TIP 391: Maximize Savings with Occupancy-controlled Outdoor Area Lighting

Context

Solid-state (LED) lighting systems show great promise to reduce energy use and operating costs and improve visibility in several types of outdoor lighting applications. However, the first cost of LED systems often takes them out of consideration for many retrofit applications, such as parking lots. Many lighting specifiers and end users are unaware of unique control attributes of LED systems that allow for additional energy savings. For example, compared to conventional high intensity discharge sources, solid-state lighting is easier to dim, either continuously or step-dimming, and enjoys instant-on capability, neither of which reduces lifetime. . For these reasons, solid-state lighting provides new opportunities for energy savings by integrating occupancy sensors, allowing the lighting to be automatically adjusted to meet the needs of a particular location (and also introduce broader security applications and even further reduced maintenance). Energy codes in the Northwest are beginning to require the use of occupancy-based controls in parking lots, and there is currently little guidance as to how to configure these controls for maximum energy savings and user satisfaction.

Description

This project demonstrated a sensor-controlled, adaptable LED lighting system in a parking lot in Seattle, Washington. The Lighting Research Center (LRC) investigated several factors including optimal dim levels, dimming ramp rates, delay times, and others to save the maximum energy while maintaining visitor's satisfaction with the lighting. This demonstration resulted in a well-illustrated guide that provides lighting specifiers with valuable information about how to select, specify, and estimate energy savings from sensor-controlled, adaptable LED lighting systems for parking lots. It can also assist parking lot lighting decision makers to meet new energy code requirements in the most cost-effective manner while maintaining or improving users satisfaction and sense of safety and security.
The research was accomplished through the following tasks:

Task 1 Site Selection, Product Specification, Documentation: LRC worked with the Lighting Design Lab at Seattle City Light (LDL) to identify a parking lot site appropriate for the installation, located in Seattle, Washington.

Task 2: Laboratory Sample Testing: The LRC procured a sample of the luminaire/occupancy control device identified in Task 1 for installation at the demonstration

Task 3: Installation: The luminaires and controls were purchased and delivered to the demonstration site.

Task 4: Controlled Field Experiment, Light Level Ratios: After the lights were installed in the demonstration site parking lot, the LRC and LDL recruited subjects to participate in experiments at the site.

Task 5: Field Study – Light Level Ratios: The greater the ratio between bi-level "high" and "low" dim levels, the greater the energy savings. However the results of Task 4 confirmed that the greater the bi-level ratio, the lower the occupant acceptance will be.

Task 6: Delay Times and Ramp Rates: A key feature of a bi-level controls system impacting energy savings is the delay time setting; the shorter the delay time, the more the energy savings. However, if delay times are minimized, occupant acceptance may be lower.

Task 7: Dissemination: Once the lighting demonstration and study was completed, the LRC created a DELTA (Demonstration and Evaluation of Lighting Technologies and Applications) publication summarizing the results of the research and providing a guide that can be used by trade allies and other lighting decision makers to specify, set-up, and configure occupancy-controlled outdoor lighting systems.

Benefits

Consultants to the US Department of Energy reported in 2002 estimates of lighting energy use for parking lots in the US. Their report estimated nearly 23 million parking lot luminaires in the US, at an annual energy use of 22.28 terawatt-hours. As the Pacific Northwest (PNW) represents 4.3% of the US population, one can estimate that there are 1 million luminaires used for parking lots in the PNW at an annual electric energy use of 1 terawatt hour. With a conservative assumption of 40% energy savings relative to the baseline of 1 terawatt hour, this translates to a potential energy savings of 370 gigawatt hours (42aMW) annually in the PNW. Lower light levels later at night will also reduce light pollution helping to eliminate sky glow and light trespass.

Accomplishments

This project demonstrated a sensor-controlled, adaptable LED lighting system and developed a well-illustrated guide that will provide lighting specifiers with valuable information about how to select, specify, and estimate energy savings from sensor-controlled, adaptable LED lighting systems for parking lots that meets or exceeds new energy code requirements.

Deliverables

The following deliverables were provided as part of this project:

- Detailed experimental design for the project
- Plan for the installation and evaluation of the controls and luminaires in the demonstration parking lot
- Copy of all data collected during the project in electronic format, if desired
- Report of results of the field demonstration and project findings in a DELTA publication
- Final project report

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Project Start Date: October, 2016

Project End Date: September, 2019

Reports

Field Test DELTA Snapshot, Issue 11, September 2019
Sensor-Controlled Bi-level Lighting for Parking Lots

Field Demonstration of Sensor-controlled Parking Lot Luninaires; Lighting Research Center, Rensselaer Polytechnic Institute; Sept, 2019

Related Projects

TIP 322: Development of Test Methods for LED Reliability

TIP 329: Demonstration of Outdoor Lighting for Maximizing Perceptions of Safety and Security

TIP 339: Luminaire Level Lighting Control (LLLC) Demonstrations

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Participating Organizations

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Rensselaer Polytechnic Institute, Troy NY

Lighting Design Lab (LDL),
Seattle City Light, Seattle WA

Conclusions:

This research showed that bi-level sensor controls for parking lot lighting provide considerable opportunities for saving energy while promoting occupant acceptance.

(Key Findings next page)

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Key Findings

Occupant feedback was generally positive:

- For all test conditions, most occupants agreed they felt safe.
- Sensor time delay of 2 minutes was acceptable to occupants.
- Dimming to low levels (26% of full light output) when unoccupied was equally acceptable as dimming less aggressively (70% of full light output).
- Despite positive laboratory tests, in the field, some sensors did not respond to pedestrians until they stood close to the sensors. Occupants expressed some concerns that sensors required close proximity (<1 pole height) before the luminaire would increase to full output.

Occupancy patterns:

- Luminaires near the building entrance had higher activity patterns than those far from the entrance.
- When the luminaires were grouped, more time was spent at high output compared to programming with independent sensor control; the average percentage of the night at low output was 86% when independently controlled, and 63% when grouped. Using summer monitoring, grouped function with a 2-minute delay was similar to estimates for a 10-minute time delay with independent operation.
- The longer the sensor delay time, the greater the percentage of the night at high output, thus reducing energy savings.

Power and energy:

- Maximum power demand (94W) was lower than expected (130W) due to a power limiting device factory-installed in the luminaires, which impacted conditions available for testing.
- At the Rainier Community Center, power factor was 0.65 when luminaires operated at 26% output. While power factor does not impact the user, this could be a concern to the utility's power generation if these luminaires were widespread in the region.
- The most aggressive sensor settings demonstrated at the Rainier Community Center were estimated to save 62% lighting energy annually, compared to the same luminaires without bi-level sensor controls.