CONTROLS AND EXTERIOR TACTICS FOR efficient illumination

MICHAEL MORAN / COURTESY LUMEN ARCHITECTURE

For a project at Claremont University Consortium, Claremont, N.Y., architect LTL and lighting designer Lumen Architecture used lighting to transform a steel-framed warehouse. An exterior slatted wooden screen is interspersed with LED strips, creating a striking nighttime effect.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ DESCRIBE the challenges for delivering sustainable, efficient lighting design in commercial projects, enhancing occupant well-being and saving resources.
+ DISCUSS illumination technologies available to project stakeholders, including benefits, drawbacks, and major recent advances.
+ LIST considerations for meeting applicable codes and voluntary green standards.
+ COMPARE current lighting design strategies and techniques, with particular attention to exterior lighting and lighting control systems that promote safety, security, energy-efficiency, and occupant well-being.

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To achieve the goals of sustainability and high performance, stakeholders in new construction and renovation projects must rein in energy consumption. Interior illumination represents a large fraction of building sector energy use, and lighting overall accounts for 19% of electricity consumed nationwide, according to the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. With this in mind, project designers, contractors, facility managers, and end-users must understand why illumination is so energy-intensive—and what to do about it.

Though lamp types tend to be top-of-mind when efficient lighting is discussed, control systems are an equally important—and highly complex—topic. This course provides an in-depth discussion of

LUKE GIBSON / COURTESY LUMEN ARCHITECTURE

For the Claremont University Consortium renovation, a dropped ceiling plane consisting of felt-wrapped baffles conceals mechanical equipment, including lighting infrastructure. Solar tubes and efficient fluorescent fixtures were arrayed above the baffles in open office space to create an ebb and flow of daylight, via precise controls tied to the BMS. The LEDs in the ceiling are also used on some walls in this project, and can morph from green to blue in response to motion sensors. Early mock-ups and computer visualization informed the design.

lighting control technology for commercial projects, plus important techniques for exterior lighting design. (For additional information on interior lighting design and daylighting, see our course "Sustainable Design: Integrating Lighting And Daylight": www.bdcuniversity.com/integratedlighting.)

The DOE's 2010 U.S. Lighting Market Characterization study illustrates the high cost of inefficient commercial lighting. Of the 700 terawatt-hours consumed by illumination in 2010, nearly 300 TWh were used to power linear fluorescent lamps in commercial and industrial buildings, turned on for an average of 11 hours daily. (Residential lighting consumed only half as much power as commercial—175 TWh vs. 349 TWh—despite using far more lamps, at nearly 6 billion).

The DOE reported good news about movement toward more efficient lamps, which produced an average of 58 lumens per watt in 2010, compared with 45 per watt in 2001. But most of the gains took place in the residential sector, where energy-efficiency awareness campaigns and successful marketing of compact fluorescents have created a shift in purchasing habits.

Clearly, the commercial and industrial sectors have plenty of room for improvement, from the earliest stages of planning through construction and O&M. One beneficial approach is to fully integrate lighting design into the process of architectural design and construction. An integrated process helps facility managers, tenants, and occupants take full advantage of energy-efficient illumination.

"Often the hardest part of lighting design is educating the client and end-user about the importance of considering the lighting in a space," says Nelson Jenkins, AIA, LC, IESNA, LEED AP, Principal at Lumen Architecture (www.lumenarch.com). "Just filling a space with lots of light is rarely the right approach for getting the light qualities that the user wants and that the architect envisions."

Shortchanging lighting design can play havoc with energy efficiency and safety, not to mention aesthetics. "Have you been in a space with bamboo floors and really bad LEDs? The room will turn green," says Avraham Mor, IALD, LEED BD+C, MIES, a partner with Lightswitch Architectural (http://architecture.lightswitch.net). "Good lighting could be the solution. And it makes us feel good in a space."

THE ROLE OF THE LIGHTING DESIGNER

Mor's comment illustrates a basic tenet for Building Teams: The interaction of materials and systems is as important as the intrinsic qualities of each product. Just as high-performance enclosures can be undermined by poorly detailed joints, a state-of-the-art lighting system can fall short due to improper installation, detrimental interactions with other MEP systems or architectural elements, or insufficiently prepared end-users.

The lighting designer, a professional who is quite different from an electrical engineer, works to prevent such problems. A lighting designer helps to ensure that illumination responds to client goals, including requirements for aesthetic quality, operating costs, occupant health and productivity, and sustainability. The work demands synergistic knowledge of architectural design and construction, interactions of structural and MEP systems, illumination technology, requirements for safety and security, and sustainability goals.

A lighting designer's efforts are based on the principle that proper illumination is essential to occupants' well-being and to their optimal enjoyment of the architectural environment.

CODES IGNITE LIGHTING INNOVATION

As with many aspects of building design, the rules of the illumination game are constantly changing. The pace of technological advancement is rapid, and state and local energy codes are in a state of flux. More jurisdictions are adopting green codes, as well, adding another layer of complexity.

ASHRAE 90.1, the energy standard most frequently referenced in building codes, has long had a co-author in the Illuminating Engineering Society of North America (IESNA). This and other standards can dictate maximum energy use per square foot, maximum *lighting power density (LPD)*, light levels in specific spaces, and in some cases maximum acceptable *light trespass*, a specific type of light pollution.

One might assume that codes and standards become more stringent as technology and design techniques improve. In fact, the opposite is often true: Jurisdictions (usually states) may create stricter lighting standards to drive advances in technology and design. California, whose Title 24 energy requirements were already tough, has even more rigorous rules since adopting a statewide green building code, CALGreen. Manufacturers and design firms hoping to do business in California must develop the needed advances, a situation that will ultimately influence action by other jurisdictions.

In general, LPD allowances have been lowered every few years in revisions of energy codes and major standards like 90.1. With each revision, lighting designers must scramble to meet illumination goals set by the new rules, which tend to limit the number of fixtures allowed. Sometimes a standard's new version can be aggressive to the point of creating nearly unmanageable stipulations.

LEED 2009 uses ASHRAE 90.1-2007 as its baseline, for example, representing a 10% minimum energy performance improvement over the previous version. The goal is admirable, of course, but it means the Building Team's job in achieving LEED certification is roughly 10% more difficult than before. As lighting efficiency improves, it becomes harder to use LPD reduction as a tool for energy compliance.

Leslie Jonsson, a project manager with CDi Engineers (http://cdi-engineers.com), remarked in the *Daily Journal of Commerce* that today in many cases, the LPD is already fairly low. "This makes it more challenging for the mechanical engineer to use lighting changes to help meet the minimum required overall energy reduction," she says.

OCCUPANCY, DAYLIGHTING, TUNING: PRINCIPLES OF LIGHTING CONTROL

For many commercial and institutional facilities, lighting control systems are effectively imposed by the building size, function, and jurisdiction-mandated energy codes. All states adhere to a minimum standard based on ASHRAE/IES 90.1, which requires shutoff controls for lighting in commercial buildings larger than 5,000 sf, with few exceptions. But high-quality controls, specified according to building type and user needs, also practically guarantee lower operating costs, and should be recommended to clients.

In general, control strategies fall into one or more basic categories: occupancy, daylighting, personal tuning, and institutional tuning.

Occupancy. This category encompasses control systems that detect occupants, indoors or outdoors, to determine needed illumination. Sensors are the core technology for occupancy-based control. Sensor types include:

- *PIR sensors*. Best for smaller enclosed spaces, PIR sensors detect humans in motion against a nonmoving background by assessing the difference in heat.
- *Ultrasonic sensors*. Similar to a bat's technique for "seeing" with sound, ultrasonic sensors emit a high-frequency signal, using the Doppler principle to determine if the reflected sound indicates a human occupant. Best for exterior and open spaces.
- *Dual-technology sensors*. By combining PIR and ultrasonic technology, these devices virtually eliminate "false-on" and "false-off." This higher degree of detection may be most useful in classrooms, conference rooms, and other spaces where occupancy changes frequently.

Lighting designers should be familiar with effective coverage patterns and layout requirements so lights are only turned on when needed. All three types of sensors have potential drawbacks. PIR sensors need a clear line of sight, for instance, and must not be mounted on sources of vibration. High levels of airflow can cause nuisance switching in ultrasonic sensors. Dual-technology devices are typically more expensive than other types. Chip Israel, FIALD, MIES, LEED AP, President at Lighting Design Alliance (www.lightingdesignalliance.com), notes that occupancy sensors now have their opposite: vacancy sensors, which dim lamps or switch them off when they determine that a room has no current human occupant.

The Building Team should navigate the market for special features, including self-calibration, manual-on, bi-level switching, isolated relay, combination dimmer/sensors, and line-voltage sensors. For aesthetic reasons, some manufacturers offer light fixtures with integrated sensors.

Other occupancy-strategy controls include time clocks, which operate according to a programmed schedule based on anticipated occupancy, and building management systems (BMS). Combining elements such as time clocks and sensors into a larger strategy for managing mechanical and safety systems, a true BMS is very complex and entirely customizable. Only a small percentage of buildings nationwide currently include BMS technology.

Daylighting. "I study a project for daylighting opportunities first," says James Benya, PE, FIES, FIALD, Director of the Advanced Lighting Design Program at the California Lighting Technology Center, UC-Davis (http://cltc.ucdavis.edu). "If analyzed early enough, natural light becomes part of a high-performance plan, providing just enough daylight to light the space most of the year, without adding to heating or cooling costs. Then we add electric lighting."

Naomi Miller, FIES, FIALD, LC, Senior Lighting Engineer in Technology Planning and Deployment at Pacific Northwest National Laboratory, agrees. "Daylight should always be the principal light source in

NICHOLAS KOENIG / COURTESY LUCIFER LIGHTING

New York City's Standard Hotel features a dramatic lobby incorporating modern high-efficiency fixtures. Striking interactions of architecture and light are facilitated by advanced control systems. The Building Team included Polshek Partnership and Roman and Willliams (interiors).

the vast majority of architectural spaces." Electrical lighting, she says, "should supplement the daylight when daylight is not plentiful."

The daylighting category of lighting control relies on photosensors that accurately measure light levels, specified and calibrated to avoid irregular or untimely ons and offs. "New photocells are more accurate, so that electric lighting can be reduced when daylight is present," says Israel. Photosensors must be carefully coordinated with occupancy sensors and other devices.

"Incorporating daylight response systems into interior lighting design for workplaces is *de rigueur* today," says Robert Prouse, IALD, FIES, Partner with Brandston Partnership (www.brandston.com). "It comes at less of a price premium now, and it's also much easier to specify in most common situations."

Daylight-controlled illumination also includes time clocks for exterior applications. While time clocks could conceivably be part of a daylighting strategy for interiors, they rarely are. (For its study Lighting Controls in Commercial Buildings, the Lawrence Berkeley National Laboratory reviewed 88 separate research papers without finding a single mention of interior time clocks used for daylighting control to achieve energy savings.)

Says Israel, "Time clocks have gotten more sophisticated—they now can tell you when the sun sets or rises, depending upon your location." However, without a good overall control strategy, systems based on clocks are limited. "The most effective use of lighting controls is the ability to turn lighting off when it isn't needed," says Dawn Hollingsworth, LC, IALD, director of lighting design for IBE Consulting Engineers (http://www.ibece.com). "Timers don't know when it is a holiday, a weekend, or daylight saving time."

However, says Hollingsworth, the ability to schedule individual days with a timer-based system could deliver considerable savings for the owner. With modern, programmable control schemes, such a scenario may become increasingly common.

Personal tuning. Many projects benefit from occupant control of illumination. As in residential settings, this strategy can ensure that many lamps are only used as needed. When dimmers are incorporated, energy savings can be robust. Given the choice of adjusting light levels, few end-users choose to work in overly bright settings.

Dimmers can be a bit tricky, according to PNNL's Miller. "Dimming of both interior and exterior lighting is essential to making energy-efficient controls acceptable, but we need to use dimming drivers and controls that do not introduce flicker or odd behavior," she says.

Spaces that can benefit from a personal-tuning strategy include private offices, open office plans with task lighting, and classrooms. Apart from wireless on-off switches, bi-level switches, and dimmers, the personal tuning strategy may also benefit from computer-based controls, or programmable controls that offer preset "scenes."

COURTESY LIGHTSWITCH ARCHITECTURAL

At the Naperville, Ill., Marriott, a first-floor renovation by Solomon Cordwell Buenz and Lightswitch Architectural incorporates modern, energy-efficient fixtures. The DALI control system allows precise regulation of each light source installed in the project, which included this bar as well as the lobby, banquet room, conference and meeting rooms, and a grand ballroom.

Institutional tuning. As mentioned earlier, linear fluorescents in commercial and institutional buildings consume more than 300 TWh of power annually. It's an astounding statistic, but it's not an easy number to reduce. Much of that lighting is intended to meet institutional policy mandates, as in government buildings, hospitals, or workplaces meeting OSHA or similar standards. Institutional tuning attempts to satisfy such requirements while reducing energy consumption.

Technologies are fairly simple, and fairly limited: on-off switches and dimmer switches for nonpersonal lighting, and dimmable ballasts installed in fluorescent fixtures. As the cost of solid-state technology falls, a time may come when linear LED luminaires overtake linear fluorescents. At that point, we may start to see significant reductions in the commercial sector's illumination-related energy load.

ILLUMINATION MANAGEMENT MOVES TOWARD DIGITAL CONTROLS

The commercial lighting market already offers a good range of lighting control systems, from simple to complex. As noted, few facilities have adopted a full-spectrum energy management system, and illumination is rarely integrated into the BMS. However, powerful technologies are being developed for lighting management, and designers are constantly making useful discoveries.

Architectural lighting has learned much from theatrical lighting experts such as Howard Brandston, FIES, Hon. FCIBSE and FSLL, FIALD, PLDA, LC, a past president of IES (www.concerninglight.com). Dimmer systems created for theatrical use have been adapted and employed in commercial settings for dramatic effect, as well as energy reduction. During the past decade, most of the country's major theaters have switched to powerful digital lighting control boards. Commercial clients are now beginning to consider the advantages of digital control systems.

Network-based digital systems for controlling illumination are largely based on International Electrotechnical Commission (IEC) standard 60929. Established as an open-standard alternative to Digital Signal Interface (DSI), IEC 60929 addresses electronic ballasts in AC supplies up to 1,000 volts, and has given rise to the Digital Addressable Lighting Interface, which four manufacturers currently produce under the DALI trademark.

A single DALI controller is a powerful tool that can control up to 64 individual ballasts and dimmers. The controllers can be networked for even greater capabilities. DALI controllers employ a unique algorithm designed to achieve uniform brightness, even among units produced by different manufacturers.

“DALI controls are the future,” says Lightswitch Architectural’s Mor. “All specifiers should be using DALI controls. They allow for the most flexibility, and they are the easiest system for the contractor to install.”

“DALI-type controls provide the most fluid integration,” Lumen Architecture’s Jenkins agrees, adding that he also prefers “intelligent” control devices coordinated with a control system. He recommends “systems that are typology-free and are secure peer-to-peer, self-organizing, and self-healing.”

Digital lighting controls are gaining broader acceptance. “With smart ballasts and drivers and a user-friendly management interface, digital allows us to use the strategies that are needed on a room-by-room basis,” says UC-Davis’ Benya.

BUYING, INSTALLING, AND TESTING LIGHTING CONTROL SYSTEMS

Experts in lighting design agree that the building sector should be able to reduce the energy consumed for illumination by improving

COURTESY LIGHTSWITCH ARCHITECTURAL

A DALI system allowed Lightswitch Architectural to create precision low-voltage control of light sources in a 50,000-sf hotel renovation. Existing electrical infrastructure did not have to be changed, saving money for the client.

industrywide familiarity with control technologies. However, owners may have a tough time deciding to invest a significant portion of the lighting budget in controls. The Building Team should make a careful analysis of the budget, and have frank discussions about whether it makes sense to spend more.

“Controls are not inexpensive,” Brandston says, but they are the key to energy efficiency. “So a cost-benefit analysis must be calculated to ensure a reasonable payback period.”

Figuring out what to spend, and what to buy, is difficult in part because technology continues to morph. “Lighting controls are changing so fast it makes my head spin,” says Benya.

With or without a computerized control component, a lighting design pays greater dividends when the controls are considered holistically, as integral parts of a larger scheme. Lighting designers must work closely with architectural designers, because illumination and daylighting are married in high-performance buildings. At their most complex, daylighting strategies for large projects can be coordinated with shading devices, smart glass, and other architectural elements to create a self-regulating, nearly autonomous building that balances illumination needs against heating, cooling, and ventilation loads. This approach optimizes energy efficiency and improves occupant health, productivity, and morale.

Jenkins explains Lumen Architecture’s strategy for making sure an over-arching design intent is realized: “At the least, we provide a control narrative outlining the intent for how the design should function. We also specify the exact control system to be used, work with the design team to determine where control units will go, and provide zoning and a load schedule to coordinate equipment and documentation.”

Control system components should be placed with the same care used to locate lighting fixtures. “Each control device has a symbol and identifying tag on our drawing, which ties back to a written specification and corresponding cutsheets,” says Jenkins. “The whole system is then diagrammed with a single line diagram, with scene schedules that sequence time-clock functions.”

Lighting experts say that, given the complexity of the technology, pre-installation mockups may prevent trouble on the back end. Software modeling can also be very helpful. “Once the Building Team determines the correct illumination level, calculation programs like AGI or Radiance can confirm the assumptions,” says Lighting Design Alliance’s Israel.

UC-Davis’ Benya adds that troubleshooting the actual installation is also crucial—a task that usually falls to contractors. “The biggest problem with modern systems is commissioning,” he says.

A word about wireless. Wireless technology is sometimes proposed as a boon to lighting system installation. Originally created for the residential market, radio frequency wireless controls appeal to some commercial project stakeholders. Nearly every component—for instance, occupancy sensors and relay switches—now has a wireless counterpart. Lighting designers may find them particularly useful for renovations in which existing walls have no plenum for wiring.

“Wireless controls entering the marketplace have great potential,” says PNNL’s Miller, “especially when the installation, commissioning, and user interface is straightforward and intuitive." She offers an important caveat, however: "With manufacturers crawling out of the woodwork to introduce wireless systems, there is a proliferation of protocols and virtually no intercompatibility. I know of one system with self-powered controls that seems to work quite well, but I don't yet know of large installations of this system here in the U.S."

Lightswitch's Mor offers another warning: "Wireless is a manufacturer's dream system. They get to sell you way more stuff and tell you it will cost less to install, but often, it doesn't." He describes a scenario in which the contractor installs wireless keypads just as he would wired ones, at a very similar cost to wired installation.

"Ultimately, I think that wireless has its place," he says, "but if you can run the wire, you should. It will be a better system, no matter what manufacturer produced it."

EXTERIOR ILLUMINATION FOR BEAUTY AND SAFETY

An excellent lighting design extends beyond the building's walls. Goals for illuminating exteriors and landscapes may start with energy savings, but they do not end there. Reducing maintenance costs and enhancing safety are also important, as is the client's desire for an appropriate visual environment and the neighbors' wish for reduced light pollution/trespass.

Sara Schonour, LC, IESNA, LEED AP, lighting designer for Cannon Design (www.cannondesign.com), says that exterior design shares some aspects of interior work, but also has special features related to the outdoor context:

- *Contrast/illuminance ratios.* "In the relatively low light of a typical residential setting," says Schonour, "a little candlepower goes a long way. Use that same source on a college campus where ambient nighttime levels are much higher for security, and that soft highlight on the same stone wall doesn't even register." She adds that understanding the adaptation of the eye to nighttime light levels, contrast, glare, and color is an important factor in selecting appropriate exterior lighting.
- *Environment.* "Will the luminaires be subject to excessive heat, dust, flooding, shaking, sun exposure, wind, inebriated sports fans, etcetera?" Schonour asks, adding that components should be easily maintained, particularly as positioned. "Selecting and locating luminaires with safeguards for longevity is critical. Often these luminaires will be fixed in their locations for the long term, so durability is essential."
- *Controls.* "In terms of optically controlling the direction, shape, and intensity of the light, as well as from an energy management perspective, lighting controls play a significant role in well-designed exterior applications," Schonour says.
- *Setting.* "Adjacencies are important to understand," says Schonour, "from both the horizontal, neighbor-friendly perspective and the vertical, dark-sky friendly perspective."

LAMP SOURCES FOR EXTERIORS

Exterior lighting design involves a larger array of lamp choices than interior design. Lamp types include:

- *Filament-based.* This type of lamp includes incandescent (traditional, low-efficiency), halogen, and HIR (halogen infrared reflecting). Though the halogen types are more efficient than incandescent, they operate at high temperatures.
- *Fluorescent.* Charging a mercury arc produces UV rays, which excite the phosphor coating on the inside of the lamp glass, producing visible light. Most varieties differ by the start type (switch, instant, rapid, program). Compact fluorescents also fall into this category. On rare occasions, there may be compatibility issues between certain lamps and ballasts, though magnetic ballasts are being phased out in favor of electronic, so this is not an issue very often.
- *Induction lamps.* Similar to fluorescents, but lacking the electrode system. Induction lamps instead use a "generator" ballast. With no electrode to eventually degrade, induction lamps have longer life than fluorescents.
- *High-intensity discharge (HID)*. Gaseous discharge lamps like fluorescent and induction, but the light is produced directly from the arc with no need for phosphor coating. This category includes mercury vapor (MV), high-pressure sodium (HPS), low-pressure sodium (LPS), and three types of metal halide: probe start, pulse start, and ceramic.

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Careful management allowed effective night illumination without undesirable light trespass at the Hubbell Lighting Headquarters in Greenville, S.C. Partnering on the LEED Silver project were architect McMillan Pazdan Smith and lighting consultant Visual Terrain, with extensive input from the client, a lighting products manufacturer.

• *Light-emitting diode (LED)*. Made from solid-state materials, LEDs continue to generate buzz, as well as criticism (below). Cannon's Schonour says LEDs are starting to have a major impact on exterior design, though they're still the most expensive choice. "LEDs solve a handful of problems traditional sources like metal halide and HPS present," she says. Maintenance benefits abound, tied to lamp endurance, expanded controllability, steadily improving color rendering, instant-on emergency capability, aggressively increasing efficiency, and compactness of the fixture package. "If the application involves color—especially changing color—often LEDs are the only choice that makes sense," says Schnour, who notes that first costs are steadily declining. "The availability of rebates can often sweeten the deal," she adds.

• *Plasma.* An emerging lamp technology, plasma shows promise of high efficiency for the future. It offers a high lumen density and long lamp life. As yet, however, its applications are limited.

IS LED KEEPING ITS PROMISES?

"We don't specify LEDs," says Avraham Mor of Lightswitch Architectural. "We specify solid-state luminaires and lamps (SSL) that use LEDs." Mor's correction of this common misuse of the term "LED" is significant, because a problem associated with SSL is often just a problem with a specific LED product. "SSL is the only source to use when trying to meet energy reduction goals while maintaining the look and feel we typically work toward," he says. "We have had great success, but it takes a great designer and client to manage the entire process."

In fact, many complaints about LEDs are often attributable to the SSL, and vice versa, leading to complaints about a technology that sometimes fails to meet expectations. But SSL, as Mor says, is really the future of energy reduction; with careful design and specification, it is also the present.

PNNL's Naomi Miller points to the myriad benefits of LED technology: "Higher lumens-per-watt than fluorescent, good lumen maintenance over time (in some cases better than fluorescent), long life compared to CFL or metal halide, and excellent color compared to almost any conventional light source." She adds that the small form factors mean LEDs are richly accommodating, allowing designers enormous creative flexibility with space, configuration, and color.

Lumen Architecture's Nelson Jenkins says blanket substitutions aren't necessarily a good strategy, however: "Not all LED products match the quality of the other sources we specify." In addition, price is still an issue. "We find that while the cost of LEDs has come down, they tend to be more expensive than, for instance, a halogen version. But the up-front cost for LEDs can often be offset by the energy savings and reduced maintenance." Jenkins suggests explaining to clients that SSL will require re-lamping less often—an especially strong selling point in vaulted spaces or exterior applications.

Ultimately, the SSL category is a work-in-progress, not a panacea. "LED is certainly very popular, and many designs would not be possible without it," The Lighting Practice's Stephen Hoppe says, referring to exterior applications. "But ceramic metal halide also provides great color rendition and warmth and can often be as efficient as LED."

James Benya of the California Lighting Technology Center, UC-Davis, has concerns about how codes and standards may be affecting the market for products and systems, particularly LEDs. He hopes to see energy codes and sustainable building standards that do not promote particular technologies.

"The current trend shows a rush to use LEDs," warns Howard Brandston, founder of Brandston Partnership. "One must determine if LED is the right choice after sifting through the qualities of all the alternate products. There is no change in the design process," he concludes, "just an additional product to select from."

EXTERIOR FIXTURES AND DESIGN PRINCIPLES

Durability, maintenance, and safety are major guides for exterior lighting design. Beyond lamp technology, the choices for fixtures seem unlimited, and are certainly too numerous to discuss in any depth here. However, at minimum, outdoor fixtures must endure and resist moisture.

Lighting Design Alliance's Israel includes sand, salt, localized chemicals, pollution, and even bugs, rodents, and birds in the list of potential hazards to the long-term durability of a fixture, and suggests gaskets or other protective measures. Stephen Hoppe, Associate IALD, a lighting designer with The Lighting Practice (www.thelightingpractice.com), recommends marine-grade aluminum and special paint treatments for fixtures installed in saltwater environments or coastal regions.

Israel says overhead structure shouldn't be seen as a perfect shield. "A fixture may appear to be protected from the weather, but what about wind-driven rain? What about pressure washers? The final issue is orientation. Many fixtures are wet-labeled, but they may only be approved when mounted in a particular orientation."

Knowing the difference between the U.S. and European listing systems is vital for making an informed fixture purchase, according to Hoppe. "European standards use the ingress protection (IP) system, which is more refined than UL for the amount of water and dust ingress expected of a fixture," he says. "For example, if a fixture is installed in an area where temporary submersion is likely, an IP68 rating will allow for that condition."

Full attention to ratings, including IP, helps "dictate a level of defense against the natural elements," says Schonour, who advises paying close attention to manufacturer warranties. "If an exterior fixture is touted as 'built to last,' but the warranty only guarantees the assembly for a year or two, red flags should go up." She also recommends asking to see a fixture that's been installed for some time, to gauge first-hand how the luminare holds up.

New computer interfaces should allow O&M staff to clock the number of hours a particular fixture has been used, says IBE's Hollingsworth. "This will become even more important as we adjust our understanding of the end of life for LEDs. Typically LEDs don't die like conventional lamps. They just get dimmer over time, appearing to be working when they are actually no longer useful. Safety of the patrons using the facility can be jeopardized by poor maintenance."

Hoppe mentions another safety issue: Exterior fixtures are often accessible to the public, and need to be located to avoid contact.

DESIGNING FOR VISUAL QUALITY

Conversations involving the architect, landscape architect, facility manager, client, and end-users should reveal priorities for aesthetics. Ideas about safety, beauty, and energy management must all be weighed in these discussions.

Rules of thumb and common sense dictate that a project in an urban area will likely need to be brighter than one in a rural area. But sustainable design principles tend toward lower lumen densities wherever possible. In fact, sustainability codes like California's CALGreen can limit or prohibit façade lighting, says Lighting Design Alliance's Israel.

"Too much of our urban landscape is over-lit," says Hollingsworth, "requiring the project next door to add just that much more, and it compounds with each building. What I like to do is find a way to capture lighting being used on the building for a secondary purpose, killing two birds with one stone." At the Hubbell Lighting Headquarters in Greenville, S.C., for example, the Building Team used building-mounted downlights to accent exterior columns and also light the sidewalk below, eliminating additional fixtures for pedestrian access.

Overlamping can cause glare, making an exterior environment less attractive and even less safe. It can also contribute to light trespass. "The hardest part," says UC-Davis' Benya, "is getting clients to break their bad habits of blasting light at empty parking lots and streets all night long."

But solutions for these challenges abound. "For pedestrian-intensive areas, it might make sense to add a small-prism lens or a glass shield with a small amount of diffusion on it, to help eliminate the direct view of a bright LED," says PNNL's Miller, admitting that this modification could alter the light distribution. "That may be a reasonable tradeoff for visual comfort for pedestrians."

"Energy codes for exterior applications are very strict and limit the amount of light available to use," The Lighting Practice's Hoppe says, adding that lighting design is less about the amount of lumens and more about how one uses the available light in a controlled manner to highlight elements of the project. "For example, a typical façade may be designed with more brightness at the crown and the street level than across the bulk of the building."

Most experts recommend a less-is-more strategy that reduces light trespass as much as possible. To limit glare and spill, the design should generally try to conceal the fixtures, Hoppe advises. "A well-designed exterior environment will contain as much of the light as possible to limit the negative effects of light in unwanted locations," he says.

Some designers strongly discourage uplighting for exteriors. "Light pollution is a serious problem," Israel says. "All of the light that goes up into the sky represents wasted energy. While selective uplighting maybe okay, the design team should look for opportunities to downlight objects." For guidance, Israel refers designers to the IES's Model Light Ordinance, as well as the IES Lighting Handbook. Others add the guidelines set forth by groups that have met the issue of light pollution head-on, including the International Dark-Sky Association (www.darksky.org), Commission Internationale de l'Eclairage/International Commission on Illumination (www.cie.co.at), U.S. Green Building Council (www.usgbc.org), and the Lighting Research Center at Rensselaer Polytechnic Institute (www.lrc.rpi.edu).

Though technology and design ideas for illumination can be complex, some of the most important principles in the field are really quite elementary, according to Schonour. "Light with awareness," she says. "Understand where you want the light to go and how the light will travel to get there. At the root of lighting design is an understanding of simple geometry and basic physics."+

Dodging pitfalls in LIGHTING PRODUCT SPECS

The typical public-sector requirement to name three alternative specifications can cause major headaches for lighting designers. This seemingly benign rule can be counterproductive, says James Benya of UC-Davis' California Lighting Technology Center. "Owners and government agencies naively believe that three-name specification guarantees competition. I warn my clients that competitive products may not perform, may require different wiring methods and materials, and may cause serious delays in construction and commissioning."

PNNL's Naomi Miller concurs: "A new complication with specifications is that LED products and their controls are not—repeat, not—interchangeable. A substitution can result in incompatible systems. A cohesive, compatible system must be specified as a complete system. How does that affect the three-name spec?"

A substituted product may underperform, use more energy, and require more maintenance. Having been held responsible in the past for inferior outcomes, some lighting designers insist on giving clients a detailed outline of the risks of substitution. "We either have to break the rules and specify the appropriate product, or take extreme chances with a performance specification," says Benya.

Lighting designers generally prefer to create complete systems, using trusted, tested products from reliable manufacturers. "Most of the product selections I personally make are with suppliers that have a long history of providing quality equipment as specified, and prompt delivery and service," says IES past president Howard Brandston.

Nelson Jenkins of Lumen Architecture agrees. "It helps to know what is available and see fixtures in person," he says. "Getting to know manufacturers and the quality of their fixtures can inform how confident you will be in specifying their product."

> EDITOR'S NOTE

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