Dual-Loop Photosensor Control System for Daylight Harvesting

The Problem

Closed-loop and open-loop photosensor control systems save energy by dimming electric lights when windows or skylights provide plenty of sunlight. Unfortunately, both of these strategies are limited in terms of how accurately they sense light level fluctuations and how consistently they respond. Over-dimming or under-dimming can result, diminishing lighting quality and energy savings. Frequent recommissioning is often required to address these issues, a costly inconvenience that explains, in part, why these systems have yet to gain widespread adoption in interior environments.

In an open-loop system, the photosensor is oriented so that it senses only daylight and adjusts the electric light accordingly. The primary drawback of open-loop controls is that they only respond to changes in daylight but do not always accurately respond to actual light levels in the interior space.

In a closed-loop system, the photosensor is oriented so that it senses both daylight and electric lighting contributions, but the device is unable to distinguish changes in daylight from occupant interference or reflectance shifts that occur when there is a change of objects in the space.

The Solution

To maximize the respective benefits of open-loop and closed-loop systems, and minimize their limitations, the California Lighting Technology Center (CLTC) developed a dual-loop photosensor control system for skylight applications. The system features a control algorithm that monitors the open-loop and closed-loop photosensors and controls the electric light to provide the designed light level. It also automatically recalibrates nightly in order to adjust to long-term changes to the interior space. The project was undertaken through the Building Energy Research Grant (BERG) program from the California Energy Commission. Results show the dual-loop technology delivers more consistent lighting and greater energy savings.

CLTC developed and tested a reliable dual-loop photosensor prototype in its lab. The center partnered with Walmart to demonstrate the device, installing it in the skylight well of the 150,000 ft^2 West Sacramento store. For 12 months, the dual-loop system and a pre-existing open-loop system were monitored. While the dual-loop system was in operation, the displays and the reflectance of the products below the skylight changed, and the dual-loop system continually adjusted.

FIGURE 1: DUAL-LOOP PHOTOSENSOR CONTROL SYSTEM
Walmart skylight, West Sacramento, CA

Features and Benefits

- Automatic recalibration reduces maintenance costs
- Differentiates between daylight and space changes for more accurate light level adjustments
- Dramatically improves lighting consistency
- Improves the energy savings of open-loop control systems by 50%

Applications

A large retail store, warehouse, industrial facility, or commercial space with existing skylights and dimmable fluorescent ballasts could potentially save 0.76 kWh / ft^2 per year, about \$0.10 / ft^2 annually based on a rate of \$0.128/kWh.

A skylit building with 1,000 fluorescent ballasts that are not dimmable could be retrofitted with dimmable ballasts and a dual-loop system. In this scenario, energy savings would equal about 26.3 kWh/ballast per month. At \$0.128 / kWh, the new lighting system, including dual-loop photosensors, could save 315.6 MWh or \$40,400 annually.

Further scenarios where the dual-loop system could have significant influence include retrofitting high-intensity discharge (HID) high-bay fixtures with high-bay fluorescent fixtures. Specifying a dimmable ballast will allow the system to incorporate a dual-loop photosensor system and save 30% more energy than a fluorescent system with no photosensor system.

California Codes and Standards

Title 24 requires automatic daylighting controls for skylit areas in most building that are 8,000 square feet or larger. In an 8,000-square-foot building with no photosensor control system, installing dual-loop photosensor controls could save 16,880 kWh annually, or approximately $2,160 per year.

In a state like California where new power plants are difficult to implement, a dual-loop system has the potential to make a significant impact.

What's next

The dual-loop system technology patented by UC Davis has been licensed to four manufacturers and is now commercially available. WattStopper was the first to manufacture a dual-loop solution, beginning production of the LMLS-600 dual-loop photosensor control in late 2012.

CLTC is currently exploring multiple photosensors in a laboratory space with windows. The existing dual-loop system for skylight applications works successfully in side-daylighting spaces when window treatments are not used; research is ongoing to develop a dual-loop photosensor system that works with side-daylighting applications with window treatments.

Collaborators

The organizations involved in this project include the California Lighting Technology Center, California Energy Commission, the Building Energy Research Grant Program, Walmart, WattStopper, and California utilities.

For More Information

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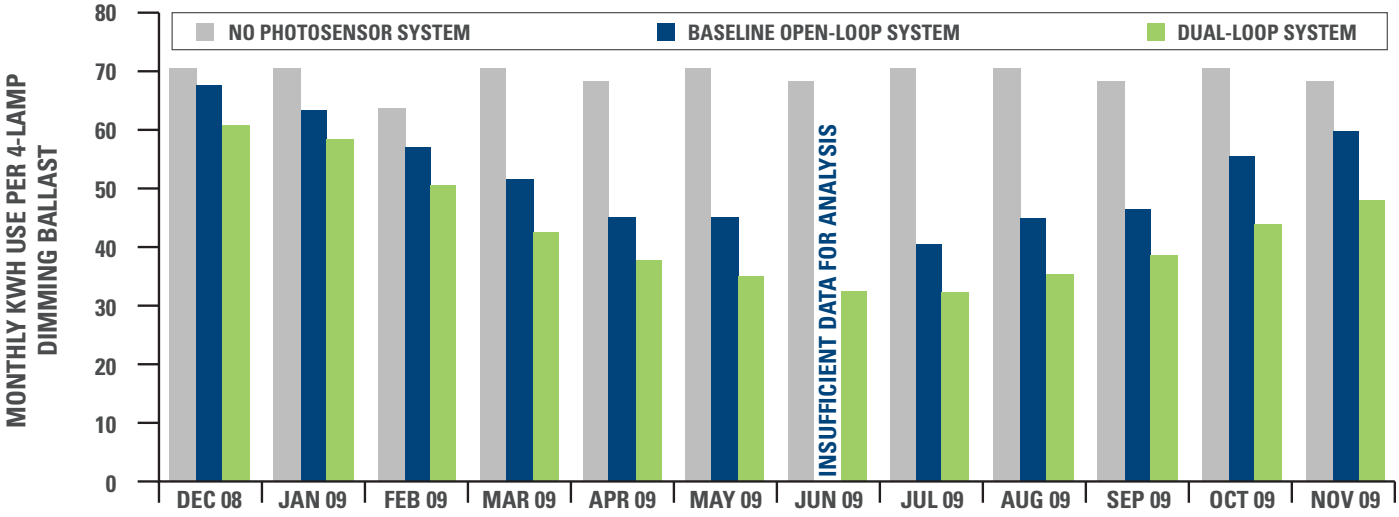
To read more about the Dual-Loop Photosensor Control System for Daylight Harvesting, visit cltc.ucdavis.edu/content/view/142/164

FIGURE 2: LIGHTING ENERGY USE COMPARISON
Prototype Demonstration, Walmart (West Sacramento, CA)



This chart compares energy savings between the dual-loop and the open-loop systems. The open-loop system saved 24.4% over a store without a photosensor system while the dual-loop system saved 36.6% over a store without a photosensor system, a 50% improvement in the energy savings achieved by the baseline technology.

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.

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