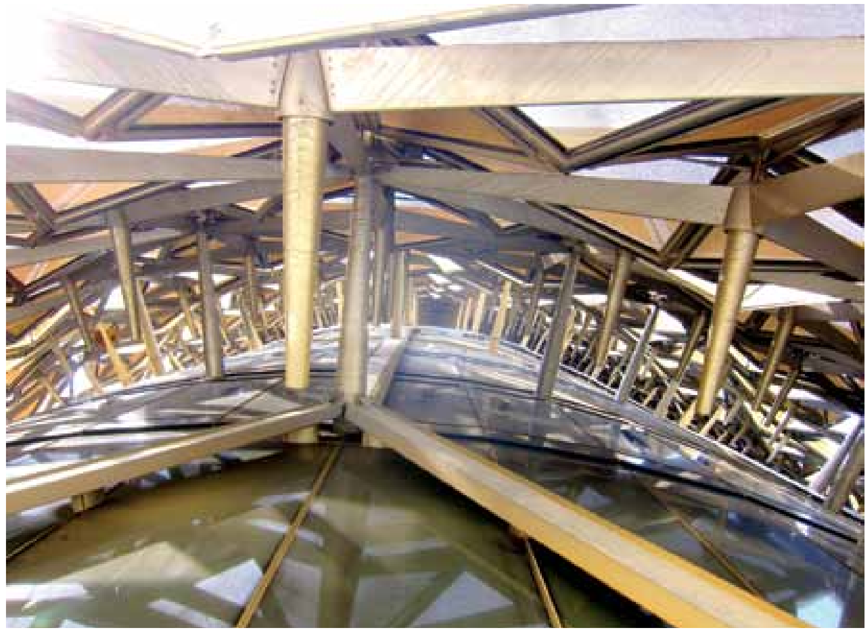
PROGRESSIVE OWNERS: A KEY INGREDIENT

In the end, as with many design decisions, a building owner with a firm grasp of life cycle benefits may be the sustainable enclosure's best advocate. For instance, The Façade Group is working on a new construction project for an anonymous client in which all the glazing, framing, and insulation was carefully evaluated to create a high-performing enclosure. Triple-glazed glass with a double low-e coating is installed in high-performance curtain wall frames, with high-quality thermal breaks and low-conductance pressure plates.

"The glass alone approaches R-8, which is nearly as good as what we used to expect from walls with R-19 batts installed between metal studs," says Altenhofen.

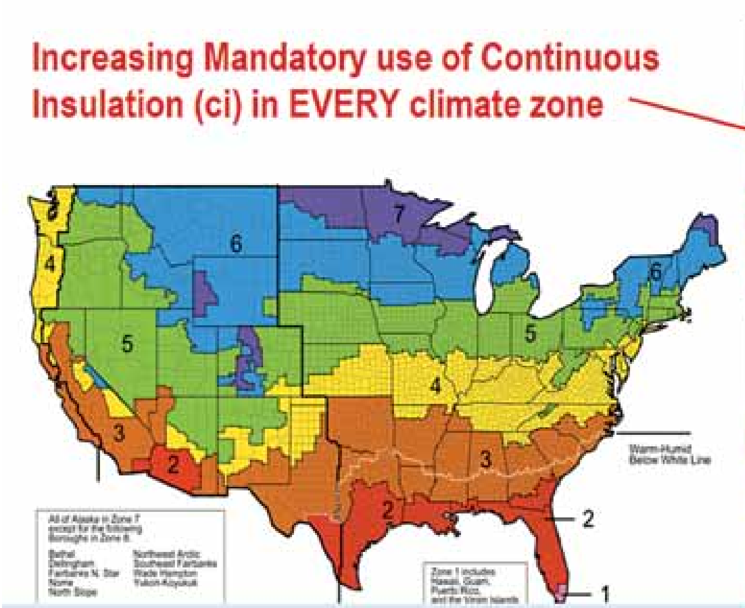
The building's south façade has an extensive curtain wall to maximize daylighting, views, and a connection to the surrounding campus, but glass was limited on the other three facades, producing an overall window-to-wall ratio of around 40%. "Consequently, the heat gain/heat loss scenario is much better, and indoor occupant comfort is improved, with less radiant loss and reduced convection drafts," Altenhofen says.

The high cost of the triple glazing was substantially offset by the engineers' ability to eliminate baseboard fin tube radiation and downsize the HVAC systems. Because the owner grasped the big picture, a highly efficient enclosure was created. Says Althenhofen, "The payback based solely on energy savings is still longer than what developers aim for, but the long-term institutional owner found it to be a preferred solution."



COURTESY PETER CHIPCHASE / ARUP

A section view of the Abu Dhabi Investment Council project (also known as the Al Bahar Towers) shows how the translucent shading panels are affixed to the façade. Linear actuators are programmed to open and close each panel based on well-known local climate patterns.



Climate Zone	IECC 2009	IECC 2012
8	R13 + R7.5ci	R13 + R7.5ci
7	R13 + R7.5ci	R13 + R7.5ci
6	R13 + R7.5ci	R13 + R7.5ci
5	R13 + R7.5ci	R13 + R7.5ci
4	R13 + R7.5ci	R13 + R7.5ci
3	R13 + R3.8ci	R13 + R5ci
2	R13	R13 + R5ci
1	R13	R13 + R5ci

Climate Zone	ASHRAE 90.1 2007	ASHRAE 90.1 2012
8	R13 + R7.5ci	R13 + R18.8ci
7	R13 + R7.5ci	R13 + R12.5ci
6	R13 + R7.5ci	R13 + R12.5ci
5	R13 + R7.5ci	R13 + R10ci
4	R13 + R7.5ci	R13 + R7.5ci
3	R13 + R3.8ci	R13 + R5ci
2	R13	R13 + R3.8ci
1	R13	R13

SOURCE: U.S. DEPARTMENT OF ENERGY/INTERNATIONAL ENERGY CONSERVATION CODE

As shown by this side-by-side comparison of IECC 2009 and IECC 2012, and AHSRAE 90.1 2007 and ASHRAE 90.1 2012, continuous insulation values requirements are continuing to increase.

BECs PROVIDE expert advice

Building Teams can often benefit from outside expertise when grappling with enclosure design and construction. Notably, the national network of Building Enclosure Councils (www.nibs.org/?page=bec) is gaining traction as codes, technology, and client preferences morph. What started as a grassroots movement of architects and building scientists has blossomed into more than two dozen chapters, with participants from the architectural, engineering, construction, and manufacturing communities. Most groups meet monthly to share best practices and educate members on the latest research, building materials, construction methods, and building code changes.

"BECs are increasing the industry's awareness of the need for early energy/building physics analysis of the façade systems under consideration, given how this can impact the architectural design/aesthetic, and the options available to overcome obstacles," says Arup's Matt Williams.

One of the movement's strengths is the local-chapter structure, allowing professionals to address unique aspects of their markets and climates. "For example, the discussions in the Boston BEC might focus on insulation in a heating climate, while the Miami BEC might focus on hurricane resistance and shading in a cooling climate," says Jonathan Baron of Shepley Bulfinch.

Some firms have begun to strongly encourage employee participation in BECs. "Gilbane University, our internal training organization, has developed a plan around our Building Envelope Managers throughout the company," says Sally Klawans, who is a National Institute of Building Sciences board member. "This plan includes Building Enclosure Council membership as well as the Building Envelope Design Guide, which is part of NIBS's Whole Building Design Guide; Air Barrier Association of America auditor training; and other training focused on the enclosure."

While much is going on locally, Klawans sees a need to better capture the resulting expertise. The *Journal of Building Enclosure Design* and the Building Enclosure Technology and Environment Council's annual Building Enclosure Science & Technology (BEST) Conference are steps in the right direction, she says, but the NIBS is pursuing other measures to disseminate more information to a national audience.

Blaine E. Brownell, Assistant Professor in the School of Architecture at the University of Minnesota, Minneapolis concludes, "Building construction has become such a complicated endeavor—especially concerning building enclosure design and construction—that BEC groups provide a welcome service to architects, engineers, and contractors."

> EDITOR'S NOTE

This completes the reading for this course.
*To earn **1.0 AIA/CES HSW/SD learning units**, study the article carefully and take the exam posted at:*
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AIA/CES MODULE

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1. In 2009, the International Energy Conservation Code added a continuous insulation (CI) requirement for enclosures in climate Zones 3 and 4. In the more northerly Zones 5 and 6, CI values were:
   A. Eliminated C. Also added to IECC
   B. Reduced D. Increased
2. The standard NFPA 285 is important for building life safety when enclosure cladding contains foam insulation or other defined combustible components. The standard requires testing to show that the wall assemblies are able to:
   A. Reduce only vertical flame propagation
   B. Eliminate all flames and smoke
   C. Limit vertical and lateral flame propagation
   D. Withstand fire for at least 2 hours
3. For window-to-wall ratio (WWR) recommendations, how do the ASHRAE 90.1-2010 prescriptive standards compare with the IECC's requirements?
   A. ASHRAE 90.1 is more restrictive for WWR.
   B. IECC is more restrictive for WWR.
   C. ASHRAE and IECC are essentially equivalent.
   D. Neither offers guidance or rules for WWR.
4. The prescriptive rules for window-to-wall ratios in current energy codes and standards help simplify calculations of how much fenestration area can be used, but larger areas may be allowed by using:
   A. Net-zero energy building approaches with energy modeling
   B. Triple-glazed insulated glass units (IGUs) as BIM objects
   C. A performance-based design approach without energy modeling
   D. A performance-based design approach with energy modeling
5. True or False: High-performance glass wall assemblies can significantly reduce energy needs, and can match more than 75% of a well-designed opaque wall's insulating value.
   A. True B. False
6. Net-zero energy goals can affect building enclosure design in two ways. Which are they?
   A. Reducing the window-to-wall ratio (WWR) and increasing R-value
   B. Increasing the window-to-wall ratio (WWR) and reducing R-value
   C. Reducing energy load and increasing power generating features
   D. Increasing energy load and reducing power generating features
7. Balcony thermal breaks, which extend from the floor slab and serve as a bridge to the wall's insulation, help reduce energy needs because in colder climates balconies can:
   A. Increase the required heating energy
   B. Increase solar heat gain
   C. Increase building insulation effectiveness
   D. None of the above
8. Building Enclosure Councils, which encourage better design of the envelope, include about two dozen U.S. chapters, organized by:
   A. Types of materials and products
   B. Local climate and market
   C. Different enclosure topics, such as air barriers
   D. None of the above
9. The Abu Dhabi Investment Council Headquarters, Al Bahr Towers, features an active façade system that suggests an Arab *mashrabiya*, a traditional element of Arabic architecture that effectively:
   A. Reduces window area when needed to block solar gain
   B. Increases the reflectivity of the building enclosure
   C. Adds insulation as needed to boost R-values
   D. Allows building occupants to see outdoors
10. Super-insulating vacuum insulated panels (VIPs) provide good thermal protection thanks to their low-conductivity core, achieving high thermal performance. Compared with urethane foam and glass wool, R-values of VIPs are:
    A. About the same
    B. About two times greater
    C. About 10 times greater
    D. About 20 times greater or more