LED Basics

LED technology continues to develop rapidly as a general light source. As more LED products and light fixtures are introduced on the market, what do retailers, energy efficiency advocates, and consumers need to know to make informed buying decisions?

Are LEDs ready for general lighting?

The number of white light LED products available on the market continues to grow, including portable desk/task lights, under-cabinet lights, recessed downlights, retail display lights, and outdoor fixtures for street, parking lot, path, and other area lighting. Some of these products perform very well, but the quality and energy efficiency of LED products still varies widely, for several reasons:

1. LED technology continues to change and evolve very quickly. New generations of LED devices become available approximately every 4 to 6 months.

2. Lighting fixture manufacturers face a learning curve in applying LEDs. Because they are sensitive to thermal and electrical conditions, LEDs must be carefully integrated into lighting fixtures. Few lighting fixture manufacturers are equipped to do this well today.

3. Important differences in LED technology compared to other light sources have created a gap in the industry standards and test procedures that underpin all product comparisons and ratings. New standards, test procedures, and ENERGY STAR criteria are coming soon. In the meantime, product comparison is a fairly laborious, one-at-a-time task.

Are LEDs energy-efficient?

The best white LED products can meet or exceed the efficiency of compact fluorescent lamps (CFLs). However, many white LEDs currently available in consumer products are only marginally more efficient than incandescent lamps. The best warm white LEDs available today can produce about 45-50 lumens per watt (lm/W). In comparison, incandescent lamps typically produce 12-15 lm/W; CFLs produce at least 50 lm/W. Performance of white LEDs continues to improve rapidly.

However, LED device efficacy doesn't tell the whole story. Good LED system and luminaire design is imperative to energy-efficient LED lighting fixtures. For example, a new LED recessed downlight combines multicolored high efficiency LEDs, excellent thermal management, and sophisticated optical design to produce more than 700 lumens using only 12 watts, for a luminaire efficacy of 60 lm/W. Conversely, poorly-designed luminaires using even the best LEDs may be no more efficient than incandescent lighting.

Diamond Dragon LED. Photo Credit: Osram Opto Semiconductor.

Terms

SSL – solid-state lighting; umbrella term for semiconductors used to convert electricity into light.

LED – light-emitting diode.

CCT – correlated color temperature; a measure of the color appearance of a white light source. CCT is measured on the Kelvin absolute temperature scale. White lighting products are most commonly available from 2700K (warm white) to 5000K (cool white).

CRI – color rendering index; a measure of how a light source renders colors of objects, compared to a reference light source. CRI is given as a number from 0 to 100, with 100 being identical to the reference source.

RGB – red, green, blue. One way to create white light with LEDs is to mix the three primary colors of light.

PC – phosphor conversion. White light can be produced by a blue, violet, or near-UV LED coated with yellow or multi-chromatic phosphors. The combined light emission appears white.

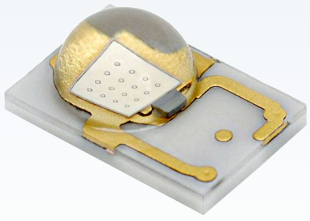

Photo credit: Philips Lumileds

How long do LEDs last?

Unlike other light sources, LEDs usually don't "burn out;" instead, they get progressively dimmer over time. LED useful life is based on the number of operating hours until the LED is emitting 70% of its initial light output. Good quality white LEDs in well-designed fixtures are expected to have a useful life of 30,000 to 50,000 hours. A typical incandescent lamp lasts about 1,000 hours; a comparable CFL lasts 8,000 to 10,000 hours, and the best linear fluorescent lamps can last more than 30,000 hours. LED light output and useful life are strongly affected by temperature. LEDs must be "heat sinked": placed in direct contact with materials that can conduct heat away from the LED.

LED downlight showing heat sink. Photo credit: LLF.

Do LEDs provide high quality lighting?

Color appearance and color rendering are important aspects of lighting quality. Until recently, almost all white LEDs had very high correlated color temperatures (CCTs), often above 5000 Kelvin. High CCT light sources appear "cool" or bluish-white. Neutral and warm white LEDs are now available. They are less efficient than cool white LEDs, but have improved significantly, to levels almost on par with CFLs. For most interior lighting applications, warm white (2700K to 3000K), and in some cases neutral white (3500K to 4000K) light is appropriate.

The color rendering index (CRI) measures the ability of light sources to render colors, compared to incandescent and daylight reference sources. In general, a minimum CRI of 80 is recommended for interior lighting. The CRI has been found to be inaccurate for RGB (red, green, blue) LED systems. A new metric is under development, but in the meantime, color rendering of LED products should be evaluated in person and in the intended application if possible. The leading high-efficiency LED manufacturers now claim CRI of 80 for phosphor-converted, warm-white devices.

Are LEDs cost-effective?

Costs of LED lighting products vary widely. Good quality LED products currently carry a significant cost premium compared to standard lighting technologies. However, costs are declining rapidly. In 2001, the cost of white light LED devices was more than $200 per thousand lumens (kilo-lumens). In 2007, average prices have dropped to around $30/klm. It is important to compare total lamp replacement, electricity, and maintenance costs over the expected life of the LED product.

What other LED features might be important?

Depending on the application, other unique LED characteristics should be considered:

- Directional light
- Low profile/compact size
- Breakage and vibration resistance
- Improved performance in cold temperatures
- Life unaffected by rapid cycling
- Instant on/no warm up time
- Dimming and color controls
- No IR or UV emissions

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