

The BNP Curve in Paris features a more than 100,000-square-foot facade that allows the interior to be flooded with natural daylight. The insulating glass includes transparent and highly selective solar control glass from Saint-Gobain and warm-edge 16-millimeter Super Spacer Triseal Premium Black Plus from Edgetech/Quanex Building Products. The architect was Chartier Dalix Architects.

# All About Glass & Metals: Guide for Architects

## The High-Performance Facade Equation

Sponsored by the National Glass Association | *By Katy Devlin*

**T**he high-performance facade equation is a challenge to solve. Design and project teams must weigh a myriad of factors to develop facade systems that meet next-level energy efficiency requirements, optimize whole-building performance, provide a healthy and comfortable environment for occupants, achieve increasingly important sustainability and carbon-reduction goals, meet budget, and more.

The good news for the building industry is that glass and glazing technologies exist to meet even the most stringent performance goals. “We can get to the point where the facade glazing systems can be better than the insulating opaque wall for any location, any orientation, any glass area,” according to Stephen Selkowitz, principal, Stephen Selkowitz Consultants, affiliate, Lawrence Berkeley National Laboratory, speaking during a presentation at the January NGA Glass Conference: Long Beach. However, meeting the wide-ranging

goals for performance comes with mighty challenges. “This is not easy,” and it can be expensive, says Selkowitz.

The National Glass Association and Glass Magazine’s 2022 All About Glass & Metals: Guide for Architects takes a closer look at three essential elements to the high-performance facade equation. Part 1: Performance, explores the often-overlooked topic of thermal bridging in the facade; Part 2: Products, looks at innovations in insulating glass technologies; Part 3: People, considers balancing daylighting and glare to optimize occupant comfort and wellness; and Part 4: Payback, answers three key performance cost-benefit questions.

This article is part of the National Glass Association’s and Glass Magazine’s in-depth All About Glass & Metals series for architects and specifiers. The complete series also addresses considerations for protective glazing, interior glass, glass and glazing specifications, complex facades, and more.

### CONTINUING EDUCATION

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#### Learning Objectives

After reading this article, you should be able to:

1. Discuss how new glass and glazing techniques can support energy-efficient building requirements and meet sustainability and carbon-reduction goals in a variety of project types.
2. Identify innovations in insulating glass technologies used in the highlighted projects to provide a healthy and comfortable building environment.
3. Explain the importance of thermal bridging in the facade, how metal penetrations in wall assemblies can significantly reduce the effective R-value of the wall insulation, and the role that glass and glazing products play in helping to mitigate potential issues.
4. Describe the balance of daylighting and glare to optimize occupant comfort and wellness, as well as performance and cost benefits of specific glass and glazing techniques.

To receive AIA credit, you are required to read the entire article and pass the quiz. Visit [ce.architecturalrecord.com](https://ce.architecturalrecord.com) for the complete text and to take the quiz for free.

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## PART 1: PERFORMANCE

### THE IMPORTANCE OF THERMAL BRIDGING

“Thermal bridging is a big deal. It is the silent degrader,” said Helen Sanders, leader in strategic business development for Technoform, during the meeting of the energy group of the NGA Fabricating Committee during the NGA Glass Conference: Long Beach held in January.

Thermal bridging occurs when building exterior cladding or structural components with higher thermal conductivity penetrate or bypass insulation, thus creating a path of least resistance for heat transfer. For example, a steel beam or balcony penetrating the wall insulation will create a path for heat transfer. This pathway could lead to heat loss and decreased energy efficiency as well as potential cold points that can lead to condensation within the building envelope on exposed, interior surfaces.

“We’re not talking about thermal bridging in the frame. That is accounted for with U-factor,” described Tom Culp, owner of Birch Point Consulting, during the conference. “This [is] about how [heat transfer] bypasses insulation in a building. ... It’s about alignment between the wall and the windows.”

In wall assemblies, metal penetrations can significantly reduce the effective R-value of the wall insulation. For fenestration assemblies, the potential for thermal bridges may occur where the window framing meets the surrounding wall if the surrounding insulation layer is bypassed.

Source: Adapted and excerpted from the “Thermal Bridging Considerations at Interface Conditions Design Guide,” published in January by the National Glass Association.

### Thermal Bridging in the Codes

Model energy codes typically address the performance of individual components in the building envelope. This includes the U-factor and solar heat gain coefficient of fenestration products as well as the R-value of opaque wall construction and roofing assemblies.

Model energy codes typically have not addressed the intersections of these components or penetration of the insulation; however, as they increase in overall stringency, some codes are beginning to address thermal bridging. For example, the Seattle Energy Code increases the amount of continuous insulation required in opaque wall construction based on percent area of metal penetrations compared to a wall with minimal metal penetrations (or thermal bridging). Energy codes in Vancouver and New York



The interior of the new Fayetteville High School in Fayetteville, Ark., is illuminated by 28,000 square feet of curtain wall and 14,000 square feet of storefront glass, creating an open, airy design that helps foster a healthy environment for students and teachers.

City require that thermal bridging details be identified on drawings and be accounted for in all performance modeling.

Most notably, ASHRAE 90.1 has been working on comprehensive new requirements to mitigate thermal bridges in many areas including roof edges, parapets, intermediate wall edges, balconies, masonry shelf angles, and the wall-to-fenestration intersection. These requirements will apply to colder regions (ASHRAE’s climate zones 4-8) and are anticipated to be included in the 2022 edition of ASHRAE 90.1, which will also be referenced in the 2024 International Energy Conservation Code (IECC).

### How to Account for Thermal Bridges

The energy codes account for thermal bridges in two ways: simple prescriptive strategies and more complex modeling.

The simple approach can be deduced to a basic concept of a “thermal line” or “thermal plane.” Just as designers and engineers look for a continuous line connecting the constructions to form the primary air and water barriers, they should also now look to construct a continuous thermal line connecting the insulating materials across the transition details from fenestration to surrounding construction to create a “thermal barrier” between components.

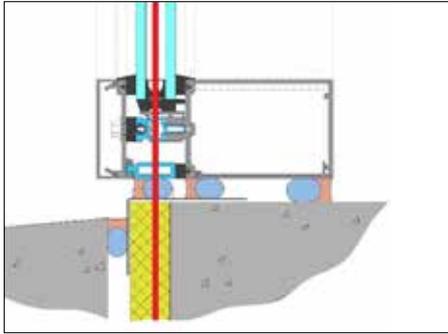
This results in different simple prescriptive strategies, shown in the diagrams pictured.

### Strategies to Consider

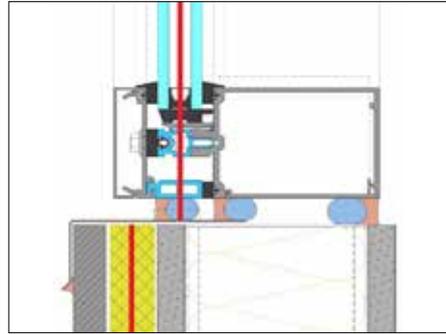
For fenestration assemblies, whether a punched opening window or a curtain wall, the concept of a “thermal line” leads to the ideal scenario: alignment of the insulating glass units, thermal breaks within the frame, and insulation in surrounding construction without any significant bypasses. This ideal is not always possible when considering the many functional design requirements regarding structural support, water management, etc. However, better alignment will generally result in less thermal heat loss and an improved (lower) psi-factor.

The simplified prescriptive requirements proposed for ASHRAE 90.1 also try to encourage this practice of alignment and/or a continuous thermal line as much as possible. ASHRAE 90.1’s primary requirement is to align the glazing layer within 2 inches of the wall continuous insulation (e.g. mineral wool or insulating foam board), or within 2 inches of the exterior side of the cavity insulation where there is no continuous insulation. Ideally, thermal breaks within the frame are also aligned with the glazing, and the benefit from doing so will be reflected in the lower U-factor

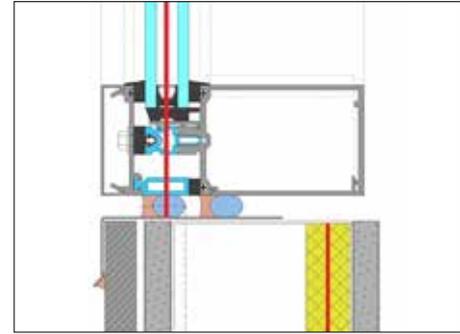
Photo courtesy of Kawneer



**Efficient:** Well-aligned glazing without conductive bypasses (thermal line illustrated in red).



**Regular:** Misaligned glazing and minor conductive bypasses (thermal line illustrated in red).



**Poor:** Cavity-insulated and conductive bypasses (thermal line illustrated in red) The energy codes account for thermal bridges in two ways: simple prescriptive strategies and more complex modeling.

rating for the product.

Aligning the glazing system and the wall insulation is not always possible because of functional considerations such as structural design or simply for design aesthetics. Therefore, ASHRAE 90.1 also includes other options for recessed windows or offset construction. In that case, the goal is to continue the thermal line from the continuous insulation to the window framing, covering any exposed area with insulating material with R-value greater than 3 or thermal conductivity less than 3.0 Btu-in/h-ft<sup>2</sup>-°F (this would also include the option to mount the fenestration within a wood buck). It is not required that the insulation be under the frame, as careful consideration must be given to the attachment and support of the window, as well as proper water drainage.

In all cases, the intent is to maintain a continuous thermal line, as much as possible, to minimize interruption of the thermal line, thus creating “thermally bridged” details. However, there are many other issues that must also be considered at the same time.

### More from the Design Guide

Download the complete design guide at [glass.org/store](http://glass.org/store) for definitions of the two thermal bridging characterizations, linear and point; a breakdown of complex thermal bridging modeling; diagrams and photography depicting thermal bridging concepts; and strategies for edges and perimeters. The guide also explores the responsibility of designers to indicate thermal lines in construction drawings, and the responsibility of fenestration industry companies to provide an overall energy rating for a glazing system.

## PART 2: PRODUCTS

### NEW IGU TECHNOLOGIES FOR CARBON REDUCTION AND NET-ZERO ENERGY

The last year has witnessed increasingly ambitious plans from organizations on the global, national, and state levels to meet carbon-neutral, net-zero goals in the next several decades. These plans look at “how we get to 2030, 2040, 2050 with some variant of carbon neutral, or net zero, or half reductions in carbon,” according to Stephen Selkowitz, principal, Stephen Selkowitz Consultants, affiliate, Lawrence Berkeley National Laboratory, speaking during the NGA Glass Conference: Long Beach.

To reduce carbon emissions and meet these benchmarks, the building sector must be addressed. “Buildings are about 50 percent of the problem [with emissions] when you look at embodied energy and carbon in construction,” Selkowitz says. “If we’re going to solve the big-picture global and national energy and carbon problems, buildings are going to have to be part of the solutions... And windows are a big part of this.”

Source: Based on a presentation at the NGA Glass Conference: Long Beach by Stephen Selkowitz, principal, Stephen Selkowitz Consultants, affiliate, Lawrence Berkeley National Laboratory.

### Opportunities of Retrofit

Window performance improvements are often focused on new construction. However, Selkowitz says the existing building stock provides the largest opportunity for performance improvements on a wider scale.

“If we’re going to get to 2050 [emissions goals], we have to address existing buildings. We can’t build our way out of this with new construction. Something like 50 percent or more of buildings that will exist in 2050 are

already here now, and most of them are single- or double-glazed. So, we need to be thinking about how we retrofit,” Selkowitz says.

Consider, if all existing commercial windows in the United States were replaced with highest-performance integrated facade systems, the market would go from a cost of \$20 billion a year to a savings of \$15 billion a year, says Selkowitz. “This is if you can magically change every building in the country, which isn’t going to happen,” he says. But it begins to demonstrate the potential savings that are possible when the industry focuses on existing buildings.

### Highly Insulating Glazing Solutions

The glass industry offers numerous solutions to improve the performance of insulating glass in buildings. “Can we make the IGUs better thermally? We can play with coatings, with glazings, with the system, and to some degree with the whole building,” Selkowitz says.

### Existing

Double glazing with gas fill represents about 89 percent of the market today. Triple and quad IGUs are in the market, but are often used only in the coldest climate zones. In the United States “in residential, triples have about 3 percent market share. I’m guessing it’s less in the commercial space,” Selkowitz says.

### Emerging

Emerging IGU technologies include vacuum insulating glazing, VIG and thin triples, which consist of double glazing with a thin-glass interior lite. The technologies can be paired with additional improvements, as well. Low-emissivity coatings can be applied

to VIG and to thin triples, with thin triples featuring up to two low-e coatings, and gas fill can be added to the thin triples.

“VIG has been around in a limited form for 20 years. There are some very good products out now, but there’s not a lot of market impact,” Selkowitz says. “There is a lot of new buzz in terms of hybrid [VIG], new R&D, new generation. That will hopefully make [the products] cheaper.”

Thin triples look to achieve the next-level performance of traditional triple IGUs, but deliver a product that is not as heavy, not as wide, and will fit in the existing pocket of a normal sash. “With the thin triple, you get about an R-8 center of glass,” says Selkowitz. “You’ve got a slightly larger glass package, you can put two pieces of thin triple and get R-14...This is great news. You can get an R-14 center of glass with a VIG, or with a quad glazing.”

#### Future

Looking ahead, Selkowitz identifies promising future IGU solutions, including two low-e vacuum hybrid units, which is an IGU that features VIG on one side of the unit. Insulating Aerogel is also promising.

“The [Department of Energy] has been putting a lot of research dollars into Aerogel in the last couple of years,” Selkowitz says. There are products out now that are highly insulating, but they are “granular diffusing,” which means they have a hazy white translucent appearance. “If you want clear Aerogel, you’ll have to wait a bit longer,” he says.

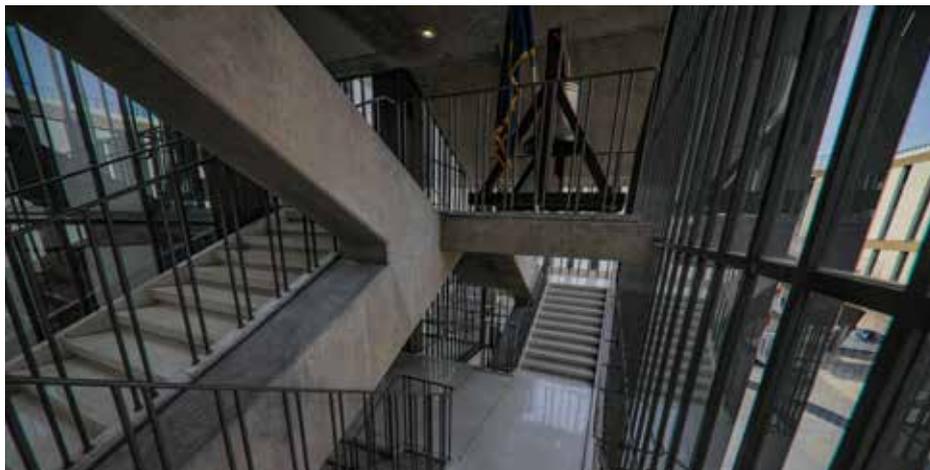
### PART 3: PEOPLE

#### DAYLIGHTING + VIEWS

In November 2021, plans for an 11-story, 1.68 million-square-foot dormitory building at the University of California Santa Barbara were revealed and quickly drew backlash from numerous leaders in the design community. The project, Munger Hall, designed by billionaire investor Charlie Munger, has been called “dangerous,” “a monstrosity,” “a social and psychological experiment with an unknown impact.”

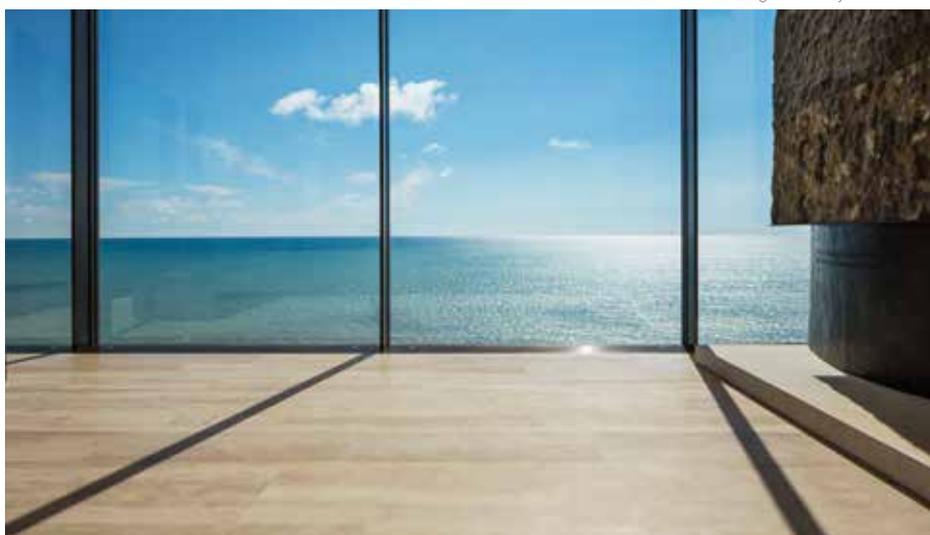
The primary target of criticism is the designer’s bold choice to greatly limit access to natural daylighting and views for the building’s occupants. While the dorm is intended to house 4,500 students, 94 percent of them would not have access to windows in their compact single-occupancy bedrooms.

How could such a proposal find traction when study after study shows that humans require access to both natural daylighting



Vacuum-insulating glazing was critical to the restoration of the 1955 Eero Saarinen-designed “Bird Cage” at the Milwaukee County War Memorial. The Bird Cage is a double cantilever staircase enclosed with a glass and steel curtain wall. The project features Pilkington Spacia VIG from NSG Group, which offers thermal performance improvements and a thin profile that allowed the glass to be incorporated into the original, restored curtain wall system. The restoration project architect was HGA Architects and Engineers, the preservation consultants, Preserve LLC, and the glazing consultant and contractor, Restoric LLC.

Image courtesy of AGNORA



and views to thrive? To ensure that people can live, work, learn and play in healthy, high-performing environments, all spaces they inhabit—from homes to schools, and offices to shopping malls—must provide ample access to natural daylight and views.

Part 3 of this article, the People section, provides an overview of effective daylighting solutions, and offers expert insights on the importance of daylighting for occupant health and wellness.

Source: Adapted and excerpted from the NGA Daylighting Glass Technical Paper, available at [glass.org/store](http://glass.org/store),

and from the Glass Magazine article, “Daylighting + Views,” from the January/February 2022 edition.

#### Maximize Daylight, Minimize Discomfort and Glare

Daylight has qualities that cannot be replicated by electrical light. The changing intensity, direction and color of natural light connect building occupants to the weather, season and time of day. Views through windows can stimulate the well-being and productivity of building occupants. With careful design and daylighting controls,

Photos courtesy of Jana Bannan Photography



The JST Production and Engineering Center in Harrisburg, Pa., touts a sustainable design using laminated timber, deep roof overhangs, flow-through ventilation and a floor-to-ceiling glass exterior, composed of 40 percent glass. The facade features a new hybrid aluminum and wood veneer framing system. YKK AP created a 3-inch veneer wall system that would match the existing size of the timber beams; a new die was manufactured to do so. A horizontal aluminum tube was then set above and below the casement window, so that YKK AP's YES SSG TU Vented Window could be set into the curtain wall pocket for easy installation. The design team included Ryuichi Ashizawa Architects and architect of record Arcari+Iovino Architect.

Daylighting can also substantially reduce lighting energy use.

The potential for daylighting and views is largely a function of orientation, window placement and window area, as well as the windows' visible transmittance. However, daylight admission must be balanced with glare control and thermal comfort.

If solar radiation causes discomfort and glare, this may not only mean an unwelcome side effect to daylighting. It can actually eliminate its benefits. As pointed out by

officials from Lawrence Berkeley National Laboratory, "the classic problem that plagues side-lit perimeter spaces is that occupants sitting nearest the window will lower the shades to avoid thermal discomfort from direct sun or visual discomfort from glare." Often, shades are left lowered for long periods of time, which can eliminate much of the useful daylight and view.

The task is to reduce contrasts and allow daylight to reach deeper into the space. As a general rule of thumb, direct sun should be blocked from falling on occupants and task surfaces, especially if computers are involved. This is partly a matter of interior design and shading devices, but glazing design can already achieve much on its own. For instance, glazing can be separated into glazing for daylighting and glazing for views

while daylight is redirected by means of light shelves. Top lighting fenestration such as roof monitors can be another means of controlled daylight access. Advanced glazing for daylight control is available with electrochromic coatings or between-glass blinds. Finally, orienting glazing along an east-west axis typically reduces the potential for glare and allows for more even light conditions throughout the day.

**The Complexity: A Science or an Art?**

Daylighting design remains an art as much as a science. One reason is that discomfort glare is difficult to quantify and predict since it is highly dependent on the occupant's direction of view and task. Few studies have been conducted to derive models that could help with such predictions. Add to this the unpredictability of occupant behavior (e.g. in terms of operating interior shading devices) and it becomes apparent that in many cases experience is still the surest guide.

In addition, some of the most effective daylighting strategies include a combination of shading, surface coloring and interior design features that is rather complicated to model in its entirety. Scientific tools can be a great help, but what really allows designers to push the envelope is innovation informed by experience.

Finally, good daylighting design also relies on the art of teamwork among the different disciplines. For example, electrical and lighting engineers should be involved early in the process of daylighting design so that architects can take their knowledge and experience into account.

The complexities of daylighting should not intimidate designers into ignoring its

Photo courtesy of AGNORA



The Marotta Family Innovation Complex at Niagara College in Ontario, Canada, features oversized IGUs in the main office, which face a southern direction to maintain constant sun exposure. The glass units feature Pilkington OptiWhite on the inboard lite and a low-iron option. The makeup properly controls heat gain and visible transmission values to create the most comfortable working environment.

Image courtesy of the National Glass Association

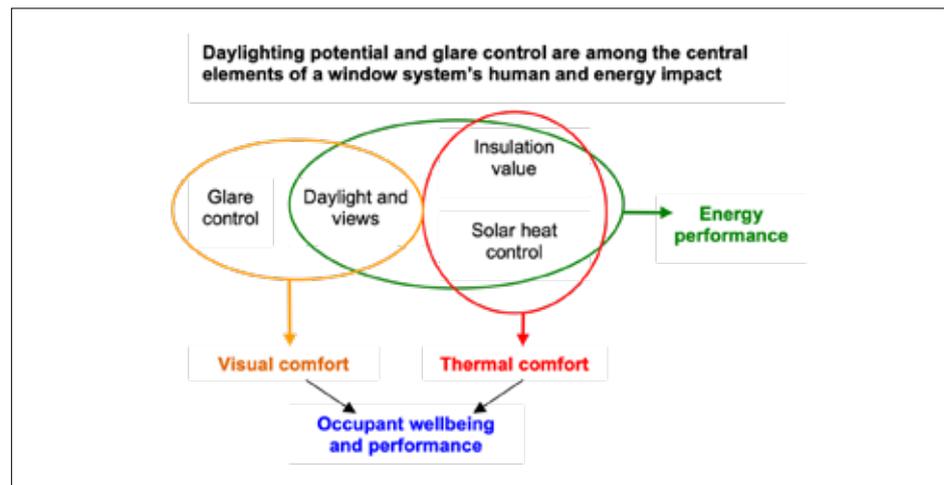


Photo courtesy of Benjamin Benschneider; Technoform



Daylighting design was a top priority for the 2013 net zero-designed Bullitt Center in Seattle. The design team relied on a daylighting simulation tool to help determine everything from window configurations to ceiling heights, according to Bullitt Center officials. The project features Technoform’s TGI-Spacer for Schüco curtain wall and operable window systems with Solarban 60 glass.

promises. Whether simple design tools or advanced strategies are used, any improvement in facade design for the purpose of daylighting can save energy as long as thermal performance is taken into account. Aside from energy savings, it is a central goal for architects and building owners to provide occupants with stimulating and comfortable work or learning spaces. With this goal in mind, priority attention to advanced glazing and facade design is well worth the effort.

**More Daylighting Resources**

Download the complete Daylighting Glass Informational Bulletin in the NGA’s glass.org. The full document provides additional information on modeling options to simulate daylighting, links to resources on daylighting from the National Institute of Building Science, Lawrence Berkeley National Laboratory and more. The NGA also developed the document, “Benefits of Decorative Glass in Daylighting Applications,” also available for download.

**Hear from the Experts**

This section features leading voices in the industry, educating about the role of natural light and views on human health and performance, and discussing the essential role of glass in daylighting design. Read insights from Lisa Hescong, a leading daylighting researcher, and from the glass industry’s Adam Mitchell of AGNORA and

Helen Sanders of Technoform.

**PART 4: PAYBACK  
THREE BUILDING PERFORMANCE COST-BENEFIT QUESTIONS**

The primary roadblock in adopting a high-performing glass product is cost. “Most of the time, [the products] are value-engineered out of a project,” says Urmilla Sowell, technical and advocacy director for the National Glass Association. However, the price tag for high-performance systems should be considered alongside the holistic costs of building construction and operations. Sources point to three primary areas to consider when weighing costs.

**Benefits of Daylighting Among Office Workers**

- Absenteeism: -15%
- Drowsiness: -56%
- Eyestrain: -51%
- Headaches: -63%
- Turnover: -200%

**How can glass and glazing cut down HVAC and lighting costs?**

HVAC systems account for about 40 percent of total energy use in commercial buildings, according to the Department of Energy. Meanwhile, lighting systems capture about 16 percent of electricity costs. Building owners can offset costs in both areas through the use of high-performance glass and glazing products, and by maximizing natural daylighting.

“If we’re smart and do it right, we can reduce the size of HVAC. This is one of the most expensive parts of building. Reduce the size of the heating and cooling systems and take money saved and put it back into the facade,” says Stephen Selkowitz, retired senior advisor for building science and former group leader of the Windows and Envelope Materials Group in the Building Technology and Urban Systems Division at Lawrence Berkeley National Laboratory.

**What is the Payback of Occupant Comfort?**

Glass and glazing—with benefits of daylighting, views, access to nature and more—are essential to occupant wellness. Numerous studies have demonstrated a relationship between glass and improved test scores among students, accelerated healing among hospital patients, and increased productivity and fewer absences among workers.

“An estimated 85 to 90 percent of our time is spent indoors. But we know our bodies need to be outside—we need to have that type of environmental connection to be happy,” says Sowell.

“There is a renewed appreciation of glass and glazing in terms of people and how they work and live,” adds Selkowitz.

When the human costs of a building are factored into building design and operations,

**Benefits of Daylighting Among Students**

- Progress in math: +20%
- Progress in reading: +26%
- Standardized test scores: +7 to -18%

Sources: (absenteeism) independent studies from Lockheed Martin in California and ING Bank in the Netherlands; (turnover) study from Story County (Iowa) Human Services; (eyestrain, headaches and drowsiness) Department of Design and Environmental Analysis, Cornell University, “Worker Reactions to Electrochromic and Low-E Glass Office Windows;” (in schools) Hescong Mahone Group, “Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance.”

the value of glass and glazing products greatly increases. “The most costly pieces [of building operations] are people,” says Selkowitz. “The cost of people is 10 times construction costs and 100 times operating costs.”

#### How will performance disclosures and penalties affect owners?

A growing number of cities and states are adopting energy performance requirements beyond those in the national codes. “There is a new urgency in the codes—strong, quick action in response to climate change,” says Tom Culp, owner of Birch Point Consulting and energy code consultant for the NGA.

Legislation, such as Local Law 97 in New York City and Washington State HB 1257, are

beginning to require post-occupancy building commissioning—performance measurements—with penalties for buildings that don’t meet requirements. “It’s essentially a carbon tax if you’re not building up to minimum levels,” Culp says. “This changes the economics.”

“The codes with proposed penalties [coming] down the road should encourage building owners to say, ‘hey, this really is a more economical approach in the long run.’ Otherwise, it’s a pay me now or pay me later situation,” says Charlie Boyer, principal, Boyer & Associates, and consultant, VIG Technologies. “You might be installing something now, but five to 10 years later you’ll have to pay for new installations or upgrades. The time is coming to advance

these technologies.”

Numerous other jurisdictions are moving toward performance benchmarking/disclosures for buildings. Culp points to legislation in dozens of cities in all parts of the country, from Seattle, to Boston, to Austin, Texas, to St. Louis, Missouri. Such disclosure requirements could affect real estate prices, incentivizing owners to prioritize performance, even without associated penalties.

▶ Continues at [ce.architecturalrecord.com](http://ce.architecturalrecord.com)

*Katy Devlin is the associate publisher and editor in chief of Glass Magazine, published by the National Glass Association.*



The National Glass Association (NGA) is the largest trade association serving the architectural glass and metals industry. A technical and educational resource, NGA envisions a future in which glass is the material of choice to enhance spaces where people live, play, learn, and work.

## COMMUNICATE THE BENEFITS OF DAYLIGHTING

By Adam Mitchell

Daylighting is an important, well-studied and well-documented subject, but this widely accepted term is still nuanced for most. Daylighting is a term used to describe glazed areas, building orientation, light reflection/transmission values, and reflective surfaces designed to distribute light in buildings interior.

Architectural glass, and its relation to daylighting, faces communication challenges across stakeholder groups within the building industry. To address these challenges, we as the glass industry can use the enormous body of knowledge regarding daylighting to model common benefits to building designers and owners. We can demonstrate how modern architectural glass products can be used to incorporate these benefits.

**1. Health** – There have been several studies outlining the improvement of health from increased daylight. A key finding is increasing daylight in a built environment is known to increase an individual’s amount of sleep. Getting proper amounts of sleep decreases cortisol (the stress hormone), increases glucose metabolism and decreases appetite. This leads to less stress, lower blood pressure and controlled weight. The merits of natural light are also attributed to a reduced length of stay in health care environments, indicating the body’s reliance on light’s healing properties, according to the 2018 study, “The Effects of Natural Daylight on Length of Hospital Stay.”

**2. Productivity** – It is well accepted that daylighting improves productivity, and often studies draw similar conclusions: productivity goes up. The 2002 study, “Effects of Natural Light on Building Occupants,” found that professionals (engineers) working in a predominantly daylight space increased output by 13 percent and decreased absenteeism by 15 percent. Light is the primary mode for humans to ingest information; consequently, it’s no wonder natural light improves these outcomes.

**3. Cost improvements** – These increased output and absenteeism rates are eye-opening and impact organizations the larger they are. According to Small Business Trends, the average U.S. business employs 10 people. Assume the business sees an increased output of a conservative 10 percent (versus 13 percent). This is equivalent to an hourly surplus of 2,940 working hours per year.

Further, daylighting greatly reduces reliance on artificial lights. As there are many factors it is difficult to quantify a savings value, but one such study, “Daylighting: An alternative approach to lighting buildings,” assumed a saving of 20 Watt/m<sup>2</sup> for the particular environment, saving an average of 2160 MWh per year based on a specific 430,000-square-foot (40,000 m<sup>2</sup>) building.

Glass is the only facade material that allows for daylighting; thus, it is vitally important to connect the technical attributes with the benefits in a clear and concise message to partners responsible for contemporary building design and construction. As an industry, we should not only address the incredible performance characteristics of today’s glass, but also attach it to the value it provides.

Factoring windows into the design of a new building does not add much in terms of the design budget, but the long-term productivity and energy reduction benefits far exceed incremental design costs. Windows are the gateway to better environments and innovations in anti-reflective technology combined with high-performance coatings can provide improved daylighting to a space.

*Adam Mitchell is marketing manager at AGNORA.*

## THE IMPORTANCE OF DESIGNING FOR OUR (UN)NATURAL HABITAT

By Lisa Heschong

*Editor's Note: The following is an excerpt from Heschong's book, "Visual Delight in Architecture," available through Routledge.*

We modern humans spend over 90 percent of our lives inside of buildings. [...] Since we now spend most of our lives inside of buildings, it matters a great deal how those buildings are designed. The indoor environment is now our (un)natural habitat! The forms, details, and functions of buildings profoundly impact our physical health and mental well-being, they set the stage for how we perceive the environment around us, they influence our social relationships, and they both form and inform our culture.

Humans are highly visual creatures. Whereas dogs understand their world largely through their sense of smell, and creatures with exceptionally large ears or long whiskers may rely more on sound or touch, we humans use our sense of sight as our primary mode for understanding the world. In many ways, due to the very evolutionary perfection of our eyes, our interaction with the visual environment is often so seamless, so very easy, that it does not demand much thought or reflection. But the design of our buildings importantly determines the visual environment in which we spend our lives. [...]

I first realized that I needed to write this book when I was working with a team of colleagues on a proposal that one of our national 'green' building codes should require at least 50 percent of all workspaces to have access to a view of the outdoors. We called it our 'view proposal.'

My team had already succeeded in persuading this same code group to adopt minimum requirements for daylight illumination, which they considered to be a reasonable expression of best practices. I knew from my experience that, a decade or two earlier, general building industry attitudes had been strongly arrayed against daylight illumination. As a design architect, I had struggled to get daylighting design included in the schools and office buildings I was working on. However, in 1999, I completed a major research study, which showed that elementary school children in classrooms with more daylight progressed faster on their math and reading curriculum. The study's findings quickly made national and international headlines, and soon 'natural daylight' became a preferred feature for high-performance school design. In the years since, many other researchers' findings have supported the positive effects of daylight, and other codes and standards groups had already moved to adopt minimum daylighting requirements. Thus, after decades of effort by many people to persuade the building industry to embrace daylight illumination, a sea change in attitudes had indeed happened.

However, the national code committee's reaction to our view proposal was very different. After many long discussions, it was soundly voted down by over 70 percent of the committee! The most succinct statement of the opposition that I received was that "a view requirement is not appropriate for a green building code because it has no health or environmental impacts: views are an amenity." An amenity is a real estate term for something for which you must pay extra. Fresh air used to be considered an amenity, back in the days when industrial air pollution was pervasive in our cities. Now it is recognized as fundamental to human health. I realized we had a long way to go to persuade these code officials, the building industry, and the public at large, that access to views mattered, at least as much as daylight illumination and maybe more so. It can take a long time to change widespread attitudes and assumptions.

## WHAT'S STANDING IN THE WAY OF DAYLIGHTING AND VIEWS?

By Helen Sanders

**1. Education gaps.** Changing business-as-usual practices is a challenge. In the design industry, it requires educating the full project team. However, there are over 100,000 architects and additionally, owners, who need to be educated on the impacts of daylight and views. Have we reached all of them with the depth and breadth of the information, or are we “preaching to a smaller choir” and not reaching the majority of architects who need to understand the negative consequences of not designing for occupant health?

**2. Good design is neither cheap nor easy.** We run into the issues of designing good day-lit spaces. The tools to assess daylight availability and glare using metrics such as spatial daylight autonomy, daylight glare potential, useful daylight illuminance, etc., are available, but they are complex to use and the solutions to creating good day-lit spaces may be difficult or costly to achieve, especially if not considered at the very outset of the design process, and in the context of meeting other design goals. Getting a daylighting professional in early in the design process has historically been a challenge. It is too late to make much of an impact when designers are brought in late into the process.

Consider as an example the uptake in the daylight and views credit in the LEED certification program. Only 31 percent of LEED certified projects achieved a daylight credit in LEEDv4, so the criteria have been changed in version 4.1 to try to make it more attractive for projects to focus on. This all leads us to the fact that it costs more to hire a daylighting designer and do the appropriate analysis than to continue with the status quo. Having a daylighting designer at the table (along with other key competencies for considering thermal comfort and air quality) at the design phase is not yet business-as-usual, but needs to become that if we are to create human-centered, sustainable buildings.

I think we also have many uncomfortable, overly day-lit spaces that have plenty of view fenestration and daylight, but where large expanses of curtain wall are used, and thermal comfort and glare control are not adequately considered. This gives glass curtain wall a bad reputation and leads to conversations about limiting glass areas.

**3. Financial payback.** We need to do a better job of communicating the payback in hard dollars and cents to building owners. The payback on these design strategies is not immediately accessible, unlike for energy, and can require owners to take a leap of faith.

Getting the results of the research (real applied research in real buildings on real people) and impact on their bottom line to building owners (and their business tenants) seems key since they are going to be making the decisions on design and budget and setting the design intent. If all building owners came to architects and said, “I want a thermally comfortable, well daylit building, with views to nature through windows, and good ventilation to provide appropriate air quality for 100 percent of the occupants of my building” as a starting point for the design requirement, then we would have different outcomes. (We also have the split incentive in speculative real estate where the owner doesn't accrue the “health and productivity” benefits of a good/more expensive design.)

**4. The real versus simulated debate.** We need to be clear about the differences between real and artificial daylight and views. The lighting industry has done a great job of selling its circadian lighting and likely gives the impression that it can replace actual daylight for the entrainment of human circadian rhythms. Data needs to be brought to the fore to demonstrate real is best, and that circadian lighting may be better than nothing, but not sufficient to replace the benefit of exposure to the much higher intensity of real daylight. Additionally, what if the power goes out? What about all the other safety issues?

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