Daylight Sensor

Design and Application Guide

LUTRON®

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Vocabulary

Daylight Harvesting: The term used in the building controls industry for a control system that reduces electric light in building interiors when daylight is available, in order to reduce energy consumption.

Daylight Row: A group of fixtures adjusted equally based on daylighting readings

Daylight Sensor: A device that reads available light and sends a signal to the control system. Daylight Sensor = Photo Cell = Photo Sensor

Multiple Row Daylighting: A form of daylighting in which multiple daylight rows are controlled by the same sensor. Each row is calibrated to provide a balanced amount of light throughout the space.

Work Surface Light Level: The light level measured in FC using a light meter at the work surface. If cubicle walls are in use then this value is measured at the cubicle height.

Desired Light Level: The target work surface light level.

Target Setpoint (TSP): The specified electric light level when there is no daylight entering the space. Also known as the Nighttime Target Setpoint.

Threshold: A specified light level that is required to turn electric lights ON or OFF. Specified light levels represent the lights levels at which an action will occur in the system. This applies to switching/non-dim scenarios.

Gain: The numeric value set during calibration that determines how aggressive the daylighting is. The higher the gain, the more the lights will dim.

Fixture Feedback: Light from a fixture shining directly onto a daylight sensor and causing the system to behave unexpectedly. Based on the Electric Light Contribution (ELC) on the photo sensor from the surrounding fixtures. Sometimes known as electric light impact.

Max Light Level: The method of daylighting through cutting off all zones above the daylighting level and leaving other zones unaffected. This cutoff point can be changed throughout the space using multi-row daylighting.

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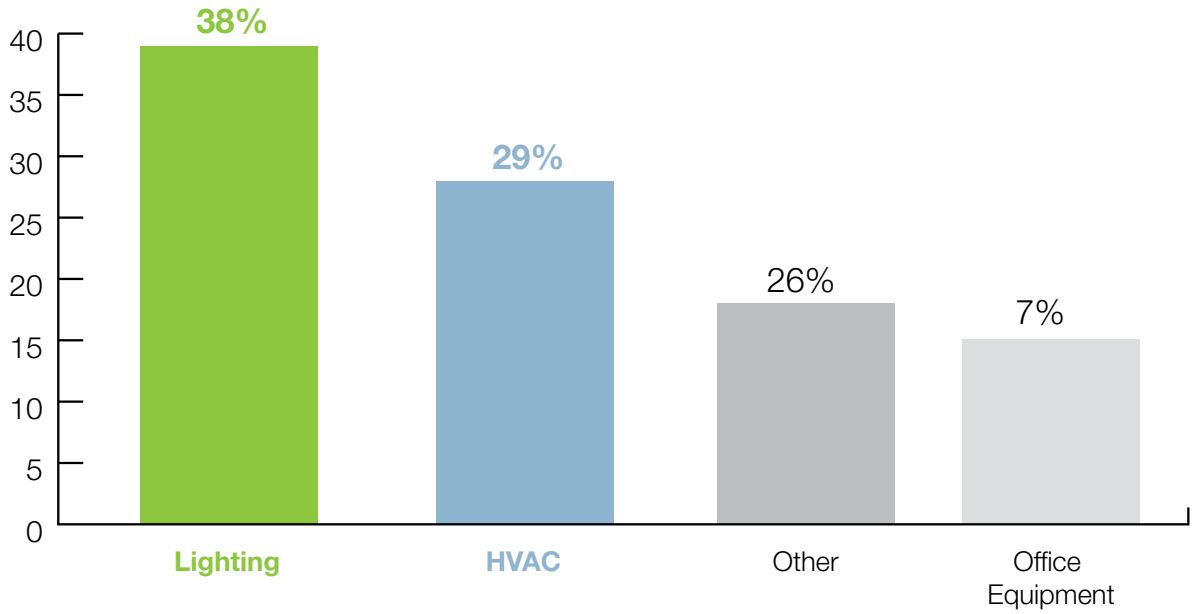
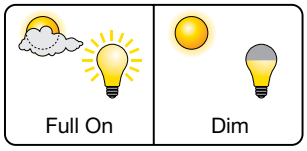
Daylight harvesting

Daylight harvesting, which takes advantage of naturally available light, is a key energy-saving strategy for commercial spaces. The principle is simple: the electric lights in a space can automatically be dimmed downed or turned off when enough natural light is entering the space.

Annual electricity use in commercial buildings[1]





Daylight Harvesting dims electric lights or switches them off during the day to take advantage of available sunlight.

20%–60% Light Savings[2]

According to the U.S. Department of Energy, lighting accounts for an average of 38% of electricity usage in commercial buildings, more than any other building system. When seeking a dramatic reduction in electricity costs, one would be well advised to start with the lights. A thoughtfully deployed daylight harvesting program for building lighting can typically deliver energy savings of 20-60%, while providing the assurance that occupants have the right amount of light in the space.

[1] Energy Information Administration, released September 2008. 2003 Commercial Building Energy Consumption Survey (CBECS)

[2] Brambley MR, et al. 2005. Advanced sensors and controls for building applications: Market assessment and potential R&D pathways. Pacific Northwest National Laboratory: prepared for U.S. Department of Energy.

Daylight sensor benefits

Saves energy

- Reduces energy consumption by dimming or turning off electric lights based on the natural daylight entering the space
- Can deliver up to 60% lighting energy savings in some areas[2]

Provides comfort and convenience

- Helps maintain the proper light level for a space, so a space is never too dark or too bright
- Continuously adjusts lights automatically so occupants don't have to manually adjust them as daylight levels change.

Meets codes and standards

- Meets the mandatory requirements set for building construction and renovation
- Can contribute to obtaining points in several LEED credit categories

Codes and standards that may apply

LEED—up to 19 points

Daylight sensors can contribute up to 19 possible points in the LEED 2009 NC rating system.

ASHRAE 90.1 – 2010 (energy standard for commercial buildings)

Parking Garage Lighting Control (9.4.1.3)

Transition lighting and lights within certain parameters with relation to natural light must be automatically reduced in response to daylighting.

Automated Daylighting Controls for Sidelighted Areas (9.4.1.4)

The lamps for general lighting must be controlled by at least one multilevel daylight control in any enclosed space that has more than 250 ft2 of window lit area.

Automated Daylighting Controls for Toplighted Areas (9.4.1. 5)

The lamps for general lighting must be controlled by at least one multilevel daylight control in any enclosed space that has more than 900 ft2 of skylight lit area.

Exterior Lighting Control (9.4.1.7)

Exterior lighting must automatically be turned off when sufficient daylight is available.

Title 24 – 2013 Part 6 (California's energy standard)

SECTION 130.1 – Indoor Lighting Controls That Shall Be Installed

(d) Automatic daylighting controls

Automatic daylighting controls must be used to provide multi-level or continuous dimming in spaces with more than 250 ft2 of daylight area.

IECC 2012 (International Energy Conservation Code)

Daylight Zone Control (405.2.2.3)

Multiple daylight zones must be separately controlled from the general area lighting and can be controlled either manually or via an automatic daylight sensor.

IgCC 2012 (International Green Construction Code)

Automatic Daylight Controls (609.5)

Automatic daylight controls shall be provided for all daylight zones.

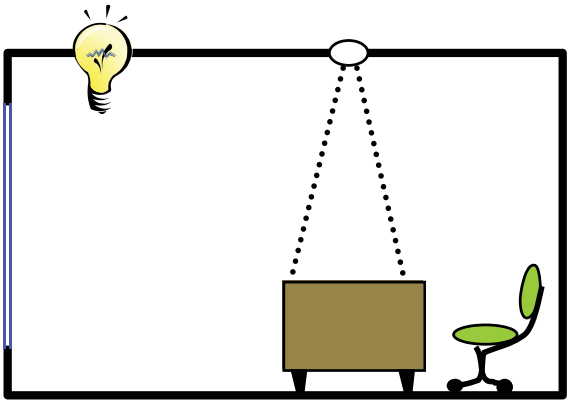
These summaries are meant as a general reference of some of the mandatory requirements that daylight sensors help meet. They may or may not apply to your project. Please refer to your local building energy code or authority having jurisdiction for your precise requirements.

Different daylighting methods

Closed loop

Closed loop is an approach to daylighting that attempts to keep the illumination at the sensor constant. This approach is task oriented; the sensor looks directly into the space of the light that it controls.

- Sensors placed inside the space, typically directly above work surface – dependent on sensor instructions
- Measures light level in a narrow viewing angle
- Adjusts electric light level up or down to maintain a desired light level on the work surface
- Affected by both electric light and daylight
- For accurate performance the sensor can only control fixtures that are contributing to the field of view
  - Generally one sensor per task surface
  - Customer would have to buy far more sensors to cover the same area
- The sensor cannot distinguish between daylight fluctuations and changes of surface reflectance

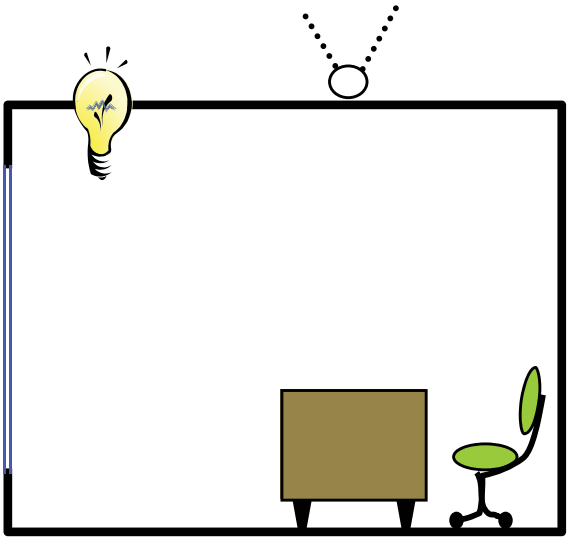


A sample private office closed loop sensor setup.*

Open loop

In this approach to daylighting, the illumination at the daylight sensor varies. It has a wide field of view; the sensor doesn't look directly into the space that contains the lights that it controls.

- Measures daylight only
- Wide field of view
- Often placed outside the space
- Does not take into account window treatments



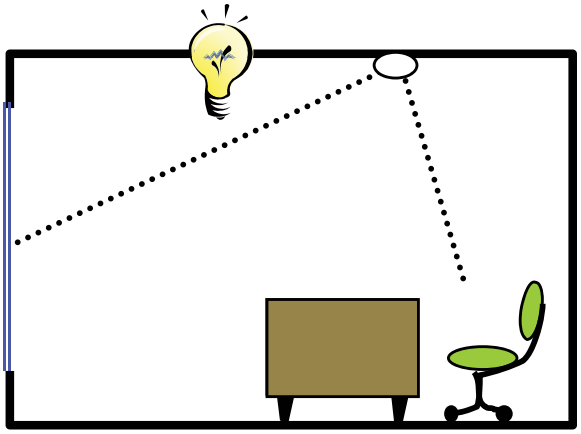
A sample private office open loop sensor setup.*

* NOTE: Dotted lines are for visualization purposes only

Partial open loop – Lutron approach

In partial open loop daylighting, sensors are positioned inside the physical space and take into account the light levels penetrating the area from natural light sources, as well as light contributions from the work surface. This approach combines both open and closed loop methods.

- Single sensor can control multiple rows
- Takes into account light level actually entering into the space, accounting for window treatments and natural weather conditions
- Not significantly affected by reflectance from the surface below
- Does not need to be placed directly above the task surface



An example of a Lutron daylighting system.*

* NOTE: Dotted lines are for visualization purposes only

How does partial open loop daylighting work?

The two main variables that define the behavior of a system are target setpoint (TSP) and gain. All of Lutron's systems use TSP and gain to determine how the sensor reading affects the artificial light in a space. The values are determined during initial set up. Based on which system is being used, one or both of the variables may then be adjusted to allow additional tuning.

Target setpoint (%)

This setting determines the ballast light level when the daylight sensor is reading 0FC.
Another way to think about it is TSP is the percentage the ballasts will go to at night.

The **HIGHER** the TSP, the **HIGHER** the electric light output.

Gain adjustment

Gain determines how much the lights will dim when daylight is present.

If you have a high gain, the lights will be more affected by the current daylight sensor readings, so electric light output will be lower.

The **HIGHER** the gain the **LOWER** the electric light output.

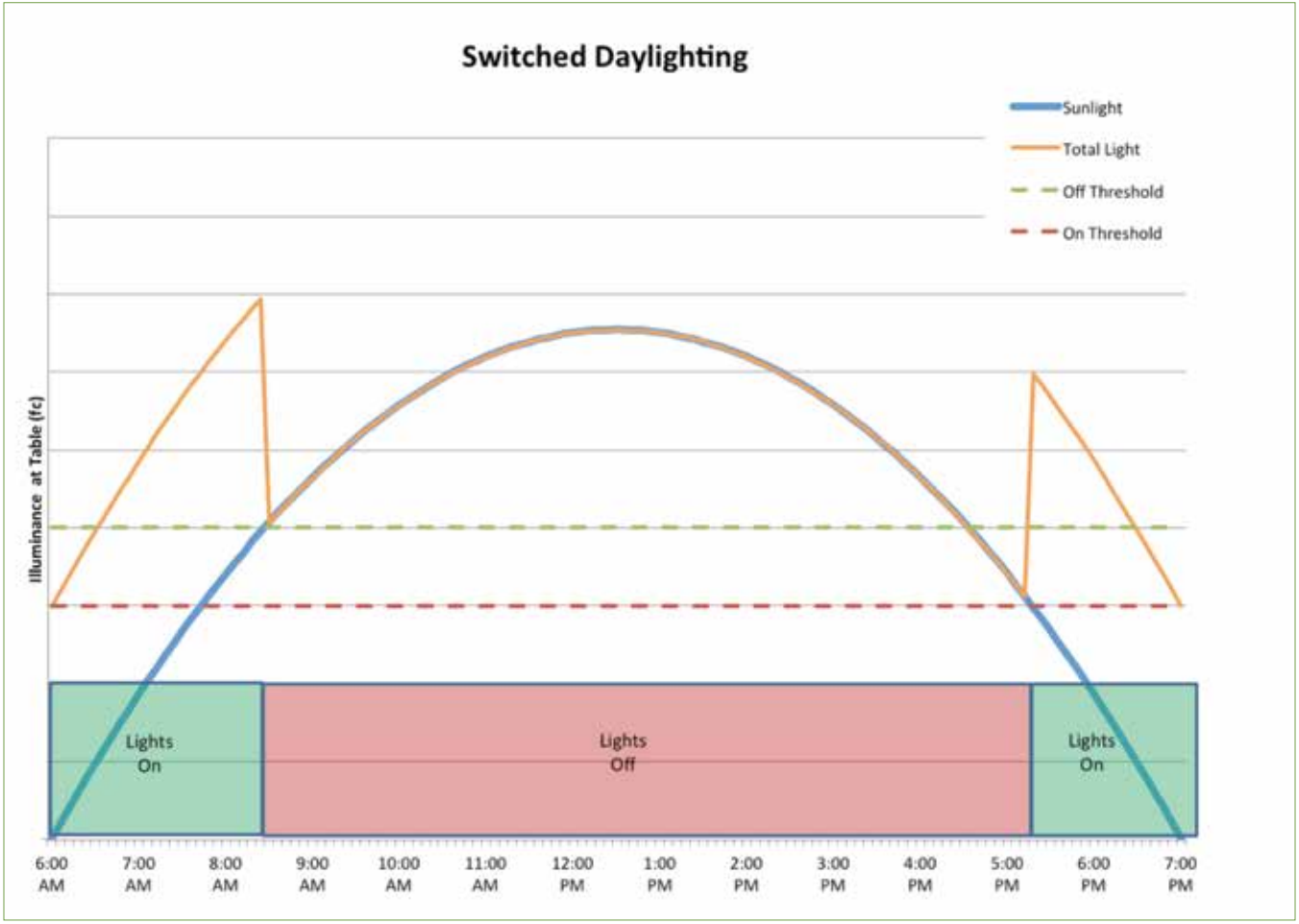
Different types of daylighting

Switched daylighting

In switched daylighting, loads are turned off when the daylight meets a minimum desired level. This type of daylighting uses a delay-to-off and hysteresis in order to prevent frequent on-off behavior.

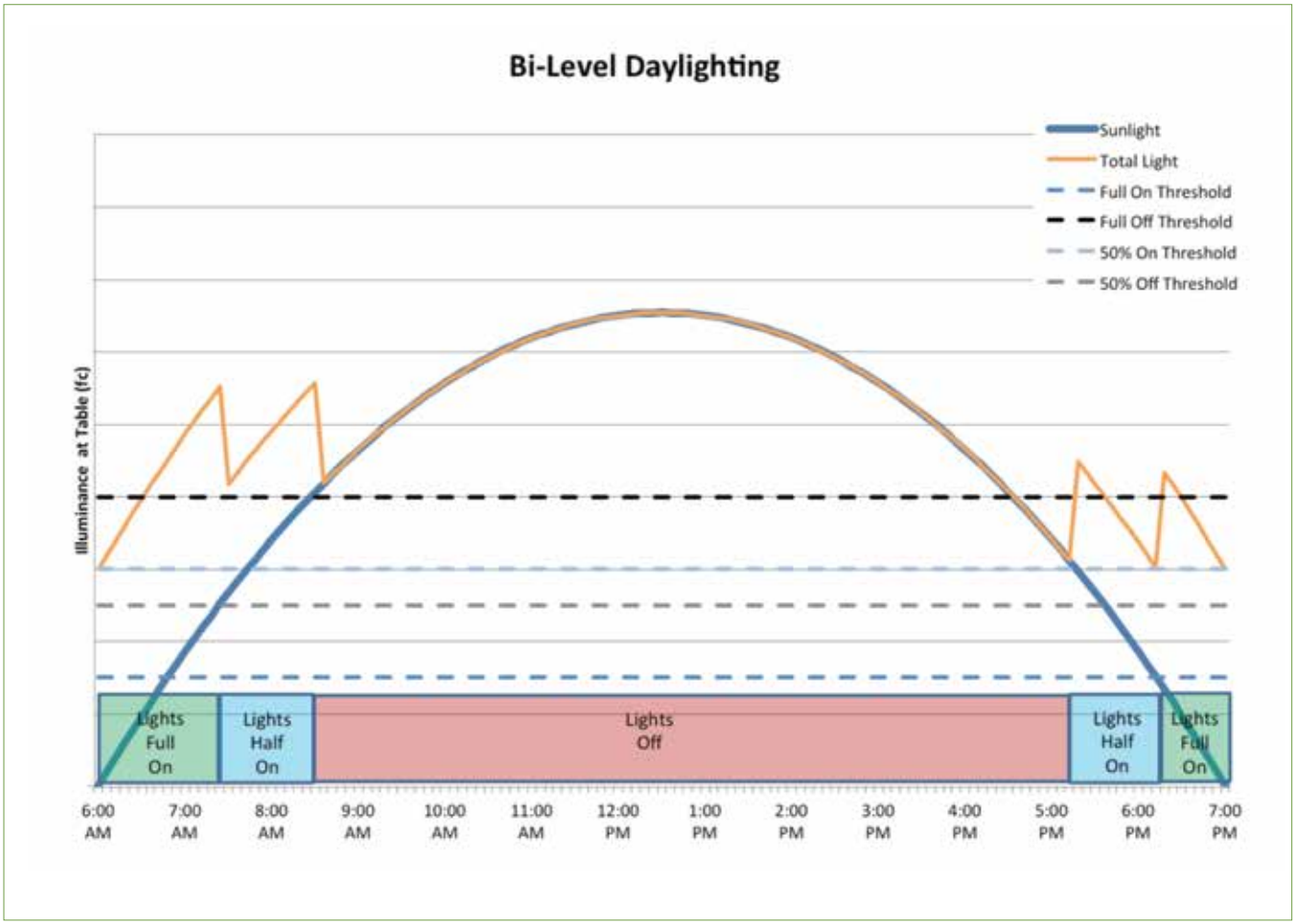
In the chart below, the electric lights have been designed to supply the desired amount of light at desk height. You can see as the sun rises the total light in the space increases. Once the daylight entering the space is enough to exceed the minimum required light level (with a built-in hysteresis), the electric lights will turn off. The electric lights will then remain off until the point in the day at which the natural light can no longer provide the minimum required light level in the space.

One of the downsides of switched daylighting is that the space is over lit just before there's enough daylight the space to provide the minimum required light level.



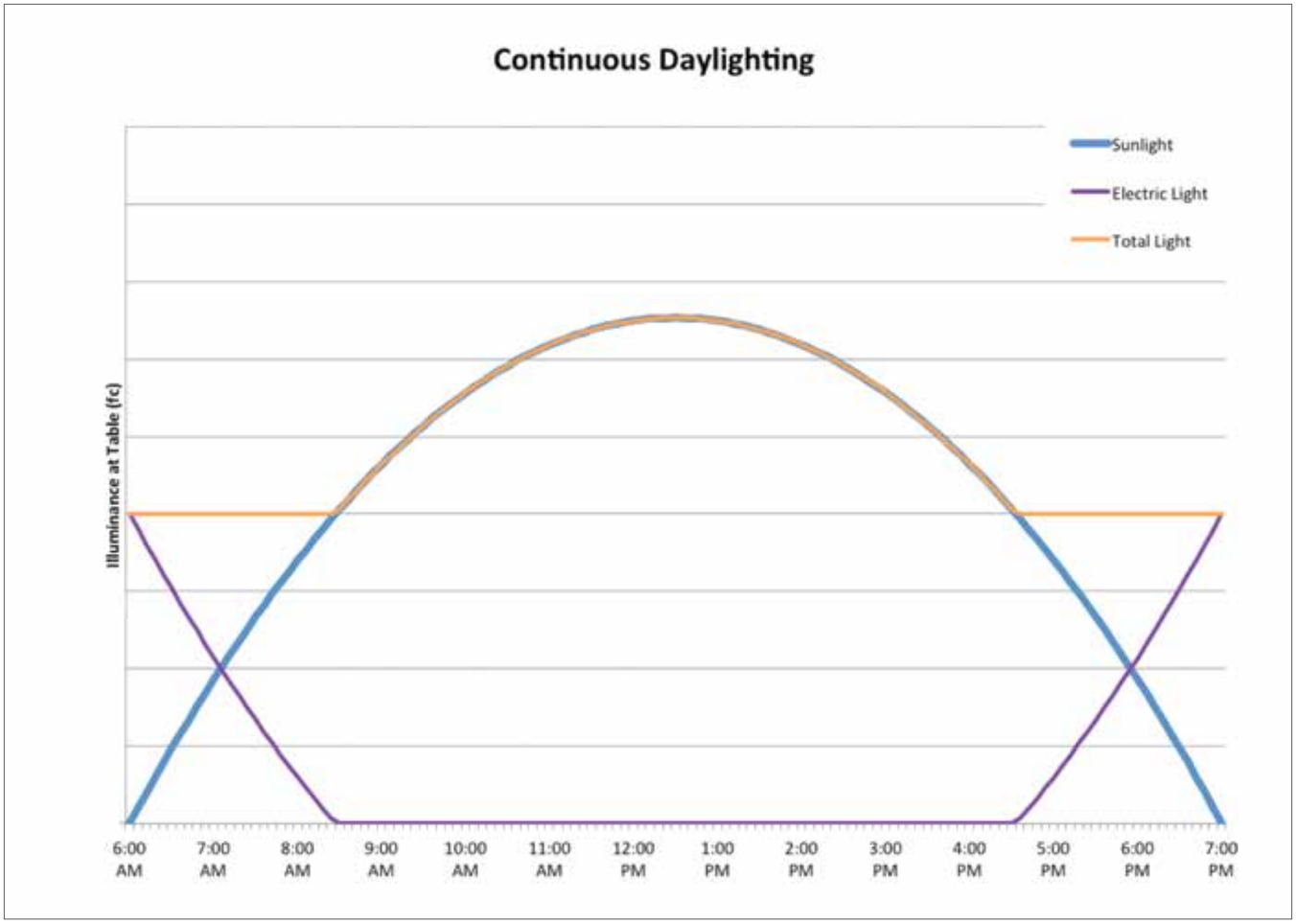
Bi-level daylighting

Bi-level daylighting is very similar to switched daylighting, but with the addition of a 50% light level. Electric lighting to the left will move from 100% to 50% to off as the daylight becomes more abundant. In the chart below, you can see how the electric light contribution in the space is additive to the daylight entering the space. As the total light in the space increases, the electric lights will dim to 50%. They'll turn off once the daylight entering the space is enough to provide the minimum required light level for the space. The bi-level, or 50% level, helps avoid having the space be over lit before there's enough daylight to provide the minimum required amount of light.



Continuous daylighting

Continuous daylighting involves smooth, continuous dimming from low end to high end in order to maintain the desired light level. Continuous daylighting adjusts lights based on the amount of daylight that's always in the space, ensuring that the minimum light level is achieved without over-lighting the space (as in switched and bi-level daylighting).



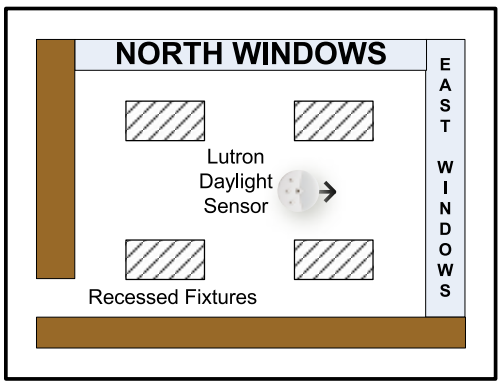
Sensor placement guidelines

General placement guidelines

- Place the daylight sensor so its arrow is pointed at the nearest window at a distance from the window of one to two times the effective window height (H).
- The effective window height (H) starts at the window sill or 3 ft (1 m) up from the floor, whichever is higher, and ends at the top of the window.
- Ensure that the view of the daylight sensor is not obstructed (e.g. ceiling fans or pendant fixtures).
- Allocate one sensor for each partitioned space such as a private office.
- In case of an open office allocate one sensor at least every 30 linear feet of window wall.
- One sensor for every individually controlled shade group will provide the ideal daylighting behavior. (See “Multiple Shades” on page 12 for more information.)
- Proper sensor placement should try to maximize the ratio of natural light to artificial light, while not being constantly washed out with sunlight.
- Avoid placing the sensor in direct light from fixtures in the space. This can cause the sensor’s readings to be off and the system to not daylight properly.

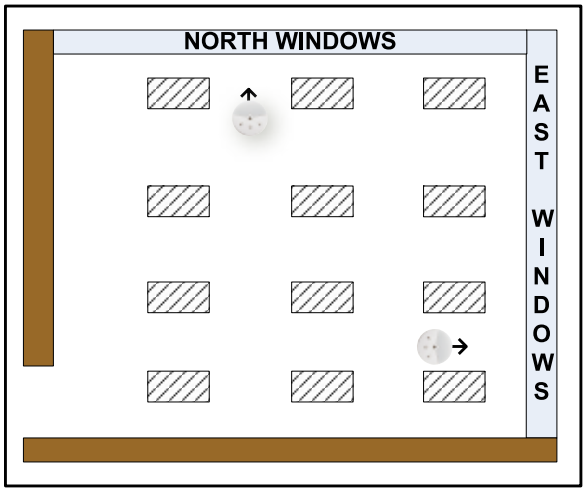
Corner office

If working with a **small corner office** point the sensor toward either window opening.



If working with a **large corner space** either use:

- Two sensors, one pointed toward each façade.
- A single sensor close to the corner, pointed at either façade

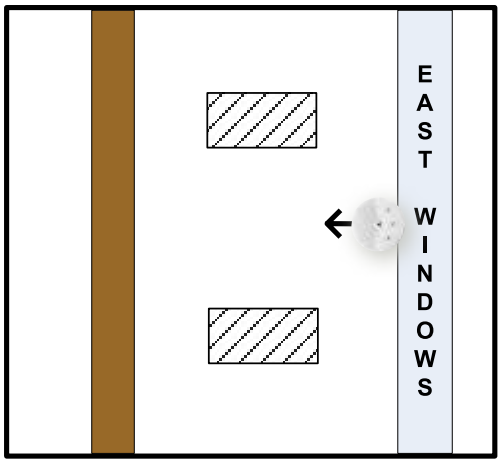


NOTE: Graphics are not drawn to scale.

Narrow private office or hallway

In this application, you won't have a good location for the sensor that's 1 to 2 window heights away from the window. If you place the sensor closer than 1 window height, the sensor will receive too much sunlight and won't be able to operate the electric lights with precision.

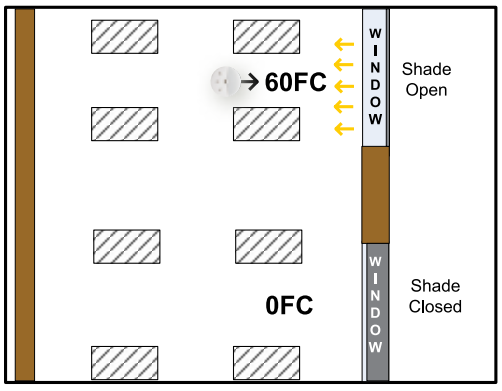
Try placing the sensor against the window, facing in toward the space.



Multiple shades/open office

Inconsistent shade (manual or electric) positions will affect the amount of light coming into the space from one section of the office to another. One sensor isn't enough for the space because the lights/shades will only respond to the sensor that is receiving the natural light, leaving part of the space under lit.

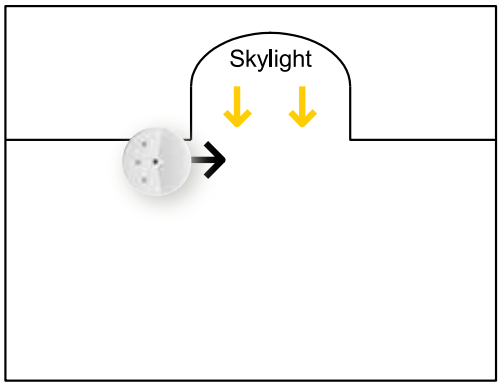
Adding another sensor ensures that the entire space will be properly lit.



NOTE: Graphics are not drawn to scale.

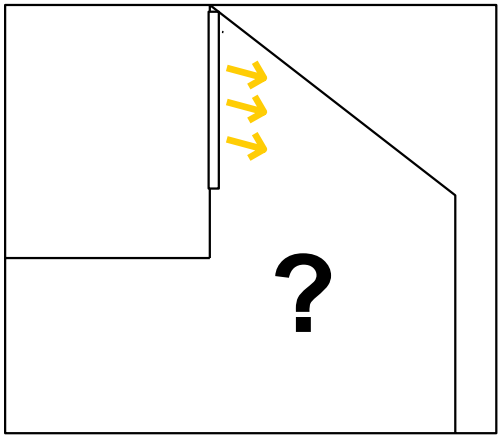
Skylights

- Mount the sensor as close as possible to the skylight with the field of view oriented toward the floor under the skylight opening.
- Do not position the sensor inside skylight.



High windows, slanted ceiling

The guidelines for high slanted ceilings are dependent on the rest of the space. For jobs with this setup please contact the System Sales Engineering Team **(systemsalesengineers@lutron.com).**



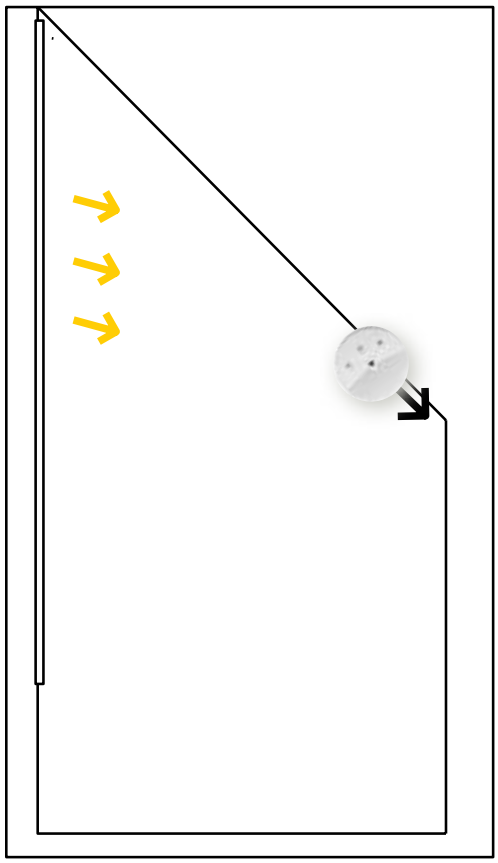
NOTE: Graphics are not drawn to scale.

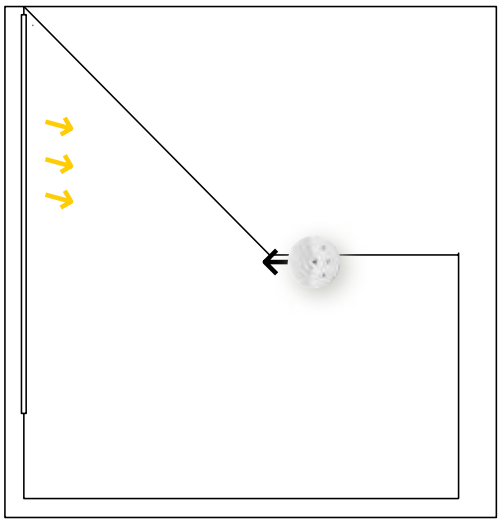
Steep slanted ceilings/narrow office space

When dealing with steeply slanted ceilings in a narrow office space place the sensor on the slant and point it away from the window.

In an office like this natural light will wash out the sensor for most of the day. This may affect the accuracy of our daylighting system. We recommend you contact Lutron in order to tweak the sensor settings.

If the ceiling has a flat section parallel to the floor, place the sensor on the flat, rather than the steep, section.





NOTE: Graphics are not drawn to scale.

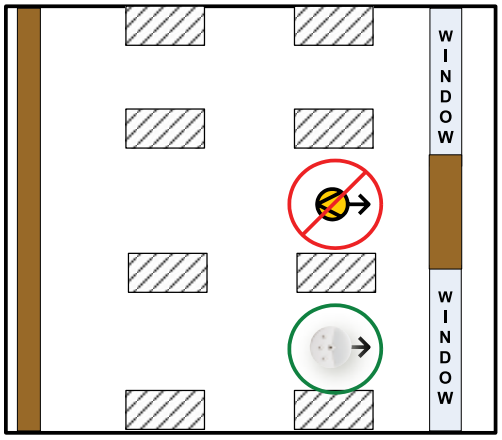
High ceilings

You can place a daylight sensor on a high ceiling as long as the sensor can still read a workable light level. (Keep in mind that a sensor on a high ceiling might lose some accuracy.)

If you place a sensor where it doesn't receive any reflected light and it's in the dark, it won't work.

Hard shadows

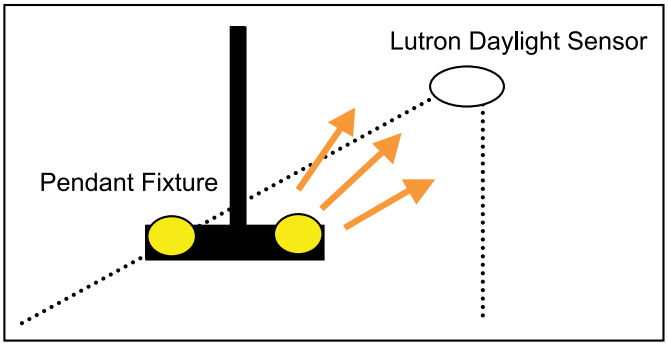
Avoid hard shadows on the sensor caused by aspects of the interior design such as columns.



NOTE: Graphics are not drawn to scale.

Fixture feedback

Fixture feedback refers to direct light from the fixtures in the daylighting area contributing to the light at the daylight sensor. High levels of fixture feedback can result in unexpected behavior including light oscillation or under-lit areas. To minimize fixture feedback, position sensors in such a way so they don't receive direct light from the fixture.



How to measure fixture feedback:

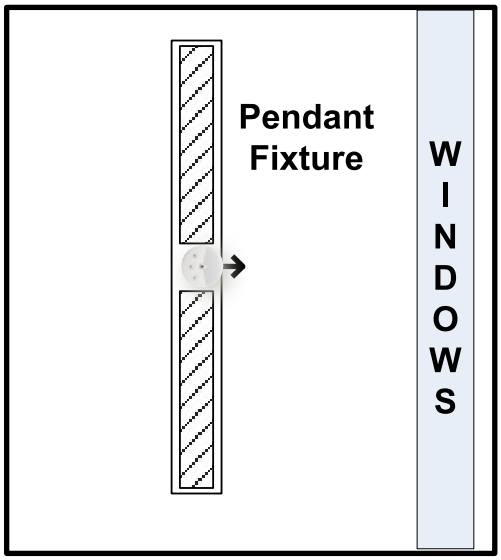
- Place a light meter on the ceiling in the same location as the daylight sensor.
- Face the lens of the light meter toward the window, perpendicular to the ceiling
- Adjust lights to high end; record light meter reading.
- Adjust lights to off; record light meter reading.
- Calculate fixture feedback = lights on – lights off
- The fixture feedback should be 5fc or less.

Tip! If you know there is fixture feedback, but you can't move the sensors, try manually decreasing gain to avoid problems. If the fixture feedback is a significant percentage of the overall sensor readings, please call Lutron tech support for assistance.

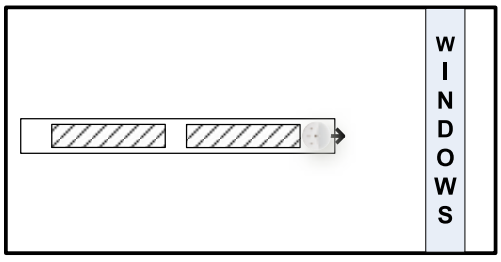
NOTE: Graphics are not drawn to scale.

Possible alternative location with indirect fixtures

Option 1: If the fixture is **parallel to the window**, you can place the sensor on the bottom of the pendant pointed toward the window.

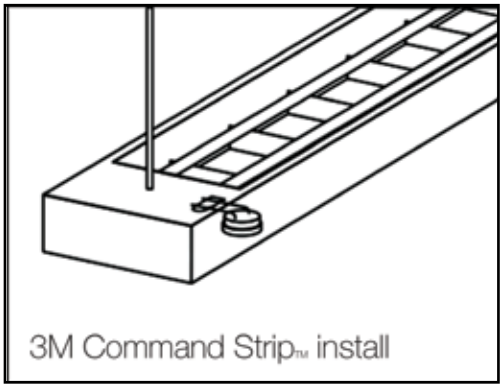


Option 2: If the fixture is **perpendicular** but one side is far enough from the window (see page 11) you can place the sensor as shown below.

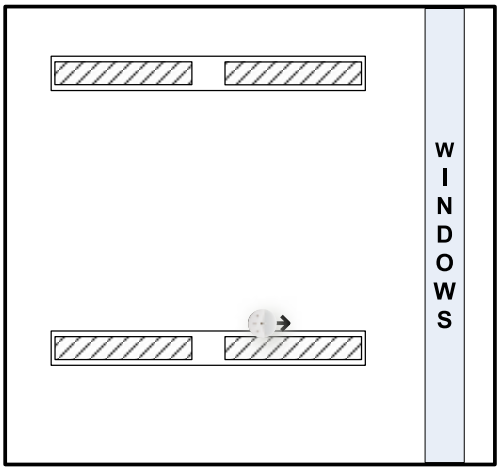


Option 3: You can also place the sensor in the same vertical plane as the pendant. This approach may work for pendant fixtures perpendicular to the window, depending on the fixture design.

Please see **App Note 426** for more information.



How to place the sensor on a pendant fixture using Option 3.

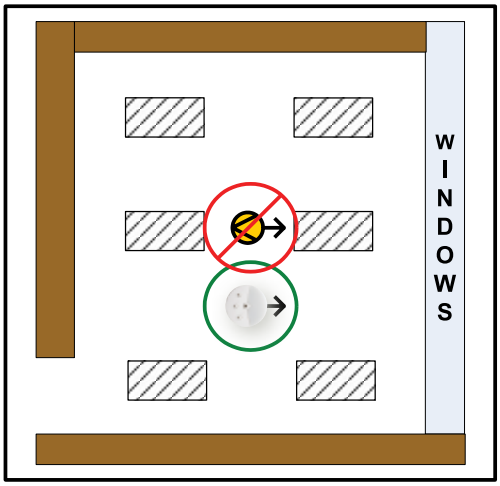


Ideal placement while using Option 3.

NOTE: Graphics are not drawn to scale.

Avoiding fixture feedback with recessed fixtures

Avoid placing a sensor directly facing a recessed fixture or down light, especially if the fixture has a wide surface area. Instead, try to place the sensor in between fixtures in a row, as shown at right.



NOTE: Graphics are not drawn to scale.

Special considerations

Not enough light at the sensor

Before calibrating, ensure at least 25% of the desired light level is reaching the sensor during calibration. Place a light meter on the ceiling in the same location as the sensor.

Solution: Move the sensor closer to the natural light source or calibrate the sensor at a different time of day.

Sensor washed out with sunlight

If the sensor is in a location where it's washed out with sunlight, the calibration will most likely result in a too low gain. Make sure the sensor placement matches the spec. This will most likely result in under lit spaces during certain times of the year, or certain weather conditions.

Solution: Move the sensor to a different location.

Reflective surfaces

Reflective surfaces can provide unexpected spikes in daylight sensor readings. This could result in the light level changing dramatically without a significant change of work surface light.

Solution: Move the sensor out of the reflection's path.

Window treatments

Window treatments will greatly affect the daylight penetration curve in the space, especially blackout shades.

Solution: Remove or open all window treatments when placing the sensor. Then replace or close window treatments to test daylighting behavior at varying light levels.

Wireless daylight sensor

Features and capacities

- Wireless daylight sensor has simple calibration
- Daylight compensation through Lutron reliable partial open loop control
- Designed to give a linear response to changes in viewed light level
- Light range 0–1600 lx (0-150 fc).
- Intuitive test mode provides instant system verification
- Multiple ceiling mount methods available for different ceiling materials
- Front accessible test buttons make set up easy.
- Battery included; 10-year battery life design
- RoHS compliant
- For indoor use only, temperature 32° F-104° F (0° C-40° C)

Dimensions and mounting

- Width: 1.6 in (41 mm)
  Depth: 0.7 in (17 mm)
- Mount within 60 ft (18 m) line-of-sight or 30 ft (9.1 m) through walls, of the receiving devices

Communication

- Communicates via Lutron's reliable Clear Connect® Radio Frequency (RF) technology to other Lutron wireless devices

Shown actual size

Model numbers

Wireless daylight sensor	
434 MHz	LRF2-DCRB-WH

Wired daylight sensor

Features and capacities

- Mounts easily on any ceiling tile or fixture
- Threaded mounting stud may be shortened for applications with limited fixture height
- Calibrated for daylight sensitivity through the lighting control system to which it is attached
- Receives IR signals and transfers them to a digital ballast, control module, or sensor interface
- The infrared receiver receives IR programming signals from up to 8.2 ft (2.5 m) away
- Constructed of flame-retardant material.
- Meets IEC 801-2. Tested to withstand 15 kV electrostatic discharge without damage
- LED indicates programming mode
- Sensor wire insulation is rated to 600 V, suitable for fixture installation
- For indoor use only, temperature 32° F-104° F (0° C-40° C)
- Light range 0–5,300 lx (0-500 fc).

Dimensions and mounting

- Width: 1.18 in (30 mm)
  Depth: 0.69 in (17 mm)
  Stud length: 1.25 in (32 mm)
- Sensor lead length = 4 in (100 mm) minimum beyond threaded stud
- Total wire length from sensor to device must not exceed 100 ft (30 m)
- Threaded stud diameter = 3/8 in (9.5 mm) maximum
- Use 3/8-16 nut (provided) for mounting

Communication

- Operates via low-voltage (PELV) standard wired communication
- 20-24 VDC, Class 2 (PELV) low-voltage wiring
- Uses one half (1/2) power draw units on the QS link, only if connected to the QS sensor module (QSM)

Model numbers

Wired daylight sensor
EC-DIR-WH

Sensor layout and tuning service

Fine tuning sensor performance is best acheived after the space is fully occupied, furniture is in place, and the HVAC system is balanced to the environment.

Lutron offers a sensor layout and tuning service to ensure that our sensors are installed and calibrated to perform as intended.

When the Lutron Sensor Layout and Tuning Service is purchased, we'll inform the installing contractor where to place the sensors (both wired and wireless). During system startup, we will provide recommendations to the installing contractor regarding sensor location in accordance with the installation instructions. We'll also provide a rough sensor calibration. Once the building is occupied, we'll return, up to two times, to perform sensor fine-tuning.

To learn more about this service, please call **1.800.523.9466** or email **LSCscheduling@lutron.com**.

For specification information, see Lutron document LSC-SENS-LT, PN 360-1235.

Lutron.com/occsensors

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