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LEDs are Finding their Niche

LEDs are finding success in many niche lighting applications, from retail to commercial to residential. But their future will rely on quality performance, proper luminaire design, and appropriate testing metrics.

Recent advancements in LED luminous efficacy, color, and life have proponents touting light-emitting diodes as the next light source to displace incandescent and fluorescent lamps in general illumination applications. Yet lighting experts say for the most part, LED general lighting is still at least five years away. So where can LEDs find success now? The answer is in a number of niche and specialty applications found in all sectors – retail, commercial, and residential.

The Lighting Research Center (LRC) at Rensselaer Polytechnic Institute, located in Troy, New York, has conducted several field studies in the past five years to explore the potential of different niche applications for LED lighting. LRC Director of Research Nadarajah Narendran, Ph.D., head of the LRC's Solid-State Lighting Program, said, "Our goal with these field studies was to show that LEDs available today can be successful, energy-efficient light sources if they are used in the right applications with proper luminaire design and installation." In each case, these field studies were geared toward showing the strengths of LEDs and how they can best be used. "Instead of trying to replace conventional technology with the new in a given application, it is better to identify alternate lighting solutions that exploit the strengths of the new technology, even if it breaks tradition," Dr. Narendran added.

LED supermarket lighting study: fluorescent on left, LED on right

Colored LED lighting for retail display windows

Because energy-efficient colored light is one of the greatest strengths of LEDs, the LRC investigated the use of colored LEDs in retail store window displays. Retail stores in the United States use as much as 37% of their total energy for lighting, according to the U.S. Department of Energy. In order to attract attention, retailers often use plenty of high-wattage halogen accent lights to highlight mannequins and merchandise in display windows, making them stand out from the background. This technique is effective but when used 12 or more hours every day, the energy consumption and costs can climb. Past research in the LRC laboratory has shown that using colored LEDs as background display lighting could capture more attention, offer greater visual appeal, and lower energy use (up to 50% for accent lighting) than the current lighting practice for store windows.

The Los Angeles Department of Water and Power sponsored the LRC field study to determine whether energy-efficient, colored window lighting could draw the interest of shoppers, reduce energy consumption in store windows, and maintain or improve retail sales. LRC researchers installed custom, slim-profile blue LED fixtures in the windows of three stores owned by a popular clothing retailer located in Los Angeles-area shopping malls. To cut energy consumption by 30 to 50 percent in each window, they eliminated all general fluorescent lighting, reduced the number and

wattage of halogen accent lights, and added LED systems to create colored backgrounds for interest. The researchers tested different window display and lighting scenarios over an eight-week period and surveyed passing shoppers about the attractiveness, visibility, and eye-catching ability of the windows. (Lighting inside the stores remained unchanged.)

The new window lighting was designed to create impact and contrast with color, instead of high light levels, allowing the amount of accent lighting and energy use to be reduced, Narendran noted.

After eight weeks and more than 700 shopper surveys, the LRC found that the colored LED lighting was popular with shoppers. Shoppers preferred the colored LED window with a 30 percent reduction in power over the typical high-energy lighting design. The survey results also showed:

- 74 percent of shoppers found the new lighting design to be eye-catching.
- 84 percent agreed that the LED display windows were visually appealing.
- 91 percent confirmed that the reduced accent lighting did not diminish the visibility of the window mannequins and merchandise.

Cutting the lighting power consumption further to 50 percent in each window resulted in no significant difference in shoppers' opinions compared with the typical lighting, and a lower opinion compared with the 30 percent reduction.

Sales data gathered by the retailer showed no significant change in sales at the three test stores during the study period, even with a 50 percent reduction in power usage. Sales were compared with the same weeks for the previous year and with comparable stores owned by the retailer.

White LED lighting for supermarkets

Though white LEDs are just beginning to make their way into some general lighting applications, today they can successfully illuminate small spaces while saving energy. One example is the interiors of refrigerated and freezer display cases found in supermarkets, grocery stores, florists, and other retailers that carry perishable goods. Fluorescent lamps typically illuminate these cases, yet they are not an ideal light source for this application. Cold temperatures cause the mercury vapor pressure inside fluorescent lamps to drop, leading to reductions in light output of up to 25% under typical conditions found inside a beverage cooler display case. In contrast, LEDs do not suffer the same fate. In some situations, their light output improves in colder

environments. Poor mounting and a lack of optics also can hinder the light output and the lighting uniformity of fluorescent lamps.

A previous laboratory study conducted by LRC researchers concluded that white LEDs would be ideal for lighting freezer and refrigerated display cases because they can improve the merchandise lighting and lower the energy cost. To further validate the findings, the LRC evaluated a prototype four-door, LED-lighted freezer case installed at an Albany, N.Y., area Price Chopper supermarket. The two-year field study was sponsored by the New York State Energy Research and Development Authority. The freezer, built by Tyler Refrigeration, was outfitted with 1-watt high-power white LEDs in a lighting system designed by GELcore (now known as GE Lumination).

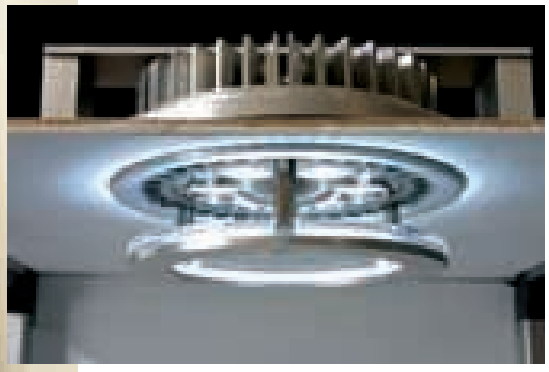
Over the course of the study, the LRC investigated shoppers' preferences for an LED-lighted freezer case compared to a matching freezer with conventional fluorescent lighting. LRC researchers also analyzed sales data and measured the energy usage of the two test freezers, which were installed side by side next to the existing freezer cases in the supermarket's frozen-food aisle.

Overall, shoppers stated that products were more appealing and the lighting was brighter, more comfortable to look at, and more even inside the LED freezer. More than 86% of shoppers selected the LED freezer as the one they liked the most, out of more than 300 surveyed.

Narendran believes that the LED freezer got high marks because of the more uniform light distribution and the sparkle that the LED lighting created within the lighted space. "Even though the average illuminance level of the fluorescent-lighted freezer was slightly higher, the uneven distribution of the fluorescent lighting led to areas at the center of each glass door that had roughly half of the average LED light level," he said. The light levels were more uniform all the way across in the LED freezer, while the fluorescent freezer had dark areas at the center of the case. "This likely led to the perception that the LED case was brighter."

A statistical analysis of sales in the test freezers compared with sales of

LED elevator lighting study



LED elevator fixture

the same products at a control store located nearby showed no significant difference in sales due to the change in lighting.

Narendran says that while this particular test freezer was not built with the intention of showing immediate energy savings, a real potential exists now for LEDs to save energy in freezers illuminated at an acceptable light level. "LEDs available today can match the energy usage of fluorescent lamps in supermarket freezer display cases. And as LEDs become more efficacious, they will eventually provide greater energy savings over fluorescent," he says. They are also expected to compete cost-effectively with fluorescents for freezer illumination.

To meet the needs of this growing niche market, the LRC with help from the Alliance for Solid-State Illumination Systems and Technologies (ASSIST) has published recommended testing guidelines for luminaires used in refrigerated and freezer display cases.

LED lighting for elevators

Another example of a small space that can be successfully illuminated by white LEDs is the elevator cabin. LEDs are an ideal solution for applications requiring small or low-profile light fixtures and are a great choice when space is at a premium, such as above a ceiling panel.

During a two-year project sponsored by the California Energy Commission's PIER program, the LRC developed and evaluated a low-profile LED downlight to replace a less efficient incandescent luminaire in an elevator. The prototype downlight consisted of six 3-watt high-power white LEDs in a custom reflector and heat sink package of less than two inches high. The design efficiently balanced the required light output and distribution, visual comfort, and thermal management within a small and attractive package.

The LRC worked with Otis Elevator Co. to select and modify an elevator on the Rensselaer Polytechnic Institute campus in Troy, N.Y., for the field installation. LRC researchers modified the existing elevator ceiling panel, removing the original incandescent fixtures and replacing them with

LED under-cabinet lighting

LED directional lighting

six prototype fixtures built with the help of Westinghouse Lighting Corp. The downlights were recessed into the ceiling and required less than two inches of space above the ceiling panel.

LRC researchers measured the LED fixtures' performance, including light output and power usage, and compared them with the existing incandescent fixtures inside the elevator. The LRC also asked volunteers to ride the elevator and rate the existing and new elevator lighting.

The six downlights required 165 watts of electricity (including a complementary LED cove system added to the ceiling perimeter) compared to 300 watts for the 50-watt R20 systems they replaced. At the system efficacy of the LEDs used, an energy savings of 45 percent was realized over the actual incandescent system. The LED luminaires provided similar light distribution and illuminance levels inside the elevator cabin with better comfort and attractiveness, according to elevator passengers.

Narendran noted that LED downlight fixtures in elevators can be expected to save more than just lighting energy. LED fixtures are expected to last 40,000 hours, or more than four years being on all day, every day, compared with traditional incandescent fixtures in elevators, which operate between 1,500 and 2,500 hours. They also have the ability to work with on-demand dimming and motion-sensing lighting controls for added savings. Their rugged design means they are resistant to elevator cabin vibration, potentially reducing maintenance needs. Overall, LEDs can provide cost savings for replacement and maintenance.

LED downlight fixtures could have an even greater impact on the elevator industry in terms of elevator design, said Narendran. "The low-profile design of the LED fixture means that elevator manufacturers can shorten the height of the elevator cabin by as much as four to six inches, the current clearance needed for traditional incandescent and fluorescent fixtures," he said. In turn, this means less material are needed to build the cabin, reducing the cabin's total weight. Less weight translates to smaller motor and braking systems—an added energy savings.

New options for residential use

Beyond the retail and commercial building markets, LEDs are now finding their way into residential lighting applications. In particular, under-cabinet, recessed downlight, and decorative LED fixtures are appearing in home improvement centers, lighting showrooms, and manufacturers' catalogs. With the growth of this market, however, has come confusion over how consumers can compare the performance of similar fixtures using different light sources. "Right now, it is very difficult for the general public to compare the performance of a fluorescent under-cabinet fixture or downlight fixture with that of a similar LED fixture because the evaluation criteria used by manufacturers are different for each light source," said Narendran.

To that end, the Alliance for Solid-State Illumination Systems and Technologies (ASSIST), an international industry group organized by the LRC, has developed ASSIST recommends publications to discuss these growing LED applications. The volumes discuss under-cabinet lighting and directional lighting in terms of general design and application, how to select LED lighting, and recommendations for manufacturers testing and evaluating their own fixture products. Testing guidelines are also available for LED light engines and integrated lamps used in decorative lighting luminaires, such as chandeliers, wall sconces, and pendants. ASSIST's top priority in developing these volumes was to begin public discussion on the need for testing criteria and methods that allow lighting fixtures to be compared on the same playing field, regardless of the type of light source technology inside, said Narendran. "At the LRC, we have developed technology-neutral, fixture-based testing methods that allow fixtures of the same type but with different light sources to be compared appropriately," he said.

One area of significant concern has been the comparison of fixtures based on luminous efficacy. Using the standard lumens-per-watt efficacy metric, one fixture may be considered more or less "efficient" than another fixture of the same type, based on the amount of light produced by the fixture for a given power usage. However, Narendran said, "What we really have to compare is the application efficacy; that is, how efficient is the fixture for the application and the task being lighted? With application efficacy, we get a better sense of luminous efficacy based on how much light the fixture is putting onto the task itself, rather than just what is coming out of the fixture." ASSIST's recommendations provide methods for testing fixtures in their intended application for the purpose of performance comparison.

Another area of concern is heat, especially with directional lighting fixtures, such as recessed downlights, said Narendran. Certain light sources, especially LED and compact fluorescent lamps, are

susceptible to shortened life, color shift, and inadequate performance when subjected to high heat. Certain installations can cause a considerable amount of heat to build inside and around the fixture, such as a recessed downlight surrounded by ceiling insulation. "If the heat isn't managed properly," said Narendran, "then the fixture's performance can be negatively affected." A particular fixture may be rated for several different types of installation, yet manufacturers may report performance for the product's operation under ideal conditions only. In its performance testing recommendations for directional lighting fixtures, ASSIST proposes that fixtures be tested at temperatures similar to the one or more environments for which they are rated. "Such testing will give users a better idea of how a fixture will perform in their own application," Narendran said.

ASSIST has also recommended new methods for evaluating outdoor and parking lot lighting, which are growing markets for white LEDs. ■

Jennifer Taylor, MSc, is a senior communications specialist for the Lighting Research Center at Rensselaer Polytechnic Institute, Troy, New York, since 2003. She works primarily in the field of solid-state lighting and LEDs, and has worked with the LRC's solid-state lighting team to produce ASSIST test methods, application guidelines, journal articles, research summaries, and other publications about LED lighting.

Jennifer Taylor