Field Test DELTA Snapshots

LED STREET LIGHTING

Demonstration and Evaluation of Lighting Technologies and Applications ▲ Lighting Case Studies

Light-emitting diode (LED) technology has matured to the extent that it can be used for street and area lighting. Specifiers can now weigh the benefits of this technology relative to conventional high intensity discharge (HID) light sources. Some claimed benefits of LEDs include long life, improved uniformity, reduced maintenance, promotion of vision at low light levels, and energy savings. To investigate several of these claims, DELTA evaluated an installation of LED street lighting.

Lighting system

The Edge™ is an LED luminaire that uses a system of LED bars to allow a lighting specifier to select the desired light output, ranging from approximately 1000-19,000 lumens. In the present design, each bar houses 20 high-output white LEDs. Correlated color temperature is rated at 6000 K, and color rendering index (CRI) is rated at >70. The system is engineered to provide the heat sinking and current (350 mA) necessary to ensure intended light output and life. The manufacturer reports 50,000-150,000 hours of operation with at least 70% of initial light output, depending on ambient temperature and specified drive current. This "L70" value provides an estimate of the useful life of the bar and depends on the LEDs, the luminaire's heat management, and other light loss factors.

Application profile

DELTA evaluated an installation of 16 Edge luminaires in a suburban business park in North Greenbush, N.Y. The curving, three-lane street was built to service a new office building. Poles are 30 ft. (9.1 m) tall, spaced 130–180 ft. (39.6-54.9 m) apart. The Edge luminaires in this installation used three light bars each, and each luminaire was rated by the manufacturer as 4680 initial lumens and 79 W. Distribution is rated as Type II, short, full cutoff.

Photometric results

DELTA measured horizontal illuminances on the ground after about one year of operation at the same location where visitors evaluated the LED installation. DELTA measured an average horizontal illuminance of 0.4 footcandle (fc)[1] and an average-to-mininum uniformity ratio of 6:1. Therefore, the installation meets the relevant industry recommendations after a year of operation,[2] but will eventually drop below the minimum as lumen degradation occurs.[3]

LED street lights along a suburban business park road

Because of greater human sensitivity to light with a "white" appearance than a "yellowish" appearance at these illuminances, it is possible to predict improved visual effectiveness using "unified luminance" calculations.[4] DELTA used the photometric information above to calculate unified luminance. DELTA estimates that the unified luminance of this system is approximately twice (1.9x) that of a high pressure sodium (HPS) system at an equivalent photopic illuminance. But at higher illuminances, the advantage of this LED light source would be reduced.

Maintenance feedback

Maintenance personnel at the business park reported no problems with the luminaires in the year since they were installed.

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1 One footcandle = 10.76 lux

2 Illuminating Engineering Society of North America (IESNA) RP-8-00 Roadway Lighting Recommended Practice recommends that a local, low pedestrian conflict roadway maintain an average of 0.4 fc, and an average-to-minimum uniformity ratio of less than 6:1.

3 A well-designed LED luminaire could have better lumen maintenance than conventional HID. However, lumen maintenance depends on junction temperature. Specifiers should request lumen maintenance data from LED luminaire manufacturers.

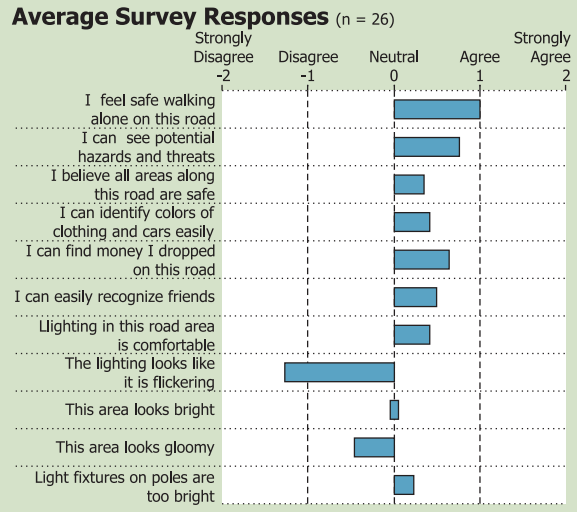
4 Rea, M.S., J.D. Bullough, J.P. Freyssinier-Nova, and A. Bierman. 2004. A proposed unified system of photometry. Lighting Research and Technology 36(2): 85-111.

Visitor survey

DELTA recruited 26 volunteers to visit the site after dark in September 2009.[5] As shown in the figures below, visitor ratings about the comfort and visibility of the installation ranged from neutral to positive. Most did not consider the installation to be too bright, and a few commented that some areas seemed dark. Questions about color identification brought mixed responses. The survey indicated that visitors did not perceive flicker when viewing the installation. Overall, most visitors considered the lighting to be the same as or better than other roadways at night.

DELTA asked many of the visitors to stand at a designated location near the edge of the property, look directly at a luminaire, and evaluate discomfort glare from a neighbor's perspective, not from a driver's perspective. Some visitors rated the luminaire as glaring, while others did not. The average of their ratings was 4.3 on a De Boer scale[6] of 1 to 9.

"Low light levels, adequate."
"Reminds me of a mercury lighting installation."
"Good color rendition."
—Visitor comments



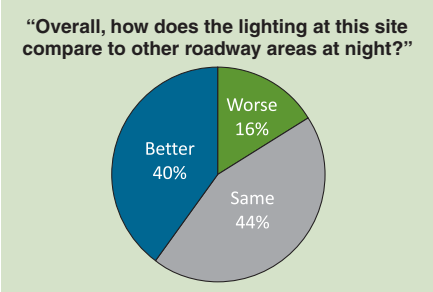
Reduced power demand

DELTA calculated the initial photopic illuminance, uniformity and power density at both the LED installation and the existing HPS installation on a neighboring street. At 79 W per luminaire, DELTA estimates that the LED installation uses 38% less power per area (0.016 W/ft^2) than the HPS system (0.026 W/ft^2).[7] However, the initial photopic illuminance of the LED installation is also lower than that of the HPS (average 0.4 fc vs. 1.2 fc). The LED installation does meet IESNA RP-8 illuminance recommendations early in its life, but after further lumen depreciation it would not. In comparison, the neighboring street with HPS lighting uses more watts than necessary (because the light level is higher than recommended) but does not meet recommended uniformity criteria.[8] Therefore, relative to the neighboring street, this LED installation uses less power while providing better uniformity.

Light pollution

DELTA compared performance of this installation with that of the neighboring HPS installation using the Outdoor Site-Lighting Performance (OSP)[9] light pollution calculation technique. Because the LED installation provides lower illuminances on the ground plane, less light leaves the boundaries of the installation. The average illuminance on a hypothetical "box" surrounding the site[10] was lower for the LED street (0.05 fc) than the HPS street (0.07 fc). However, when comparing the average illuminance leaving the box to that falling on the ground plane within the box, the LED installation had a higher percentage of light leaving the site (16%) than the HPS installation (6%). DELTA therefore concludes that the LED installation is successful in limiting potential sky glow primarily because of its lower illuminances rather than because of its control of light within the boundaries of the site.

OSP uses maximum illuminance to gauge potential light trespass; both solutions had similar maximum illuminances leaving the boundary of the box (1.3 fc maximum for the LED street vs. 1.6 fc for the neighboring HPS street).



[5] The visitors were knowledgeable about lighting.

[6] De Boer, J.B. 1967. Visual perception in road traffic and the field of vision of the motorist. In: De Boer, J.B., editor, Public lighting. Eindhoven: Philips Technical Library: 11-96. The De Boer scale runs from 1 ("unbearable"), 3 ("disturbing"), 5 ("just acceptable"), 7 ("satisfactory"), to 9 ("just noticeable"). An average rating of 4.3 is between "disturbing" and "just acceptable."

[7] Conventional luminaires leading up to the site use high pressure sodium (HPS) lamps, 250 W nominal, assumed 289 W system power. Luminaires are Type III, medium, semi-cutoff on 25 ft. (7.6 m) poles.

[8] DELTA used AGi32 software (version 2.04, by Lighting Analysts, Inc.) to calculate illuminances along several hundred feet of each roadway. The LED installation had an initial calculated average of 0.4 fc and a uniformity ratio of 4:1, thus meeting IESNA RP-8-00, while the HPS installation had an initial calculated average of 1.2 fc (12 lx), and did not meet the uniformity requirements because some points were 0 fc (0 lx).

[9] Brons, J.A., J.D. Bullough, and M.S. Rea. 2008. Outdoor site-lighting performance: A comprehensive and quantitative framework for assessing light pollution. Lighting Research and Technology 40(3): 201-224. For more details on OSP, visit www.lrc.rpi.edu/researchAreas/outdoor.asp.

[10] The OSP box was formed following the right-of-way, using the increment between two luminaires. At both sites, the shortest increment between luminaires was used, as this provided the most conservative results.

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Issue 4, March 2010
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Field Test DELTA evaluates new energy-efficient lighting products to independently verify field performance claims and to suggest improvements. A primary goal of the Field Test DELTA program is to facilitate rapid market acceptance of innovative energy-efficient technologies.

ISSN 1075-3966

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