Bi-level Street and Parking Area Lighting
California Polytechnic State University
San Luis Obispo, CA

The Problem

It is estimated that there are approximately 60 million street and area lights currently in operation in the U.S.[1] This amount is anticipated to grow at an annual rate of 1–1.2% over the next two decades.[2] 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 in order 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. With growth and environmental concerns apparently at odds, 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 lighting emitting diodes (LED) used in combination with bi-level electronic generators, ballasts, and drivers.

The PIER Solution

PIER sponsored research, development, and demonstration (RD&D) 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 innovative products achieve 30–75% energy savings compared to traditional street and area luminaires, meet stringent energy-efficiency standards, and provide excellent lighting 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 lights off is often unacceptable, switching between high and low light levels based on space 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 impact. Approximately 60% of existing street and area luminaires utilize 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 broad-spectrum sources such as LED or induction, which demand 25–50% less energy to maintain the same perceived light levels. LED and induction sources may also 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.

[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.

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

- *Everlast® Bi-level Induction Cobrahead:* This luminaire combines a long-life induction light source with a bi-level induction generator that switches light levels from 50% to 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° radius at distances up to approximately 50 feet from the pole.
- *The Edge™ LED Area luminaire with two-level option:* This luminaire utilizes high CRI, long-life white LEDs in conjunction with a fixture-integrated PIR occupancy sensor controlled by a custom bi-level electronic driver. During occupied night time 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° detection radius, and also acts as a photocell to extinguish the luminaire during daytime hours.

Features and Benefits

- Approximately 30–75% energy savings (highly application dependent)
- Broad-spectrum source increases visual acuity
- Occupancy sensors maximize energy savings
- LED and induction systems last 2–3 times longer than the most traditional products decreasing maintenance costs

Market

- Exterior lighting for street and parking areas
- New construction and retrofit applications

Exterior lighting, including parking, area and security lighting, represents 3,067 GWh and 1.4% of California's energy usage.[3] Although the technology for bi-level control of this exterior lighting is not new, until just recently, products were not readily available from manufacturers. During the past two years, several major manufacturers, including Lithonia Lighting, BetaLED, Day-Brite Lighting, Emco Lighting, Gardco Lighting, Wide Lite, and Everlast Lighting have developed, or are in active development, of 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, San Luis Obispo are expected to catalyze market acceptance and lead to increased product offerings.

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

Demonstration Results: California Polytechnic State University San Luis Obispo

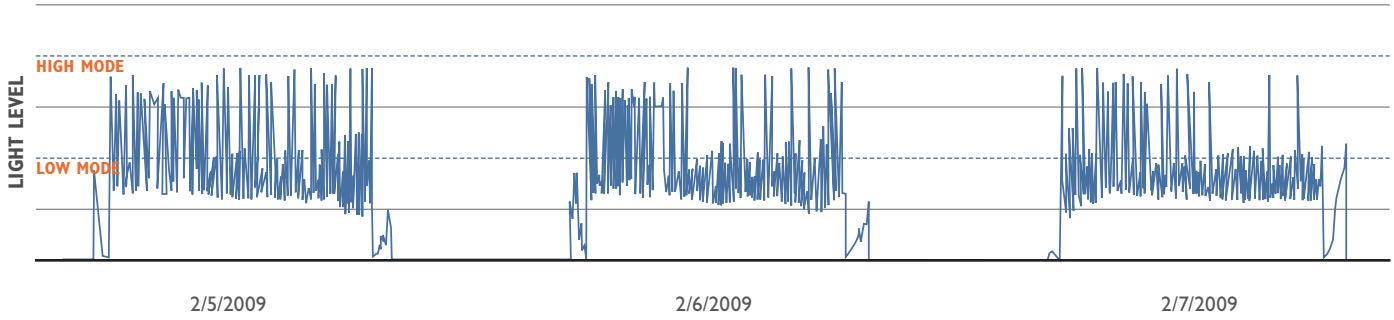
Bi-level induction cobrahead and bi-level LED streetlights were installed at two locations on the Cal Poly campus. The bi-level induction cobrahead luminaires (110 W system, high mode) replaced HPS cobrahead luminaires (280 W system) in the H4 Facility Management parking lot. Bi-level LED luminaires (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 utilizing 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.

BI-LEVEL INDUCTION COBRAHEAD LUMINAIRE
Cerro Vista Circle, Cal Poly San Luis Obispo

[1] Occupancy + Demand

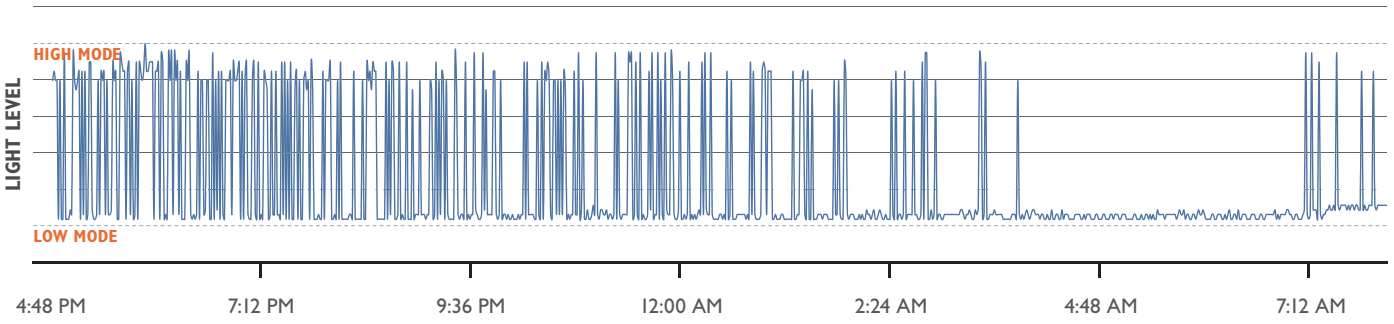
To quantify the actual energy saved from the use of occupancy controls, engineers installed small, light level loggers at each bi-level luminaire installed on the Cal Poly campus. These loggers recorded the relative light level provided by the luminaire, in five minute increments. Measurements were taken for approximately 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 below.

BI-LEVEL INDUCTION STREETLIGHT USAGE PROFILE
Cal Poly San Luis Obispo
H4 Facility Management Parking Lot

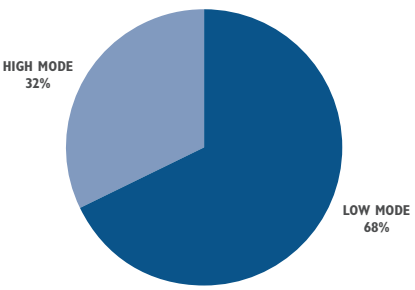


The bi-level streetlight demonstration saw lower average savings than the parking lot application. Bi-level LED luminaires operated in high mode 60% of the time due to higher pedestrian and vehicle traffic from nearby residence halls. The following graph shows maximum energy savings occurs between midnight and 7:00 am.

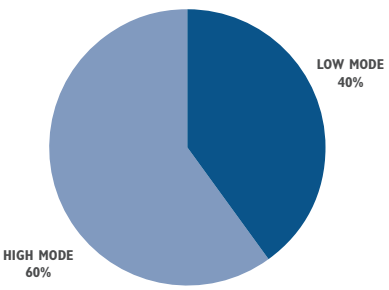
BI-LEVEL LED STREETLIGHT USAGE PROFILE
Cerro Vista Circle, Cal Poly San Luis Obispo 5:00 PM Monday evening, 02/02/09, through 8:00 AM Tuesday morning, 02/03/09



BI-LEVEL INDUCTION PARKING AREA LIGHTING SAVINGS
Cal Poly San Luis Obispo



BI-LEVEL LED STREETLIGHT SAVINGS
Cal Poly San Luis Obispo



Economics

Consumers should expect a higher initial investment when specifying bi-level luminaires for exterior lighting retrofit and new construction projects. The initial cost increase is often off-set 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 $0.24 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–$1500 depending on manufacturer, make, and model. Information on the bi-level luminaires detailed in this case study, including luminaire cost, may be obtained from the resources listed under the "For More Information" section of this report.

- Instant to 6 year simple payback in new construction projects when compared to traditional HPS luminaires
- 5–15 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

For More Information

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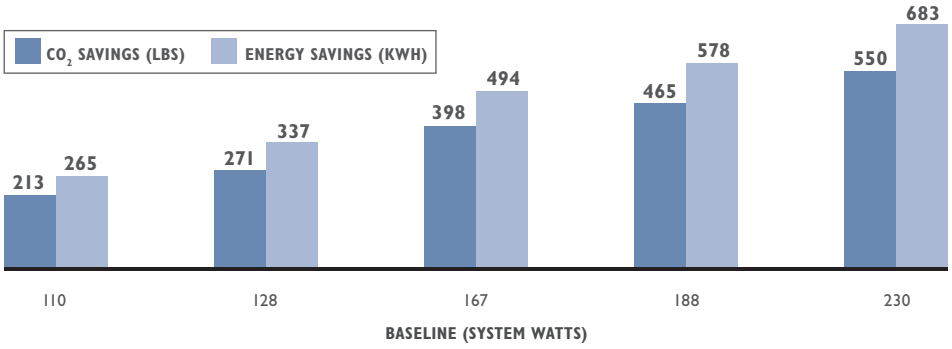
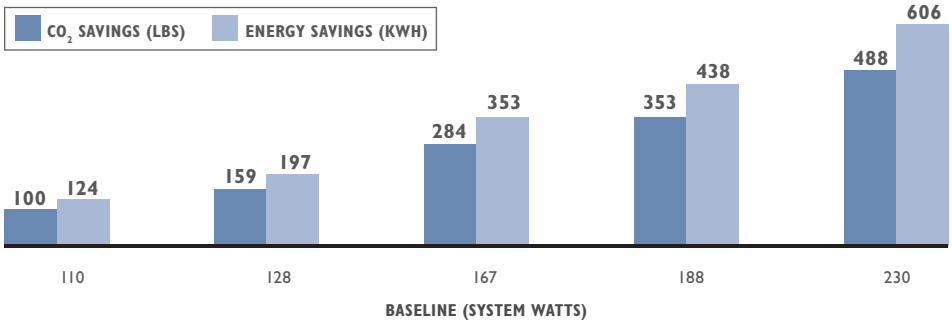
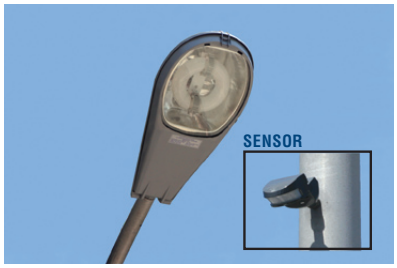
- www.cltc.ucdavis.edu
- www.fullspectrumsolutions.com
- www.betaled.com
- www.pierpartnershipdemonstrations.com

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



ANNUAL ENERGY AND CARBON EMISSION SAVINGS
Bi-level Induction Cobrahead Luminaires in Retrofit Projects
80 W System





About PIER

This project was cosponsored 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* **For more information see** www.energy.ca.gov/research

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