LED Frequently Asked Questions

LED technology continues to develop rapidly as a general light source. As more LED lighting products 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 a wide range of replacement lamps, as well as integrated light fixtures, such as portable desk/task lights, under-cabinet lights, recessed downlights, track heads, and outdoor fixtures for street and 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 evolve very quickly. Performance and pricing of LED packages/devices are dynamic but both are steadily improving.
2. Lighting manufacturers face a learning curve in applying LEDs. Because they are sensitive to thermal and electrical conditions, LEDs must be carefully integrated into lighting products. Manufacturers vary in their ability to do this effectively.
3. Price pressures can affect the quality of components used in LED products, particularly replacement lamps targeted to the general consumer.

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 "perfect" reference light source. CRI is given as a number from 0 to 100, with 100 being equivalent to the reference source.

Lumen Maintenance – the percentage of initial light output produced by a light source at some percentage of rated useful life (usually 100% for LED and 40% for source types characterized by sudden failure).

LED light sources used in a residential application.

Courtesy of Osram Opto Semiconductor.

Are LEDs energy-efficient?

The best white LED products meet or exceed the efficiency of fluorescent and high-intensity discharge (HID) light sources. However, many LED products currently available in consumer market channels are only marginally more efficient than incandescent lamps, and many suffer from very low light output relative to incandescent lamps and CFLs.

For several categories of luminaires (complete lighting fixtures), LED products are now widely available and meet or exceed the performance of conventional light sources. For example, nearly 500 LED recessed downlights are now listed by DOE's Lighting Facts program (*www.lightingfacts.com*), which requires verification of each product's light output, efficacy, and color characteristics. More than half of those downlights exceed the initial output and efficacy requirements of the ENERGY STAR® program, indicating they may perform at least as well as fluorescent downlights.

An LED package used in lighting products

Courtesy of Philips Lumileds

How long do LEDs last?

Unlike other light sources, LEDs usually don't suddenly "burn out;" instead, they gradually fade in brightness over time. LED useful life is generally 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 rated useful life on the order 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 some linear fluorescent lamp-ballast system can last more than 40,000 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) and driven at an appropriate input current.

Courtesy of CREE.

LED downlight showing heat sink.

Do LEDs provide high quality lighting?

Color appearance and color rendering are important aspects of lighting quality. Until recently, most white LEDs had very high CCTs, often above 5000 Kelvin. High CCT light sources appear "cool" or bluish-white. While very high CCT LEDs are still common, products with neutral and warm-white LEDs are now readily available. They are less efficient than cool white LEDs, but have improved significantly, and the efficacy gap between cool and warm LEDs is narrowing. Whereas warm-white (2700 to 3000K) is appropriate for most indoor residential applications, neutral-white (3500 to 4000K) is more common in commercial settings.

The CRI measures the ability of light sources to render colors, compared to incandescent and daylight reference sources. The CRI has been found to be an unreliable predictor of color preference of LED lighting products. A new metric called the Color Quality Scale (CQS) is under development, but in the meantime, color rendering of LED products should be evaluated in person and in the intended application if possible.

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. Recent industry roadmapping indicates prices for warm white LED packages have declined by half, from $36 to $18 per thousand lumens (kilolumens, klm) from 2009 to 2010. Prices are expected to continue to decline significantly to approximately $2/klm by 2015. 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 may merit consideration:

- 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
- No IR or UV emissions

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

More Information

For SSL Program information visit *www.ssl.energy.gov*.
Direct fact sheet feedback to *SSL.Fact.Sheets@pnnl.gov*.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
www.eere.energy.gov/informationcenter

PNNL-SA-58429 • May 2011
Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.