Making LED Lighting Work

For Facility Managers

facilitiesnet

facilitiesnet

Common and emerging LED applications highlight the benefits and challenges of this technology

Introduction

As institutional and commercial facilities increasingly turn to LED lighting technology, the challenge for facility manager and engineers is clear: What are the benefits that can justify the expense, and do they apply to my application(s)? This e-book discusses practical issues involved in choosing LED fixtures to replace other lighting types, looking at the benefits and challenges of LEDs for various interior, exterior and emerging applications.

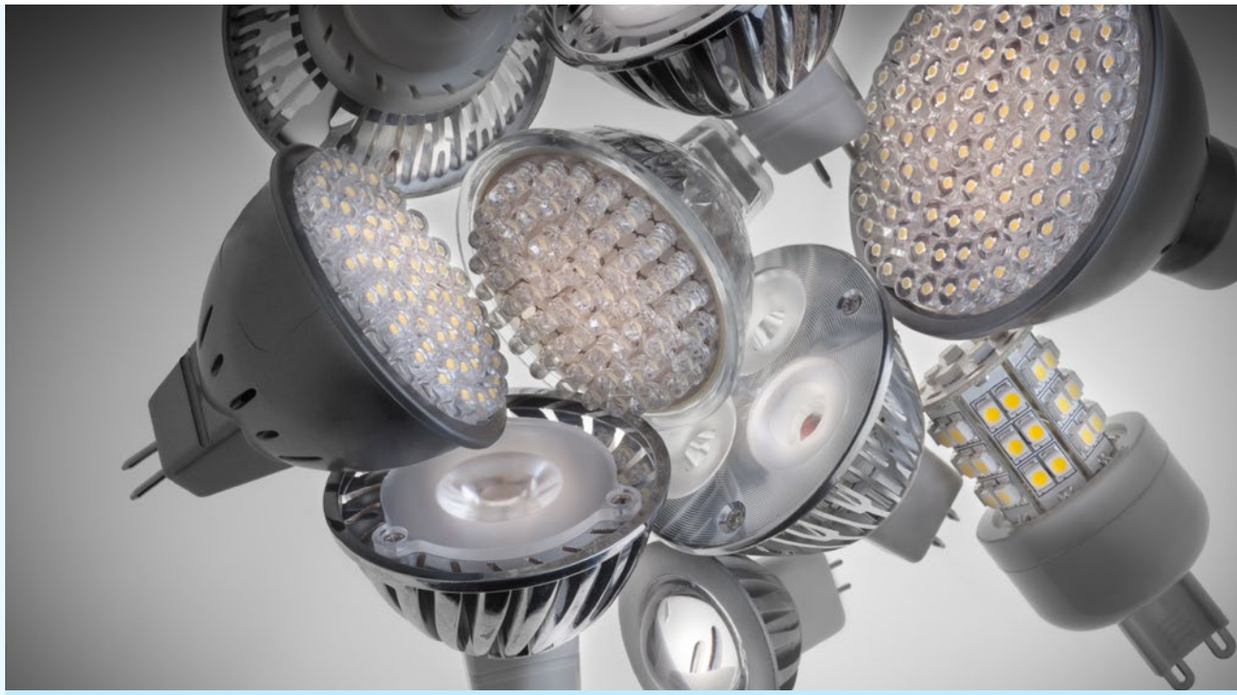
LED lighting offers facility managers and engineers a host of benefits over standard commercial and institutional lighting technologies such as low- and high-pressure sodium, T8 fluorescent, compact fluorescent, incandescent, and others.

One of the most important is a longer life compared to traditional light sources, which can significantly reduce the maintenance costs. LEDs are still a new technology, however; and new technology typically demands diligence and intelligence in order to develop effective applications and reap the reward of lower costs.

The technology also has the potential for very high efficacy – more lumens of light per watt of power – compared to other lighting sources. Compared to incandescent bulbs, LEDs are six to seven times more energy efficient, and can cut energy use by up to 80 percent. This can translate into great energy savings, and overall lower costs. LED lighting is also easily controllable, adding even more potential cost savings.

Other benefits are apparent in specific applications. So while lighting is commonly thought to be a simple technology, and therefore easy to apply, the better that facility managers can understand the way LEDs function, the more likely they are to apply it effectively.

In this eBook:



Three generations of light bulbs: Regular incandescent lamp, energy saving fluorescent lamp, & energy saving lamp.

Benefits of LEDs

Benefits of LEDs

To evaluate whether LEDs are a good fit for a particular application, managers need to consider a host of factors, starting with the benefits that make LED lighting a viable option. These factors include:

- **Long life:** One of the most important benefits of LEDs is a longer life compared to traditional light sources, which can significantly reduce maintenance costs.
- **High efficacy:** LED technology has the potential for very high efficacy – more lumens of light per watt of power – compared to other lighting sources, and is also easily controllable. This can translate into great energy savings, and overall lower costs.
- **Small format:** This benefit allows for more controlled application and flexibility in luminaire design. LEDs' compact size allows them to be used in very small spaces where other light sources might not fit.
- **Directional:** LED technology naturally radiates light in 180 degrees, making it potentially more efficient in most applications than incandescent and fluorescent lighting, which naturally radiates in a 360-degree

field and requires reflective surfaces to direct the light.

- **Robustness:** LEDs contain no fragile filament or large glass enclosure that can break.
- **Cold Tolerant:** LEDs have no mercury and can operate in cold temperatures, making them suitable for outdoor applications.
- **No significant ultraviolet or infrared radiation:** This benefit means LEDs are suitable for use with fragile artifacts such as paintings, fabrics and other materials sensitive to ultraviolet radiation (UV), as well as for use with goods like food, chemicals and other materials that can be damaged by infrared (IR) heat.

Kyle Thompson, director of buildings and grounds for the Mequon Thiensville School District, and his staff, know these benefits. “We do several lighting projects a year,” said Thompson. “And we look at everything — fluorescent lamps, parking lot lights, pools. If it lights up, we talk to our (lighting) reps about what we can do from an LED standpoint to not only provide better lighting, but more cost-effective lighting.”

The seven-building, 3,500-student district in Southeastern Wisconsin contains about 1 million square feet of space, and Thompson's department has performed 10 lighting upgrades over about six years — each designed to build on advances in LED technology for the benefit of students.

The projects have served as a source of savings the department can devote to other facilities projects and a laboratory to learn from the potential benefits of LED technology. Light retrofits "are the single simplest thing a building manager can do to get a good return on invest that allows you to reinvest those dollars somewhere else," Thompson says.

"Not only are we saving money on our electrical bills," Thompson adds. "In many cases, the local energy provider also is giving us cash incentives. That money doesn't go into some magic piggy bank somewhere. It goes right back into the schools and allows me to paint a room or do something that doesn't save me money."

Case Study:

Improving the Pool

Whatever the Mequon Thiensville School District lacks in sheer size it more than makes up for in its embrace of technology – in particular, LED lighting. The seven-building, 3,500-student district in Southeastern Wisconsin contains about 1 million square feet of space. The most complex LED upgrade the department has undertaken – and the one that generated the most savings – involved the nearly Olympic-sized swimming pool at the district's Homestead High School. The condition and performance of the old lighting system, coupled with the many demands on it created by the pool's heavy use, meant the stakes were high for the department.

"It's in use from 5 a.m. to 8 or 9 o'clock every week night – rental clubs, morning swimmers, physical education classes all use it," Thompson says. "The pool area had 44 400-watt high-pressure sodium lamps. For supplemental lighting, we had 100 T8 fluorescent lamps around the deck. With the combination of those high-pressure lamps and the fluorescent T8 lamps, we were using about 20,800 watts of power."

The lighting system was failing to meet the school district's demands for energy efficiency, and it was not

delivering the kind of lighting the application required. "The environment for learning suffered because of" the poor lighting, Thompson says. "We had about 9 lumens per square foot in there (before the upgrade). It was dull and dingy, and it wasn't what we needed. We couldn't keep the fluorescents working. Everything about it was just kind of haphazard. So we took those 44 400-watt lamps to 600K 100-watt (compact fluorescent lamps) in order to see if there was a way to bring down the power and still brighten the space. And it worked. We brought that watt spend down from 20,800 to 7,820."

Thompson continues: "It's a high-bay solution rather than the 400-watt lamps, and we reduced it from 44 light fixtures to 22. We also brought the wattage of each of those 22 (fixtures) to 185. I increased the wattage and reduced the number of fixtures. As for the pool deck, we replaced the T8 fluorescent lamps with screw-in LED 4-foot tubes. That took it from 32 watts down to 15. Overall, we were able to reduce the amount of wattage used on the pool deck from 20,800 down to 5,570 watts. That's a 73 percent reduction in wattage from where we started."

Completed in 2016, the project has delivered both savings and satisfaction."We're ecstatic with it," Thompson says. "We took a system that needed a lot of maintenance with a lot of people touching it and turned it into a rock-solid system that we don't touch anymore. And it's instant on. With the old lamps, you had to wait for them to warm up. Now it's bright, it's well-lit, and I can see to the bottom of the pool."

The total investment to put the LEDs in was just over $7,000, adds Thompson.

> *"Overall, we were able to reduce the amount of wattage used on the pool deck from 20,800 down to 5,570 watts."*

– Kyle Thompson, Director of Buildings & Grounds, Mequon Thiensville School District

A lighting system upgrade enabled the Mequon-Thiensville School District to reduce system wattage by 73 percent. (PHOTO: Lifetronics International)

Where LEDs Can Be Best Applied

Where LEDs Can Be Best Applied

LED systems are tremendous success stories In certain applications, achieving energy savings and lowered maintenance costs as promised. Based on anecdotal evidence and testing by the U.S. Department of Energy, LEDs perform best when mated to drivers that are designed for the LED lamp.

Determining which applications are best suited to available, effective LED products depends primarily on specific application needs and site characteristics. But in some application categories, manufacturers have been able to provide products that make these applications more successful than others.

Ceiling troffers: Many LED linear tube products exist as replacements for the current fluorescent linear lamp market. These products have improved in the past few years in terms of efficacy and cost, but issues remain with the variety of electrical configurations and the potential impact on the original lighting fixture design. Newer to the market are dedicated LED troffer fixtures

LED DETAILS
while the potential for high efficacy is inherent in LED lighting technology, that doesn't mean every LED is highly efficient. Many design and material decisions impact the ultimate performance of an LED luminaire or replacement lamp, including the LEDs themselves, the driver and other electronics, thermal design, and reflector and diffuser materials.

that provide the benefits of LED technology without direct tube replacements.

Downlights: This application was one of the first categories developed by the industry, and many capable products exist to replace the typical incandescent or fluorescent downlights in the form of a replacement lamp or an integrated LED downlight fixture. Their efficacy and color can be good, but managers need to be careful with heat buildup issues for replacement lamps and make sure the product is rated for use in downlight or enclosed fixtures.

Directional Lighting: Among the best potential LED applications are those in areas where directional light is needed, such as floodlights or spotlights for accent light on artwork or architectural elements. Recessed downlights are also particularly good applications for LEDs because most of the light produced from the LED is directed out of the downlight, unlike incandescent or compact fluorescent lamps, which produce light that gets trapped inside the can and requires additional reflectors to direct the light to where it is needed.

Dimmable Lighting: LEDs are inherently dimmable, but not all products dim in the same way, and there are numerous methods for dimming exist and a variety of ways LED products dim. Typically, as LEDs dim, light output decreases proportionally and efficacy actually might increase. Some products experience flickering or color shift, or they might drop out at the low end. Compatibility issues exist between some dimming systems and LED products, and while standards for LED dimming are under development by industry organizations, until standards are in place, managers have to rely on manufacturer recommendations. Lamp and fixture manufacturers should be able to provide a list of compatible dimming controls.

Task Lighting: LED lighting also works well where the light source is close to the task or there is a small area to illuminate, such as under-cabinet lighting or portable desk lights. This could also include applications where there are space constraints, such as ceiling coves or step and rail lighting.

LEDs Outside: Exterior Applications

LEDs Outside: Exterior Applications

LEDs can work well for outdoor lighting, especially in cold climates, and are commonly used for landscape lighting, street and area lighting, parking garages, wall-mounted security lights, decorative pole-mounted lights, and porch lights.

Outdoor applications are well suited to LED technology primarily because LED directionality can be exploited to provide light where it is needed, while limiting light trespass and wasted energy. Also, outdoor applications generally have an absence of surrounding heat that can degrade LED performance.

High-quality LED lighting does afford a number of advantages in outdoor settings, according to Eric Richman, senior research engineer at the Pacific Northwest National Laboratory. For one thing, LED lights come on immediately, unlike high-intensity discharge (HID) lights such as metal halide or high- or low-pressure sodium, all of which need time to warm up. Some HID lights can take up to 30 minutes to get to full luminescence. As a result, HID lights generally do not work well with occupancy sensors, because once the lights go off, they need re-strike time to come back on.

"There are some metal halide lights with quartz re-strike lamps that can work with occupancy sensors. If the light goes out and comes back on, the quartz lamp provides a reasonable level of light until the metal halide fully kicks in," Richman says.

> *"They have more longevity than HIDs – either sodium lamps or metal halides"*
>
> **– Eric Richman,** Senior Research Engineer, Pacigic Northwest National Laboratory

Quality LED lighting also performs well in cold temperatures, which can be an advantage over HIDs or fluorescent lights. In moderate climates, where the temperature is cool to cold in the evening, LEDs are performing in their optimum environment. By contrast, HIDs need more time to warm up in colder climates. Fluorescent lights also have trouble warming up in the cold and might not reach their full output when they do.

“In really cold climates, you need specifically rated fluorescent bulbs for colder temperatures,” Richman says.

LED lights also can provide an advantage when it comes to uniformity of illumination. Unlike any other type of light, LEDS have many point sources of light within the fixture. So it is possible to take the diodes and aim them a row at a time or even one diode at a time.

“You can tilt them so that the ones on the outside [of the board on which the diodes are arrayed] are aimed

at an outward angle, while others are aimed straight down," Richman says. "This provides more uniform illumination across a wide area.

"You can bend the reflector that's behind the light source to try to get more rays to shoot out to the side and fewer to shoot straight down, and you can put a refracting lens in front of (the light source), but this decreases light efficiency."
Every light source depreciates over time. Technically, LEDs can work for a very long time, but they will degrade like other lights, Richman says, although at a slower rate. Still, longevity is another reason LEDs are a good choice for outdoor lighting, despite their higher cost.

"They have more longevity than HIDs — either sodium lamps or metal halides," Richman says.

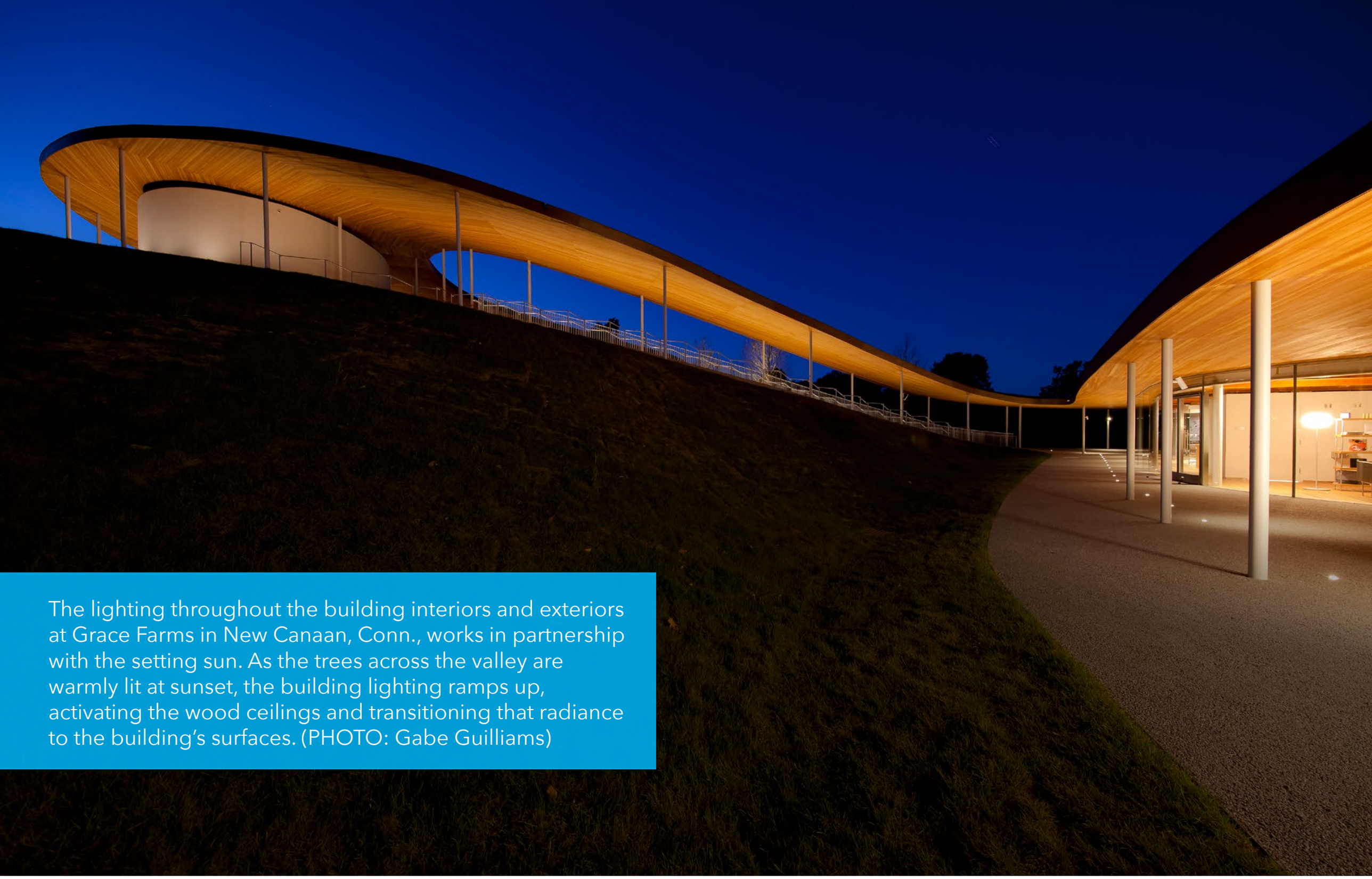
Case Study:

Color Temperature Control

LED lighting provides a versatile range of options to facility managers, with advances in controls enabling more than just on/off/dim. Some LEDs offer manual adjustment of color temperature, from cool white to warm white.

The LED lighting throughout the building interiors and exteriors at Grace Farms in New Canaan, Conn., is designed to work in partnership with the setting sun. According to lighting designers Gabe Guilliams and Farhad Rahim, as the trees across the valley are warmly lit at sunset, the building lighting ramps up, activating the wood ceilings and transitioning that radiance to the building's surfaces.

A warmly lit up covered walkway becomes a wayfinder through the site, taking people from social centers at the base of the building to the contemplative spiritual space at the top of the hill. Inside, custom-designed LED pendant are also crafted to complement the interior wood ceilings, creating a serene setting for evening worship, reminiscent of candlelight.



The lighting throughout the building interiors and exteriors at Grace Farms in New Canaan, Conn., works in partnership with the setting sun. As the trees across the valley are warmly lit at sunset, the building lighting ramps up, activating the wood ceilings and transitioning that radiance to the building's surfaces. (PHOTO: Gabe Guilliams)

New Technologies & Emerging Applications

New Technologies & Emerging Applications

LED technology opens a new palette of possibilities for managers beyond what was possible with legacy lighting. They have revolutionized the lighting industry. What might be a surprise to managers, however, is that LED lighting systems may now be poised to turn building automation on its ear by becoming the platform for the Building Internet of Things (IoT).

LEDs and Building Automation: Lights are a uniformly spaced building technology that is just about everywhere IoT wants to be. In addition, LED systems have a few attributes that make them particularly suited to the Building IoT.

First, LEDs are "self-funding," due to the energy savings they can achieve over legacy systems. Second, LED fixtures are digital devices. It is easier and less expensive – relative to alternative standalone solutions – to combine them with other digital devices, such as sensors, unleashing a potential world of new

The red "moving room" at the Sperone Westwater Gallery in NYC includes embedded LEDs in its perimeter, roof, and around mechanical equipment to illuminate the full shaft no matter the position of the room. (PHOTO: Gabe Guilliams)

applications the facility management industry has not seen before.

With LED fixtures, power and data can go to and from the fixture. Power Over Ethernet (POE) describes any of several standardized or ad-hoc systems that pass electric power along with data on twisted pair Ethernet cabling. POE provides 30 watts, and at least one proprietary standard can provide 60 watts per port. As a result, LED luminaires offer the opportunity for people to converge building systems onto the IT network.

LED tape and linear profiles: The use of LED tape and linear profiles using printed circuit board (PCB) embedded LED chips open new application and design flexibility. More options for lengths and optics that were not previously feasible in design, or achievable within given budgets, are now available.

For example, previous methods of cove lighting for spaces and tasks governed by energy codes entailed the use of fluorescent strips. These left pronounced socket shadows and were only available in a small selection of standard lengths. This greatly hampered their use without significant manipulation. LED tape or linear profiles commonly offer very small lighting increments — as short as 2 inches — which easily suit odd cove lengths and also reduce physical space requirements.

Smart lighting: As inherently digital devices, LEDs can work with controls and other systems to create unique solutions. One museum is exploring the use of Bluetooth-enabled LED spotlights. While the project is still under development, the track mounted spotlight with motion sensor and lux sensor could provide an intelligent lighting solution that could aid in the preservation of artwork.

The motion sensor could reduce the amount of light the artwork is exposed to in the gallery when it is unoccupied while the lux sensor could set the maximum limit of illumination the work would be exposed to at any one time. An onboard chip would be able to provide useful feedback on the module intensity, power, LED temperature, PCB temperature and input voltages characteristics.

LED light sheets: LED light sheets are very slim panels with perimeter embedded LED modules. The sheets have a matrix of linear cut grooves to refract light distribution from the perimeter onto the panel's surface. There are multiple uses for and advantages to this product. Applications include retail display shelves, where the heat from the LED source can be dissipated at the edge boundaries with further reduction with the use of a metal bezel at the shelf edge. Other applications include backlit panels recessed flush within wall or ceiling surfaces where space is limited for use of conventional light boxes.

Color: LEDs also can give better saturation and rendering of color, as evidenced by the many building facades now entertaining the use of color. LED lighting allows the use of digital multiplexing, which was originally used for control of stage lighting and effects. It is one of the most common control protocols regulating variable colors and the manipulation of pixels in both internal and external commercial lighting schemes. Some LEDs offer manual adjustment of color temperature, from cool white to warm white.

The use of color can provide dramatic visual effects; however, the application of color requires careful consideration to ensure appropriate use, with coordinated external lighting schemes tending to work more successfully.

Case Study:

Layers of Light

The David and Helen Gurley Brown Institute for Media Innovation at Columbia University in New York City is devoted to the co-evolution of technology and storytelling. When deciding on the lighting strategy for the 4,600-square-foot space, the challenge was to design lighting that would support the institute's varied programmatic needs: classroom, workshop, film screening, conferences, panel discussions, concerts, and cocktail parties.

The application required flexibility and very simple maintenance. To answer these needs, the lighting strategy includes the use of a single fixture in three different capacities. The resulting application uses a series of intertwining luminous elements, achieved with LEDs embedded within pipework, building a network of ambient light for the room, according to designers Gabe Guilliams and Fahad Rahim.

Each element within the network provides indirect lighting along its length, with a direct punctuation at its end. The final layer is built into the walls. Backlight, integrated into the perimeter fabric screen, adds depth and richness to the space. It helps define the screen and allows the structure holding it to be seen as an extension of the ceiling network.

The fixtures are low-voltage and are magnetically held in place, creating the freedom to easily shift fixture positions during construction to optimize the light effect and minimize reflections in the perimeter glazings. Being held in place magnetically also means modules can be removed and replaced as needed.

The lighting concept at the David and Helen Gurley Brown Institute for Media Innovation at Columbia University embraced the institute's mission of speculating how stories are discovered and told in a networked, digital world with a series of intertwining luminous elements. (PHOTO: Michael Moran)

RESOURCES

The website FacilitiesNet.com is a rich source of facility management and maintenance advice, budget benchmarks, new product information and more from Building Operating Management and Facilities Maintenance Decision magazines. Search tips and advice by product or project category, including LED lighting, by visiting this page.

Post a question and find answers on MyFacilitiesNet.com, a forum for facility managers, building engineers, owner/operators and staff.

Learn more on specific LED lighting topics mentioned in this ebook by reviewing the following article sources:

Design Case Studies/Lighting Retrofits
http://www.facilitiesnet.com/lighting/article/LED-Lighting-Upgrades-Deliver-Savings--17109

http://www.facilitiesnet.com/lighting/article/4-Benefits-of-LED-Lighting-Beyond-Energy-Efficiency--17024?source=part

Emerging Applications
http://www.facilitiesnet.com/lighting/article/LEDs-Are-An-Ideal-Platform-for-the-Building-IoT-Facilities-Management-Lighting-Feature--16775

Benefits
http://www.facilitiesnet.com/lighting/article/Evaluate-LEDs-for-Possible-Use-in-Outdoor-Safety-and-Security-Lighting--13954

http://www.facilitiesnet.com/lighting/article/Advantages-of-LED-Technology-Facilities-Management-Lighting-Feature--14480

http://www.facilitiesnet.com/lighting/article/10-FAQs-for-Selecting-LEDs--12980