

LED Lighting: Now In The Present Tense

Energy-efficient design is becoming an important priority for today's building owners, and lighting is a major target for those seeking to reduce their properties' energy consumption.

Major energy codes contain provisions regarding maximum allowable lighting wattages. Prominent among these codes are California's state energy code and the "ASHRAE 90.1" standard (referenced in federal regulations). The 90.1 lighting requirements are the product of two organizations, ASHRAE (the American Society of Heating, Refrigerating and Air-Conditioning Engineers) and the IESNA (Illuminating Engineering Society of North America).

To stay within power-consumption limitations and yet respond with creativity that building owners and other lighting buyers have come to expect, lighting designers are taking a closer look at light-emitting diodes (LEDs).



Evolution—from watches to fixtures

This technology has been around for years; you've seen it at work—in readouts in calculators and digital watches, and as power indicators on electronic devices. However, LEDs are relatively new additions to the lighting world where, not many years ago, they were consigned to the future. No longer!

Also called solid state lighting (SSL), LED technology uses microchips to create illumination. Older lighting approaches use electricity to create heat, as in incandescent lamps, or excite a gas, as with fluorescent and metal halide approaches.

In contrast, these lighting units are manufactured using layers of semiconducting material to create a chip that illuminates when current passes through it. The chip is then mounted on a small circuit board; these assemblies then may be attached to a light fixture or architectural feature, or incorporated into a lamp that resembles a traditional bulb.

Technologically, LEDs are still "evolving." While many of today's products offer great energy-saving opportunities, they can be expensive. What's more, a lack of uniform standards can make product comparison shopping difficult.

As of mid-2008, some applications are especially good fits. Task and accent lighting, for example, can benefit from this technology's strength as a directional lighting source.

However, this situation is fluid, not static. In a short while, this electronically driven lighting resource could become common, as it moves into what some in the electrical industry reference as "general lighting."

Further, advances on the cutting edge—in organic LEDs (OLEDs), for example—could redefine lighting design as we now consider it.

Advantages:

More LPW, no mercury

To begin evaluating new lighting sources, building owners must first learn a new way to evaluate lighting sources. Even if you are familiar with incandescent light bulbs or standard fluorescent tube lamps, you will find yourself in a new world.

Typically, we've all relied, in our evaluations, upon the amount of electricity used. So if we saw a lamp with a "28W" designation, we knew that lamp consumed 28 watts.

LEDs require different comparisons, in which we must compare the *amount of lighting fixtures produce...as measured in "lumens."*

Matching light production to the amount of energy used allows us to compare various technologies on the basis of *lumens per watt (LPW)*. So the comparison boils down to: *How much electricity different lamps use to create the same amount of illumination.*

Here's the nub: High-output LED fixtures, *now on the market*, produce up to 60 LPW. That compares with 12 to 15 for incandescent bulbs and 50 LPW for CFLs.

Wait, there's more. Every four to six months, according to researchers (at the U.S. Department of Energy) a new generation of LED lamps comes to market. So 60 LPW may not be the limit!

Coloring Your World

Producing "white" light comes naturally to incandescent and fluorescent lamps—these sources emit electromagnetic radiation across a range of wavelengths within the visible spectrum, creating a light human eyes perceive as "white."

LEDs, however, operate within a very narrow range, generally in areas our eyes see as red, green or blue. Developers are pursuing two different approaches to producing the kind of white light we need for our homes and workplaces.

Phosphor conversion is the more mature of these two technologies. It coats a blue or near-ultraviolet chip with a yellow phosphor so that the resulting illumination appears white.

On the other hand, there's the RGB approach (RGB = red, blue, green). It mixes the output of red, green and blue chips—combined within a single fixture—to achieve the same goal.

Each design comes with advantages and drawbacks. Phosphor conversion enables high-volume manufacturing at relatively lower cost, but the resulting light may appear too cold for some users. RGB fixtures offer more color flexibility by varying the output of the three different chips. But each chip also may respond differently to current, dimming, and temperature conditions and added required controls add to the cost.



From a distance, the colors in this LED sign at Nationals Stadium, Washington, DC, appear solid. Actually, the sign is made up of clusters of red, blue and green lights. The black areas have all the lights turned off, the variations in the grass have various combinations of the colors lit, and the white letters are formed by lighting all three.

Additionally, these new lamps can last up to 50,000 hours—approximately *five times* the useful life of a CFL. Another LED advantage: They are manufactured without mercury, which—comparatively—can make disposal of fluorescent products a chore.

Still on the learning curve

Where incandescent lamps were invented by Thomas Alva Edison, LED lighting remains a new technology. When it comes to optimizing this technology's potential, manufacturers are still on a learning curve.

For example, LED lamps are very sensitive to heat. This is important. Note that these light sources do not throw heat into the environment (as do incandescents). However, with heat as an internal issue, the new light sources require “heat sinks” to handle the heat created on the non-illuminating side.

Manufacturers are trying to deal with heat; it complicates design, for example, for recessed can fixtures that need to fit into tight, above-ceiling spaces.

Another issue: At this stage of LED evolution, color appearance and color-rendering capabilities can vary greatly between the various manufacturer offerings. That makes it imperative for one to test LEDs in a potential application (try out a few LEDs in fixtures in the space in which they will be used) before finalizing a purchase and installation.

New design options

LEDs offer advantages that entice lighting designers.

- **No wasted lighting:** These lamps disperse light in a hemispheric pattern, instead of in a 360-degree circle. As a result, *all light can be directed where it is needed*—meaning that none of it is wasted within the fixture (as can be the case with fluorescent and incandescent lamps) This makes the units a good option in undercabinet and task-light settings.
- **No infrared or UV light:** LEDs don't emit the infrared or ultraviolet light that can damage fabrics and artwork, making them ideal as spotlights in museums and galleries.
- **They love the cold:** LED performance actually *improves* in colder temperatures, they're also seeing new opportunities in refrigerated cases and cold-storage facilities. One place where these new lamps are finding rapid acceptance is in lighting in supermarket and convenience-store refrigerators.
- **Outdoor edge:** That preference for the cold is also a plus in outdoor settings. With their low power requirement, LEDs used out-of-doors provide another advantage—they drain less energy from solar-charged batteries than traditional light sources. LEDs could enable building owners to update their exterior lighting with minimal wiring expense.
- **No dimming issues:** Dimming presents none of the problems with LEDs that it can with various fluorescent technologies. This means these advanced products could be a great complement to daylight-harvesting plans that use photosensitive lighting controls to maximize the use of natural sunlight while still maintaining uniform light levels.
- **Retail use:** LED lighting is programmable, which means light level and color control are (potentially) infinitely variable. By combining red, green, and blue LEDs in a single fixture, manufacturers are giving retail and entertainment designers new options for creating dramatic and flexible lighting displays.



LED color varies from cool white to warm white.

Photo courtesy Cree, Inc., www.cree.com

A bright future

One sign of LEDs' growing commercial acceptance is the recent announcement by the Department of Energy that a number of these fixtures have earned its certification as Energy Star-qualified products. These include offerings in the following categories:

- Undercabinet kitchen and shelf-mounted lighting
- Portable desk task lights
- Recessed downlights
- Outside wall-mounted, step and pathway lights

As exciting as current LED opportunities appear, researchers already are looking ahead to the technology's next great leap forward. OLEDs have the potential to revolutionize how we think about lighting, altogether.

OLEDs are composed of a film of organic compounds that are printed onto a thin, potentially flexible substrate. The materials already are being used as displays in cell phones and other small electronics; televisions are now being marketed with OLED screens. Designers and manufacturers envision OLED-embedded wallpapers and ceiling tiles that could give new definition to the phrase "ambient lighting," and allow our rooms to literally *glow*.

Our world's need to cut energy consumption is driving lighting into this new, sci-fi-like future. This is not intended to be a pun: *Within the next decade or so we all could be looking at building illumination in a whole new light.*

Research To Hasten Adoption

The U.S. Department of Energy (DOE) is leading two separate programs to highlight successful LED applications and help address the standards issues that can make specifying LED systems problematic today.

Program managers hope these measures will hasten adoption of the new technology and energy savings it offers.

■ The Gateway Demonstration effort showcases commercial or near-commercial products by documenting actual performance and cost data drawn from actual installations. In many cases, projects are installed side-by-side with other light sources, to enable realistic comparisons between alternate light sources.

■ The DOE's Commercially Available LED Product Evaluation and Reporting (CALiPER) program is a testing effort designed to evaluate current, commercially available LED products. Tests are carried out at independent testing labs, and the process is helping researchers develop standards for use across the product category.

For more, see www.netl.doe.gov/ssl/strategy.html



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