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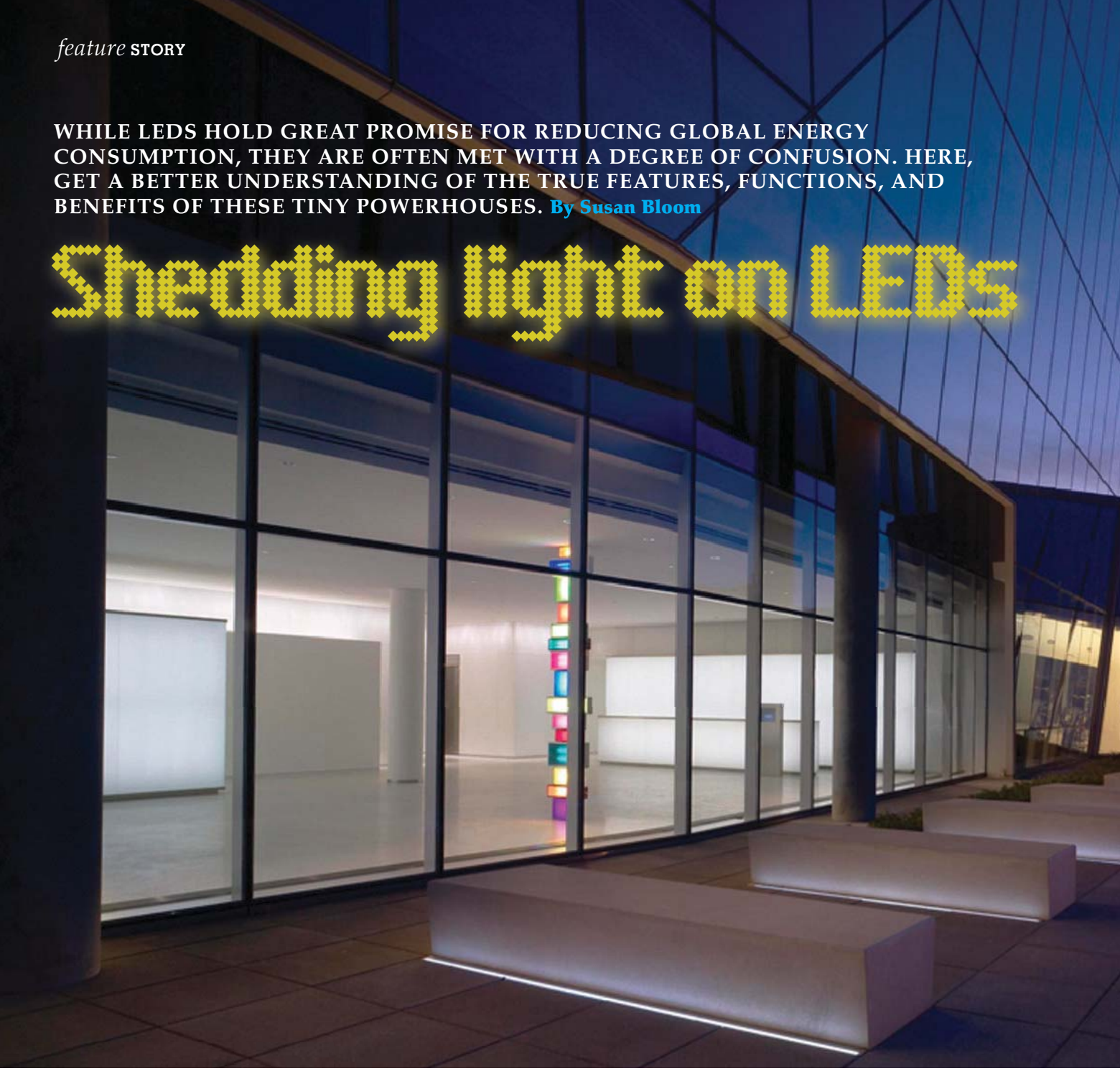
MORE SUN, BUT STILL LOTS OF CLOUDS

WHILE LEDS HOLD GREAT PROMISE FOR REDUCING GLOBAL ENERGY CONSUMPTION, THEY ARE OFTEN MET WITH A DEGREE OF CONFUSION. HERE, GET A BETTER UNDERSTANDING OF THE TRUE FEATURES, FUNCTIONS, AND BENEFITS OF THESE TINY POWERHOUSES. By Susan Bloom

Shedding light on LEDs



A technology that holds great promise for reducing global energy consumption and that stands on the threshold of a new era in lighting technology worldwide, LEDs are nonetheless currently met with a degree of confusion by users and channel members in terms of their specs, applications, and future potential. The following overview of LEDs will aid in better understanding the true features, functions, and benefits of these tiny powerhouses as well as provide tips that will help distributors capitalize on the emerging market for LEDs and serve as champions of their growth.

WHAT ARE LEDS?

LEDs are currently the most commonly seen member of a family of technologies called solid-state lighting (SSL), which refers to a class of products that use semiconductors to convert electricity into light—as opposed to incandescent or fluorescent lamps, which create light through a system of filaments and gases encased in a glass bulb. In contrast to many lighting technologies that emit light as a function of heat generation, LEDs are semiconductors that produce light when electricity passes through them.

LEDs have been in practical use for more than 50 years, but until recently

Lightboxes and a luminous reception desk orient visitors and differentiate the interior spaces of the lobby of a new office tower in the North of Massachusetts Avenue (NoMA) district of Washington, D.C.

IMAGE COURTESY OF GE LIGHTING SOLUTIONS

were used mainly in electronic devices such as indicator lamps due to their small size, ruggedness, fast switching capability, low power consumption, and compatibility with integrated circuitry. Today, thanks to the breakthrough technological developments in the past two decades that have built upon their inherent attributes, LEDs are successfully penetrating more and more professional and general lighting applications and representing a viable alternative to incandescent, halogen, fluorescent, and HID technology in a rapidly expanding range of settings.

WHY LEDS?

LEDs offer an extensive and powerful range of benefits, including:

• **Long life.** Their lifespan of up to 50,000 hours "is nearly 50 times longer than a traditional incandescent bulb," according to Michelle Murray, communications director for Cree LED Lighting (creelighting.com). "This equates to reduced waste and significant cost savings on maintenance."

• **High efficiency.** As a technology that is cool operating, "LEDs can use as much as 80% to 90% less electricity than traditional incandescent lamps," explained Garrett Grega, senior SSL product manager at Philips Lighting (lighting.philips.com). As a result, the DOE estimates that replacing incandescent light bulbs with LEDs could save 190 terawatt-hours of energy annually —the amount of energy consumed by more than 95 million homes.

• **Directional light.** LEDs direct light where it's needed rather than scattering it.

• **Free of hazardous materials.** Free of materials such as mercury and lead and with a long lifespan that will significantly reduce the number of bulbs ending up in landfills, LEDs are "an environmentally preferable lighting option," said John Zimmerman, professional SSL product marketing manager for OSRAM Sylvania (sylvania.com).

• **Small size.** Their extremely compact and low-profile nature enables enhanced versatility and design flexibility.

• **Durable.** Because they contain no breakable glass or filaments, LEDs have a higher resistance to damage, vibration, and shock than other lighting technologies. "Breakage during transportation, installation, and operation—a common problem with traditional light sources—is virtually eliminated," said Steve Briggs, vice president of marketing and global product management for GE Lighting Solutions (gelighting.com). "This robustness speeds installation as well as installer training time."

Common misconceptions

We asked our experts to share the myths that they would most like to dispel about LEDs. Here's how they responded:

• "Probably the most common myth is that LEDs last forever," said Jim Brodrick, SSL portfolio manager for the DOE. "The DOE's fact sheet *Lifetime of White LEDs* addresses this." (Find it at apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds_aug16_r1.pdf.)

• "There's a misconception that LEDs are only viable in niche applications and aren't applicable to the general illumination market," said Michelle Murray, communications director for Cree LED Lighting. "The LED lighting revolution is happening now. End-users can realize the energy and maintenance savings associated with LED general illumination now—from their homes to their businesses to the streets they drive on."

• "There's a misconception that we should wait until LEDs have the same lumen levels as incandescent or halogen technology before we replace our lamps," said Garrett Grega, senior SSL product manager at Philips Lighting. "The truth is that LEDs are a directional light source and, as such, can often deliver more light with lower lumens than an incandescent or halogen source with higher lumens because the LED light output isn't as scattered."

• "One myth is that all LED systems are the same," said GE Lighting Solutions's Steve Briggs, vice president of marketing and global product management. "LED systems vary greatly in design, performance, and reliability. Although the industry is moving in a positive direction, market surveillance proves that many manufacturers' performance claims are erroneous and misleading." John Zimmerman, professional SSL product marketing manager for OSRAM Sylvania, agreed: "Quality is everything in today's LED market. You get what you pay for." —*S.B.*

• **Flicker-free.** The solid-state nature of LED technology virtually eliminates the issue of flickering.

• **Cold-temperature operation.** LEDs experience performance improvements and actually gain efficiency in cold weather, making them ideal for low-temperature applications.

• **Instant-on and dimming capabilities.** LEDs require no warm-up time, as do other lighting technologies (such as CFLs), and are also dimmable.

• **Rapid cycling capability.** LED lifetime is not affected by frequent switching.

• **Controllability.** LEDs can be controlled electronically to affect light levels and color characteristics.

• **No hazardous emissions.** LEDs intended for lighting don't emit infrared or ultraviolet radiation.

• **Color quality.** As measured by CRI, high-quality LED fixtures often produce light that shows color more effectively than fluorescents and other traditional light sources.

A LOOK AT THE MARKET

According to the *2009 LED Replacement Lamps* study by Strategies Unlimited (strategiesunlimited.com), "The total U.S. LED market size was about $160 million in 2008, less than 1% of the total market for replacement lamps, which is estimated at $20 billion to $25 billion."

The study further broke down the $160 million replacement market for LEDs, revealing that "the largest replacement lamp type was MR16, at $73 million, or 45.8% of the overall market. This was followed by A-lamps and globes at $65 million, or 40.6% of the total market. PAR- and R-lamps accounted for $11 million, or 7%; candelabra and other decorative lamps were 5.4% of the market, and linear fluorescent replacements were about 1.2%." The study continued by forecasting that the overall LED replacement market is expected to grow by 89% between 2008 and 2009.

Today, Jim Brodrick, SSL portfolio manager for the DOE, estimates that the current LED market represents 2% to 3% of all lighting-related sales—still only a small slice of the replacement market, but one that is poised for explosive growth in the next five to 10 years. "This is based on market drivers including the impending phaseout of incandescent bulbs, continuously rising electricity rates, and the nation's emphasis on green products and energy independence," Brodrick noted.

GTM Research and Groom Energy concurred in the *2010 Enterprise LED Lighting: Commercial and Industrial Market Trends, Opportunities & Leading Companies* study, reporting that the "U.S. market for commercial and industrial LED lighting is forecasted to see $330 million of revenue in 2010, with potential to grow next year at over 30% and surpass $1 billion in annual revenues by 2014."

The Cole Haan Soho, N.Y., store was lighted using LED cove, PAR, and replacement lighting products.

PHOTO COURTESY OF PHILIPS LIGHTING

KEY APPLICATIONS

Today's LEDs support a broad range of applications, from downlights to decorative lights, PARs, MRs, A lamps, R20s, and more. But where does it end?

"LEDs are being used for almost all directional lighting applications, from downlights to spot and floodlights, troffer replacements, and wall washers," said Murray. "With every advance in LED component technology, additional applications become possible. For example, with the advent of dispersed phosphor LEDs and their associated smooth light output, linear lighting applications such as cove and undercabinet lighting became possible. With high-power LEDs capable of withstanding high-drive currents, very bright but focused lighting applications are now coming on board. And there are billions of lighting sockets out there today—all consuming vast amounts of energy—that can be addressed with LED lighting."

"Common general lighting applications for LEDs in the professional sector include illuminated signage, architec-

What makes LEDs different?

By understanding the similarities and differences between LED and conventional lighting, distributors can evaluate LED products, compare them with conventional sources, and take full advantage of their unique characteristics.

Similarities include the fact that LED products are typically manufactured in familiar forms, from fixtures to replacement lamps. LED fixtures emit light in familiar distribution patterns, are available in fixed color temperatures, and can be dimmed. Performance of LEDs is affected by operating conditions and they suffer lumen depreciation over time, run off of AC power, and require a driver just as gaseous discharge sources require a ballast.

"Distributors and contractors should recognize that the terminology used to describe LED lighting fixtures is similar to the terminology used to describe traditional lighting fixtures," said Tom Hamilton, global product manager for Philips Color Kinetics (colorkinetics.com). "The industry has matured to a point where we are speaking a familiar language of lighting and not using exotic terminology."

Similar enough for retrofits of existing fixtures? "Not likely at this time," said Kevin Willmorth, principal of Lumenique (lumenique.com). "In the near term, there are so few LED products that are truly equivalent to conventional lamps, so finding an exact replacement product as a 1:1 replacement is difficult. For those willing to do the research and understand where LED products are a good substitute, there is success to be realized. However, there are far too many issues with advertised 'equivalents' that are simply not; manufacturer data alone cannot be assumed to be accurate."

Despite the similarities, there are critical differences between LEDs and conventional lighting:

1. LEDs produce light using a nontraditional method. Conventional sources produce light by passing electric current through an element until it glows (incandescence) or by exciting a gas (fluorescence and high-intensity discharge). LEDs produce light by passing current through a solid (solid-state lighting). As a result, LEDs are more robust than traditional sources, making them more resistant to shock and vibration. Today's LED sources are very small but produce high levels of light output, making them very bright and potential sources of glare if not properly controlled.

2. LED lighting products are highly integrated devices. Conventional light fixtures are built from components manufactured to widely accepted standards. LED products, meanwhile, are typically highly integrated devices, consisting of the LED device itself plus optics, heat sink, drive electronics, and fixture housing. Ideally—but not always—this means product performance is optimized as a complete lighting device. The disadvantage of this is that when the "lamp" fails, the entire fixture must be replaced.

3. LEDs are highly efficient. Well-designed LED products can produce light at higher efficacies—expressed as lumens of light output per watt of electrical input—than conventional sources. While the potential for deep energy savings is significant, note that some manufacturer claims compare the best LEDs can do to the worst conventional products, which can be misleading.

4. LEDs promise long service life. Many architectural LED products carry a rated life of up to 50,000 hours. Unlike most conventional sources, service life is based on useful life, which in turn is based on lumen depreciation (for general lighting products, L70, the point at which the source will be producing 70% of its initial rated light output). Long-life fluorescent lamps are now available that are competitive in terms of rated service life. However, LED devices do not fail over time as sources such as fluorescents do, which, on a predictable mortality curve,

tural lighting, outdoor area and street lighting, display lighting, and traditional screw-base incandescent lamps," noted Briggs. "Indoor, directional lighting is also taking shape, and more and more LED-based ambient lighting applications are emerging."

Grega added that LED technology is also ideal for the retail sector. "LEDs don't produce UV or IR in the beam, so they won't fade colors in fabrics and other materials," he said, adding that LEDs can be used in a host of other applications too—from retrofits of traditional incandescent medium-based screw sockets to downlights, floor or table lamps, track heads, pendant fixtures, and décor candle lights for chandeliers.

"We see the opportunities for LEDs as endless: from freezer cases to retrofits and outdoor area lighting to architainment," added Zimmerman. "Wherever light is today, LEDs can be utilized, as well as where lighting traditionally was not, such as in wallpaper or furniture" —a nod to the flexibility that allows LED technology to offer a new range of solutions that don't necessarily look or perform like traditional lighting and are limited only by one's imagination.

KEY DOWNFALLS OF LEDS

Of course, there are certain applications for which LEDs are not currently an ideal solution. "The most difficult applications for LED technology today are linear fluorescent ones," said Briggs. "Linear fluorescent is the most cost-effective technology for ambient lighting applications. In addition, tight color control and high-intensity applications provide challenges for LEDs in terms of performance and cost compared to halogen and ceramic-metal halide."

With respect to their shortfalls, Brodrick noted that "Not all LED lighting products are created equal. Some perform quite well, while others don't currently measure up to the technology they're intended to replace.

"For example, LED linear replacement lamps don't necessarily perform as well as their fluorescent counterparts in terms of total light output, light dis-

tribution, color quality, and reliability—plus they cost more," he added.

The issue of cost is one facet of LEDs that all experts agree remains a hurdle to mass adoption of the technology. "Although the performance and cost roadmaps are extremely exciting, the fact remains that today, first-time cost may not enable a quick enough economic payback to broadly activate many segments and applications," Briggs said.

Zimmerman noted that the current price of LED technology does pose a barrier, though history suggests that LED prices are likely to fall as manufacturers achieve critical mass in this area and market acceptance grows. "Still," he said, "though LED products are becoming more affordable due to economies of scale, they're not yet cheap. If you or your customers are buying solely on the basis of lowest acquisition cost, you may become dissatisfied with the result, especially over time, because quality counts in this market."

UNDERSTANDING LEDS: A GUIDE FOR DISTRIBUTORS

Lighting manufacturers and industry experts offer many resources to help distributors assess LED options and determine whether LEDs represent a good choice for a certain customer or project.

On the technical side, many manufacturers have developed a list of questions that should be addressed as part of an assessment of an LED solution, such as:

- How does the manufacturer define "lifetime" in the context of an LED's lumen maintenance?
- Does the stated lifetime include the electronics and other components necessary to drive the LED source?
- What is the maximum ambient temperature under which the fixture can operate and achieve rated life?
- Does the fixture or lamp design have any special features for heat sinking/thermal management, which can impact lamp life if not handled properly?
- What is the manufacturer's warranty?

In addition to these questions, Grega pointed out that LEDs can come in many different color temperatures and lumen levels and recommends that distributors understand the required color temperature for the application.

"For instance," he said, "hospitality accounts generally look for warmer color temperatures such as 2700K, while retailers prefer a cooler color temperature like 3000K, and certain geographic areas may have a preference for 4000K products. Canada, for example, has a demographic that prefers daylight-type products that operate at a higher Kelvin temperature, while the southern latitudes also show a preference for a cooler color temperature, perhaps to offset the bright red of the sun or the high outside ambient temperatures. It helps if distributors can understand what their customers are trying to

makes fluorescents' rated life an average. With a long mean time between failures—little or no spot relamping for years until the fixtures fail—LED products present a distinct advantage over conventional sources.

5. LEDs are inherently directional sources. Almost all of their light output is emitted in one direction. This can be highly beneficial for directional lighting applications and also improves the efficiency of light fixtures containing LEDs.

6. LEDs are highly dependent on the operating environment. As with sources such as fluorescent, LEDs are sensitive to ambient heat. LED sources are significantly more sensitive, however, which must be taken into account in the design of the fixture. While LEDs produce no radiated heat in the light beam, waste heat is produced inside the LED itself, which must be removed via some type of heat sinking that draws the heat away from the device and dissipates it into the air surrounding the fixture housing.

7. LEDs have special color considerations. LEDs can be specified with a fixed color temperature and with color rendering index (CRI) ratings higher than 80, making them suitable for most commercial applications. However, due to binning, there may be slight differences in color appearance between fixtures. And regarding CRI, while an 80+ CRI is available from many LED products, LED fixtures that produce white light by combining red, blue, and green LEDs may produce poor color rendering (13 to 32 CRI). By combining white LEDs with other colors, however, different shades of light can be achieved through dimming.

8. LEDs play well with controls. LEDs can be controlled similarly to conventional sources but with the advantages of instant-on operation, no reduction in service life due to frequent switching, maintained efficacy over the dimming range (until the lowest dimming levels, where efficacy actually increases), and extension of service life due to dimming.

9. LEDs produce no UV radiation. This makes LED suitable for applications sensitive to UV energy in the light emission, such as museum and some retail applications.

10. LEDs contain no mercury. This simplifies disposal.

Jeff Quinlan, vice president of technology for Lithonia Lighting (lithonia.com), added that there is one more critical difference: LEDs are still relatively new. Distributors should be careful about selecting products that will work as intended in the application to avoid getting burned by overstated sales claims and poor products. "Always ensure that your LED product is coming from a reputable lighting manufacturer," he advised. "Buying from a manufacturer you can trust is key to the success of your business as well as to the success of the LED market in general. Consult the Lighting Facts label to ensure that you're getting a quality product. Look for manufacturers that are able to provide the appropriate accreditations and testing reports in compliance with IES, ANSI, and UL lighting standards."

Hamilton pointed out that these differences mean LEDs are not plug-and-play replacements for conventional sources and require specialized fixture construction. But in the end, LEDs are just another source. "Research the application and try to understand what the important criteria are—for example, power consumption, footcandle requirements, beam angles, and color rendering—regardless of the lighting technology to be used," he said. "Then make sure the LED fixture you are proposing will deliver the performance to meet those requirements. Again, it is critical to remember to use the right light for the right application." ■

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achieve in order to guide them toward the product and color temperature that fit their lighting goals."

Zimmerman noted that "The Illuminating Engineering Society [IES] has approved methods for measuring electrical and photometric performance of solid-state lighting products [LM-79] as well as lumen maintenance of LED light sources [LM-80]. The data associated with the product should substantiate the claims made by the supplier regarding its performance over life.

"If you sense a disconnect between a supplier's claims and its data, ask for additional data," he added. "A quality supplier will appreciate the interest and will happily provide that data with an explanation that a nontechnical person will understand."

Murray takes a good-judgment approach to assessing LED options. "Seeing is believing," she said. "Don't recommend or specify a product that you haven't seen—no matter what the data sheet says. Only your eyes can tell you how closely a fixture replicates incandescent color. In addition, seek out lighting manufacturers with successful customer feedback that can demonstrate their products' success in a variety of applications and markets."

Murray noted that the DOE is making it easier for distributors to determine the viability of a product through its Energy Star program. "This program provides a minimum level of acceptability for many criteria including color quality, efficacy, and justification of projected lifetime," she noted. "Seeking the Energy Star mark will help narrow the field of products for consideration—but there's still a significant differentiation among Energy Star products. So it's still best to compare products side by side. Don't just trust a spec sheet."

THE FUTURE FOR LED TECHNOLOGY

According to Briggs, efficiency gains and cost reductions are the keys to LEDs emerging as the premier technology in the next five years. "Color and control will become more stable and binning [the means by which LED

manufacturers sort products to account for manufacturing variation] simpler, and LED system components will also continue to evolve," he said. "Thermal, optical, and driver improvements are all in play. Investment in these key platforms will deliver efficiency gains that improve overall system-level performance and economics."

Omnidirectional lighting, such as traditional A lamps, is the next frontier, noted Murray. "You'll be seeing more and more of those products enter the market in 2011 and beyond," she said. "Enhancements to LED performance and form factor can also open up new applications—such as smaller, brighter directional lamps, smooth-light applications like linear and undercabinet, and ultra-bright high-bay and roadway."

"Manufacturers are already looking at new approaches for 'smart lighting' systems that integrate electronics and controls for maximum performance and energy savings, as well as at novel luminaire concepts and form factors," said Brodrick. "In the next five to 10 years we'll see the emergence of OLEDs [organic LEDs, or LEDs made from organic, carbon-based materials] as a force in the lighting market."

"As LED technology evolves, it will increasingly be able to replace the traditional fluorescent mainstays of T12 and T8," said Grega. "In addition, we'll see a great uptake in LED for architectural, street, and other outdoor lighting as they continue to evolve to higher-lumen efficacies."

Philips Lighting's EnduraLED A19 dimmable LED A-shape lamp was a retrofit solution that addressed the Mirage Hotel and Casino's concerns for lighting quality, maintenance costs, and energy efficiency.

PHOTO COURTESY OF PHILIPS LIGHTING

FINAL THOUGHTS

Experts agree that LED technology represents the future of lighting and they encourage electrical distributors to invest the time in understanding the different products available. "Not only will a familiarity with LED options help distributors better serve their customers with a quality lighting alternative, but their use will also help meet the market's growing number of green mandates and efficiency standards," explained Grega. "Based on their long life, reduced maintenance requirements, and high efficiency, their ROI will quickly overcome the initial up-front costs."

"Don't wait to start selling LED lighting, as it's among your best opportunities to increase sales and margins in an economic downturn," Murray added. "Get LED lights in your hand to see how they perform. And talk to satisfied LED customers—there are more and more of them every day."

Zimmerman noted that there are many products, many claims, and many options for LED lamps. "We advise distributors to offer high quality and reliable products in their portfolio to meet customers' application requirements and safety standards," he said.

Briggs suggested that distributors promote LED fixtures with modular, replaceable components. "The technology is still in its infancy, so next-generation products are only going to get better and cheaper," he explained. "Therefore, locking an end-user into integrated luminaires with no upgradeable or replaceable parts is an injustice to the entire value chain. A system with modular components that could be easily upgraded or replaced will help future-proof the end-user and enable a profitable retrofit for the distributor."

Distributors are further encouraged to seek out the market's resources, from manufacturer-developed materials and training to government-sponsored tools designed to provide assistance with LED standards, specs, and evaluation guidelines. The DOE is a great source of objective data on LEDs, from Energy Star standards and ratings to SSL workshops, electronic SSL updates (which share information on public meetings, document postings, and other issues pertinent to the DOE SSL Portfolio), SSL Fact Sheets, and the CALiPER database, which currently shares test data on LED lighting products in 19 categories—from cove to undercabinet, downlight, roadway, and troffer applications. (Visit ssl.energy.gov for more information.)

"It's an exciting time for new LED opportunities," said Brodrick. "Start familiarizing yourself with the capabilities of LED technologies so you'll be ready." ■

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