MEASURE 9.5.3 Install interior photocontrols to exploit daylighting.

RATINGS

New Facilities	Retrofit	O&M
B	C	

SUMMARY

A technique with great untapped potential. Don't overlook any lighting that would benefit, such as emergency lighting. May be tricky to design and install. Expect to combine photocontrol with other types of control.

SELECTION SCORECARD

Savings Potential	$ $ $
Rate of Return, New Facilities	% % % %
Rate of Return, Retrofit	% % %
Reliability	✓ ✓
Ease of Retrofit	☺ ☺

Turning interior lighting on and off with photocontrols is a possibility that deserves more attention because it may save substantial amounts of energy in spaces that have glazing. Photocontrol of interior lighting is more difficult to accomplish in a satisfactory manner than photocontrol of exterior lighting, which was recommended by the previous Measure. Here, we cover the additional complications of indoor photocontrol.

Where to Consider Photocontrol for Inside Lighting

Consider photocontrols for any space that has lighting from windows or skylights, provided that the space has fluorescent or incandescent lighting. Figures 1 through 4 show favorable examples.

Don't overlook opportunities in spaces that are only partially daylighted. A common example is using photocontrol for the row of fixtures adjacent to the windows of a room, as in Figure 2. Figure 4 shows where photocontrols should be installed in the area adjacent to a daylighted atrium.

To find out whether there is enough daylight to make photocontrol worthwhile, survey candidate areas using a light meter. There should be a many hours during which the daylight level is about three times higher than the minimum lighting level required for the activities. The reason for this ratio is explained below.

If there is adequate daylight, consider whether the abrupt changes in lighting level that occur as fixtures turn on and off will be an annoyance. The worst problem is created by thick, localized clouds of the kind shown in Figure 5. However, don't assume that clouds are an insurmountable obstacle. When light fixtures are turned on and off in a brightly daylighted space, the change is much less noticeable than turning lights on and off in a dark space. Furthermore, if the photocontrols are installed properly, the lights will not switch often.

Interior photocontrol is most acceptable in transient areas, such as daylighted corridors (Figure 1), common

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Fig. 1 Daylighted corridor This is an ideal application for photocontrol of lighting. Daylight provides ample illumination under most daytime conditions. The light fixtures are fluorescent, with multiple lamps, so they can even be switched in stages for a more gradual response.

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Fig. 2 Daylighted reading area in a library The row of light fixtures adjacent to the windows is a prime candidate for photocontrol.

areas in shopping malls that are illuminated by skylights, and daylighted atriums (Figure 3). Photocontrols are less likely to be acceptable in offices and classrooms. However, a greater awareness of the need for energy conservation may make photocontrol acceptable even in such locations.

Security lighting is an especially fruitful application for photocontrol. Only low levels of light are needed for emergency egress, so daylighting may serve as emergency lighting for a much larger portion of the building than for conventional lighting. For example, photocontrol may eliminate the need for most emergency lighting on weekend days, when no people are present to require high lighting levels. Also, photocontrol of emergency lighting may not require the complexity of other applications. Check that local codes allow turning off electric emergency lighting when daylight is available. This is an unusual way of dealing with emergency lighting, so you may have to request a variance.

Limitations with HID Lighting

All types of HID lamps (mercury vapor, metal halide, and high-pressure sodium) require a time of several minutes to start, and most require an even longer time to restart from a hot condition. Therefore, do not use photocontrols with HID lamps in applications where fluctuations in daylight during the day, typically caused by clouds, might require starting or restarting during occupied periods.

Combine with Other Types of Lighting Controls

Expect to combine photocontrol of interior lighting with other methods of control. Photocontrols alone would keep the lights turned on during all hours of darkness. Provide additional controls to turn the lights on and off in response to the presence of people. Photocontrol alone is useful only for lighting that is required throughout hours of darkness, such as security lighting.

A common pitfall is using manual switches in combination with photocontrols. In such cases, the manual switch may inadvertently be left in the on position even though the photocontrol has turned off the lights. At sunset, the photocontrol will turn the lights on even though the facility is vacant.

Solving this problem requires a combination of controls. Use a timeclock to keep the lights turned off during hours of darkness when the space is normally unoccupied. In addition, install another type of automatic control, such as a motion sensor, to override the timeclock if people are present during these hours.

Types of Photocontrols

Most photocontrols are designed for exterior lighting. They are rugged and inexpensive, but they

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Fig. 3 Why are all these lights turned on? This atrium in a government building is excessively illuminated by a huge skylight. The illumination provided by the light fixtures is not noticeable during the daytime. A single inexpensive photocontrol could save a lot of money and many light bulbs in this area alone.

lack setting flexibility. They are described in Measure 9.5.2. Interior photocontrol is uncommon, so the market does not offer a wide selection of photocontrols intended specifically for indoor applications, although some are entering the market. You can use exterior photocontrols for interior applications, but you may have to be creative in how you install them.

How to Install Interior Photocontrols

Interior photocontrol usually is part of a system consisting of several types of lighting control. Designing the system requires some thought, and installation details are important. Work out the following issues carefully.

■ Sensor Location and Orientation

Choosing the location of the light sensors is tricky. Remember that the purpose of the sensor is to detect how much daylighting is available within the space, not to sense the total lighting level. Therefore, aim the sensor somewhat toward the outside, so that it senses the available daylighting without being influenced too much by the electric lights inside the space.

On the other hand, if you aim the sensor too far outside the space, it will see a scene whose brightness does not correspond to the amount of sunlight entering the space. Also, this can lead to situations that trick the sensor into turning the lights off. For example, if the sensor looks toward a parking lot, reflections of the sun from the windshields of parked cars may blind the sensor. Or, reflections from the windows of adjacent buildings may do the same thing.

To minimize these difficulties, locate the sensor as close to the perimeter as possible. Ideally, you would like to install the sensor outside the window, looking inward. If there is a soffit over the window, consider this seriously. If you choose this arrangement, be careful to install the sensor so that it cannot be fooled by reflections from the glass.

Sensors mounted on swivels are worth the small additional cost. They provide flexibility in mounting, and they make it easy to experiment to find the best orientation. Figure 6 shows a unit that has this feature.

■ Number of Sensors

Use separate sensors for each area that has a different response to exterior changes in sunlight. For example, use separate sensors for spaces that face in different directions, and for spaces that fall into the shadow of adjacent buildings at different times of day.

One sensor can control any number of fixtures, either directly or through a power relay. However, sensors are cheap in comparison with the cost of wiring labor. This makes it more economical to install a sensor in each lighting circuit, rather than extending the wiring to allow a single sensor to control a larger area.

■ Light Sensitivity Settings

Most photocontrols allow you to adjust the light levels at which the fixtures turn on and off. Most inexpensive photocontrols achieve this with a simple shutter that changes the amount of light entering the light sensor. However, even with the shutter set to admit minimum light, exterior photocontrols typically turn lights off when the illumination level rises to about 15 footcandles (150 lux). This may be adequate for corridors and other peripheral areas, but it is too dim for most work activities. For example, offices and retailing typically require about 50 footcandles (500 lux).

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Fig. 4 Area surrounding a large, brightly lighted atrium This area deserves several photocontrols. The inner and outer rows of light fixtures should have separate control. And, each side of the atrium should have separate control.

You can solve this problem by installing a simple light-absorbing filter in front of the sensor. For example, make the filter from translucent plastic diffuser material. Each sheet typically has a transparency of about 60%, so three layers reduce the light to the sensor by a factor of about five. Keep plastic diffuser material out of direct sunlight and away from light fixtures, as heat and ultraviolet light darken it.

Ordinary exterior photocontrols typically turn lights off at about three times the lighting level at which they turn lights on. In inexpensive photocontrols, this ratio is fixed. The wide ratio keeps small fluctuations in the light level from cycling the lights on and off. Clouds passing in front of the sun reduce sunlight by a factor of three to five. This is not likely to cause much cycling, unless maximum and minimum light levels happen to coincide with the upper and lower limits of the photocontrol.

The wide on-off ratio also makes the orientation of the sensor less critical. It allows the sensor to be aimed more into the space, where it senses artificial light along with daylight, without the risk of short-cycling the lights.

To save as much energy as possible, adjust the photocontrol to turn on the lights at the lowest acceptable lighting level. Unfortunately, the wide on-off ratio keeps the lights on until the light level in the space has risen considerably. How much energy saving is lost by this factor depends on the geometry of the space, the effectiveness of daylight distribution, and other factors that are covered in Reference Note 46, Daylighting Design.

Explain the Controls to the Occupants

Install effective placards to inform occupants how the lighting is controlled. This will get them interested, and minimize annoyance. See Measure 9.4.1 about placards.

Arrange Circuits to Maximize Daylighting Potential

Lighting control cannot exploit daylighting unless the fixtures are grouped in a way that corresponds to the availability of daylight in the space. For example, if the space has a continuous row of windows, the fixtures should be wired in rows parallel to the windows, with each row switched separately. The outer row of fixtures is turned off during most daylight hours, the next row is turned off for a lesser period of time, and so forth.

In existing buildings, you may have to rearrange the light fixture circuits to make daylighting possible. See Measure 9.6.4 for details.

There are various techniques that you can use to increase the raw amount of daylight that is available to exploit. See Reference Note 46 and Subsection 8.3 for the full story.

Alternative Method: Dimming Controls

If switching lamps on and off is not acceptable as a method of exploiting daylight, consider automatic dimming controls. These change the output of fixtures smoothly in response to the light level in the space.

Automatic dimming has become a fairly reliable technique with fluorescent lighting. Fluorescent dimming requires special electronic dimming ballasts

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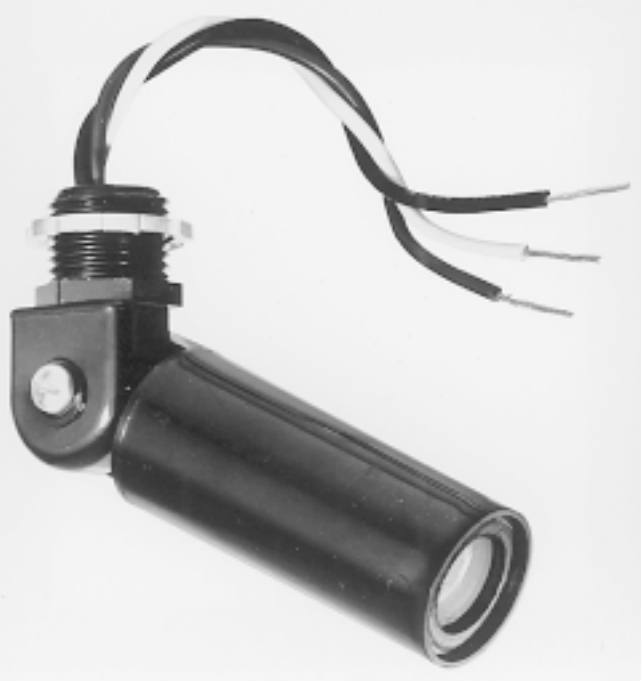
Fig. 5 Puffy clouds Cumulus clouds like this are the worst problem for daylighting control because the clouds are small and thick. Thus, the light level changes are large, abrupt, and frequent. Think of this situation when you decide whether to use photocontrol for interior lighting.



Paragon Electric Company, Inc.

Fig. 6 Photocontrol with swivel base The ability to point the sensor accurately is important. Aiming the sensor for proper response can be tricky, and it is likely to require trial-and-error.

and controls that respond to daylight. The best equipment can control the output of fluorescent lamps over a wide range. However, fluorescent dimming is much more expensive than on-off photocontrol. See Measure 9.2.6 for the full story.

HID lighting can be dimmed over a limited range. It is not yet well established. See Measure 9.3.2 for the details.

Automatic dimming is not commercially available for incandescent lighting. The best way to save energy with incandescent lighting is to get rid of it.

ECONOMICS

SAVINGS POTENTIAL: *30 to 70 percent of the energy used by controlled fixtures. Lamp cost and replacement labor may be reduced by a similar percentage.*

COST: *Common photocontrols designed for exterior applications cost less than $10 apiece. The cost of wiring and finish work varies widely, averaging perhaps several hundred dollars per sensor.*

PAYBACK PERIOD: *Less than one year, to several years.*

TRAPS & TRICKS

PLANNING: *Wherever daylight enters a building, consider using it instead of electric lighting. Make sure that occasional abrupt changes of lighting level are acceptable to occupants. Lay out the fixture wiring to exploit daylight as much as possible. Be sure to satisfy all lighting needs, including emergency and off-hours lighting.*

INSTALLATION: *Expect to spend some time finding the best sensor location for each space. Be sure to install informative placards.*

MONITOR PERFORMANCE: *This is still an experimental activity. It affects occupant comfort and productivity. Monitor it carefully, until you are sure that lighting needs are satisfied under all conditions. Expect to make adjustments. Schedule periodic checks in your maintenance calendar.*