LED Provides Effective and Efficient Parking Area Lighting at the NAVFAC Engineering Service Center

New lighting technology reduces energy consumption and reduces maintenance while providing effective illumination.

Photo courtesy of PNNL

New LED parking area lights at the NAVFAC Engineering Service Center at Port Hueneme provide high quality, evenly distributed light.

Photo courtesy of PNNL

New LED lights over the parking area.

Light-emitting diodes (LED, a type of solid-state lighting) is an emerging light source that offers potential energy savings, improved directionality, better color rendition, longer life, and instant-on capability. While still more expensive than high-intensity discharge (HID) lights, the cost of LED luminaires is coming down as capacities and efficiency are increasing.

High-pressure sodium (HPS) lights have been frequently used for outdoor lighting because of its long rated life and high efficiency relative to other options. However, high-pressure sodium technology is not without drawbacks, such as a low color rendition, a result of its narrow spectral distribution and low color temperature. While metal halide lamps provide whiter light and better color rendition compared to high-pressure sodium, metal halide is not as efficient, experiences longer strike and re-strike times, and frequently has a shorter lamp life. Today, LEDs can provide white light, excellent color rendition, instant on, high efficiency and long life, all in one package.

> "The new lighting is whiter and more evenly distributed than before. It is easier to see across the parking lot."
>
> — **Paul Kistler**, Program Manager, NAVFAC ESC

In this Fact Sheet:

Introduction

Investigating ways to reduce energy consumption and costs, the Navy's Technology Validation (Techval) Program with support from the Department of Energy, Federal Energy Management Program, sought to demonstrate the new LED technology for parking areas. The Naval Facilities Engineering Command Engineering Service Center (NAVFAC ESC) Headquarters was selected as their first LED demonstration.

Building 1100 at the Naval Base Ventura County located in Port Hueneme, California has a fairly typical parking

Image courtesy of Google Maps

The parking area around building 1100 is fairly typical. The parking area wraps part-way around the building. There are some scattered trees, shrubs and other vegetation planted in the mediums. The parking area is illuminated by lights atop 12, 33-1/2-foot square poles.

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Nighttime Illuminance

Standard illuminance meters are calibrated to the photopic luminous efficiency function, a curve determined by physical research and codified by the International Commission on Illumination (Commission Internationale de l'Eclairage or CIE). The human eye has two types of photoreceptor cells, known by their shape as "cones" and "rods." The photopic luminous efficiency function describes the sensitivity of the cones to all wavelengths in the visible spectrum. The rods have a different sensitivity curve, called the scotopic luminous efficiency function.

The photopic response curve dominates in moderate and daylight conditions, and results from the "cones" in human eyes. During very low light conditions, perception follows the scotopic response curve, which results from the "rods" in the human eye. At moderately-low light levels, however, such as those typical under nighttime lighting in an outdoor setting, both the photopic response curve and the scotopic response curve are important with respect to visual acuity. This is known as the 'mesopic' range.

Unfortunately, the relative importance of scotopic illuminance and photopic illuminance in the mesopic range is still uncertain. However, because of the potential importance of this range for nighttime outdoor lighting, both photopic and scotopic illuminace were recorded for this project. The light meter used in this project has two receptor sensors: one calibrated to the photopic curve and one calibrated to the scotopic curve.

Photo courtesy of PNNL

Close up view of new LED luminaires atop an existing light pole.

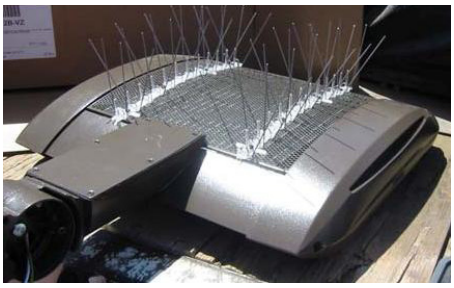

Photo courtesy of SEI Group, Inc.

Bird spikes serve a critical function. LEDs need to reject heat to remain efficient. Bird spikes deter the build up of bird droppings, which would block heat transfer.

area. The parking area was illuminated by 23, 400-Watt high-pressure sodium lamps in shoe-box-style fixtures mounted on 12, 33½-foot poles distributed through the parking area. The 10.9-kW lighting load is controlled by the building automation system, which turns the lights on at dusk and off at 10:00 PM. Illumination levels with the high-pressure sodium lamps, while averaging 43 lux (4 footcandles), ranged from a high of 280 lux (26 fc), directly under a luminaire, to a low of 1.2 lux (0.1 fc), in the far reaches of the parking area. The high variation in illumination is typical for outdoor lighting systems.

New Lighting Technology

To reduce energy consumption and gain experience with an emerging technology, the Navy Techval Program replaced the old HPS shoe-box fixtures with new LED luminaires.

The new lighting system was designed around the existing 12 light poles. The 23 old HPS fixtures were replaced with 19 BetaLED™ 6-bar luminaires, rated at 156-Watts each. The luminaires were angled 15° up to improve the light distribution.

Photo courtesy of SEI Group, Inc.

A work crew with a lift truck removed the old fixtures and installed the new LED luminaires during normal work hours with vehicles in the lot.

A team from the Pacific Northwest National Laboratory measured photopic and scotopic light levels, as well as color temperature, at over 100 points in the parking area (see side bar on nighttime illuminance). For a fair comparison, the fixtures were cleaned and new high-pressure sodium lamps were installed and allowed to burn in prior to measurement. Power and power quality measurements were also documented.

After the new LED luminaires were installed, the process was repeated. Table 1 shows the comparison of photopic illuminance measurements taken with the HPS luminaires (before) and the LED (after). Table 2 shows the comparison of scotopic illuminance measurements.

Light Type	Average Light Level (lux)	Minimum Light Level (lux)	Uniformity* of Illumination (Avg to Min)
HPS	43.6	1.2	36.3:1
LED	8.8	1.0	8.8:1

* Uniformity indicates the variation of the lighting level (hot spots to dark spots) in the lighted space.

Table 1: Comparison of Photopic Illumination Measurements

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Light Type	Average Light Level (lux)	Minimum Light Level (lux)	Uniformity* of Illumination (Avg to Min)
HPS	27.6	1	27.6:1
LED	17.5	4	4.4:1

Table 2: Comparison of Scotopic Illumination Measurements

While the overall average photopic light level was reduced with the LED luminaires, this is because the bright spots were reduced. The overall light levels in the dimly lit areas of the parking lot (where previous photopic illuminance was below 5 lux) were increased by 18%. Although, the minimum photopic light level did decrease (1.0 lux with the LED, down from 1.2 lux with the HPS), using the scotopic measurements, there was a notable improvement with the LEDs (4 lux with the LED, up from 1 lux with the HPS, an increase of 300%).

The LED luminaires reduced the "hot spots," which had been directly under the high-pressure sodium lights. The LEDs provided more uniform illumination across the parking area.

Table 3 summarizes the energy performance and economic analysis of the two lighting systems. In this demonstration, the operating hours are very low compared to more typical applications, which did contribute to the lengthy payback. In addition, the new LED technology is still expensive compared to high-pressure sodium and metal halide lights.

Overall, the LED system offers some advantages over the previous lighting system.

- Lighting power was reduced to 2.81 kW from 10.88 kW, a reduction of 74%.
- Illumination distribution is more uniform.
- Higher (whiter) correlated color temperature (CCT); 6400K for the LED compared to 2000K for the HPS.
- Instant on with no strike or re-strike delay.
- Longer lamp life; an expected 50,000 hours for the LEDs and driver versus 24,000 hours average for the HPS lamps.

	HPS	LED
Total measured power, kW	10.9	2.8
Operation, hours per year*	1,046	1,046
Annual energy consumed, kWh/yr	11,968	3,091
Annual energy reduction, kWh/yr		8,437
Annual energy cost reduction†, $/yr		$1,012
CO_2 reduced per year, tons/yr		7.0
Installed cost‡		$49,808
Simple payback, yr		49

* Operating hours based on civil twilight to 10:00 PM.
† Electricity rate - $0.12/kWh. Reference: NBVC FY07 Energy Management Report.
‡ Installed cost = $13,043 (design) + $32,015 (LED luminaires) + $4,750 (installation labor and equipment)

Table 3: Energy Performance Comparison

Conclusions

LED lighting for outdoor parking areas shows significant potential. The technology has the potential to reduce energy consumption, while improving visual quality, and reducing maintenance requirements. In this demonstration, power was reduced by over 8-kW, a notable 74% reduction. The simple payback was long as a result of the extremely short hours of operation and the cost of the emerging technology. The LED luminaires are still expensive compared to conventional HID luminaires. However, costs are expected to come down as demand increases and the technology gains market share.

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For More Information

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Produced for the U.S. Department of Energy, Energy Efficiency and Renewable Energy, by the Pacific Northwest National Laboratory

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PNNL-SA-67734 • August 2010

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