Hurdles and Highlights of LED Streetlights

By Mark McClear, Business Development Director, Cree

While LED technology has been readily adopted by applications such as color-changing architectural lights, outdoor signs and traffic signals, some of the most significant white-light market opportunities for LEDs, including streetlights, have remained a challenge that has not yet been met on a wide scale. Until now, concerns about excessive cost and substandard brightness have made the case for remaining with traditional lighting technologies in most mainstream white applications rather than migrating to LED solutions. With recent advancements in LED technology, these concerns are being addressed.

What Not to Do

The first thing lighting designers typically attempt to do with LEDs is force them into an Edison socket or utilize them in an existing fixture. We have seen even the most sophisticated companies and smartest designers make this same mistake and the results can be disappointing. At that point, some will shy away from the technology and give up, even many of those who were convinced of LEDs' superiority at the start.

LEDs can't be force-fit into the form factor of the previous generation of lighting. It's like trying to drive a car down a railroad track: cars are an advanced technology but they're just not made to ride on rails. Lighting designers must strive to create all-new designs that take into account LEDs' unique functionality in order to take full advantage of this technology.

Another key design consideration is the inherent directionality of LED light. LEDs, unlike conventional lighting technologies, emit light only in one direction. This affords the potential for unprecedented control and nearly total elimination of wasted light, but also demands that lighting designers comprehend this feature up-front, and not rely on the 360° nature of conventional bulb technology.

The Illumination Engineering Society prescribes five lighting pattern standards for roadways in North America (see figure 1). Concrete, asphalt and aggregate roadways will exhibit different degrees of reflectivity depending on the composition of the roadway, and depending on traffic flow and the nature of surrounding structures, different types of roads will require different degrees of lighting brightness, direction and concentration.

One consideration in defining these road lighting standards is how much light escapes upward into the sky. Is it being wasted on an area that does not need to be lit? Is it shining into a neighbor's window rather than illuminating a traffic lane? This is often the case with conventional lighting, and again, addressing this issue is very achievable with LEDs due to the inherent directionality of the technology.

Of the five roadway lighting patterns, the type II lighting pattern is the most challenging for LED technology to cover. The type II pattern is a very long, tightly controlled ellipse. Cree decided to apply its XLamp LEDs to the type II pattern first, realizing if the most difficult challenge could be solved, the other less complicated patterns could be implemented as well.

Following the most common train of thought, Cree placed LEDs in a conventional cobra-head lighting fixture. While this design has served the industry well for decades with conventional bulb technology, with the LEDs, the cobra-head fixture resulted in thermal problems because it was not designed as a heat sink. It also did not cover the type II lighting pattern-the LEDs did not affect the oblong pattern specified but created a much smaller, rounder splotch on the road directly under the light.

Next, Cree attempted to meet the type II pattern with a "surfboard" design. While the surfboard design does solve the thermal problems encountered with the cobra-head fixture, it still shoots light straight down, missing just about all of the area of the type II IESNA pattern.

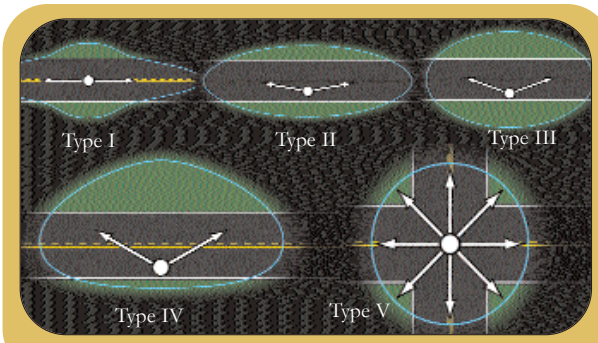
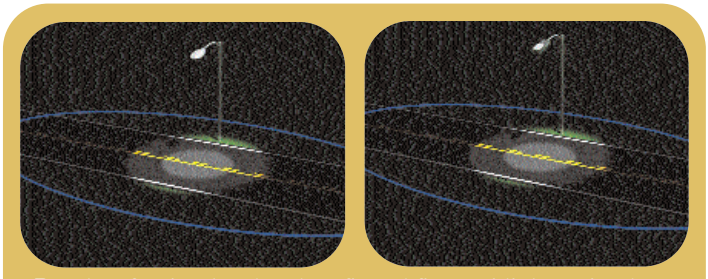


Figure 1.

How to Do It

In a third attempt, Cree moved away from conventional lighting fixture designs and created something with LED technology specifically in mind. Just 13-inches across, the design incorporates rows of packaged LEDs angled so each row emits light in a different direction, covering the entire surface of the type II pattern ellipse. The bare LEDs at the center hit the near field; the oval optic hits the mid-range and the collimating optic hits the far end of the ellipse. This fixture design meets IESNA type II roadway specifications and matches the output of a conventional 150 W lighting fixture.

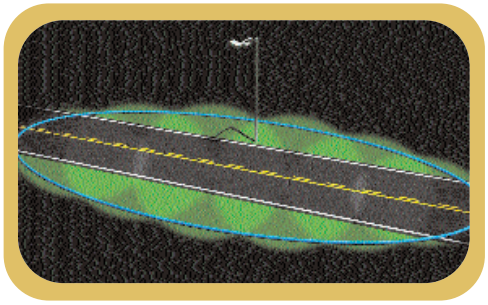


Results of cobra-head and surfboard fixtures' light emitted against type II pattern shadow

Cree's prototype fixture solution is just one way of adapting LEDs to streetlight requirements, but with some creative thought, many more are sure to be found. Only when conventional lighting designs are put aside and the inherent directionality of LEDs is capitalized on can lighting designers efficiently and effectively make use of LED technology in streetlight applications.

Reprinted from the January/February 2007 issue of LED Journal. ©2007 Webcom Communications Corp.
7355 E. Orchard Rd., Ste. 100, Greenwood Village, CO 80111 USA Phone 720-528-3770. Fax 720-528-3771. www.infowebcom.com

The Business Case of LED Streetlights



From the customer's point of view, the initial outlay for a conventional cobra-head lighting fixture is about $150, while an angled LED fixture like the one created for Cree's prototype experiment would cost about $300. The costs for servicing each fixture would be about the same. The value for the customer would be in savings over the life of the lighting fixture, because an LED fixture typically requires much less maintenance than a conventional streetlight.

For example, a typical XLamp LED from Cree has lumen maintenance of greater than 70 percent on average after 50,000 hours.

Every known lighting technology fades as a function of time and then fails catastrophically. LEDs, if the design is implemented properly, fail "gracefully," fading without burnout or catastrophic failure over the life of the fixture. By the time the customer needs to perform the first maintenance call on the LEDs (which should be after about 10 years of 12 hour per day operation), the fixture will have paid for itself, as conventional metal halide bulbs will have had to be replaced about every 2.5 years. Over a 10-year period, the cities or power companies that own these fixtures could save approximately $400 per pole. For New York City, which has about 300,000 streetlamps, that could mean a savings of $120 million over a decade.

Recent advances in LED technology have made LED streetlamps more viable than ever. When typical LED output was 40 to 50 lumens per watt at 350 mA, a fixture would require so many LEDs, around 150, to meet the roadway lighting illumination standards, it would be oversized (and therefore potentially unstable and unsafe) not to mention cost-prohibitive. But now that LEDs provide outputs of 80 to 100 lumens at 350 mA, the same streetlamp fixture would only require about 75 LEDs to satisfy the roadway pattern specifications, resulting in a more compact, stable fixture design that is also much more cost-efficient than traditional lighting technologies.

So considering all of the unique features of LED technology and following good optical, thermal and electrical design procedures, Cree has built a prototype streetlight that meets the IESNA type II roadway standards. This system is bright enough and efficient enough to replace an incumbent 150 W metal halide fixture, and also is targeted to deliver tangible economic benefits both to the end customer as well as the fixture manufacturer. Due to the inherent directionality of LED light, all lumens are useful lumens, and with the latest generation of LED technology, which is 40 percent brighter and 50 percent more efficient than previous Cree power LEDs, it is now quite realistic that LEDs can provide the same level of brightness and even better efficiency than traditional streetlamps.

Mark McClear is responsible for marketing and business development in Cree's solid-state lighting business. Prior to joining Cree in August 2005, he worked for the Dow Chemical Company as General Manager for their Semiconductor Materials SBU.

Mark can be reached via email at Mark_McClear@cree.com.

Reprinted from the January/February 2007 issue of LED Journal. ©2007 Webcom Communications Corp.
7355 E. Orchard Rd., Ste. 100, Greenwood Village, CO 80111 USA Phone 720-528-3770. Fax 720-528-3771. www.infowebcom.com