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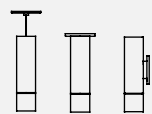
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


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*NanoLED NXT cable mount Pendant shown.*

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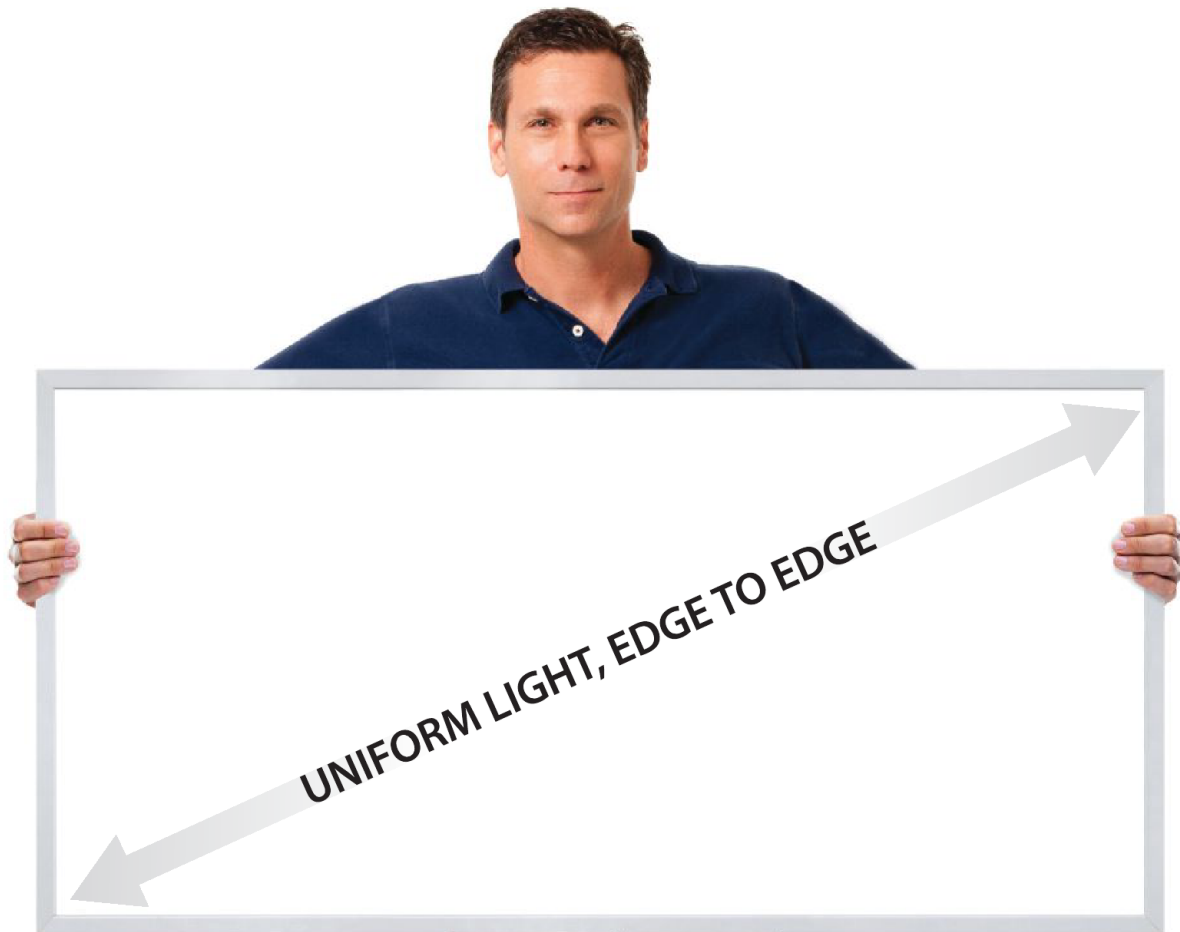
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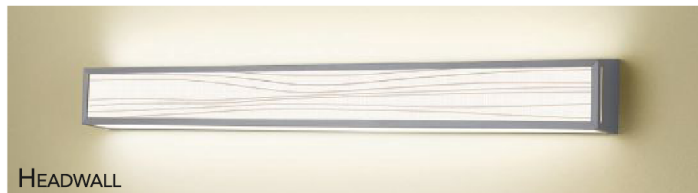
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As always, check our website for expanded article content, videos, and news. Also, subscribe to our email newsletter, AL Notes, and find a link to ARCHITECTURAL LIGHTING'S digital edition.

### On the Cover:

The Renzo Piano Pavilion at the Kimbell Art Museum in Fort Worth, Texas, designed by Renzo Piano Building Workshop and lighting design by Arup. Photo by Richard Barnes.

Clockwise From Top Left: Nic Lehoux; Courtesy AECOM; Tang Yau Hoong



# LIGHT DEFINES THE EXPERIENCE

New England Aquarium  
Boston, MA, United States

Architect: Cambridge Seven Associates, Inc.  
Lighting Design: Available Light

Photographer: Kwesi Budu-Arthur /  
Cambridge Seven Associates, Inc.

Designers Available Light took advantage of Lumenpulse's options to modernize the New England Aquarium. Their new design has:

- Enhanced visitor experience with separate zones of control and lighting
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# NEW YEAR, NEW RESOURCES

**“What does this all mean for you? Greater resources, and more opportunity for engagement, knowledge, and interaction with AL and with the lighting community. I encourage you to take advantage of all of our platforms. While there is continuity of content between them, each offers a slightly different type of presentation and, in that way, a richer reading experience.”**



As one calendar year comes to an end and another begins, I wanted to take this opportunity to update you on several new editorial initiatives underway here at ARCHITECTURAL LIGHTING. As an outlet focused on lighting and design, our goal has always been to bring you the most compelling content. Each of our platforms provides a different type of reading experience for you, our audience, and we are always thinking about the particular strengths of each so as to offer you the most engaging and informative content.

Our 2013 Reader Survey confirmed for us many of our hunches about the type of content in which you are interested and the ways in which you engage with the magazine, the website, the newsletter, and our social media outlets, as well as programs such as our AL Light & Architecture Design Awards.

One thing is absolutely clear: You are engaged. The average reader has been reading the magazine for 6.6 years, has read three of the last four issues, and spends at least one hour with each issue. That's incredible, given the demands on everyone's time. The most rewarding thing to see was that 78 percent of our readers find AL's editorial coverage superior or above average relative to other industry publications.

But we're not one to rest on our laurels, and we're not satisfied unless we are pushing ourselves. That is why I am excited to let you know about a couple of our new initiatives.

First, we are working to bring you a seamless transition between print and online content. We started adding hyperlinks in stories back in 2011 and are going to do so at a greater scale going forward. When you read an article in this issue, you'll notice, when appropriate, a link to a related article or articles in our online archive. In the digital edition, these links are interactive; by clicking on them you'll be taken directly to the location. It makes the reading experience that much more dynamic and provides you with a greater awareness of how the articles you are reading connect both to the continuum of the publication's content and the body of lighting knowledge.

Our Technology story this month takes hyperlinks one step further. In December, we launched a "Resources" section at the end of the Technology articles to provide a snapshot of the latest papers, reference books, and websites related to the topic being discussed. And in the text of the article itself, there is a more detailed use of references to the relevant studies and papers contributing to the research. Our intention isn't to be a research journal. Instead, we are alerting you to the important body of lighting research that has existed for some time and that makes design work possible.

Second, we are producing more videos. We have just launched a dedicated video page: [archlighting.com/videos](http://archlighting.com/videos). Here you will find original video content created by AL as well as shared video content from our sister publications. The page is organized into content areas, and for the launch we started with Projects, the AL Light & Architecture Design Awards, and AL 25th Anniversary. Over the next few months we will roll out new sections and continue to build on the library of videos.

What does this all mean for you? Greater resources, and more opportunity for engagement, knowledge, and interaction with AL and with the lighting community. I encourage you to take advantage of all of our platforms. While there is continuity of content between them, each offers a slightly different type of presentation and, in that way, a richer reading experience.

As always, I encourage you to reach out to us with your comments, questions, and suggestions. We're always interested in hearing from you as we bring you the most up-to-date, thought-provoking, factual, and responsible reporting.

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## SLIM REPLACEMENT

*Philips' latest LED 60W replacement is among a new crop of lamps melding old-school form with new tech.*

text by Hallie Busta

The lighting industry is meeting the phase-out of general service incandescent-lamp production—which went into effect for 60W and 40W varieties earlier this month—with a handful of new LED and CFL lamps that aim to replicate the user experience of their incandescent forerunners. Among them is Philips' SlimStyle LED 60W-replacement lamp, which is catching buzz for its thin profile and familiar A-shape form factor. ARCHITECTURAL LIGHTING spoke with Todd Manegold, the company's director of marketing for LED lamps, about whether the product's reinterpreted shape, minimal heat sink, and low price-point relative to previous models might help turn consumers on to the new technology. Read the full interview at [bit.ly/1grogWQ](http://bit.ly/1grogWQ). •



## GOOD DESIGN CAN MAKE A BETTER BULB

*Hulger is making high-end design the value proposition for its growing line of CFL lamps and accessories.*

text by Hallie Busta

London-based design studio Hulger is back with a new CFL lamp more than three years after launching its award-winning Plumen 001, a bulb that is now a part of the permanent collection at the Smithsonian Cooper-Hewitt, National Design Museum in New York. The latest in the up-and-coming manufacturer's portfolio, Plumen 002 is a respectful "nod" to the familiar Edison-shaped lamp, says Hulger's co-founder Nicolas Roope, but the 30W CFL replacement aims to push the envelope with a slightly larger and more sculptural body. ARCHITECTURAL LIGHTING spoke with Roope about how new mandates and consumer awareness for energy-efficient lamps are spurring a renaissance in light-source design. Read the full interview at [bit.ly/1d8m9zp](http://bit.ly/1d8m9zp). •

## MAYORS FOCUS ON ENERGY EFFICIENCY

text by Elizabeth Donoff

According to a recent survey by the United States Conference of Mayors at their 82nd Annual Winter Meeting, energy-efficient technologies are a principal investment area for the next five years. The survey, conducted from Nov. 25 to Jan. 14 and available online at [usmayors.org/2014energysurvey](http://usmayors.org/2014energysurvey), was sponsored by Philips, a partner in the Mayors' Lighting Partnership. Nearly 1,400 cities were contacted and 288 responded by the deadline. Some of the key findings were:

- Three in 10 cities are making LED/energy-efficient lighting their top priority over the next 24 months.
- Four out of five called LED and other energy-efficient lighting the most promising to reduce energy use and carbon footprint. Solar electricity followed at 54 percent and low-energy buildings at 53 percent.
- Public buildings (83 percent) and outdoor lighting (54 percent) are the top two priorities for cities in improving the energy efficiency of city infrastructure.
- Three-quarters have an emergency response plan that maintains key municipal services during power outages. Four in 10 have experienced outages in the past five years due to a severe climate event.
- 36 percent already have a comprehensive energy plan. 79 percent are expected to have one by 2016. •

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# 10

## THE AL LIGHT & ARCHITECTURE DESIGN AWARDS CELEBRATING A DECADE OF EXCELLENCE IN ARCHITECTURAL LIGHTING DESIGN

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Above: The 2013 AL Light & Architecture Design Awards recipients who were in attendance at the AL Light & Architecture Design Awards Tenth Anniversary celebration on October 16 in New York City. From left to right: Stephanie Daigle, Focus Lighting; Paul Gregory, Focus Lighting; Erin DeVries, Tillotson Design Associates; Suzan Tillotson, Tillotson Design Associates; Francesca Bettridge, Cline Bettridge Bernstein Lighting Design; Stephen Bernstein, Cline Bettridge Bernstein Lighting Design; Sean O'Connor, Sean O'Connor Lighting, and Brian Stacy, Arup.

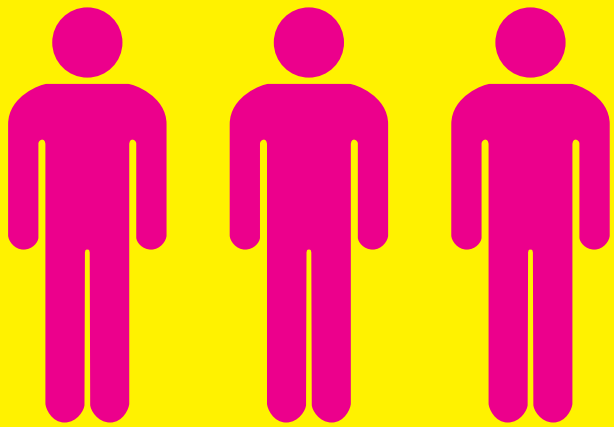
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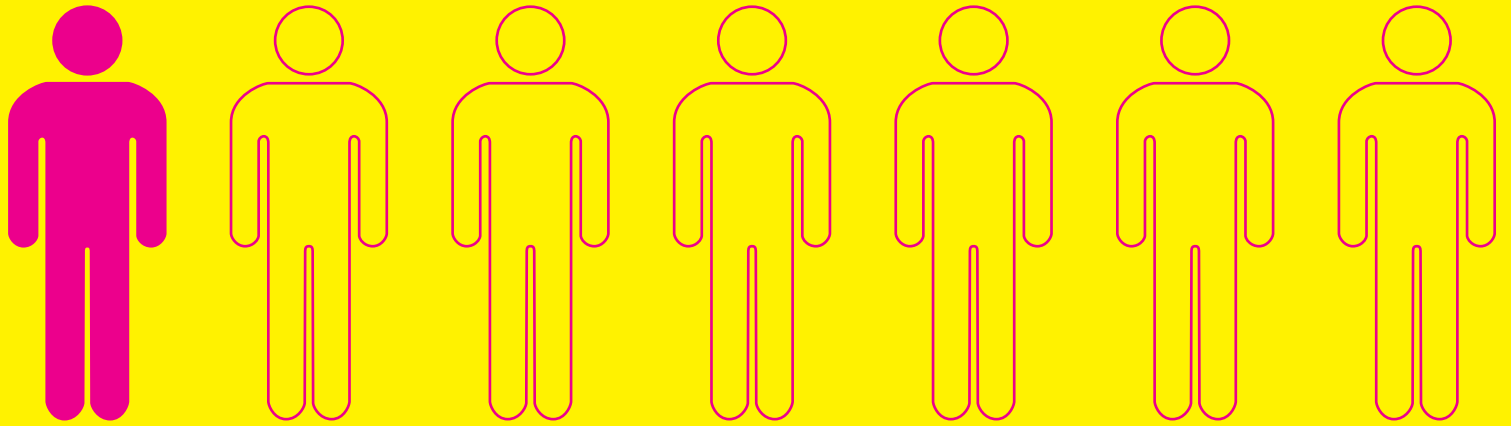
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# • DESIGN



## REPORT

# IT'S THE END OF THE BULB AS WE KNOW IT (AND EISA FEELS FINE)

*Consumers haven't gotten the full story about the phase-out of inefficient incandescent lamps. The change in standards is expanding options, not reducing them. We talk to experts who boil down the essential information.*

text by Bill Millard

According to the 6th Annual "Sylvania Socket Survey," only four in 10 consumers are aware that the phase-out of 60W and 40W incandescent lamps started on Jan. 1, 2014 (above).

**Compilers of light-bulb jokes** may want to add a new one to their pages this year: How many mainstream journalists does it take to replace an incandescent bulb? None, apparently. They seem to prefer lamenting that the bulb shouldn't have to be replaced at all.

With the third phase of the 2007 Energy Independence and Security Act (EISA) having taken effect on Jan. 1 — which applies the same 28-percent-higher energy-efficiency standard to 60W and 40W general service lamps that it had already applied to 100W and 75W bulbs over the last two years — major lamp manufacturers, retailers, and utilities are taking steps that could save the nation a considerable amount of energy. Because the 60W and 40W lamps make up more than 60 percent of standard household lamps sold in the U.S., the steady replacement of these

older incandescents with more-efficient halogen incandescent lamps, compact fluorescent lamps (CFLs), and LED lamps will cause a sea change in a sector that accounts for about 461 billion kWh of electricity each year, according to U.S. Energy Information Administration estimates of residential and commercial lighting usage. That's equivalent to about 12 percent of all U.S. consumption of electricity. Putting a 28 percent dent in that by reducing waste could offer cost-saving benefits that should be obvious even to those who remain indifferent to the environmental benefits.

"There are still about 3 billion screw-based sockets in U.S. homes that don't have energy-efficient light bulbs in them," says Noah Horowitz, director and senior scientist at the Natural Resources Defense Council

EISA, it bears repeating, does not ban or impose any category of technology. It's a performance standard, points out the NRDC's Noah Horowitz like those that the DOE has enforced in product categories for decades. Traditional incandescents that don't meet the EISA mandates are, thus, no longer manufactured or imported.

(NRDC's Center for Energy Efficiency, Energy & Transportation Program. "Once we get something that's as efficient as a CFL or an LED in them, we can cut our nation's electric bill by \$13 billion a year. And that's the equivalent amount of electricity saved [as is] generated by 30 large coal-burning power plants ... the amount of electricity used by all the homes in Texas each year."

The majority of citizens, however, aren't aware of this potential windfall. At a media briefing in New York City sponsored by Lutron Electronics in December, communications director Melissa Andresko cited survey data from a company report that showed only 28 percent of adults were aware of the phase-out. Only 10 percent were "very knowledgeable" about their lighting options after the change. Other surveys differ, and some have been a shade more optimistic. Sylvania's 6th Annual Socket Survey ([bit.ly/1fcUJLb](http://bit.ly/1fcUJLb)) in November 2013, for example, found that four in 10 Americans are aware that the 60W/40W

phase-out was imminent and that 65 percent said they'd be likely to switch to lamps from the three other source options (halogens, CFLs, and LEDs). Whatever margin of error one attributes to such reports, it's apparent that the lighting industry and related professions face a large consumer-education challenge—but this could also be interpreted as an opportunity.

"I can't imagine a more interesting time to be in the lighting business than 2014 and '15," says Terry McGowan, director of engineering and technology for the American Lighting Association (ALA) and a speaker at Lutron's recent panel. "I think the whole world's going to change, and we'll be right in the middle of it."

Sticker shock, McGowan believes, will be a widespread reaction by shoppers who have not followed the legislation but are now seeing the prices of these alternative lamp options in stores. Thus far, it has largely been up to the lighting industry and nonprofit organizations to explain how better energy performance and longer lamp life will more than offset that up-front cost. "Not many people know that in EISA there was \$10 million [per year] set aside for education, but it was never appropriated," McGowan says. With the DOE's outreach efforts striking him as "not enough to make even a ripple," advocacy groups, such as the LUMEN (Lighting Understanding for a More Efficient Nation) coalition have taken up the charge to inform the public.

#### **BOTH METAPHORICALLY AND LITERALLY, MORE LIGHT THAN HEAT FOR A CHANGE**

The proliferation of disinformation hasn't helped the situation. Observers of the politics surrounding EISA will recall earlier outbursts of rhetoric about the new standards "banning" the familiar incandescents or forcing consumers to buy CFLs, framing the issue within a discourse of coercion vs. freedom, instead of as, say, stages of technological evolution. Efforts by Republicans in Congress to reverse the provisions of EISA that affect lighting failed, as did an attempt in the South Carolina state legislature to nullify the federal law. In 2011, amid negotiations over a threatened government shutdown, Congress defunded the enforcement of EISA, but this symbolic action is moot: The law remains on the books, and America's lighting manufacturers are complying with it. They have supported EISA since its enactment, preferring consistent federal guidelines to a patchwork of state-level regulations, and have treated the new standards not as a straitjacket but as an opportunity for wider product development.

EISA, it bears repeating, does not ban or impose any category of technology. It's a performance standard, Horowitz points out, like those that the DOE have enforced in

product categories for decades. Traditional incandescents that don't meet the EISA mandates are, thus, no longer manufactured or imported. They will, however, remain on store shelves probably well into 2014, speculates Stan Mertz, director of retail operations at Applied Proactive Technologies in Springfield, Mass., and another of the panelists at Lutron's December briefing. There are also 22 exempted categories of incandescents, he notes, including small appliance lamps below 40W, bug lamps, reflectors, rough service and vibration service lamps, and three-ways. (See "Legislating Lighting," Jan/Feb 2008, [bit.ly/1grK6JG](http://bit.ly/1grK6JG), and "Meet the Replacements," Mar/Apr 2013, [bit.ly/1exYaKS](http://bit.ly/1exYaKS).)

Today's halogen incandescents do meet EISA standards, and they are the logical, familiar choice for consumers with a strong allegiance to the color temperature of conventional incandescents (2700K to 3000K). Halogen incandescents also perform as smoothly as their predecessors when installed in dimmers. With a moderately higher initial cost (twofold to threefold, or roughly \$1 to \$1.50, per lamp), a comparable lifespan (around 1,000 hours), and about 28 percent lower energy consumption for the same level of illumination (so that a 43W halogen incandescent is the equivalent of a 60W standard incandescent, both generating 800 lumens), the halogen lamp saves about \$13 across 10 years of use, according to NRDC cost estimates ([bit.ly/Lb3r3c](http://bit.ly/Lb3r3c)).

One important point to make with clients—says Brooklyn, N.Y.-based lighting designer Jason Byron Teague, and a speaker at the Lutron panel—is that the EISA standard has helped drive an expansion of options. Consumers can now select from the three main lamp categories according to their relative preferences for efficiency, color, dimmability, and longevity as well as cost, appearance, and brand familiarity. Because LED products are evolving so quickly and attracting new entrants, there are also considerably more manufacturers than in the days when lamps came almost exclusively from the big three (Philips, Osram Sylvania, and General Electric) plus a handful of discount-level firms. The expanded field of hundreds of manufacturers, some of which are new to lighting, couples turbulent innovation with new questions to ask.

#### **CHOICE IMPLIES COMPLICATIONS**

With more information and more variables come more idiosyncrasies and more decisions, particularly in retrofit scenarios. Some customers retain a poor general impression of energy-efficient lamps from the early days of CFLs, when that technology's novelty—the spiral tube—was not always accompanied

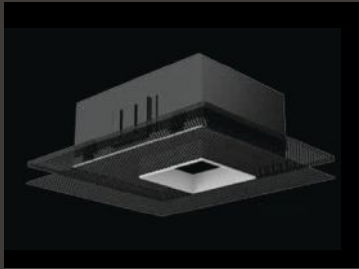
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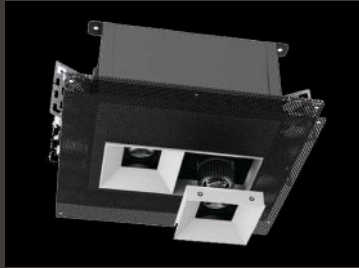
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72% of consumers do not realize that not all CFL and LED lamps are dimmable.

Source: Lutron Electronics, "Consumer Knowledge of 60–40 Phase-out and Dimmer Knowledge" (2013)



by close attention to light quality and truthful claims about dimmability. Dimming is particularly confusing for consumers, says Lutron spokesperson Amber Lutz: The company's survey found that 72 percent of adults were unaware that CFLs and LEDs are dimmable only if indicated as such on the package. And the important "Not for use in dimmers" caveat often appears only in small type on the backs of many packages, says Lutron's LED engineering leader Ethan Biery.

Resistance to the color temperature of CFLs (which can range from a warm 2700K to a cold 6000K) remains widespread, particularly for residential uses. "I always encounter a lot of resistance from my clients to anything that resembles fluorescent light," Teague says. "They just don't like the idea of fluorescent lighting in their homes." This aversion occurs despite CFLs' advantages over incandescents in energy saving (more than fourfold) and lamp life (typically up to 10 years). The presence of small amounts of mercury (less than 5 milligrams), a minor nuisance at recycling time and a somewhat worse nuisance in the event of breakage, is another disincentive for some buyers. So far, market penetration for CFLs has remained flat, at around 20 percent, McGowan says, since an initial peak around 2007.

When clients don't warm to CFLs but still want better energy performance than they can get from halogens, Teague steers them toward LEDs, which he describes as "a more genuine replacement." The NRDC makes a similar recommendation, says Horowitz, especially when dimmers are involved. The cost of these lamps has dropped from approximately \$50 to near \$10, and the expected lifetime can reach 25,000 hours. LEDs also offer optimal energy performance: A 10W LED produces the same 800-lumen output as the standard 60W incandescent. Between longer life and optimal efficiency, 10-year use of an LED costs about \$26, not substantially different from a CFL.

Dimming considerations affect only about 4 percent of the lamps in an average home,

McGowan says, mostly in ceiling fixtures. Still, says Biery, manufacturers have learned their lessons from the difficulties with dimming CFLs, so that today most LEDs are dimmable. But there's a catch: LEDs have so many varieties of circuitry and draw so little power in comparison with older lamps that they may require well-matched controls; mixing proprietary lamps and controls without testing and guidance can be a crapshoot. Older dimmers rated at 300W or 500W, designed to handle a circuit with multiple 60W or 100W lamps, are unlikely to work well if paired with several 10W LED lamps and voltage toward the very low end of the range, says Horowitz. Newer dimmers, designed to work with low-power-consuming products, are marketed as LED-compatible (or CFL-compatible, although adequately dimmable CFLs themselves are a minority of the market and often expensive). The consumer should look for this indication in marketing materials or in discussions with retailers. When components are mismatched, performance problems can include erratic step-function dimming, flicker, audible buzzing or humming, light dropout or pop-on, or premature product failure.

Another source of confusion involves color-temperature expectations based on incandescents' tendency to become warmer (more amber) when dimmed. LEDs don't usually change color when the voltage is lowered, Biery says, so many people perceive their low-level light as cold. Color temperature, Horowitz suggests, is a matter of widely varying personal taste, sometimes with a cultural component. "In Southeast Asia, in warm climates, 5600K, the cool bluish-white look, is predominant," he says. "Sometimes people prefer a bright, coolish white light for reading. But in other applications, they'll say 'I don't like the way that light looks.'" Buyers who are new to the topic of color temperature should look for designations as "soft white" or "warm white" (the 2700K to 3000K range familiar from incandescents) or "daylight" (5000K—much higher and bluer).

Lutron offers a line of C•L dimmers, which it bills as compatible with all major lamp categories. Recognizing that confusion about compatibility could hold back the evolution and acceptance of the entire field, the company has set up a 24/7 hotline and an LED Control Center of Excellence. Working with more than 150 manufacturers, it has tested more than 1,000 products and compiled lists of some 200 lamps known to perform well with its dimmers ([lutron.com/dimcfiled](http://lutron.com/dimcfiled)).

The basics of consumer research and comparison apply to lamp, luminaire, and control purchases: buyers should check for Energy Star certification and for warranties. The EPA's criteria for the Energy Star label include standards for lamp brightness, constant light output, color quality, efficiency, instant switch-on, dimmability without flicker, and amount of power draw in the off state, along with more general characteristics such as energy saving and durability (in the form of a minimum three-year warranty above the industry standard). Horowitz says that LED manufacturer Cree has begun offering 10-year warranties on its lamps—rare for any home product and unthinkable for incandescent lamps. An end-user may admittedly have little certainty that a manufacturer will still be in business in the event of a future warranty claim, but Horowitz does say that major retailers like the Home Depot will often honor manufacturers' warranties.

#### THE TRANSITION TO THINKING IN LUMENS

An important and overdue change in a consumer's understanding of lighting should logically follow once EISA standards become familiar: abandoning the wattage-based lamp categories in favor of levels of actual illumination. Using wattage (an energy input) rather than light output as a criterion for categorizing lamps has never made a great deal of sense. Imagine if people shopped for cars on the basis of the gallons of fuel they consumed, with no reference to the resulting miles they'd



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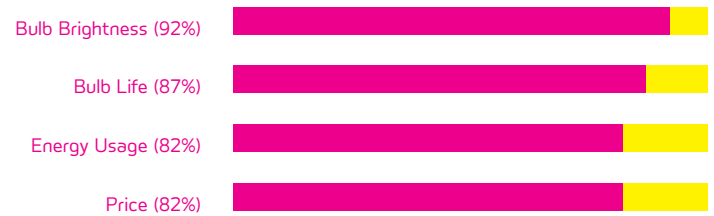


## Why People Have Dimmers



Source: Lutron Electronics

## Top Factors Influencing Lamp (bulb) Purchase



Source: Osram Sylvania

travel on that fuel used. It is the ratio of output for that given input—miles per gallon or lumens per watt—that is the more pertinent piece of information.

The lumen is still an unfamiliar term to the general populace, and so manufacturers have begun the EISA era with prominent displays of familiar wattage equivalents on packaging. The Federal Trade Commission has also worked with manufacturers to develop a standard five-item Lighting Facts label (see “Just the Facts,” Jan/Feb 2009, [bit.ly/1iMOXW7](http://bit.ly/1iMOXW7) and “FTC Evaluating Labeling System for Light Bulbs,” Jan/Feb 2010, [bit.ly/Lb94yi](http://bit.ly/Lb94yi)) that presents brightness in lumens, estimates yearly energy cost (based on three hours’ usage per day and an average

utility price of 11 cents/kWh), lamp life, light appearance (on a warm-to-cool Kelvin scale), and energy consumption (in watts). CFLs are required to display an additional caution: “contains mercury.”

Media and political friction over EISA is understandable in some respects. Thomas Edison’s lamp, Biery says, has had a run of more than 100 years, all while producing good light quality cheaply and raising no compatibility problems. It is a cultural icon, drawn above the head of any cartoon character who gets a fresh idea. And examples of modernization that never quite caught on aren’t hard to find: Horowitz recalls the Metric Conversion Act, which was passed during

Gerald Ford’s administration and was no more effective than Thomas Jefferson’s metric-system advocacy had been two centuries before. Yet the more proximate and relevant precedents suggest that the transition to more-efficient lamps should be relatively uneventful, less like metric adoption and more like the shift from rotary phones to tone dialing or the conversion from analog to digital broadcast TV.

California, which was in the process of setting its own standard and served as a catalyst for the federal regulations, began its EISA transition a year earlier. The change to modern lamps, like the state’s earlier change to its Title 24 energy-efficient building code, has gone smoothly. In a more-resistant sector than lighting, Horowitz

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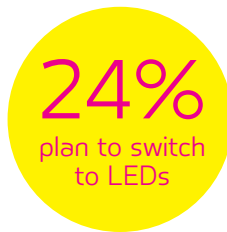
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Among those consumers who plan to choose new lighting solutions as a result of EISA:



Source: Osram Sylvania

recalls, regulation opponents predicted dire consequences that turned out to resemble claims that the sky was falling. “We just set standards in California for big-screen TVs,” he says. “The industry said if we move forward with that, many of the stores would close, we’d lose jobs, and everybody would go out of state to buy a TV. The reality is [that] TVs today use 60 percent less energy than they did back in 2008, they have even more features and better pictures and are less expensive than those TVs [were] back then. So a lot of this is unnecessary hysteria and fear mongering.” In lighting, he notes, “the industry has really stepped up, both the traditional companies as well as lots of new innovative upstarts.”

EISA, signed by President George W. Bush with broad bipartisan support (a fact its current Republican opponents forget), involves a rare level of corporate-government-nonprofit cooperation. The National Electrical Manufacturers Association has joined the ALA and the Alliance to Save Energy on the LUMEN coalition’s steering committee. Retailers, manufacturers, and utilities are working with third-party implementation contractors like Applied Proactive Technologies to negotiate discounts and make EISA-compliant lamps and controls more affordable. Ample, diverse, and efficient products on shelves nationwide prove that regulation in this area is guiding and energizing the markets, not impeding them.

That the backlash is perverse, even quixotic, does not rule out the possibility that it could have consequences. “After the first phase” of EISA, McGowan says, the “DOE is mandated to review it. They sent out an order the week of Dec. 9 that they are going to start hearings to see what should be done the next time. This is going to come up again, and it will be debated. I don’t know what’s going to happen. I talked to one manufacturer, who said it’s going to be a free-for-all.”

But regardless of the surrounding noise in Washington, the signal throughout the lighting industry is clear: EISA’s mandate on efficient lamps is in our national interest, and it’s in consumers’ interests to get up to speed on it. •

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4. Hardcopy color printout of the digital image(s) being included as part of the submission. Images can include just the product image or the product in an installation/application setting. Include the submitter's name, address, phone number, and email address on all printouts.
5. CD or USB drive with all of the entry materials—product literature (text materials in PDF or Word format) and images in correct file format (see Artwork Submission Requirements below). Please note, if the entry materials are being sent electronically, please coordinate with the editor for file transfer instructions via Dropbox. Hardcopy of all materials must be sent, regardless.

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All artwork must be 300 dpi, and at least 4" x 6" or the closest approximation. Appropriate file types are JPEG, TIFF, EPS, or PSD. There should be no text on the images. Please label the digital image files using the following format: Manufacturer\_Product Name.

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# • TECHNOLOGY



## TECHNOLOGY

### **THE BENEFITS OF NATURAL LIGHT**

*Research supports daylighting's positive effect on building performance and human health.*

text by Kevin Van Den Wymelenberg

illustration by Tang Yau Hoong

In 1862, Henry David Thoreau wrote, "In Wildness is the preservation of the world." If he were to see our modern cities, our buildings, and what remains of the wild, perhaps his reaction would be similar to what David Orr, the Paul Sears distinguished professor of environmental studies and politics at Oberlin College, noted in his book *Design on the Edge: The Making of a High-Performance Building* (The MIT Press, 2006): "Modern designers filled the world with buildings and developments divorced

“Productivity is incredibly difficult to quantify in terms of time and money,” says Joseph Park, national sales manager at Lutron Electronics. Yet, it is the factor that decision-makers most often value when choosing whether to include daylight and advanced controls for lighting and blinds.

from their context, existing as if in some alien realm disconnected from ecology...and place.” In cities today, daylight might be the last trace of Thoreau’s idea—and might be, in fact, the preservation of wildness.

In the practice of architecture, daylighting refers to the use of natural light, be it brilliant sunlight or muted overcast light, to support the visual demands of building occupants. In “Daylight Dialect,” which I wrote for ARCHITECTURAL LIGHTING in March 2008, I noted that daylighting purists argue that for a space to be considered daylit, it must use natural light as the primary source of daytime illumination, create a visually and thermally comfortable place connected to outdoor phenomena, and persistently maximize electric lighting energy savings while minimizing peak energy demand. The rest of us, however, might consider a space daylit if it simply has a window with a view.

#### DAYLIGHTING, EFFICIENCY, AND PRODUCTIVITY

Daylighting has been touted for its many aesthetic and health benefits by designers and researchers alike. Scientists at the Lighting Research Center (LRC), in Troy, N.Y., for example, have reported that daylit environments increase occupant productivity and comfort, and provide the mental and visual stimulation necessary to regulate human circadian rhythms.

Utilizing natural light can lead to substantial energy savings. Electric lighting in buildings consumes more than 15 percent of all electricity generated in the United States, according to the U.S. Department of Energy and the U.S. Energy Information Administration. Spaces outfitted with daylight-sensing controls can reduce the energy used for electric lighting by 20 percent to 60 percent, according to the studies “Photoelectric Control: The Effectiveness of Techniques to Reduce Switching Frequency” (2001) and “Summertime Performance of an Automated Lighting and Blinds Control System” (2002), both of which are published in the journal *Lighting Research & Technology*; and “The New York Times Headquarters Daylighting

Mockup: Monitored Performance of the Daylighting Control System” (2006), which was published in the journal *Energy and Buildings*.

Independent field studies published in the past two decades have also shown a range of results, from outperforming predicted savings by 56 percent to experiencing an uptick in energy usage due to increased voltage of some dimming ballasts or lights left powered on after hours even though they were daylight controlled to an off setting. Given these findings, as well as the known thermal interdependencies associated with daylight glazing, a strategy to integrate daylight into a building can reduce or increase its total energy consumption.

“Daylight can also be too much of a good thing,” says Joseph Park, national sales manager for the commercial window treatments division at Lutron Electronics, headquartered in Coopersburg, Pa. A building that has aggressive daylighting goals but is poorly operated will likely use more energy and might subject its occupants to excessive glare and thermal stress. On the other hand, Lisa Heschong, managing principal at TRC Companies—which acquired Heschong’s namesake California-based consulting firm, Heschong Mahone Group (HMG), in January 2013—says that when she interviews workers in daylit retail, commercial, and education spaces, “they consistently report how they love working there, and hope they never have to transfer elsewhere.”

Along with happier workers, substantial financial and human-performance benefits have been associated with increased daylight. In 2003’s “The Benefits of Daylight Through Windows,” LRC researchers discussed anecdotal evidence that commercial real estate with no windows leases for about 20 percent less—or \$2 to \$4 per square foot less—than spaces with windows.

The 1999 study “Skylighting and Retail Sales: An Investigation Into the Relationship Between Daylighting and Human Performance” and the 2002 study “Daylighting Impacts on Retail Sales Performance,” both by HMG, are arguably two of

the most robust investigations into daylight and its effects on retail sales to date. The studies concluded that the presence of skylights was the third-most-important criteria of five observed and statistically significant factors in increasing sales volume; the first and second were hours of operation per week and years since the last retrofit, respectively.

In the 1984 *Science* article “View through a Window may Influence Recovery from Surgery,” Roger Ulrich, now a professor of architecture as well as a co-founding director of the Center for Health Systems and Design at Texas A&M University, reported that surgery patients in rooms that had windows facing trees recovered 8.5 percent faster and took fewer analgesics than did those patients whose view was a brick wall. Subsequent research by others has substantiated the results for patients who stayed in general hospital rooms.

In a 1999 study “Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance,” commissioned by the Pacific Gas and Electric Company, HMG found a high correlation between schools that reported improvements in student test scores—upwards of 10 percent—and those that reported increased daylight in the classroom. The findings sparked discussion on the influence attributable to daylighting, or the daylighting effect size. HMG attempted to pinpoint the relationship in a look-back paper “Daylighting Impacts on Human Performance in School,” published in *Leukos, the Journal of the Illuminating Engineering Society* in 2002. Though HMG and research collaborator RLW Analytics found a statistically significant relationship between lighting conditions and student test scores, they could not definitively explain the effect. Peter Boyce, LRC’s head of the human factors program, likewise cautioned against prematurely drawing scientific relationships in his 2005 *Leukos* article, “Reflections in Behavioral Lighting Research.”

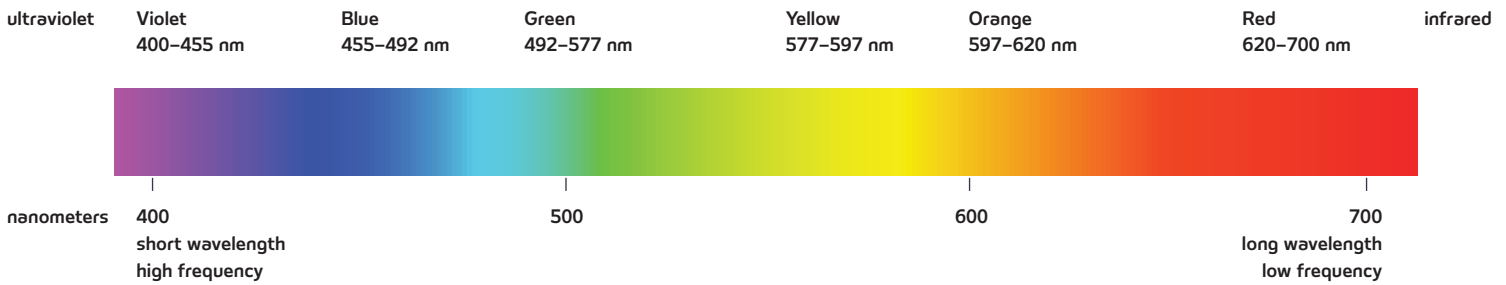
For its part, HMG could not replicate exactly the results of its 1999 study in a 2003

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follow-up, but they still found evidence that an “ample and pleasant view out of a window, that includes vegetation or human activity and objects in the far distance, support better outcomes of student learning.”

As Lutron’s Park notes, poorly daylit and glaring spaces can have detrimental effects. While these decreases in performance have yet to be quantified, I have found in the course of my doctoral research that occupants in environments they describe as having “just uncomfortable” glare rather than the “most preferred” conditions did report a 10 percent decrease in their own perceived productivity.

Despite all the research mentioned, a quantitative relationship between daylighting and human health and productivity remains elusive. “Productivity is incredibly difficult to quantify in terms of time and money,” Park says. Yet, it is the factor that decision-makers most often value when choosing whether to include daylight and advanced controls for lighting and blinds. A belief that daylighting is beneficial does exist, but hard evidence is still scarce. This is due, in large part, to the difficulty in conducting research tied to the dynamic nature of daylight, along with the myriad other variables that are difficult to control in the field. Is it the amount of light that matters, or is it the variability, the view, or the connection to nature?

Overall, the available research suggests that a successful daylighting design—one that factors in taming glare and solar heat gain—is likely to improve worker satisfaction, mood, and productivity. “The right balance can be achieved through the use of active daylighting control strategies, [such as] automated shades, as well as passive strategies, [such as] light shelves or louvers,” Park says. “The markets for automated shades, light shelves, and dynamic glazing are increasing rapidly within the industry.” These technologies mitigate the dynamic movement of direct sunlight while admitting diffuse daylight inside the space.

Recent research has underscored the effect of daylight on human health and biological

functions. According to the U.S. Environmental Protection Agency, humans in modern cities spend upwards of 90 percent of their lives indoors. If they are occupying statically, perhaps stagnantly, lit environments, they can become disassociated with the natural outdoor cycles and variation of illuminance levels.

### DAYLIGHT AND THE CIRCADIAN CYCLE

The biological processes that regulate our sleep–wake cycle make up our circadian system. Primarily through the use of the neurohormone melatonin, our circadian system regulates our patterns of alertness and sleepiness. Without exposure to normal 24-hour light–dark cycles, a person’s sleep–wake cycle can stray by as much as two hours per day.

The cumulative effect of this can be significant. An imbalanced sleep–wake cycle may produce advanced or delayed sleep-phase disorders and lead to chronic sleep debt. In “The Benefits of Daylight Through Windows” (2003), LRC investigators also noted that “[p]eople with chronic sleep debt feel permanently tired and are unlikely to work effectively.” Furthermore, in the 2006 longitudinal study “Light at Night—Cancer Risks of Shift Work,” researchers from Thomas Jefferson University (TJU), in Philadelphia, and the Mary Imogene Bassett Hospital, in Cooperstown, N.Y., found an increased rate of breast cancer in night-shift workers that resulted from the suppression of the pineal gland’s production of melatonin.

A lack of daylight inside a building doesn’t necessarily spell doom for its occupants. Exposure to bright light at the appropriate time of day and for the appropriate duration can alleviate these disorders. Daylight just happens to be one resource that can provide this exposure with the timing and duration that is most beneficial for humans. Darkness at night, not just brightness during the day, is also critical to a healthy sleep–wake cycle.

In order to minimize melatonin suppression, “one should keep exposure to light at night as short as possible, as dim as possible, and as

warm or red as possible,” says Steven Lockley, an associate professor of medicine in the division of sleep medicine at Harvard Medical School and at Brigham and Women’s Hospital in Boston. With this in mind, daylighting design in spaces with sleeping quarters should also consider accommodating nighttime darkness.

The discovery of both a novel retinal photoreceptor in the human eye and the photopigment melanopsin has renewed the attention paid to circadian research and has drawn substantial interest from the lighting community. In the 2001 paper “Action Spectrum for Melatonin Regulation in Humans: Evidence for a Novel Circadian Photoreceptor,” TJU researchers found that the circadian system is most sensitive to short-wavelength (bluer) light, ranging from 446 to 477 nanometers (see “Visible Light Spectrum” above). They also found evidence supporting the existence of a photopigment that mediates circadian photoreception, now coined as circadian photoreception, which complements scotopic vision (which is rod-dominated, dim-light vision, with a peak of 507 nanometers) and photopic vision (which is cone-dominated, bright-light vision, with a peak of 555 nanometers).

Since photopic vision is critical to visual tasks, most electric light sources are designed to support it. However, short-wavelength light of 460 nanometers has been found to increase alertness as compared to longer-wavelength light of 555 nanometers. Furthermore, multiple studies have shown that students who did not receive short-wavelength visible light in the morning had delayed melatonin production and sleep onset in the evening by about 30 minutes.

### INTEGRATING DAYLIGHT WITH DESIGN

While daylight is a variable, often unpredictable, light source with a spectrum that depends on solar position and sky conditions, it is also rich in the short-wavelength portion of the visible spectrum found to support both alertness and circadian sleep–wake entrainment. As a result, daylight in buildings may support

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human health and well-being, particularly for people in northern latitudes who occupy areas near a window or other daylight sources. But regardless of latitude or exposure duration, daylight may support human alertness and productivity. At the same time, it is important to remember that it is the daily—and possibly the seasonal—variation associated with the day-night light and dark cycles that supports human health. Lighting manufacturers, for one, have jumped on the bandwagon and attempted to mimic these cycles through electric light sources and lighting systems.

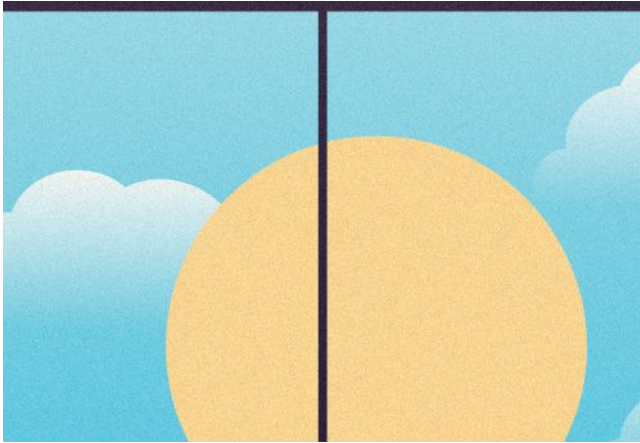
Designers can glean two points from this trove of research. First, daylight spaces hold the potential to yield substantial benefits, including increased energy savings, increased revenue in retail applications, and improvements to human health and productivity. Second, several important factors ranging from design to installation and operation must be carefully addressed in order to realize these benefits.

Many resources are available to guide decision-making in daylighting design (for a starter list, see “Resources” to the right), but three tasks that are critical to a successful daylighting installation are: the control of direct sunlight at visual task areas during all occupied hours; the provision of balanced luminance on interior surfaces, particularly between perimeter windows and key vertical surfaces within the interior volume; and the provision of sufficient ambient daylight illumination for visual tasks. Modeling and testing design decisions with the increasing selection of daylighting software tools are also important. Once a design is executed, ensure operational success by educating building occupants and operators on the intent of the daylighting design, how to use lighting controls, and how to access and use shading controls.

It is the “seasonal variability of interior daylight illumination,” Heschong says, “along with views to the outdoors that provides important stimulus to the circadian system, [and] along with making any space more pleasurable and interesting for its occupants.”

If Thoreau’s belief about “Wildness” is true, then we should take the opportunity to introduce the wildness of daylight into our structures. It can be difficult to tame, but its presence in our buildings is important for the preservation of the rhythms of human life, connecting people more closely to place, and revealing local ecology in our built environment. •

*Kevin Van Den Wymelenberg is an associate professor of architecture at the University of Idaho, director of the university’s Integrated Design Lab, and chair of the IES Daylight Metrics committee.*



## RESOURCES

Quantifying the effects of daylight is a nascent topic of study but research on daylight and design in general has been growing for decades. Below is an introductory list of educational resources and articles.

### ONLINE

*Daylighting Pattern Guide*, by New Buildings Institute with the University of Idaho and the University of Washington. Available at [patternguide.advancedbuildings.net](http://patternguide.advancedbuildings.net). This free resource features design strategies for common building types.

*Daylighting*, by the Illuminating Engineering Society, uploaded February 2012. Available at [youtube.com/user/IES1906](http://youtube.com/user/IES1906). Five narrated presentations, subtitled *Podcast 01* to *Podcast 05*, cover basic daylighting concepts and design strategies.

*eLAD Body of Knowledge*, by the U.S. Department of Energy, last modified Aug. 5, 2012.

[elad.su-per-b.org](http://elad.su-per-b.org). This free resource is intended for users of all experience levels interested in daylighting design.

### IN PRINT

*Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)*, by the Illuminating Engineering Society (IES), 2013.

This document defines recommended daylighting metrics and the associated simulation protocols, and provides design criteria recommendations.

*Daylighting Design in the Pacific Northwest*, by Christopher Meek and Kevin Van Den Wymelenberg, University of Washington Press, 2012.

This architectural monograph reviews the daylighting consulting work of the Pacific Northwest Daylighting Labs at the University of Idaho and the University of Washington.

"The Benefits of Daylight Through Windows," by Peter Boyce, Claudia Hunter, and Owen Howlett, Lighting Research Center, 2003. This literature review examines the effects of daylight on human health and worker performance.

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PRODUCTS

# THE GREAT OUTDOORS

*A roundup of the latest innovations in outdoor illumination, from private pathways to the open road.*

text by Hallie Busta



**Game, Torremato** • Game, an outdoor pathlight with a sculptural form, is lamped with either an E27 23W ES 1XMax lamp or a 13W LED in 3000K and 5000K. The fixture's base measures 7" by 7" and the unit is 14.7" tall. Its metal housing is offered in two finish options: natural antique or gray. • [torremato.com](http://torremato.com)



**Mongoose LED, Acuity Brands/Holophane** • An eco-friendly alternative to high-pressure sodium and metal-halide roadway and area lighting systems, the Mongoose LED luminaire cuts energy costs and carbon dioxide emissions by up to 60% and reduces maintenance costs by more than 50% in new and retrofit construction, according to the manufacturer. Offered in 4000K and 5000K with a minimum CRI of 70, the fixture has a light output of 15,000 to 36,000 lumens. Three mounting options are available, including a horizontal arm (shown), a horizontal mast arm, and a vertical tenon. The fixture head measures 6.6" tall by 40.8" long by 17.7" wide, with tilt options of zero degrees to 18 degrees and 27 degrees to 45 degrees. Intended for mounting heights of 30' to 50'. • [holophane.com](http://holophane.com)



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**Candela, Santa & Cole** • Barcelona-based designer Gonzalo Milá developed the Candela LED street lamp as a streamlined alternative to traditional streetscape illumination. The luminaire is offered with arrays of up to 96 LEDs, in 3000K and 4000K. Its thin profile and oval shape help the unit blend into the environment while its die-cast aluminum housing disperses heat. Available with pole heights of 26.25' and 32.80', and with arm lengths of 2.5' and 4.9'. Candela is offered in the U.S. through Landscape Forms. • [santacole.com](http://santacole.com) and [landscapeforms.com](http://landscapeforms.com)



**PAR38, Toshiba** • A replacement for 90W to 110W halogen lamps, Toshiba's PAR38 LED lamp offers 1,000 to 1,200 lumens in 2700K, 3000K, and 4000K. The Energy Star-certified lamp uses up to 75% less energy and emits up to 90% less UV light than halogen lamps, its maker says, and it contains neither mercury nor lead. The lamp, which is offered in 16W and 18W versions, is rated at 40,000 hours of life, according to the manufacturer. • [toshiba.com/lighting](http://toshiba.com/lighting)



**Vetrinella, Tivoli** • Designed for exterior pathway or low-level interior illumination, the Vetrinella LED luminaire is outfitted with surface-mounted LEDs in 3000K, 3500K, and 4000K. The fully dimmable fixture consumes 6.5W and provides 163 lumens. Designed to fit a standard, two-gang deep-well junction box in either new or retrofit construction, the luminaire includes an integral driver and field-serviceable LED board. • [tivolilighting.com](http://tivolilighting.com)

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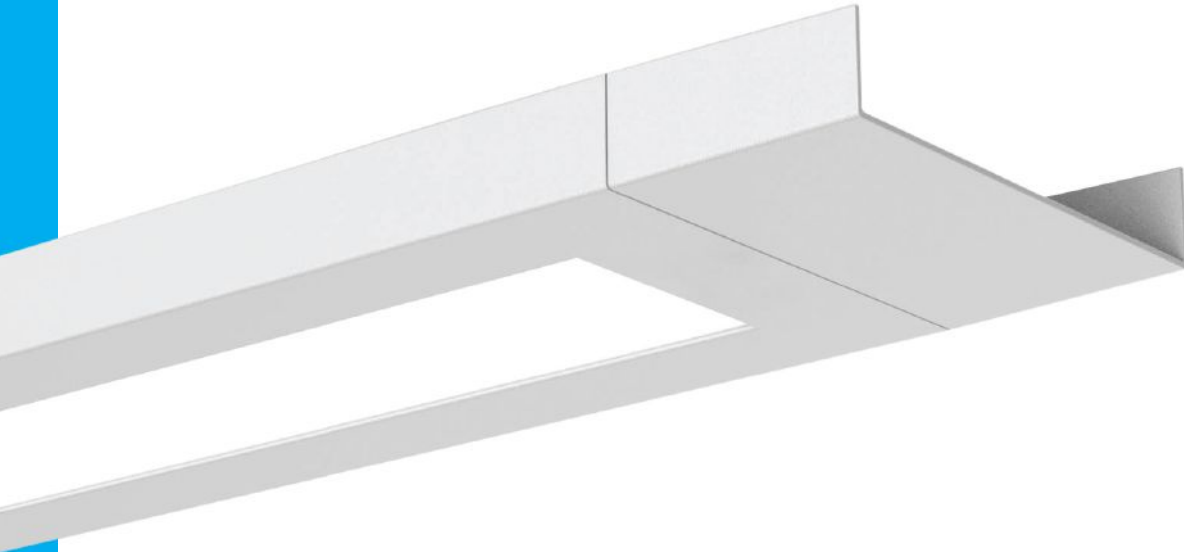


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TEXT BY HALLIE BUSTA



## Bruno, Acuity Brands/Peerless •

This LED luminaire can be suspended or wall-mounted and includes a fully dimmable driver. An integrated sensor detects occupancy and daylight and adjusts the luminaire's light levels accordingly. The direct/indirect fixture is offered with LEDs with outputs ranging from 1,800 lumens to 4,800 lumens in color temperatures of 3000K, 3500K, and 4000K. The luminaire can be synced with the manufacturer's nLight modules to allow network connections that facilitate energy management. • [peerlesslighting.com](http://peerlesslighting.com)

**Covert, Focal Point •** Designed to illuminate architectural coves, Covert is a dimmable, indirect LED luminaire offered in 3000K, 3500K, and 4000K, with a minimum CRI of 80. Four adjustable profiles—vertical and horizontal light-bar bases, each with an optional scoop—are available to accommodate the range of space types and dimensions. The vertical base measures 2.44" wide and 3.44" tall while the horizontal base measures 4" wide and 2.25" tall. • [focalpointlights.com](http://focalpointlights.com)



## DynaGraze Interior Standard Output, Acclaim Lighting •

This low-profile, single-color LED luminaire is intended for interior linear wall-grazing applications and comes in 1' and 4' sections. It is offered in 2700K, 3000K, 3500K, and 4000K, with a minimum CRI of 85. The dimmable fixture is fitted with electronic low-voltage modules and with TRIAC dimmers. No additional signal or control cabling is required when replacing fixtures within an existing installation. • [acclaimlighting.com](http://acclaimlighting.com)

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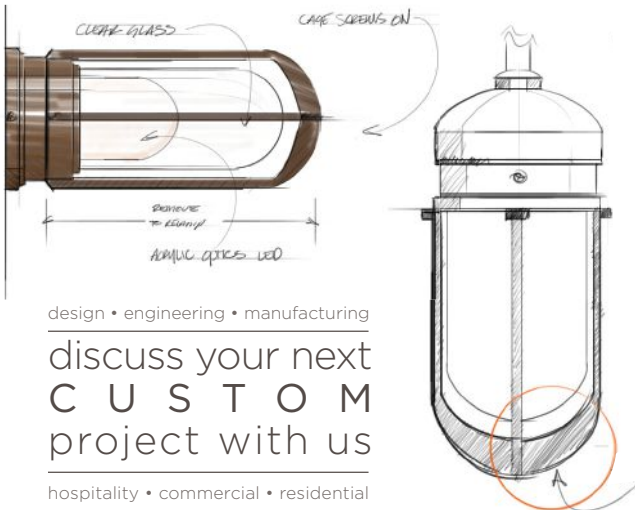
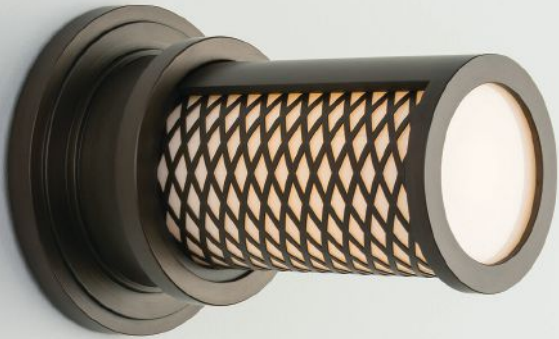
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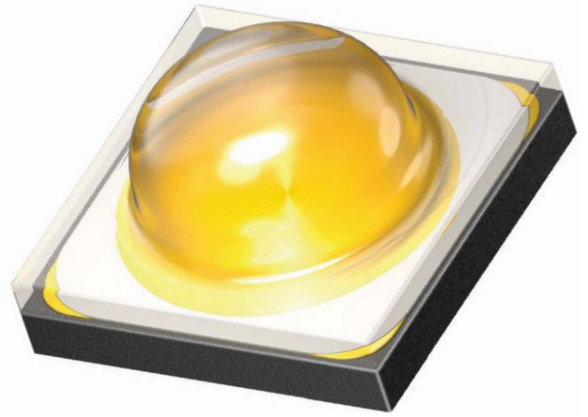
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**Oslon Square, Osram Opto**

**Semiconductors** • Designed to withstand high ambient temperatures, the Oslon Square LED utilizes a smaller heat sink to help streamline the design of luminaires and lamps. The LEDs are available with a typical luminous flux of 202 lumens and color temperatures from 2400K to 5000K, all with a minimum CRI of 80. According to the manufacturer, the driver has a lifetime of more than 50,000 hours. The LED unit is composed of a ceramic package with silicone resin and a silicone lens. • [osram-os.com](http://osram-os.com)



**Finiré LED Recessed Lighting,**

**Lutron** • LED fixtures, drivers, and

controls are synchronized in this 4" downlight for recessed lighting applications. Finiré, from the Lutron Ivalo Collection, incorporates dimmable Xicato LED modules that are available in 2700K, 3000K, and 3500K and have a CRI of either 83 or 95-plus, depending on the color temperature. Finiré's field-adjustable beam spreads can accommodate applications such as directional lighting in residential and commercial spaces with high ceilings, and spot and tasklighting. The fixture is available in round, square, trimmed, and trimless apertures. • [lutron.com](http://lutron.com)





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### **BLED Bollard, RAB Lighting •**

The BLED bollard, part of a family of outdoor luminaires that also includes a wall sconce version, is fitted with a polycarbonate lens to enhance its durability, and it incorporates precision-engineered optics to reduce glare. The fixture is available in 12W, 18W, and 24W with beam spreads of 180 degrees, 270 degrees, and 360 degrees, respectively. According to the manufacturer, the LED luminaire has a 100,000-hour lifespan. The 42"-tall bollard is available in round and square profiles, each measuring 6.5" wide at the head and 5.5" wide at the base, and comes in either a bronze or a white finish. • [rabweb.com](http://rabweb.com)



**Vivid 2 MR16 GU10 230V, Soraa •** Vivid 2 is the company's second-generation Vivid MR16 GU10 LED lamp. A continuous, full-visible-spectrum, high-color, white-rendering, high-light-output lamp, it consumes 9.8W. A 10-degree spot and a 25-degree beam spread are included in the series. It is the equivalent of a 65W halogen lamp and comes in 2700K, 3000K, and 5000K, with a CRI of 95. • [sora.com](http://sora.com)



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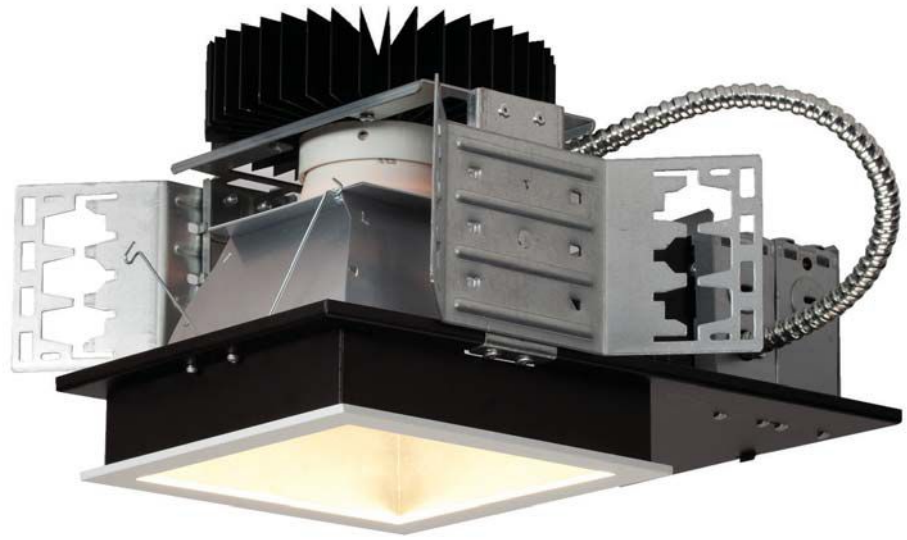
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**PrevaLED Cube, Osram Sylvania** • A thin profile and white-colored facing help the PrevaLED Cube light engine blend into a space's design aesthetic as well as accommodate retrofit applications. This series offers between 94 and 120 lumens per watt. The engine is dimmable to 1% and is available in 2700K, 3000K, 3500K, and 4000K and lumen outputs of 1,000, 2,000, and 3,000. It is compatible with fixed or programmable power supplies and its light output can be adjusted so OEMs can match lumen output across multiple fixtures. • [sylvania.com](http://sylvania.com)



**DI Series, GE Lumination** • The DI Series, a modular LED downlighting system, features a twist-and-fit design that allows building occupants to upgrade or service the lamp without replacing the entire fixture. The system uses the company's Infusion LED technology, offering modules with lumen outputs ranging from 1,000 to 4,000 and with CRIs of up to 90. Designed to provide ambient light in high-ceiling applications including retail, office, and hospitality spaces, the fixture comes in 4" and 6" round and square apertures. • [gelifighting.com/na](http://gelifighting.com/na)

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**Optima LED StretchLite with Perimeter Lighting, Stylmark** • For large-format interior graphic applications, the Optima LED StretchLite with Perimeter Lighting light box is the latest addition to the Optima LED StretchLite products family. A slim surround and invisible perimeter tensioning create a frameless look. Perimeter lit, it is available in 6000K and uses 6W per linear foot at 24V DC. Its depth for single-sided images is 3.95" and for double-sided images is 8". • [stylmark.com](http://stylmark.com)



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**SlimStyle, Philips** • The company's third-generation A19 LED 60W and 40W replacement lamps, SlimStyle emulates an incandescent but with a slender profile. The lamp is available in 10.5W at 5000K or 2700K, each at 800 lumens; in 8W at 2700K at 450 lumens; and in 7W at 5000K at 450 lumens. All models have a CRI of 80. Dimmable, the lamp measures 4.2" tall by 2.6" wide and fits an E26 medium base. • [usa.philips.com](http://usa.philips.com)



### Elysée Suspension, Leucos •

The Elysée family of chandeliers, designed by Marina Toscano for Leucos, creates a whimsical appeal when illuminated. The fixture, with its clear crystal armature, is available in two sizes — 65" wide by 43" tall and 43" wide by 29.5" tall (shown). The larger version is lamped with either one 60W or one 11W 3000K LED; the smaller version is lamped with either seven 5W or one 40W 3000K LEDs. Both models are dimmable and feature a polished-chrome frame. • [leucosusa.com](http://leucosusa.com)


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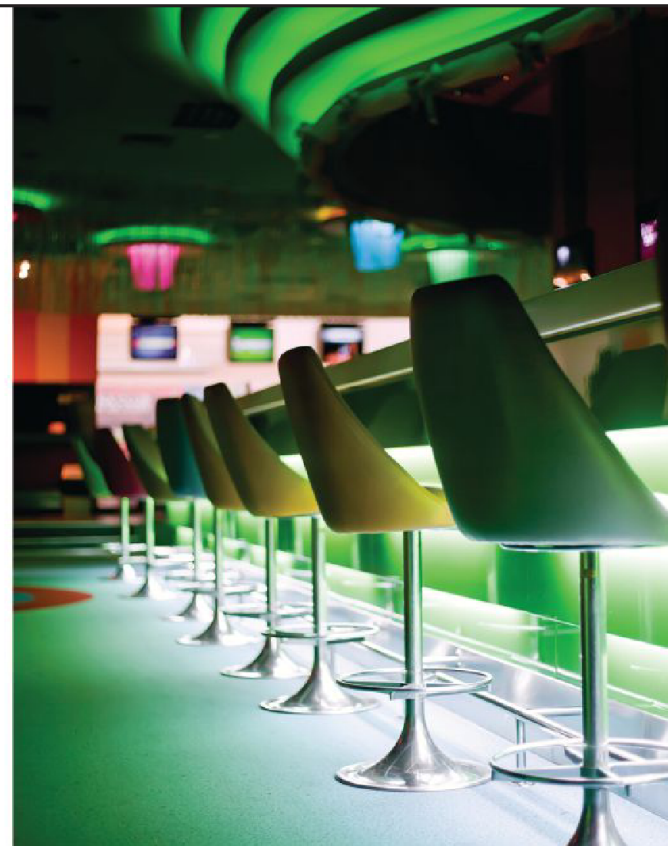


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# Light Takes Flight







## HORTON LEES BROGDEN LIGHTING DESIGN TEAMS UP WITH AECOM TO GIVE LOS ANGELES INTERNATIONAL AIRPORT A CONTEMPORARY LIGHTING TREATMENT.

TEXT BY DEANE MADSEN

The lights of Los Angeles are visible as far east as Palm Springs, Calif., with a brightness that builds in a steady crescendo with your proximity to the Pacific coast. On approach into Los Angeles International Airport (LAX), a cluster of color-changing, illuminated pylons marks arrival at the airport. These pylons, which were installed in 2000 to coincide with the Democratic National Convention, have become an identifying feature of the airport and are, in part, serving as design inspiration for a new series of improvement projects that are currently underway.

### **The Plan**

In recent years, Los Angeles World Airports (LAWA), the authority that runs LAX, which serves 63.7 million passengers annually, has proposed a series of enhancements to upgrade the airport's dated facilities. From the centrally located 1960s-era Theme Building to the general passenger experience, LAWA will spend

approximately \$4.11 billion on airport modernization projects over the next five years.

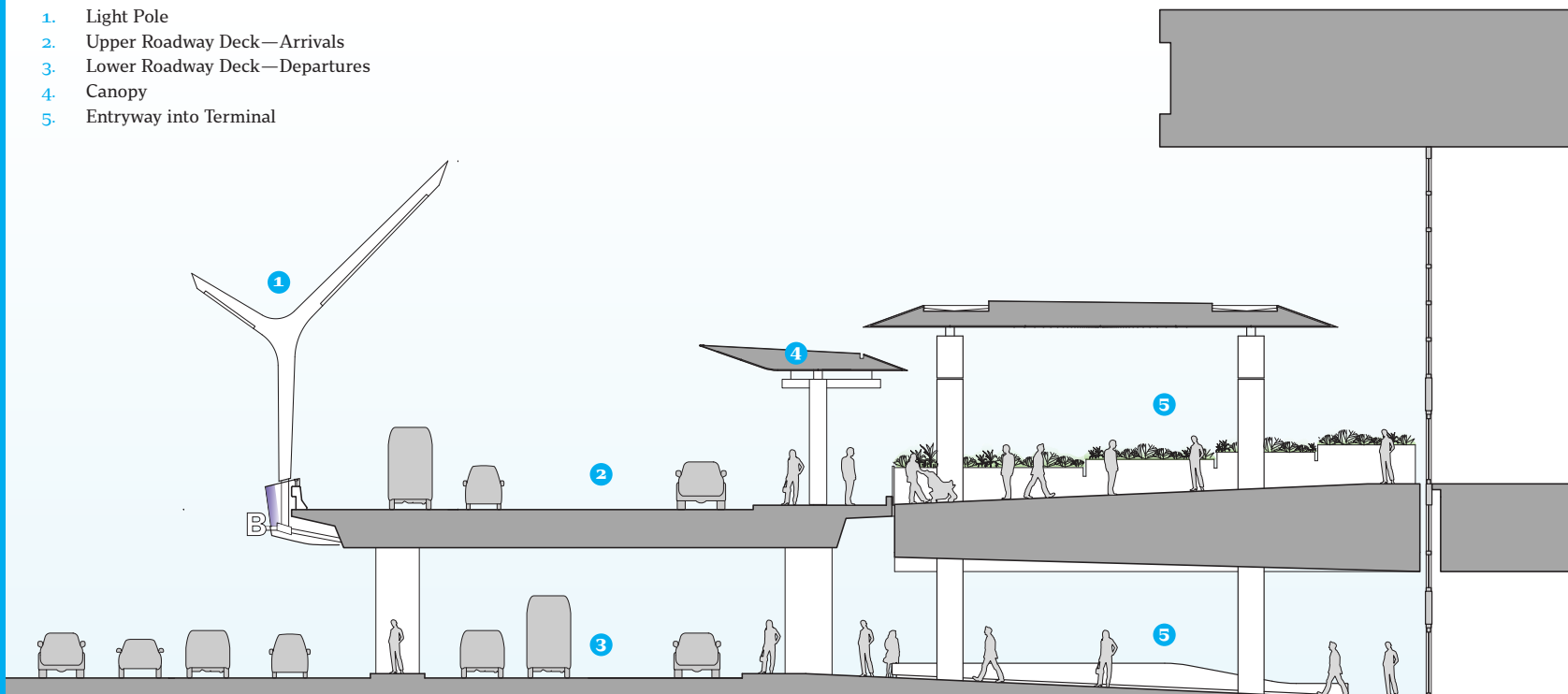
As part of these improvements, a team made up of AECOM, which is headquartered in L.A., and the Culver City, Calif., office of Horton Lees Brogden Lighting Design (HLB) executed the first phase of lighting upgrades outside the Tom Bradley International Terminal (TBIT), components of which will be rolled out across the rest of the terminals in phases over the coming months. These kit-of-parts upgrades include new canopies at the entries to TBIT, new light poles to illuminate two levels of circulatory roadways, and a polychromatic horizontally oriented light ribbon to tie all of these elements together.

When the gateway pylons were first installed, each of the cylindrical towers—which range from 30 feet tall along Century Boulevard to 100 feet tall at the entrance to the airport—was outfitted with 32 exterior-rated color-changing luminaires. In 2006, another



SECTION THROUGH THE ROADWAY DECKS AT TOM BRADLEY INTERNATIONAL TERMINAL

1. Light Pole
2. Upper Roadway Deck—Arrivals
3. Lower Roadway Deck—Departures
4. Canopy
5. Entryway into Terminal



initiative to upgrade the airport facilities and reduce maintenance costs, timed well with evolving lighting technologies and saw the switch to LEDs from fluorescents, which had been falling into disrepair. (See "LAX Pylons Undergo Makeover," Jan/Feb 2006.) The current effort, dubbed the Central Terminal Area (CTA) Curbside Appeal Project, aims to extend the iconography of the gateway pylons through the rest of the airport using a light ribbon—LED strips mounted behind a glass fascia that sits at the edge of the upper roadway bulkhead and the canopy—that syncs with the changing colors of the entry pylons to create a cohesive lighting experience.

### Light Poles

Along the roadway itself, 91 new light poles, lit with LEDs, replace the existing high-pressure sodium fixtures. These light poles—inspired by the '60s style of the Theme Building and taking their sculptural form from airplane propellers—illuminate both the lower departures level and the upper arrivals level to create what designer Carlos Madrid calls "a celebratory procession moving through the airport." (Madrid was with AECOM at the time of the first phase. He has since joined Skidmore, Owings & Merrill.) HLB senior principal Teal Brogden describes the design process as emanating from "an aesthetic desire to create something that feels uplifting or upward-reaching, but also speaks in the vocabulary of the Theme Building."

One of the challenges that the light poles presented was finding a fixture that would fit within the length and slender profile of the arms. The lower arm of the pole houses a nine-foot-long fixture with nine 12" LED boards. The upper arm of the pole holds two, 9-foot-long LED fixtures, or 18 LED boards. As Brogden tells it, LAX has embraced solid-state lighting, so there was never any question about the use of the technology, just a question of fit. "There's a very nuanced detail of how the wires are managed," she says. "Changing the way the wires are managed to

the edges of products, rather than directly behind the LEDs, gives us a little more room to set the LEDs further into the sculptural form, to make the experience of the cut-off a little more gradual." HLB found an existing 1-inch-wide roadway component which would fit—when oriented 180 degrees from how it would normally be applied. The pole arms themselves serve as heat sinks, and modifications by the manufacturer allow for end-to-end placement of the linear LED arrays for uninterrupted lines of 3500K white light cast on both levels of the roadway.

Now that the installation of the first phase is complete, Brogden says that the team is planning a few modifications to the LED components for the next phases, which will deploy light poles around the rest of the airport's horseshoe-shaped circulation artery. "We're working alongside maintenance at LAX to make sure [the fixtures] are a little more plug and play."

Brogden also credits the pole fabricator and the manufacturer of the pole LED fixtures for ensuring that their products would work in this environment. The designer-manufacturer relationship has taken on an even more collaborative approach in the second phase. "It's been the kind of work environment that I think everybody dreams to be able to work in," Brogden says.

### Canopies

In addition to modifications to the entry landscaping, AECOM and HLB have established a new series of entry portals into TBIT. What was a sunken plaza has now been filled to be level with the sidewalk. Above, a continuous, 800-foot roadside awning replaces steel-and-glass space frame canopies from the 1970s. Three entryways into the terminal feature 16-foot-diameter skylights with perforated screens that filter natural light during the day and are backlit at night.

AECOM was careful in its efforts to make these simple, blade-like structures appear weightless. "While they all seem quite simple; they're quite complex," Madrid says. "It's all kind of concealed on top



**OPENING SPREAD:** The arrivals level of Tom Bradley International Terminal features a new 800-foot-long canopy, with a light ribbon at its edge synced to change colors with the gateway entry pylons. **OPPOSITE, TOP:** The LAX gateway pylons, installed in 2000, were designed by the Los Angeles-based team of Ted Tokio Tanaka Architects, Paul Tzanetopoulos, and Moody Ravitz Hollingsworth Lighting Design (the latter of which has since disbanded). **THIS PAGE, TOP:** A perforated screen filters light into the departures level entryway. **THIS PAGE, ABOVE:** Aerial view of TBIT.



The light poles draw their form from the shape of propellers and illuminate the upper and lower roadways around LAX in a “celebratory procession.”

of the canopies, so you can't see it from the street level. But there's been a lot of modeling." Beneath the canopies, 5W-per-foot 3500K dimmable LED fixtures provide an ambient layer of light to make the space feel more welcoming.

Brogden speaks about influencing passenger experience through subtle details like materiality and surface finishes. "The intent was to have an environment that felt softly luminous, but had enough specular components to have a little bit of glitz," she says. Using specular finishes on white surfaces and matte finishes on silver surfaces was a way of "catching the light and reflecting it back to you in that softer muted way that feels a little bit like the glisten from a receding wave."

### Light Ribbon

Expanding on that metaphor of the ocean, the light ribbon—synced to the gateway light pylons—will also feature color shifts that mimic waves. The HLB team captured video of the beach at sunset and fed it into a scrambler for the DMX control system, which abstracts the images across the broad pixels of the light ribbon to emulate an understated sense of motion.

In addition, from the same earlier project that brought the entrance's gateway pylons came a roadside planter installed along the upper roadway edge. "That's just been a maintenance issue for them ... and it was never very lush with plants," Madrid says. "So that is coming down, and will be replaced with the light ribbon that runs through the whole CTA on the edge of the roadway." The light ribbon, now installed along the upper roadway bulkhead, will also be extended to both ends of the terminal roadways in upcoming phases, merging the experience with the gateway pylons.

HLB and AECOM conducted luminosity tests from the LAX

control tower to ensure that their lighting enhancements would not disrupt visual sight lines and the day-to-day activity of aircraft landings and takeoffs. "We were excited that we actually got to go up into the tower and take measurements, so that we could then give them some predictive luminous mapping for new schemes," Brogden says. "Everyone was on board with not only creating a more forward-looking experience, but also enhancing the safety with full white light. We're glad that they were curious, because it would be unfortunate if anything along the way was to be an issue and we hadn't studied it ahead of time."

The spirit of curiosity inspired the entire team. With AECOM, HLB, and the light pole manufacturer all located in the Los Angeles area, drop-in meetings to discuss the design became routine. "I was fortunate to be in the city in which the manufacturer and engineering team sat," Brogden says. "I made arrangements to just stop by and show the project to them. ... If the folks that are working on the project can get excited about the vision of it, you usually have people's buy-in, and you can encourage their partnership in the process and honor their expertise."

Now that the first phase is complete, the team is focusing on finding the best solutions for rolling out the next of its kit-of-parts improvements. Already, the collaborations between designers and manufacturers have yielded a more customized, more maintenance-friendly solution for the LED light poles. When complete, the entire airport will reflect the glow of the gateway light installation, pulsating with the vibrancy of the city it occupies. "L.A. is a city that's very spread out," Brogden says, "but there are always bits of L.A. in motion." •

Courtesy AECOM

**DETAILS** **Project:** LAX Central Terminal Area (CTA) Curbside Appeal Project, Los Angeles • **Client:** Los Angeles World Airports (LAWA) • **Architect:** AECOM, Los Angeles • **Lighting Designer:** Horton Lees Brogden Lighting Design, Culver City, Calif. • **Project Size:** 15,350 square feet (roadway and light ribbon); 28,750 square feet (canopy) • **Project Cost:** Withheld at Owner's Request • **Watts per Square Foot:** 4.11 (light ribbon); 0.409 (other areas) • **Energy Compliance:** California Title 24 • **Manufacturers/Applications:** **Acuity Brands/Winona Lighting** (linear LED fixtures at the canopy) • **Bega-US** (22W LED spotlights uplighting the light pole) • **Cooper Lighting** (custom LED fixtures for light pole) • **ETC** (light ribbon lighting controls) • **Lutron Electronics** (lighting controls) • **Penwal Industries** (light pole fabricator) • **Philips Color Kinetics** (color-changing LEDs for light ribbon)



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# STRUCTURAL LIGHT

*Renzo Piano Building Workshop and Arup join forces to create a contemporary lighting scheme for the new Renzo Piano Pavilion at the Kimbell Art Museum, one that keeps the original work of Louis Kahn and Richard Kelly in mind.*

text by Elizabeth Donoff  
photos by Richard Barnes



## Site Plan



1. Kahn Building
2. Reflecting Pool
3. The Garden
4. Piano Pavilion

The new Renzo Piano Pavilion at the Kimbell Art Museum sits across the garden from the original Kahn-designed building with its signature barrel vaults (above). "The soft illumination of the landscape, trees, and accent to the concrete walls creates a visual link between the historic Kahn building and the new pavilion," Arup's Giulio Antonutto says. Hundred-foot-long, Douglas-fir, laminated wood beams are the structural feature of the lobby of the new pavilion (opposite, left). LED spotlights are suspended from tracks positioned in between the wood beams. The structure and lighting assembly continue through to the galleries beyond (opposite, right).

**Some buildings** are known for their architectural form, some for their use of materials, others for their quality of light. In the case of the Kimbell Art Museum in Fort Worth, Texas, designed between 1966–72 by architect Louis Kahn, it's the perfect triumvirate. How then, could anyone think of disturbing this masterwork, which has secured its place as an icon of modern architecture? The dilemma of how to approach architectural expansion has become more pressing in recent years as a generation of buildings come of age and the institutions they house have come to exceed their spatial limits.

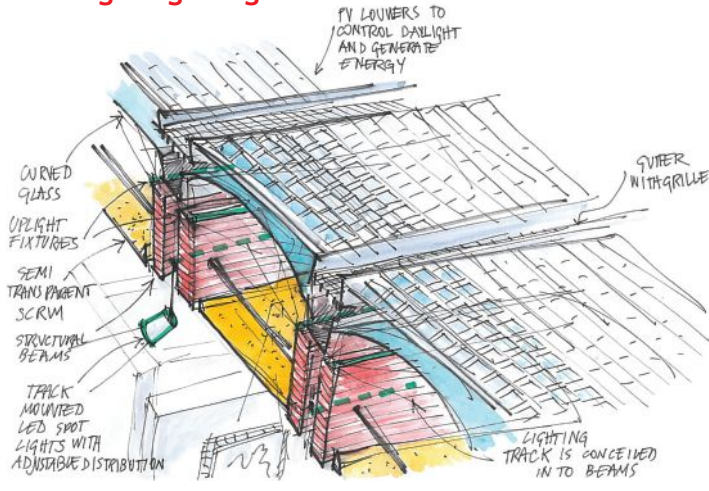
Like many art museums, the Kimbell has faced spatial constraints in its galleries for years. It has not been able to display the full extent of its collection and traveling exhibitions at the same time. As a result, it has had to house much of its permanent collection in storage while special exhibitions were occurring.

In 1989–90, the museum pursued an expansion plan with a design by Mitchell/Giurgola Architects. But the proposal, which called for replicating Kahn's architectural bays with their distinctive cycloidal concrete barrel vaults, met with significant outcry from the architectural community and even Kahn's daughter, Sue Ann. Unnerved by this public relations fiasco, the museum shelved the plans. The need for more space, however, remained.

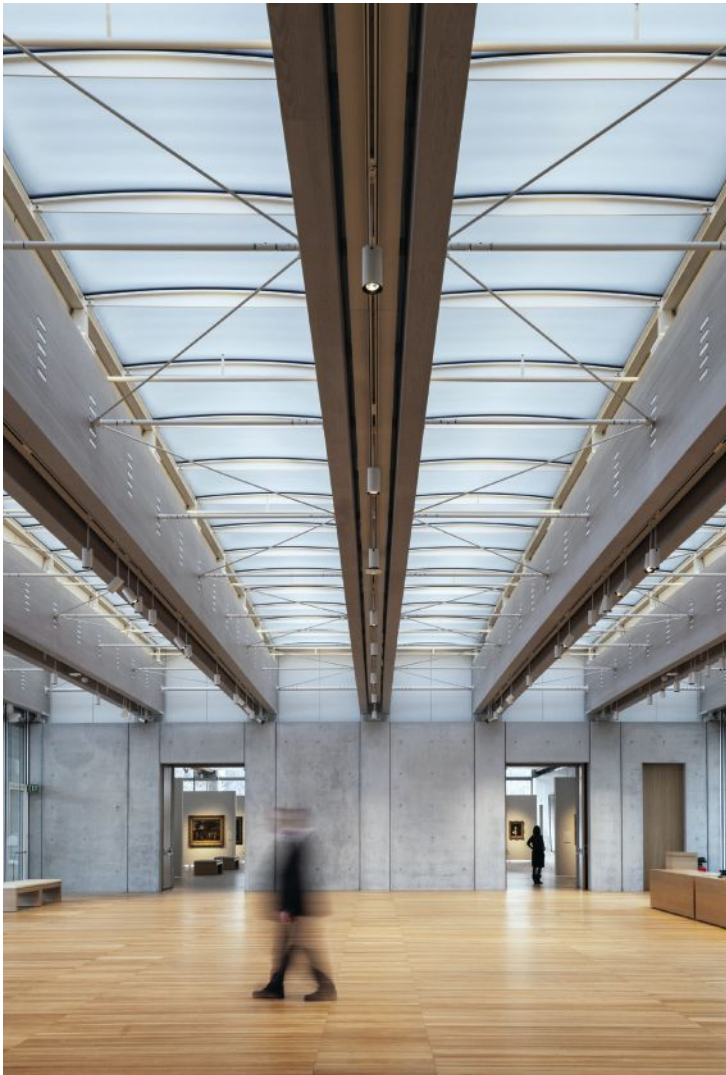
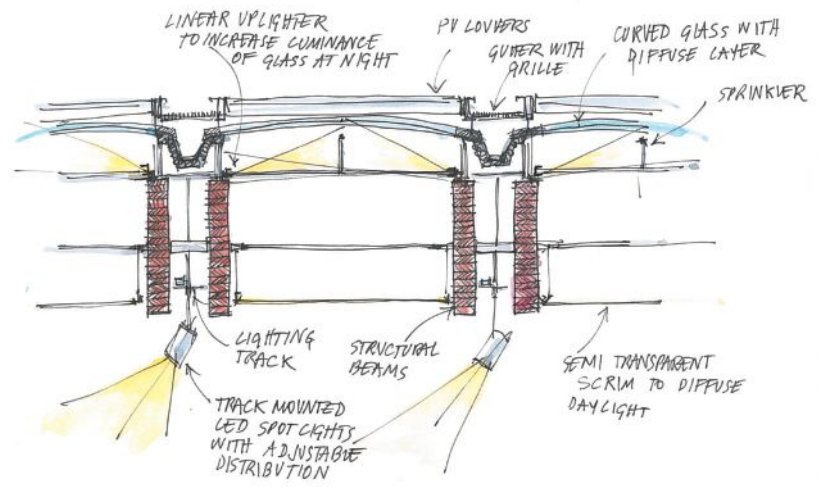
Jump ahead almost 17 years to 2006. The Kimbell Trustees, who had since gotten Sue Ann Kahn on board with expansion by introducing the idea to construct a separate building across from the existing museum, approached architect Renzo Piano and his firm Renzo Piano Building Workshop (RPBW) with the commission. Piano was reluctant at first, as he saw what had happened during the last go-around. More importantly, as a young architect, he had worked in Kahn's office in the early 1960s, and this was someone's work whom he admired.



### Sketch of Roof Louver System and Lighting Integration



### Sketch of Lighting Integration with Glass Roof and Beam Assembly



Sketches Courtesy Arup

In time, though, Piano accepted the challenge and began work on a preliminary design, but there still remained the issue of where this new addition would be located. The museum had purchased land across from its rear entrance. Then, when it was suggested that the new building be built across the garden that faced the front of the Kahn building, the expansion project was infused with a new momentum.

**Piano's design** for the new building is respectful of Kahn's work, drawing inspiration not only from its architectural organization and attention to materials and textures, but its masterful use of natural light, which infuses the interiors with a sublime quality. And just as Kahn worked with lighting designer Richard Kelly to develop a lighting strategy for the project, so Piano worked with the lighting group at Arup on the illumination design of the new addition. It is not the first time RPBW has worked with the lighting team at Arup. The two firms have collaborated on a number of art museum additions over the past decade, including the High Museum in Atlanta, the Art Institute of Chicago, and the Isabella Stewart Gardner Museum in Boston.

At the Kimbell, the new building, referred to as the Piano Pavilion, houses gallery spaces, a 298-seat auditorium, classrooms, the education department offices, an expanded library, art preparatory areas and storage, a café, and a gift shop. It faces east and sits exactly 65 yards wall-to-wall from Kahn's building.

The magnitude of the design challenge goes well beyond the architecture. Trying to create a lighting scheme, and particularly a daylighting scheme that was the match of the original building was no easy task. Kahn and Kelly, along with the assistance of Edison Price and Price's computer consultant Isaac Goodbar, devised a daylighting system for the galleries that has earned its place as one of the gold standards in lighting design. Kahn wanted there to be indirect sunlight in the galleries. Given the Texas climate, however, the designers had to be extremely careful about how much light would be allowed into the space. What Kahn hadn't figured out was how to diffuse this light.

After in-depth research and elaborate lighting calculations, the team established the exact position and angle that a reflector would need to sit below the curved ceiling in order to properly diffuse the light. This passive system allows light to enter through a slot in the barrel-vault ceiling and then hit the main surface of the polished-anodized-aluminum reflector. (Kelly had suggested the use of a perforated metal screen, commonly found in commercial light fixtures.)

Most of the light is bounced up to the concrete ceiling vaults while a small amount is allowed to diffuse through the perforated reflector into

the gallery below. Kahn is said to have called the reflectors "natural-light fixtures." A splayed armature suspends below the reflector (which follows the reflector's reverse curve) with two rails of tracklighting to provide complementary electric light. Additional natural light enters the space at each end wall through a narrow, glass light-band that follows the curve of the barrel vault. The outcome of this light manipulation is a slivery, diffuse light that creates an environment that respects the sensitive artworks on display and connects the museum visitor to the outside.

**To tackle the lighting** in the new Piano Pavilion, the Arup team knew they would have to make a careful study of Kahn and Kelly's work, not just in terms of the technical components but the qualitative as well. "We did a thorough assessment of the Kahn building looking at what made the lumen levels, what the distribution of the light was, and what was the luminance distribution on the surfaces of the gallery spaces," says Arfon Davies, associate director of lighting in Arup's London office who led the lighting efforts alongside associate lighting designer Giulio Antonutto. "It quickly became apparent that the feeling of light there is much more significant than the actual amount of daylight in the space. It's a very clever trick; when you enter the gallery space you feel the presence of daylight is much more significant than it actually is. That was something that we really felt was an important characteristic of the Kahn [building] that we wanted to try [to use] and form the design of what we would do in the Piano Pavilion."

With a nod to the form and materiality of Kahn's building, Piano's design is respectful, yet consistent, with his own architectural vocabulary of glass, wood, and steel. The building's 300-foot-long east façade, which faces the Kahn building, is divided into three bays: a recessed glass entrance and a wing to each side finished in a light-gray concrete. The entire elevation is capped off by the glass roof structure supported by Douglas fir wood beams.

According to Davies, Piano wanted a lighting design that was adaptable and tunable. To that end, the gallery lighting marks a milestone for the RPBW-Arup team. It is the first time they used an all-LED solution. The design of the space, with its 29 pairs of 100-foot-long laminated wood beams, allows the galleries to be completely open and a system of movable partitions to be rearranged based on the needs of the exhibit. The space can be lit primarily with daylight, or can be changed to be lit primarily lit by electric light. The spotlights, outfitted with 24W 3000K LED modules, and other building systems such as sprinklers and security cameras are run on tracks positioned in between the beams to keep the ceiling plane as clean as possible.



## West-East Section

1. Galleries, Kahn Building
2. The Garden
3. Galleries, Piano Pavilion
4. Glass Corridor Link, Piano Pavilion
5. Auditorium, Piano Pavilion
6. Education Studios, Piano Pavilion
7. Parking



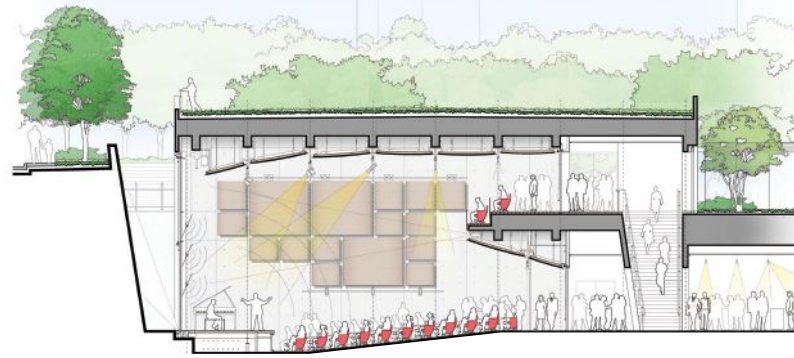
The galleries are lit with daylight and 24W 3000K LED spotlights mounted on tracks positioned in between the wood beams.





Natural light permeates the auditorium via a light well. The cant of the wall was calculated to bring in the greatest amount of natural light. Theatrical lighting is suspended from the ceiling along with Piano's Le Perroquet fixtures, which are fitted with a 28W 3000K LED module (top). This stairway leads down to the auditorium (above). At night, 20W CDM-T metal halide uplights illuminate the glass canopy and push light away from the façade (opposite, top right).

## Auditorium Section



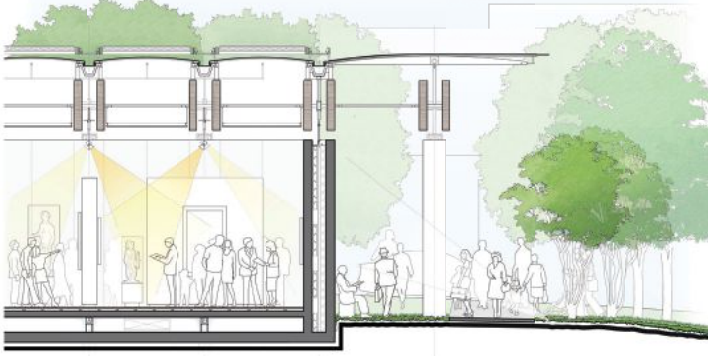
Whereas other roofs that the RPBW-Arup team have collaborated on consist of multiple layers, the Piano pavilion's roof is a single layer that performs an array of functions. Sitting just above the glass is a photovoltaic louver system. Its first job is to control the amount of light entering into the space, and it can be either fully closed or open to any position between zero and 45 degrees. In the case of serious weather, such as hail, they rotate and fold over to protect the glass roof structure. The PV cells within the louvers generate enough power to meet about 70 percent of the lighting energy needs for the building, Davies says. The louvers also keep sun off the glass, and each module is individually controlled by a dedicated louver control system.

On the underside of the skylight glass, which has a white interlayer with an acid etch on the inside surface for a more matte finish, a scrim further assists in diffusing the light. (The scrim does not exist in the lobby so that the wood beams can be seen.) Custom 10.5W 3000K LED fixtures with an adjustable shield are tucked up out of sight above the wood beams to uplight the glass ceiling and increase the luminance at night. "The intention was to avoid the ceiling becoming a black void at night, and to reveal the volume above the scrim that can be experienced during the day," Davies says.

Another area where light plays a significant role is in the auditorium. Natural light permeates the space through a light well that sits behind the stage and its rear glass curtainwall. At the base of the curtainwall, a line of shielded wallwashers keeps the source out of view from the audience and the performers.

Different, yet rooted in the same desire to create a serene gallery experience, the new Piano Pavilion at the Kimbell Art Museum offers a contemporary interpretation of how to marry light and architecture. •

## South Gallery Wall Section



The entry of the Kahn Building and its signature ceiling reflector system allows daylight to illuminate the interiors.

Top Right: Nic Lehoux; Drawings Courtesy Renzo Piano Building Workshop

**Details Project:** Renzo Piano Pavilion, Kimbell Art Museum, Fort Worth, Texas • **Client/Owner:** Kimbell Art Foundation, Fort Worth, Texas • **Design Architect:** Renzo Piano Building Workshop, Genoa, Italy • **Executive Architect:** Kendall/Heaton Associates, Houston • **Lighting Designer:** Arup, London • **Project Manager:** Paratus Group, New York • **Construction Manager:** The Beck Group, Dallas/Fort Worth, Texas • **Structural Engineer:** Guy Nordenson and Associates, New York • **M/E/P Engineer:** Arup, London, with Summit Consultants, Fort Worth, Texas • **Project Size:** 101,130 square feet • **Project Cost:** \$135 million • **Code Compliance:** ASHRAE 90.1-2007 • **Watts per Square Foot:** 1.1 • **Manufacturers/Applications:** **Acuity Brands/eldoLED** (DMX LED driver for fixture in beam assembly) • **Bega** (exterior site lighting) • **Cooper Lighting/io** (interior ambient lighting in beam assembly) • **iGuzzini** (above-ground tree lighting, auditorium house lighting, and linear fluorescent lighting in offices and education studios) • **Lighting Services Inc.** (gallery tracklighting) • **GIG** (motorized photovoltaic louvers on the roof) • **Mermet** (roller shade fabrics) • **Nysan** (roller shade system) • **Philips Strand Lighting** (lighting controls) • **We-ef** (exterior inground uplighting) • **Xicato** (LED modules for gallery tracklighting)

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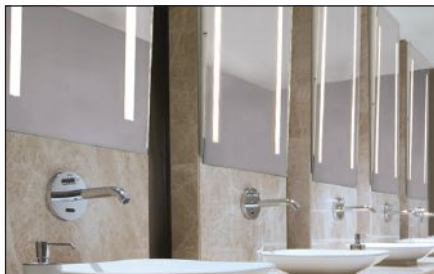
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11	Amerlux Global Lighting Solutions
38	Ayre Architectural Lighting
42	B-K Lighting, Inc.
28	Chengdu Tunghsu Lighting Technology
39	Columbia Lighting
29, 40	Dial GmbH
C-3	Eaton's Cooper Lighting Business
20	Engineered Lighting Products
19	Intense Lighting
2	LEducation
17	LF Illumination LLC
51	Lighting Services
9, 37	Lumenpulse
C- 4	Lutron
5	MechoShade
31	Messe Frankfurt, Inc.
34	No. 8 Lighting
4	Oldenburg Electronics
41	OptoLum Inc
13	Peerless Lighting
1	RAB Lighting
45	Seesmart Corporate
25	SELUX
45	Shanxi Guangyu-GYLED
21	Sichuan Jiuzhou Electric Group Co. Ltd.
21	Signcomplex
33	The American Institute of Architects
27	Times Square Lighting
C- 2	USAI
44	USHIO America, Inc.
6	Visa Lighting



# PHILIP GABRIEL

interview by Elizabeth Donoff

photo by John Kealey

“Any profession has a strong academic educational base; that’s what holds it together. Lighting is so young and dispersed. We need university degrees in lighting design. We can’t continue to be satisfied with people coming out of architecture, interior, and theater schools with only a tiny bit of lighting experience. There are only 20-plus programs worldwide that offer some kind of lighting degree, and just seven in the U.S. We need to help grow their programs. It is essential to the future of our profession.”

**Having practiced** architectural lighting design for more than 40 years, Philip Gabriel hasn’t just witnessed lighting’s evolution, he’s lived it. After working in New York for 10 years, he moved to Ottawa, Canada, and in 1974 established his firm, now known as Gabriel Mackinnon. As a past president of both the International Association of Lighting Designers (IALD) in 1998–99 and the IALD Education Trust in 2007, he’s played an active role in helping to form lighting’s professional footprint. Conveying experience and knowledge to the next generation of designers has always been central to Gabriel’s approach; it’s evidenced in his own firm and in his partnership with Andrew Mackinnon. And ever the student himself, his commitment to lighting education has earned him the respect of his colleagues worldwide.

**What fascinates you about light?**

The way things are revealed by shadows and reflections, how light bounces through space.

**Are clients more sophisticated today?**

Twenty years ago the lighting designer was being hired by the architect. Now a lot of us are working for the end user or the person who hires the architects. They are signing the checks; it makes a huge difference.

**Do you have a lighting design philosophy?**

The best lighting solutions are the ones where the light reveals a space without drawing any attention to itself. It’s the idea that light itself is almost nothing. We see a source once in a while, but we don’t see the light. We see what the light does, what it reveals, and what it affects.

**A misunderstood aspect of lighting design?**

The role that lighting calculations serve. They are an important aspect of what we do, but very secondary to what we do with light in the space.

**As the world of semiconductors and electronics enters the arena, what will the lighting industry look like going forward?**

Change is inevitable as products become more “electronics” than “electrical.” Electronics being the products that are driven by chips. In the future, products may not have a wire and a plug, or be installed by a contractor. And the network of product distribution should radically change.

**What do you think new lighting technologies offer in terms of your ability to design?**

There’s so much emphasis and even infatuation with the light source that we tend to forget that it’s the light itself that we’re really interested in. Once it comes out of that source and begins to work with a space, all the design principles that we have been practicing still hold true. •



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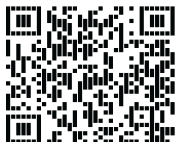
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