Energy Efficiency and Renewable Energy
Federal Energy Management Program

How to Select Lighting Controls For Offices and Public Buildings

Why Agencies Should Buy Efficient Products

- *Executive Order 13123 and FAR section 23.704 direct agencies to purchase products in the upper 25% of energy efficiency, including all models that qualify for the EPA/DOE* ENERGY STAR® *product labeling program.*
- *Agencies that use these guidelines to buy efficient products can realize substantial operating cost savings and help prevent pollution.*
- *As the world's largest consumer, the federal government can help "pull" the entire U.S. market towards greater energy efficiency, while saving taxpayer dollars.*

Federal Supply Source:

- Defense Logistics Agency (DLA) offers occupancy sensors, dimmable ballasts, and other lighting controls equipment.
  Phone: (800) DLA-BULB
  dscp103.dscp.dla.mil/gi/general/light1.htm

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and World Wide Web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  www.eren.doe.gov/femp/procurement
- Illuminating Engineering Society of North America (IESNA) publishes helpful information on lighting products, including controls.
  Phone: (800) 862-2086
  www.iesna.org
- Lighting Research Center has references to documents on lighting controls, including the National Lighting Product Information Project (NLPIP).
  Phone: (518) 687-7100
  www.lrc.rpi.edu/NLPIP/online/pubs.html
- Lightsearch.com provides a tool for searching for controls product, as well as other valuable lighting resources.
  www.light-link.com
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 646-7950

Typical Lighting Control Applications[a]

Type of Control	Private Office	Open Office – Daylit	Open Office – Interior
Occupancy Sensors	++	++	++
Time Scheduling	+	++	++
Daylight Dimming	++	++	0
Bi-level Switching	++	+	+
Demand Limiting	+	++	++

a) ++ = good savings potential; + = some savings potential; 0 = not applicable

Definitions

Daylight dimming employs sensors that detect ambient light levels and then allow ballasts to dim nearby lights.

Bi-level switching uses two separate on-off controls, usually manual switches, to operate different lamps (bulbs) within a light fixture.

Demand limiting refers to centralized control of lighting, usually by dimming or bi-level switching, in order to reduce electrical demand at high-cost times (or to prevent outages).

Lighting Controls: Where and Why

Lighting controls can save energy and reduce peak demand in offices and other facilities. Controls save money while providing user convenience and an improved lighting environment. There are several different kinds of controls. The choice of control type should be based on lighting usage patterns and the type of space served (see table, above).

Areas with intermittent occupancy are well-suited to occupancy sensors. In large, open office areas with many occupants, scheduled switching ("time scheduling") is often an effective energy-saving strategy. In daylit offices, properly adjusted daylight sensors with dimming ballasts make sense. Because some workers prefer lower lighting levels, bi-level manual switching is another option. Advanced lighting controls can be used for demand limiting to allow building managers to reduce lighting loads when electricity demand costs are high.

Some types of lighting are not well suited to certain controls. For example, daylight dimming and occupancy sensing are not generally appropriate for high intensity discharge (HID) lighting (which requires a delayed re-start), whereas time scheduling is usually a good match for HIDs.

Lighting Control Types

Characteristics of the most common lighting controls for offices and other public buildings are outlined below:

Occupancy Sensors

Occupancy sensors are the most common lighting control used in buildings today. Two technologies dominate: infrared and ultrasonic. Infrared sensors detect temperature changes in a room, and work well where the entire room is within the sensor's field of view. Ultrasonic sensors use high frequency sound, much like bats do, to detect motion (even around corners). Dual-technology sensors use both methods, increasing accuracy and flexibility, but at a higher price. Even though lamp running life may be somewhat shortened by increased switching due to occupancy sensors, the overall chronological life of lamps is usually extended by the reduced daily burn hours.

Definition

Infrared, or "heat," radiation is given off by humans. Infrared sensors can easily detect the change in radiation when a person enters, or moves within, a space.

Time Scheduling

Large open office areas work well with simple time scheduling – automatic switching at fixed hours of the day. Overrides allow users to turn on the lights after hours (using wall switches or telephone dial-up codes). Time scheduling can be accomplished with simple time clocks or more sophisticated computer controls. To save more energy, time scheduling systems can be designed so that lights are turned on manually rather than automatically at the beginning of the day, but are turned off automatically at 1- or 2-hour intervals after close of business.

Bi-level Switching

Some people prefer lower overhead lighting levels (especially if daylight is available). Lower light levels are often preferred for computer use, meetings or tasks that are not visually demanding. Bi-level switching can provide simple manual control. For example, in a typical 3-lamp fluorescent fixture, the outer lamps are switched separately from the middle lamp, allowing the user to switch on one, two, or all three lamps. This low-cost measure is a minimum control requirement in some state energy codes, and can provide a simple means of load-shedding during peak hours if the bi-level lighting circuits are remotely controllable.

Manual Dimming

In rooms where different light levels are needed at different times, such as conference rooms and some private offices, the use of manually-operated dimming controls is a common solution. These controls can be either wall-mounted or, for convenience, use wireless remote controls (like the controls for a TV or VCR).

Automatic Daylight Dimming

Automatic daylight dimming, or "daylighting," uses a light sensor to measure the amount of illumination in a space. Then, light output from a dimming ballast is adjusted to maintain the desired level of illumination. The combination of daylight dimming with appropriate task lighting is often very effective.

Definition

Illuminance is the amount of light striking a surface, usually measured in footcandles (fc) or lux (lx).

Corridors and open cubicles near windows, particularly those with task lighting, are good candidates for daylighting controls. Private offices with windows can also be equipped with individual daylight sensors. Initial commissioning and calibration of light sensors and controls is critical for effective daylighting, however; poorly calibrated daylight sensors can result in little or no savings, and may annoy occupants.

Demand Limiting

During peak demand periods utilities often charge significantly higher prices for electricity. Remote operation of dimming ballasts or bi-level switching helps operators to respond to price signals or utility requests to shed load to help avoid power outages.

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Operating Cost Comparison: Private Office, 128 sq. ft.

Performance	Base Case	Occupancy Sensors	Daylighting	Occupancy Sensor + Daylighting
Annual Energy Use[a]	450 kWh	340 kWh	330 kWh	250 kWh
Annual Energy Cost	$33	$24	$24	$18
Annual Energy Cost Savings	–	$9	$9	$15

a) Average daily "on" hours for wall switch is 14.7. Average daily occupied hours for the office is 12.9.

Operating Cost Comparison: Open Office Area, 1000 sq. ft.

Performance	Base Case	Time Scheduling	Occupancy Sensors	Daylighting	Time Scheduling + Daylighting
Annual Energy Use[a]	5700 kWh	5100 kWh	5000 kWh	4200 kWh	3700 kWh
Annual Energy Cost	$340	$305	$300	$250	$220
Annual Energy Cost Savings	–	$35	$40	$90	$120

a) Average daily "on" hours for wall switch is 9.1. Average daily occupied hours for the office is 6.8.

Assumptions

Each of the two Operating Cost Comparisons, left, assumes that the workspace has approximately 1.5 watts per square foot of ceiling lighting, with parabolic troffer luminaires containing T-8 lamps and electronic ballasts. Daylighting examples assume a design light level of 55 footcandles at work surfaces. The assumed electricity price is 6¢/kWh, the federal average electricity price (including demand charges) in the U.S.

Appropriate Illumination Levels

Proper illumination levels depend on the type of work being performed, and on occupant preference. Recommended illuminance levels for offices range from 30 to 60 footcandles, but the quality of the visual environment can have a substantial impact on the "appropriate" amount of illumination. In well-designed office spaces, with light-colored surfaces, appropriate task lighting, and careful placement of lights and furniture to avoid glare and shadows, much lower illuminance levels are acceptable, and usually even preferred.

Installation and Maintenance

Proper placement and orientation of both daylight and occupancy sensors is essential. Placement of controls should take into account furniture placement as much as possible. Occupancy sensors must be able to sense all occupants to avoid turning off lights while the space is occupied. At the same time, "false-on" incidents can be triggered by an automatic on/off sensor that is exposed to passersby in an adjoining hallway. Daylight sensors that are placed where they are exposed to an amount of daylight not proportionate to the daylight at the desktops being served will not properly control lighting levels (and will likely result in dissatisfied users who may attempt to disable the control system).

Set time scheduling controls so that the switching times and intervals make sense for the occupants and usage pattern of the space. Occupants need to know how to override the schedule easily when needed.

Choose daylight sensors that can be calibrated quickly and easily, and take the time to calibrate them correctly. The dimming adjustment should be easily accessible to the installer and provide an acceptable range of dimming.

Commissioning and calibration of lighting controls are essential if energy savings are to be achieved and maintained. Occupancy sensors with sensitivity set too high can fail to save energy, but occupancy sensors with too low a sensitivty or too short a delay time can be annoying to occupants. Similarly, improperly adjusted daylighting controls can dim the lights too low, causing occupants to override them (e.g., by taping over the sensor), or can fail to dim the lights at all.

Definition

Automatic on/off sensors switch on when they sense an occupant and off when they don't. Better energy savings are usually attained from sensors that are manual-on/automatic-off. These avoid unneeded turn-ons.

Metric Conversions

1 Foot = 305 mm
1 Footcandle = 10.8 lux

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Case Study: The Phillip Burton Federal Building

The U.S. General Services Administration took advantage of a floor-to-floor re-modeling already planned (for asbestos abatement) in San Francisco's Phillip Burton Federal Building. Various control combinations of daylighting, occupancy sensing, manual dimming, and time scheduling were installed and carefully monitored to allow GSA to learn how to make best use of lighting controls in the office spaces it manages nationwide.

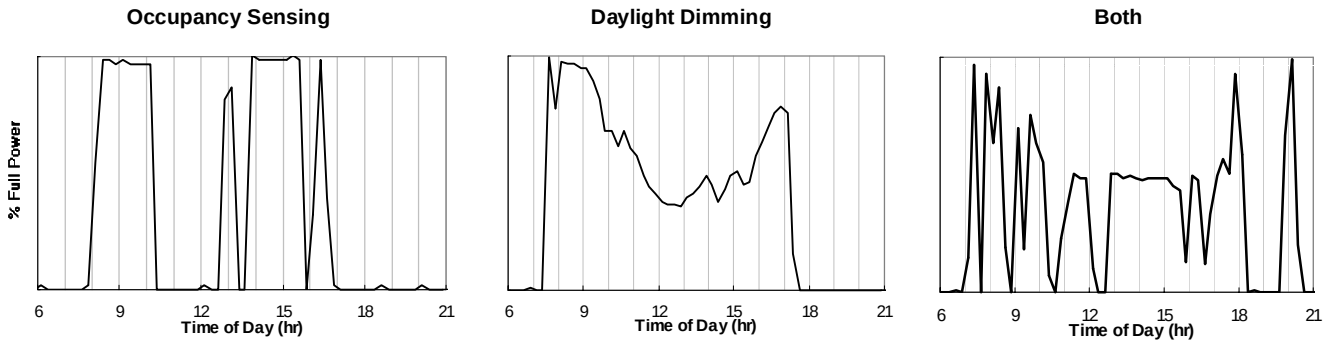
The original lighting design in this facility was typical of large leased-space office buildings. In "open-plan" areas, three-lamp parabolic troffers were evenly spaced on 8-ft. centers over the entire ceiling, without regard to furniture placement. In most private offices, two 3-lamp fixtures were spaced evenly in the ceiling.

In the new design, daylight dimming is used in both private offices and open-plan perimeter areas with daylight access, with and without occupancy sensors. Manual dimming and bi-level switching were tested in private offices.

In half of the open-plan interior (without daylighting) office areas, dimming ballasts allow adjustment of the light levels either manually, or through use of "closed-loop" light sensors to maintain a constant level of illumination. The dimming ballasts also permit reducing lighting loads at times of peak demand using the building energy management system.

As shown below, savings were impressive. In private offices, the use of occupancy sensors alone reduced lighting energy by 25% on weekdays. Automatic daylight dimming saved an average of 27% of lighting energy, and the combination of both the sensors and dimming saved approximately 45%. In open daylit offices, savings from daylighting alone were also substantial, particularly in the first and second cubicle rows from windows (especially south-facing ones).

Open interior offices with time scheduling or occupancy sensors saved about 10% over wall switches alone. In open areas close to windows, automatic daylighting saved more than a quarter of previous lighting energy, and more than a third when combined with either occupancy sensing or time scheduling.



Lessons Learned

Some key findings from the GSA lighting controls project provide useful guidance for building owners and managers:

- Proper installation and adjustment of lighting controls are essential to both occupant satisfaction and energy savings.
- Properly adusted occupancy sensors reliably save energy.
- In areas with available daylight, well-designed and adjusted automatic daylight dimming systems can save a substantial amount of energy.
- The choice between time-scheduling and occupancy sensing controls for a given open-plan space depends on several factors, including budget, variations in occupancy patterns, and the frequency of after-hours use. Time-scheduled controls (with overrides for those working late) may be as effective in some cases, especially where the primary savings comes from assuring that lights are turned off after normal business hours.
- In private offices whose occupants travel a lot or who move from place to place within the building frequently, occupancy sensors tend to save more than daylighting, but in window offices where the occupants work most of the day at their desks automatic daylighting provides greater savings.
- Occupant preferences vary: Some occupants with bi-level switching choose partial light levels consistently, while others always choose full lighting.
- For new construction or major renovation, designing lighting circuits to be switched in smaller "zones" has many advantages, especially where these zones conform to similar usage patterns and similar levels of daylight availability. Small lighting zones with dimming controls can also allow individual workers to adjust lighting levels to their own preferences, and to switch on only a few lights when they work late.