Bi-level Street and Parking Area Luminaires

California Polytechnic State University
San Luis Obispo, CA

The Problem

An estimated 60 million street and area lights currently are in operation in the U.S.[1] This number is anticipated to grow at an annual rate of 1–1.2% over the next two decades.[2] Exterior lighting, including parking, area, and security lighting, represents 3,067 GWh and 1.4% of California's energy usage.[3]

Concerns regarding energy efficiency and light pollution are growing as well. Many states have passed legislation regulating the types, amounts, and placement of outdoor stationary lighting to reduce sky glow and light pollution. In addition, some states have passed energy-efficiency standards such as California's Title 20 and 24, which affect street and parking area lighting. Although the technology for bi-level control of this exterior lighting is not new, until just recently, products were not readily available from manufacturers.

With growth and environmental concerns apparently at odds, the California Energy Commission's Public Interest Energy Research (PIER) Program, in partnership with multiple lighting manufacturers, has developed innovative solutions that solve both energy and environmental problems. These exterior lighting technologies include the use of alternative light sources such as induction, ceramic metal halide, and light emitting diodes (LED) with bi-level electronic generators, ballasts, and drivers.

FIGURE 1: BI-LEVEL STREET AND PARKING AREA LUMINAIRES
BetaLED The Edge™ LED area luminaire (left) and Everlast® Bi-level Induction cobra head (right)

The Solution

PIER-sponsored research, development, and demonstration has focused on the combination of occupancy-based lighting controls and broad-spectrum light sources to create intelligent, bi-level luminaires designed for street and parking area applications. These products achieve 30–75% energy savings compared to traditional street and area luminaires, meet stringent energy-efficiency standards, and provide excellent light distribution for reduced night sky pollution.

Bi-level controls, which switch lighting between a high and low level rather than on and off, offer a safe and effective method for capturing untapped energy savings inherent to many exterior parking and street light applications. Luminaires, in these applications, are generally controlled by photocells or astronomical timeclocks, with no regard for actual traffic patterns or occupancy. While completely turning off lights often is unacceptable, switching between high and low light levels based on occupancy maintains sufficient light for security and wayfinding, and maximizes energy savings.

In addition to intelligent lighting controls, simple changes to the type of light source used in exterior street and parking area luminaires can have a significant energy-savings effect. About 60% of existing street and area luminaires use high pressure sodium (HPS) lamps. These sources could be replaced with lower-wattage, long-life, broad-spectrum alternatives. Proposed alternative sources offer significantly increased correlated color temperature (CCT) and color rendering index (CRI). Studies show that less broad-spectrum light is required to maintain perceived brightness and visual acuity under nighttime conditions, when compared to some traditional high intensity discharge (HID) sources. Most notably, low pressure sodium or high pressure sodium lamps may be replaced with

[1] Parking lots and garages not included

[2] Navigant Consulting, Inc., U.S. Lighting Market Characterization Volume I: National Lighting Inventory and Energy Consumption Estimate. Prepared for U.S. Department of Energy, September 2002.

[3] Sam Pierce (RLW Analytics). 2003. California Outdoor Lighting Baseline Assessment. California Energy Commission, PIER Program. P500-03-082-A-18.

TABLE 1: SMART BI-LEVEL EXTERIOR LIGHTING
Demonstration summary, Cal Poly, San Luis Obispo

APPLICATION	LIGHT SOURCE	SYSTEM SIZE (W)	BASELINE LUMINAIRE	BASELINE SYSTEM (W)	DEMAND REDUCTION	OCCUPANCY RATE: HIGH MODE	OCCUPANCY RATE: LOW MODE	TOTAL ENERGY SAVINGS
PARKING LOT	Induction	110	HPS	280	60%	32%	68%	74%
STREET LIGHTING	LED	118	HPS	128	7%	60%	40%	32%

broad-spectrum sources such as LED or induction, which may demand 25–50% less energy to maintain the same perceived light levels. LED and induction sources also may be quickly dimmed or switched between light levels, further facilitating the use of intelligent controls in exterior applications. The use of such sources, coupled with bi-level occupancy-based controls, could lead to 30–75% energy savings in street and parking area applications.

Two types of bi-level luminaires were successfully demonstrated at California Polytechnic State University in San Luis Obispo.

- *Everlast® bi-level induction cobra head:* This luminaire combines a long-life induction light source with a bi-level induction generator that switches light levels from 50–100% based on occupancy. A low-voltage passive infrared (PIR) occupancy sensor, mounted to the luminaire pole or integrated in the fixture, detects motion within a 270-degree radius at distances up to 50 feet from the pole.
- *BetaLED The Edge™ LED area luminaire with two-level option:* This luminaire uses high CRI, long-life white LEDs with a fixture-integrated PIR occupancy sensor controlled by a custom bi-level electronic driver. During occupied nighttime hours, the luminaire operates at full output, but reduces power by 66% during vacancy with only a 50% reduction in light output. The sensor has a 360-degree detection radius, and also acts as a photocell to maintain the low level only when sufficient ambient light is available.

Features and Benefits

- About 30–70% energy savings (highly application dependent)
- Broad-spectrum source increases visual acuity
- Occupancy sensors maximize energy savings
- LED and induction systems last two to three times longer than most traditional light sources, decreasing maintenance costs

Technology Costs and Incentives

Consumers should expect a higher initial investment when specifying bi-level luminaires for exterior lighting retrofit and new construction projects. The initial cost increase often is offset by energy and maintenance cost savings, as well as utility incentives designed to reduce the financial impact of these innovative technologies. For example, the Investor-Owned Utility (IOU) Partnership Program for University of California and California State University campuses provides an incentive of $.015 per kWh saved (annual total) up to 50% of the project cost.

Bi-level LED and induction street and area luminaires may range in cost from $400–1,500 depending on manufacturer, make, and model.

- Instant to six-year simple payback in new construction projects when compared to traditional HPS luminaires
- Five- to 15-year simple payback in retrofit projects compared to HPS luminaires
- The addition of network-enabled monitoring and diagnostics could lead to an additional 10–20% reduction in maintenance costs

Demonstration Results

California Polytechnic State University, San Luis Obispo

Bi-level induction cobra head and bi-level LED streetlights were installed at two locations on the Cal Poly campus. The bi-level induction cobra head luminaires (110 W system, high mode) replaced HPS cobra head luminaires (280 W system) in the H4 Facility Management parking lot. Bi-level LED luminaires (118 W system, high mode) replaced HPS shoebox-style street lights (128 W system) along Cerro Vista Circle, a one-way street leading through campus housing units. Both products were installed as one-for-one replacements for existing luminaires using existing poles and pole spacings. These retrofit demonstrations resulted in annual energy savings of 74% in the parking lot application and 32% for the streetlight application.

To quantify the actual energy saved from the use of occupancy controls, engineers installed small, light level loggers at each bi-level luminaire installed on the Cal Poly campus. These loggers recorded the relative light level provided by the luminaire, in five-minute increments. Measurements were taken for about six weeks. These measurements were binned into three groups: high mode, low mode, and off. The time spent in these modes was determined for each bi-level luminaire and then averaged across each technology to determine the average savings. A plot of a small data sample is given in Figure 2.

FIGURE 2: BI-LEVEL INDUCTION STREETLIGHT USAGE PROFILE
Cal Poly, San Luis Obispo
H4 Facility Management parking lot

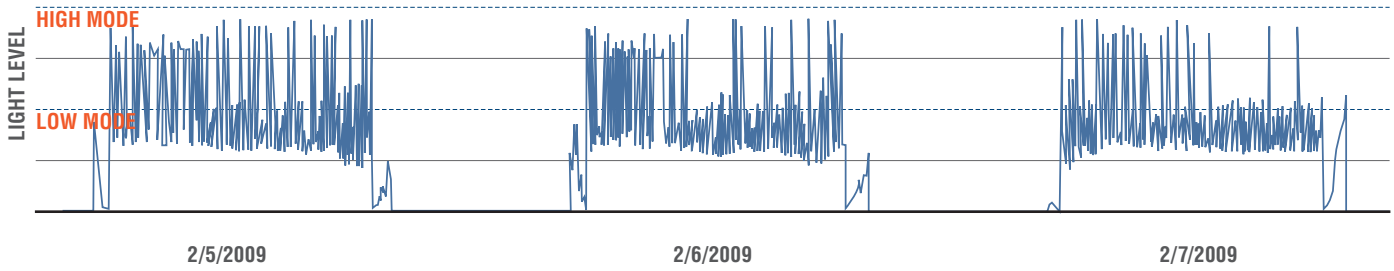


FIGURE 3: BI-LEVEL LED STREETLIGHT USAGE PROFILE
Cerro Vista Circle, Cal Poly, San Luis Obispo: 5 p.m. Monday, 02/02/09, through 8 a.m. Tuesday, 02/03/09

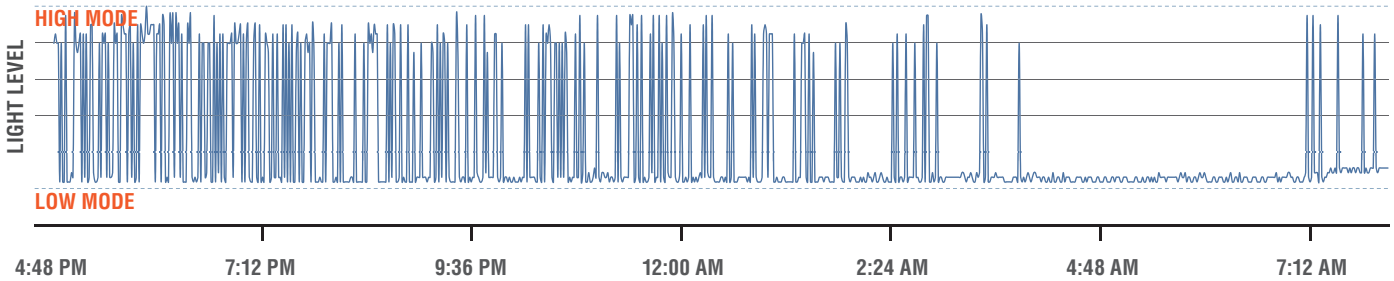


FIGURE 4: ANNUAL ENERGY AND CARBON EMISSION SAVINGS
Bi-level LED Area Luminaire in New Construction Projects
118 W System (High Mode)

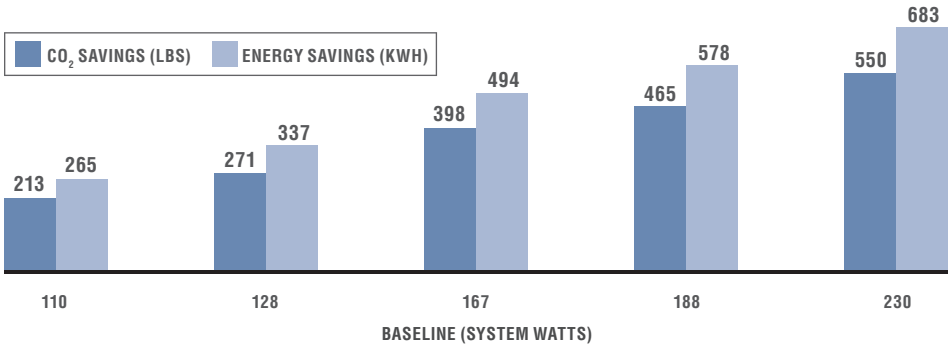
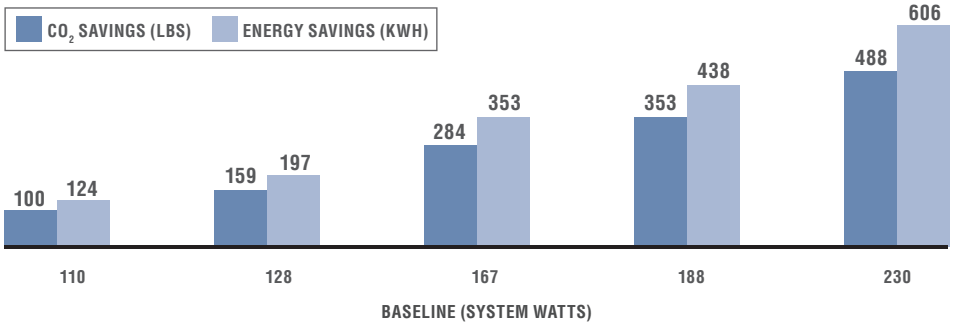


FIGURE 5: ANNUAL ENERGY AND CARBON EMISSION SAVINGS
Bi-level Induction Cobra Head Luminaire in Retrofit Projects
80 W System



The bi-level streetlight demonstration saw lower average savings than the parking lot application. Bi-level LED luminaires operated in high mode 60% of the time because higher pedestrian and vehicle traffic from nearby residence halls. Figure 3 shows maximum energy savings occurs between midnight and 7 a.m.

Product Availability

Several major manufacturers, including Lithonia Lighting, BetaLED, Day-Brite Lighting, Emco Lighting, Gardco Lighting, Wide-Lite, and Everlast Lighting have developed or are actively developing bi-level lighting technology for exterior applications. Several of these manufacturers participated in California Energy Commission demonstrations of bi-level systems, including pole mount, deck mount, wall pack, and bollard-style systems, using metal halide, induction, and LED illumination sources. Successful demonstration projects by early adopters such as Cal Poly are expected to lead to increased product offerings.

What's next

CLTC continues demonstrations of smart exterior luminaires as part of the State Partnership in Energy Efficiency Demonstrations (SPEED) Program. In addition to bi-level street and parking area luminaires, the program includes bi-level wall packs and bollards. New demonstration projects are slated for the University of California, San Francisco, and Los Angeles Trade Technical College.

Collaborators

This demonstration project is a collaboration between BetaLED; Everlast Lighting; Facilities Management at Cal Poly, San Luis Obispo; and Southern California Edison.

For More Information

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- To read more about bi-level street and parking area luminaires, visit cltc.ucdavis.edu/content/view/765/402
- More information on PIER demonstrations is available at www.pierpartnershipdemonstrations.com
- More information on the BetaLED The Edge LED area luminaire is available at www.betaled.com
- More information on the Everlast bi-level induction cobra head is available at www.everlastlight.com

TABLE 2: ENERGY AND MAINTENANCE COST AND SAVINGS
Demonstration summary, Cal Poly, San Luis Obispo

TECHNOLOGY	SYSTEM SIZE (WATTS)	ANNUAL ENERGY CONSUMPTION (kWh)	ANNUAL ENERGY COST	ANNUAL MAINTENANCE COST	TOTAL ANNUAL COST	LIFECYCLE ENERGY COST	LIFECYCLE MAINTENANCE COST	TOTAL LIFECYCLE COST
HPS	280	1,226.40	$156.98	$7.88	$164.86	$3,584.00	$180.00	$3,764.00
INDUCTION	110	337.26	$43.17	$0.00	$43.17	$985.60	$0.00	$985.60
SAVINGS		889.14	$113.81	$7.88	$121.69	$2,598.40	$180.00	$2,778.40
HPS	128	560.64	$71.76	$8.27	$80.03	$1,638.40	$189.00	$1,827.40
LED	118	314.48	$40.25	$6.57	$46.82	$919.04	$150.00	$1,069.04
SAVINGS		246.16	$37.51	$1.70	$33.21	$719.36	$39.00	$758.36

Years of use: ~23
Induction lamp cost: $0
Annual hours of use: 4380 hours
Time to replace lamp: 0.5 hours
Cost of labor: $100/hour
Occupancy: 40%
HPS lamp cost: ~$62
Cost of energy: $0.128/kwh
LED lamp cost: $150

About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Arnold Schwarzenegger, *Governor*

California Energy Commission

For more information, see www.energy.ca.gov/research

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