Energy-Efficient Lighting and Light-Emitting Diodes

Light-emitting diode (LED) technology is developing rapidly as a general light source. This fact sheet discusses some of the key challenges facing the technology and the important questions to ask when evaluating new LED products.

What is solid-state lighting?

Solid-state lighting (SSL) uses semi-conducting materials to convert electricity into light. It is the first truly new lighting technology to emerge for many years. SSL is an umbrella term encompassing different types of technologies including light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs). While both technologies are evolving rapidly, LEDs are the more mature technology, particularly for white-light general illumination applications.

Are LEDs available for general lighting?

A variety of white LED products are available on the market including desk and under-cabinet lights, flashlights, head lamps, outdoor pathway lights, and decorative string lights. For most illumination applications, however, white LEDs cannot yet compete with traditional light sources on the basis of performance or cost. Colored LEDs are often cost-effective and offer energy efficiency and durability for traffic signals, exit signs, commercial signage, and other indicator applications.

Are white LEDs energy-efficient?

The best white LEDs are similar in efficiency to CFLs, but most of the white LEDs currently available in consumer products are only marginally more efficient than incandescent lamps. Lumens per watt (lpw) is the measure of how efficiently the light source is converting electricity into usable light. The best white LEDs available today can produce about 45-50 lpw. For comparison, incandescent lamps typically produce 12-15 lpw; CFLs produce at least 50 lpw. Many LED products use only a small amount of energy, and therefore may appear energy efficient, but they often have very low light output. True energy efficiency means using the most efficient light source or system that is capable of providing the amount and quality of light needed. On-going research and development efforts are making steady progress in improving the performance of white LEDs to levels suitable for general lighting applications.

What is DOE doing to help develop this technology?

The U.S. Department of Energy has formed a partnership with the Next Generation Lighting Industry Alliance to support research and development leading to enhanced performance and energy efficiency of LED lighting. The Alliance is made up of major manufacturers including 3M, Acuity Brands Lighting, Air Products, CAO Group, Color Kinetics, Corning Inc., Cree Inc., Dow Corning, GELcore LLC, General Electric Company, Eastman Kodak Company, LPI LLC, Lumileds Lighting LLC, Osram Opto Semiconductors Inc., Osram Sylvania, and Philips Electronics North America. Working with these partners, DOE is planning a full range of activities including:

- ENERGY STAR® criteria for SSL technologies and products
- Design competitions for lighting fixtures and systems using SSL
- Coordination with utility promotions and regional energy efficiency programs
- Technology procurement programs that encourage manufacturers to bring high-quality, energy-efficient SSL products to the market, and that link these products to volume buyers
- Consumer and business awareness programs


Cree, Inc.

What are light-emitting diodes (LEDs)?

An LED is a very small (dot-sized) electrical device that produces light through the semi-conducting properties of its metal alloys. LEDs have been around since the 1960s, but were used mainly as simple indicator lamps in electronics and equipment. White LEDs are now approaching performance levels that make them attractive for use in automobiles, aircraft, elevators, and some task light applications.

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.

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What should I look for?

You must be an educated consumer to receive the most benefit from LED lighting. The following questions will help you determine if an LED product is right for your application.

How much light is produced?

To approach the total light output of a typical incandescent or CFL, a number of LEDs must be grouped together. Even the "high-brightness" white LEDs typically come in just 1-watt to 3-watt sizes. However, for some applications, LEDs can provide enough light on the task, even though the total light output is lower than comparable incandescent or fluorescent sources. This is because the light emitted from an LED is directional in nature, and in some applications, less light is lost in the fixture than with traditional light sources. Still, it is helpful to know how much total light the LED product provides and compare it to competing products using traditional light sources.

How long do LED lights last?

Unlike other light sources, LEDs don't "burn out;" they simply get dimmer over time. Although there is not yet an official industry standard defining "life" of an LED, the leading manufacturers define it as the point at which light output has decreased to 70% of initial light output. Using that definition, the best white LEDs have been found to have a useful life of around 35,000 hours (that's four years of continuous operation). For comparison, a 75-watt incandescent light bulb lasts about 1,000 hours; a comparable CFL lasts 8,000 to 10,000 hours.

LED lifetime depends greatly on operating temperature. An increase in operating temperature of 10 °C can cut the useful life of an LED in half. When evaluating LED product life claims, ask about the assumed operating temperature and any measures to mitigate heat in the device.

What do LED lights cost?

White-light LEDs currently cost significantly more than traditional light sources. The combination of high price and low light output may make them a poor replacement for current technology in most general illumination applications. However, for applications with long running hours, difficult access, or other specific requirements, LEDs may make sense. Today's white LEDs cost more than $50 per thousand lumens; a typical 75-watt incandescent light bulb, providing 1,000 lumens costs about $1.00; a comparable CFL costs less than $5.00.

Does LED lighting have the features I need?

In some applications, the extra durability that LEDs can provide is worth a higher purchase price. Outdoor pathway and step lighting is an example of a sensible application for today's white LEDs. They provide a small amount of light right where it's needed, avoid frequent bulb changes in fixtures that are difficult to access, and can be powered by solar cells, eliminating the need for running wire outdoors. LEDs are also good for applications where vibration often leads to early failure of conventional light sources. Being a solid-state device, LEDs are highly resistant to damage caused by vibration.

How can I compare LED lighting to other sources?

Because of the current lack of standardized reporting practices among LED product manufacturers, consumers have no reliable way to compare product performance based on information provided by the manufacturer. The best way to assess a product you are considering is to ask for a sample from the vendor.

Lumileds Lighting

For Program Information on the Web:

http://www.buildings.gov
http://www.netl.doe.gov/ssl

For Information on the Next Generation Lighting Industry Alliance:

www.nglia.org

For Program Information:

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PNNL-SA-45784
May 2006

Printed on 30% post-consumer recycled paper.