2013 TITLE 24, PART 6

LIGHTING FOR OFFICE APPLICATIONS

A guide to meeting, or exceeding,
California's 2013 Building Energy Efficiency Standards

DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS

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This guide is designed to help builders and lighting industry professionals become more familiar with the office nonresidential lighting portion of California's 2013 Building Energy Efficiency Standards (Title 24, Part 6).

The guide provides information on current lighting technologies, lighting design terms and principles, and best-practice recommendations. It is designed to complement lighting courses developed through CLTC and sponsored by Pacific Gas and Electric Company through its Energy Education program.

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2013 TITLE 24, PART 6:
LIGHTING FOR OFFICE APPLICATIONS

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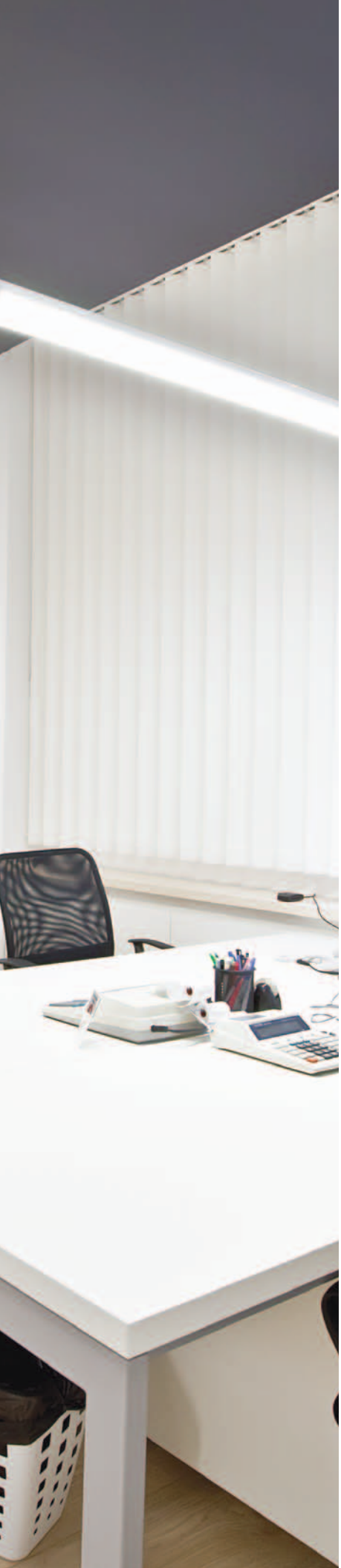

CHAPTER 1

INTRODUCTION

THE BENEFITS OF EFFICIENCY

Bigger Energy Savings

Making office buildings more energy efficient reaps benefits including environmental and cost savings. The lighting requirements of California's Title 24, Part 6 Building Energy Efficiency Standards are aimed at reducing energy use while maintaining high-quality lighting.

Commercial buildings, which include office buildings, are one of the largest energy users in the United States. Today's commercial buildings consume 36% of U.S. energy, release 18% of carbon dioxide emissions and cost more than $190 billion in energy each year, according to the Department of Energy's Office of Energy Efficiency & Renewable Energy.

Office buildings make up the largest sector of building type within the commercial sector, comprising 17% of all commercial buildings in the U.S. and 19% of the energy, according to the DOE's Buildings Energy Data Book. In 2010, commercial interior lighting accounted for nearly 49% of California's lighting energy use.[1]

The potential to reduce energy consumption in existing and commercial buildings is enormous. On average, 30% of the energy used in commercial buildings is wasted, according to the U.S. Environmental Protection Agency. Lighting has the largest potential for energy savings for any U.S. building end use, with a significant fraction of that potential coming from lighting controls, which including occupancy, daylighting, institutional tuning, and personal control.[2]

Some of the drivers influencing the installation of lighting controls are energy code requirements, green building design, energy efficiency, and safety and security.

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[1] *Jackson, Cori and Konstantinos Papamichael. (California Lighting Technology Center, University of California, Davis). 2014. Lighting Electricity Use in California – Baseline Assessment to Support AB 1109. California Energy Commission.*

[2] *Williams, Alison A., Barbara A. Atkinson, Karina Garbesi, and Francis M. Rubinstein. 2012. (Lawrence Berkeley National Laboratory). Quantifying National Energy Savings Potential of Lighting Controls in Commercial Buildings.*

Dimmable light sources paired with advanced lighting controls reduce energy use while adding flexibility to lighting designs. Today's offices serve multiple functions and their lighting needs may change. Smart lighting systems allow employers to adjust lighting quickly, maximizing the benefits of work stations while saving employee time.

Some factors to consider in office lighting design include human needs such as visibility, safety, and visual comfort; environmental and economic issues such as energy and equipment costs and sustainability; and how well the lighting complements the building design. A successful lighting design utilizes the right equipment to maximize visual comfort while reducing costs and the carbon footprint.

Types of Use

The lighting technology and use trends are similar for the commercial and industrial sectors. These consumers are typically facility managers who are concerned about the lifetime costs of a product. Lighting products with high efficacy and long lifetimes are more popular despite higher initial costs. This is why linear fluorescent and high-intensity discharge (HID) submarkets dominate these sectors, representing 80% and 99% of the installed lumen-hour base of commercial and industrial markets. Light emitting diode (LED) products provide promise in reducing energy use in the commercial and industrial sectors whose consumers require long operating hour requirements and a high value on the annual costs of a lighting product.[3]

[3] *Navigant Consulting, Inc., January 2012. Energy Savings Potential of Solid-State Lighting in General Illumination Applications. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy.*

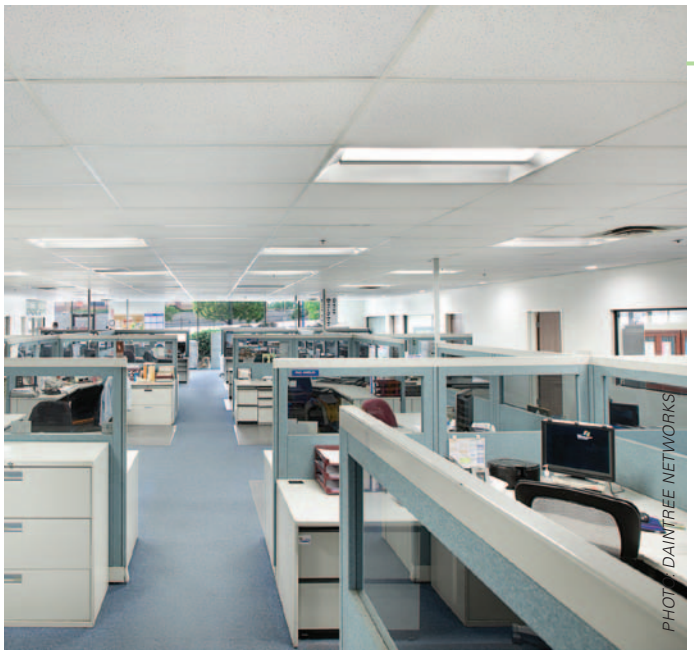


PHOTO: DAINTREE NETWORKS

United Stationers
Sacramento, California

United Stationers achieved a significant monthly lighting savings of 94% by installing LED fixtures and Daintree's ControlScope smart building control solution at its Sacramento office facility. The new lighting system allows them to see the status of their lighting facility-wide via internet and provides maximum granular control along with automated ON/OFF switching, daylight and motion sensing to deliver dramatic energy savings while improving employee productivity and overall comfort. The project results included:

- Pre-project wattage (fluorescent fixtures): Office area: 21,672 watts
- Post-project wattage (LED fixtures): Office area: 3,930 watts
- Total savings: 94%
- Savings attributable to ControlScope control system: 41%

A case study is available at: ***daintree.net/wp-content/uploads/2014/02/cs_daintree_unitedstationers_web.pdf***

ABOUT THIS GUIDE

This guide is designed to help builders, lighting designers, contractors, and other end users become more familiar with the lighting portion of California's 2013 Title 24, Part 6 nonresidential standards as they apply to office spaces. It is designed to serve as a resource for lighting industry professionals involved in the construction, maintenance, or retrofit of California's office buildings. The guide includes compliance requirements and recommendations for implementing the standards in new construction or renovation projects.

The Compliance Process

The guide begins with an overview of the compliance process including the responsibilities, requirements and documentation involved in each phase of a project, from design to final inspection.

Technology Overview

This section is devoted to lighting concepts and principles such as color rendering, color temperature, light output, and lamp life. These concepts are vital for making informed decisions about lamps, luminaires and controls.

This portion of the guide also describes luminaire classification under the standards, control strategies, and control systems relevant to most office applications.

Compliance Requirements

Mandatory code requirements related to electric lighting, daylighting and lighting controls in office buildings are explained in Chapter 4. This chapter also examines the prescriptive requirements of Title 24, Part 6, including the available methods used to calculate allowed lighting power.

Designing to Code

This section of the guide includes recommendations for meeting and exceeding the lighting standards in office applications.

NOTE: This guide is not intended to be used in lieu of California's Title 24 Building Energy Efficiency Standards, and it is not a substitute for the code itself. Please visit **www.energy.ca.gov/title24** to obtain the official 2013 Title 24 Building Energy Efficiency Standards, Errata, Reference Appendices, and the Nonresidential Compliance Manual. To request a hard copy of the standards, contact the California Energy Commission's publications unit at (916) 654-5200.

THE COMPLIANCE PROCESS

The following is an overview of the compliance process for nonresidential lighting. Additional information and resources, including the 2013 Nonresidential Compliance Manual and forms may be found on the California Energy Commission website:
energy.ca.gov/title24/2013standards

Step 1: Comply with All Mandatory Measures

All nonresidential buildings must be designed and built to comply with the **mandatory measures** of Title 24, Part 6.

Step 2: Comply with All Prescriptive Requirements

In addition to meeting the mandatory requirements, commercial buildings must also meet lighting power density (LPD) requirements specified within the standards. Two approaches may be taken to meet these requirements:

The **Performance Approach** provides one path to compliance. It requires using software approved by the Energy Commission and is best suited for use by experienced professionals familiar with Title 24. This method allows for energy trade-offs between building systems. For example, under the performance approach, efficient lighting can allow for a larger portion of the energy budget to be allocated to heating and cooling loads.

The **Prescriptive Approach** does not require software or the same level of building design expertise as the Performance Approach. This guide focuses on the Prescriptive Approach. With this approach, designers may use one of the following methods to ensure each area of the office space is in compliance:

Complete Building Method: The Complete Building Method may only be used in projects involving entire buildings with one primary use, or in mixed-use buildings or tenant spaces where 90% of the spaces have one primary use.

Area Category Method: A single lighting power allowance (LPA) is applied to all lighting in a given space. Different office space types are allowed different LPA.

Tailored Method: This detailed method is often used for retail applications, and rarely for office spaces.

Step 3: Verify Compliance

After choosing a compliance method, calculate the actual LPD of the building or spaces within the building. This value should not exceed the allowed LPD specified in the standards. If the lighting design does not comply, then it will have to be revised to achieve a lower LPD.

Step 4: Prepare and Submit Plans

Once the standards have been met, the design team must ensure that the plans include all the documents that building officials will require to verify compliance. Plans and compliance forms are submitted to the enforcement agency at the same time as a building permit application.

Step 5: Pass Inspection and Receive Permit

A building department plans examiner must check that the building or system satisfies Title 24 requirements and that the plans contain the information to be verified during field inspection. A building permit is issued after plans are approved.

Step 6: Complete Construction

The installation team must follow the approved plans and specifications during construction. The building department field inspector(s) must verify that the building or lighting project follows the plans and specifications approved when the building permit was issued.

Step 7: Commission Building Systems

Once construction is complete, the contractor and/or the design team must properly commission the building and its systems. The contractor and/or design team must also advise the building operators of their responsibilities to comply with Title 24 standards. They must provide information or training on how to maintain and operate the building and its energy features.

Step 7: Pass Inspection by an Acceptance Test Technician

Title 24, Part 6 requires that Certified Lighting Control Acceptance Test Technicians (CLCATTs) review and test lighting controls installations to ensure controls operate as required by the standards.

CLCATTs trained and certified through an approved curriculum provider will:

- Review installation certificates and associated documentation
- Test installations to ensure controls are positioned and calibrated to operate in compliance with the standards
- Check that all necessary set points or schedules are in place as required by the standards
- Fill out required Certificates of Acceptance and submit these to the enforcement agency

Visit **energy.ca.gov/title24/attcp** for information on CLCATT certification providers.

Step 9: Provide Documentation to Building Owners

Upon occupancy, the building owner must receive copies of the energy compliance documents, including Certificates of Acceptance, along with instructions for operation and maintenance.

CALCTP-AT Technician Training

calctp.org

CALCTP is one of two training and certification programs recognized and approved by the Energy Commission to carry out lighting controls acceptance testing as required by Title 24, Part 6.

In order to be certified as a CALCTP Acceptance Test Technician, a person must:

- *Be employed by a listed CALCTP-certified employer:* ***calctp.org/acceptance-technicians/contractors***
- *Have at least three years of experience with lighting controls*
- *Register on the CALCTP website:* ***calctp.org/acceptance-technicians***
- *Take the training course offered at one of the CALCTP training centers:* ***calctp.org/training-center-list***

INDOOR LIGHTING COMPLIANCE DOCUMENTS

The compliance process includes the completion of an extensive set of forms to submit for review by a plans examiner within the authority having jurisdiction. Not all forms are required for all projects. Instructions for completing these forms are provided in **Section 5.10** of the Energy Commission's Nonresidential Compliance Manual. The Energy Commission plans to have electronic documents replace paper documents for nonresidential building projects in 2015.

NR CC – LT I – 01 – E

NR: Nonresidential

CC: Certificate of Compliance
CA: Certificate of Acceptance
CI: Certificate of Installation

LT: Lighting

O: Outdoor
I: Interior
S: Signs

Number in Sequence

E: Used by Enforcement Authority
A: Used by Acceptance Tester

Certificates of Compliance

Compliance forms and plans are submitted at the same time that a building permit application is submitted to the enforcement agency (see Step 4 in the compliance overview).

NRCC-LTI-01-E	Indoor Lighting
NRCC-LTI-02-E	Indoor Lighting Controls
NRCC-LTI-03-E	Indoor Lighting Power Allowance
NRCC-LTI-04-E	Tailored Method Worksheets
NRCC-LTI-05-E	Line-Voltage Track Lighting Worksheet

NRCC-LTI-01-E, **NRCC-LTI-02-E** and **NRCC-LTI-03-E** are required for all projects. **NRCC-LTI-04-E** must be submitted when the tailored method is followed for prescriptive compliance. **NRCC-LTI-05-E** is required when line-voltage track lighting is installed.

Because lighting power trade-offs are not allowed between conditioned and unconditioned spaces, most nonresidential indoor lighting compliance documents must be completed separately for conditioned and unconditioned spaces.

Certificates of Installation

These forms, signed by licensed individuals, certify that the lighting installed for the project corresponds with the lighting proposed on the Certificates of Compliance.

NRCI-LTI-01-E	Validation of Certificate of Compliance (All Buildings)
NRCI-LTI-02-E	Energy Management Control System or Lighting Control System
NRCI-LTI-03-E	Line-Voltage Track Lighting
NRCI-LTI-04-E	Two Interlocked Lighting Systems
NRCI-LTI-05-E	Power Adjustment Factors
NRCI-LTI-06-E	Video Conferencing Studio Lighting

Certificates of Acceptance

An ATT trained and certified through a state-approved program must complete forms **NRCA-LTI-02-A**, **NRCA-LTI-03-A** and **NRCA-LTI-04-A** when required. The forms are also signed by the responsible party and the document author, if different than the ATT. Information in these forms certifies that the lighting controls were tested and operate in compliance with the standards:

NRCA-LTI-02-A	Lighting Controls
NRCA-LTI-03-A	Automatic Daylighting Controls
NRCA-LTI-04-A	Demand Responsive Lighting Controls

NEW IN THE 2013 STANDARDS: AN OVERVIEW OF UPDATES

For those familiar with the 2008 standards for nonresidential indoor lighting, these are the most significant changes that affect office lighting.

More alterations trigger compliance upgrades

Alterations now include projects where at least 10% of all luminaires in the enclosed space are altered (the threshold was 50% in the 2008 standards). When at least 40 luminaires in a building (or on a floor if the building has multiple floors) are modified in the locations where they are currently installed in the course of a year, Title 24 requirements are also triggered. A new category, luminaire modifications-in-place, has been added for these projects.

New controls required, dimmable steps expanded

Occupancy-based, automatic-shutoff controls are now required in more spaces, with an increased number of steps required for mandatory multi-level lighting controls. General and display lighting must automatically shut OFF when buildings are unoccupied.

Acceptance test requirements expanded

Acceptance tests must now be performed to verify compliance for automatic daylighting controls, shut-off controls (indoor and outdoor), and demand response (DR) controls. Lighting controls acceptance test technicians must be certified through a training program approved by the Energy Commission. More information is at: **energy.ca.gov/title24/attcp**

Automatic daylighting controls now mandatory

Daylight harvesting is now mandatory in the primary daylit and skylit zones, except for areas with less than 24 ft^2 of glazing and less than 120 watts of total general installed lighting power in the combined primary daylit and skylit zones. Under the prescriptive approach, automatic daylighting controls are also required for the secondary sidelit zone.

Demand response required in buildings 10,000 ft^2 and larger

The 2013 code expands DR requirements to include all commercial buildings 10,000 ft^2 in size or larger. The lighting system must be capable of automatically reducing lighting energy use at least 15% in response to a DR signal.

FINDING COMPLIANT PRODUCTS

Certain devices must be certified to the Energy Commission as meeting California's Appliance Efficiency Standards (Title 20 of the California Code of Regulations). Others are regulated under the Building Energy Efficiency Standards (Title 24, Part 6).

Products Regulated Under Title 20

The following lighting appliances must be certified under Title 20:

- **Fluorescent lamp ballasts** (**Section 110.1**)
- **Lighting control devices** (**Section 110.9**)
  - Time-switch lighting controls: automatic time-switch controls, astronomical time-switch controls, multi-level astronomical time-switch controls, outdoor astronomical time-switch controls
  - Daylighting controls: automatic daylight controls, photo controls
  - Dimmers
  - Occupant sensing controls: occupant sensors, motion sensors, vacancy sensors, partial-ON sensors, partial-OFF sensors

Products Regulated Under Title 24

The following lighting control devices are regulated under **Section 110.9** of Title 24, instead of Title 20:

- Part-night outdoor lighting controls (**Section 100.1**)
- Track lighting integral current limiter (**Section 110.9**)
- Supplementary overcurrent protection panels for use with line-voltage track lighting
- Field-assembled lighting control systems

Lighting specifiers wishing to work with a product not yet listed in the Appliance Efficiency Database can encourage the manufacturer or a pre-approved third-party certifier to submit appliance certification data to the Energy Commission.

Appliance Efficiency Database

The Energy Commission's database lists a variety of products certified as meeting Title 20 or Title 24 requirements, including lamps, ballasts, and lighting controls.

ENERGY STAR®

While many Energy Star products meet California's efficiency requirements, not all Energy Star labeled products comply with Title 20 and Title 24 standards. In some cases, California's compliance requirements are more stringent.

DesignLights Consortium®

The DesignLights Consortium (DLC) maintains a Qualified Products List that provides information on available products for the commercial sector that passed a review of test results as verification of performance for listed products. Members of the DLC are comprised of regional, state, utility, and energy efficiency programs throughout the United States and Canada. Products on the list are often eligible for incentives through participating programs.

Appliance Efficiency Database

appliances.energy.ca.gov

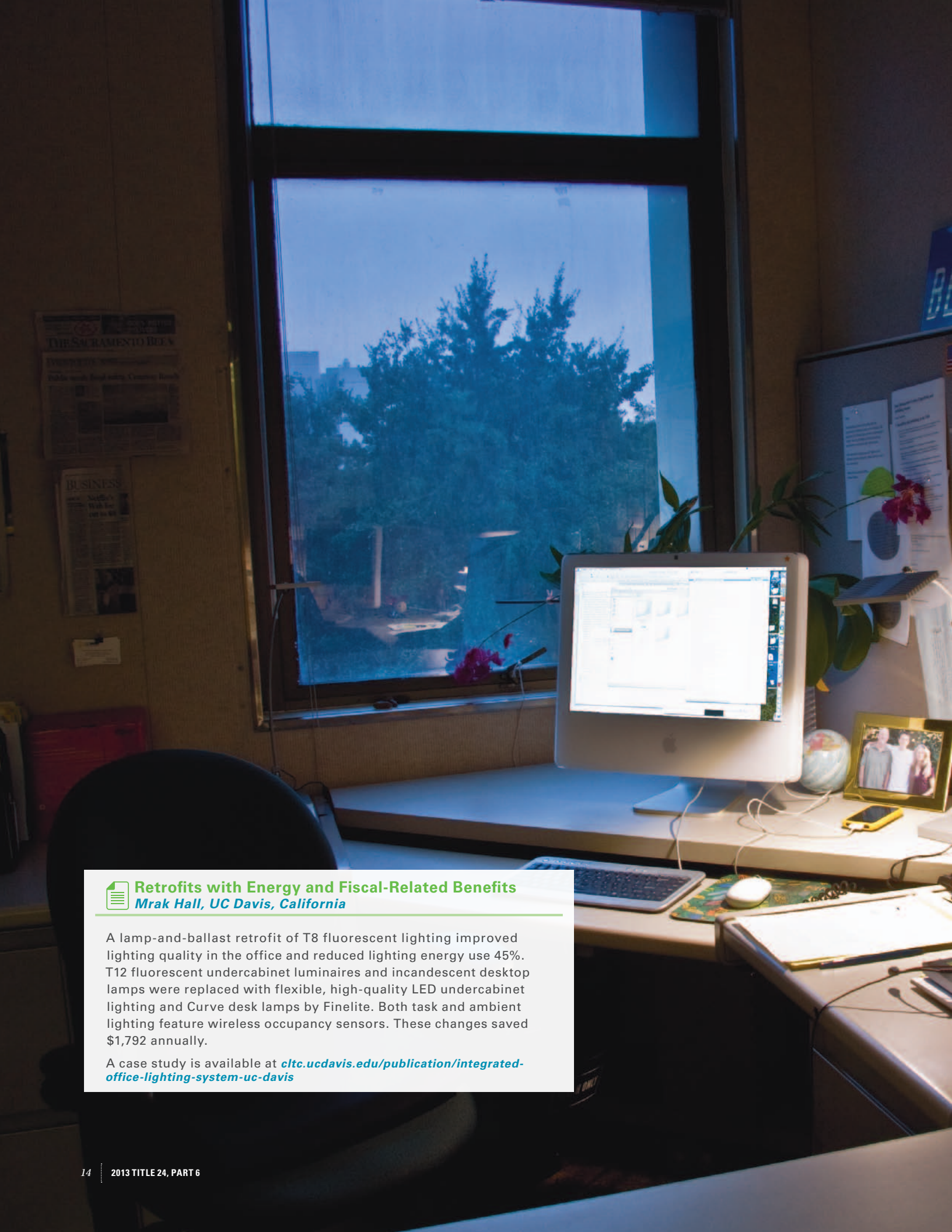
This online database of products certified to the Energy Commission has a Quick Search function allowing users to search by product type, brand or model.

PHOTO, CLTC, UC DAVIS

Luminaires & Lamps

"Luminaire" is the lighting industry's term for what is also commonly described as a light fixture. A luminaire consists of the housing, power supply (ballast, transformer or driver), lamp, and optical components such as reflectors or lenses.

"Lamp" is the lighting industry's term for a light bulb. Desk and floor lamps are classified as portable luminaires under the standards. Portable luminaires are regulated under California's Title 20 Appliance Efficiency Regulations.



Retrofits with Energy and Fiscal-Related Benefits

Mrak Hall, UC Davis, California

A lamp-and-ballast retrofit of T8 fluorescent lighting improved lighting quality in the office and reduced lighting energy use 45%. T12 fluorescent undercabinet luminaires and incandescent desktop lamps were replaced with flexible, high-quality LED undercabinet lighting and Curve desk lamps by Finelite. Both task and ambient lighting feature wireless occupancy sensors. These changes saved $1,792 annually.

A case study is available at ***cltc.ucdavis.edu/publication/integrated-office-lighting-system-uc-davis***

PHOTO: CLTC, UC DAVIS

CHAPTER 2

TECHNOLOGY OVERVIEW

CHOOSING THE RIGHT LIGHT

An effective indoor lighting system combines the right source technology with the right luminaire and the appropriate lighting controls for the desired function and effect.

Selecting the right type of light source and lighting controls for different lighting needs means comparing a variety of factors, including:

- Luminous output
- Efficacy
- Distribution
- Color rendering
- Controls compatibility
- Product life
- Manufacturer warranties
- Long-term energy and cost savings

In many cases, a higher up-front investment in a more efficient, more functional lighting system yields a higher return in the long term. This technology overview briefly describes the benefits and limitations of technologies currently on the market and offers guidance for selecting products that comply with Title 24, Part 6 and Title 20.

CONCEPTS & PRINCIPLES

Many consumers estimate the light output of lamps and luminaires based on the amount of power they draw, but it is lumens (lm), not watts (W), that indicate luminous output. More efficient sources can produce the same amount of light as legacy sources while consuming less energy.

Luminous Output

The amount of visible light emitted by a light source is measured in lumens (lm). The more lumens, the more light emitted, but other factors also affect visibility and perception of brightness, such as contrast ratios and color characteristics. In addition, the type of fixture or housing can greatly affect the amount of lighting reaching its intended target.

Recommendations

- Compare the light output, not the power rating, of existing and replacement light sources or luminaires to ensure adequate lighting is maintained.
- Consider other factors, such as contrast, distribution and color rendering; these also affect nighttime vision and perceived brightness.
- Install lighting controls, such as dimmers or motion sensors, to maximize energy savings while automatically tailoring light levels to occupants' needs.
- To avoid energy waste and excessive illumination, factor task lighting and ambient lighting into the overall lighting design for a space.

Comparing Lumens vs. Watts

LUMENS →		450	800	1,100	1,600
		DIMMER ←			→ BRIGHTER
MORE EFFICIENT ↕ LESS EFFICIENT	Standard Incandescent	40W	60W	75W	100W
	Halogen Incandescent	29W	43W	53W	72W
	CFLs	10W	13W	16W	20W
	LEDs	5W	10W	15W	19W

Sources: U.S. Department of Energy Building Technologies Office, "CALiPER Snapshot: Light Bulbs," October 1, 2013. Natural Resources Defense Council, "Your Guide to More Efficient and Money-Saving Light Bulbs," October 30, 2013.

Luminous Efficacy

In lighting, the term efficacy refers to the ratio of luminous output produced by a light source to power rating of that source (lm/W).

Efficacy = Lumens/Rated Watts

Different source technologies provide different efficacy levels. For example, a 75 W A19 incandescent lamp, a 16 W A19 compact fluorescent lamp (CFL) lamp, and a 15 W A19 LED lamp use different amounts of power to produce the same amount of light (approximately 1,100 lumens). Each type of lamp has a different rated efficacy, with the LED example being the most efficacious (producing the most lumens per watt).

When assessing the overall value of lamps or luminaires, efficacy and initial product costs are two factors to consider. It is also important to compare longevity, lifetime performance, and long-term energy and maintenance costs.

Vision Needs Change with Age

As we age, our eyes require more light to see clearly. The Illuminating Engineering Society of North America (IES) sets lowest average minimum maintained recommendations for light level (lux) requirements based on the needs of occupants under 25 years old. These illumination requirements doubled for those ages 26–65 and quadrupled for those over age 65.

Life

Electric light sources have the potential to fail due to several factors, including faulty electrical components, corrosion inside the lamp, or lumen depreciation (the gradual decrease in lumen output that occurs over time).

Incandescent lamps typically last 1,000–2,000 hours and lose about 10–15% of their initial lumen output before burning out. A CFL lamp lasts about 12,000 hours and loses about 10–15% of its output before burning out. Linear fluorescent lamps typically last 25,000–40,000 hours, losing 5–10% of their original lumen output before failing.

LEDs do not burn out in the same way as many legacy sources, their lumen output decreases very gradually over time. Many LED A19 replacement lamps are rated to last 25,000 hours or more before they lose 30% of their initial light output, and recent testing indicates the diodes in these lamps may maintain useful light output longer than previously predicted. Capacitors or other components that provide power to the LED circuit are more likely to fail before the LEDs themselves. Basing LED product life on lumen depreciation (L_{70} or 70% of initial lumen output, for example) may not be the best way to measure the useful life of LED lamps and luminaires.

LED life testing methodologies are still evolving as the technology improves. Here are some best practices to maximize the life of LED lighting:

- Always follow manufacturer installation instructions, including references to base position for replacement lamps (e.g. base-up, base-down or horizontal)
- Pair LED lamps and luminaires with manufacturer recommended dimmers and other controls
- Observe manufacturers' recommendations on operating temperature to prevent heat-related performance degradation

Warranties

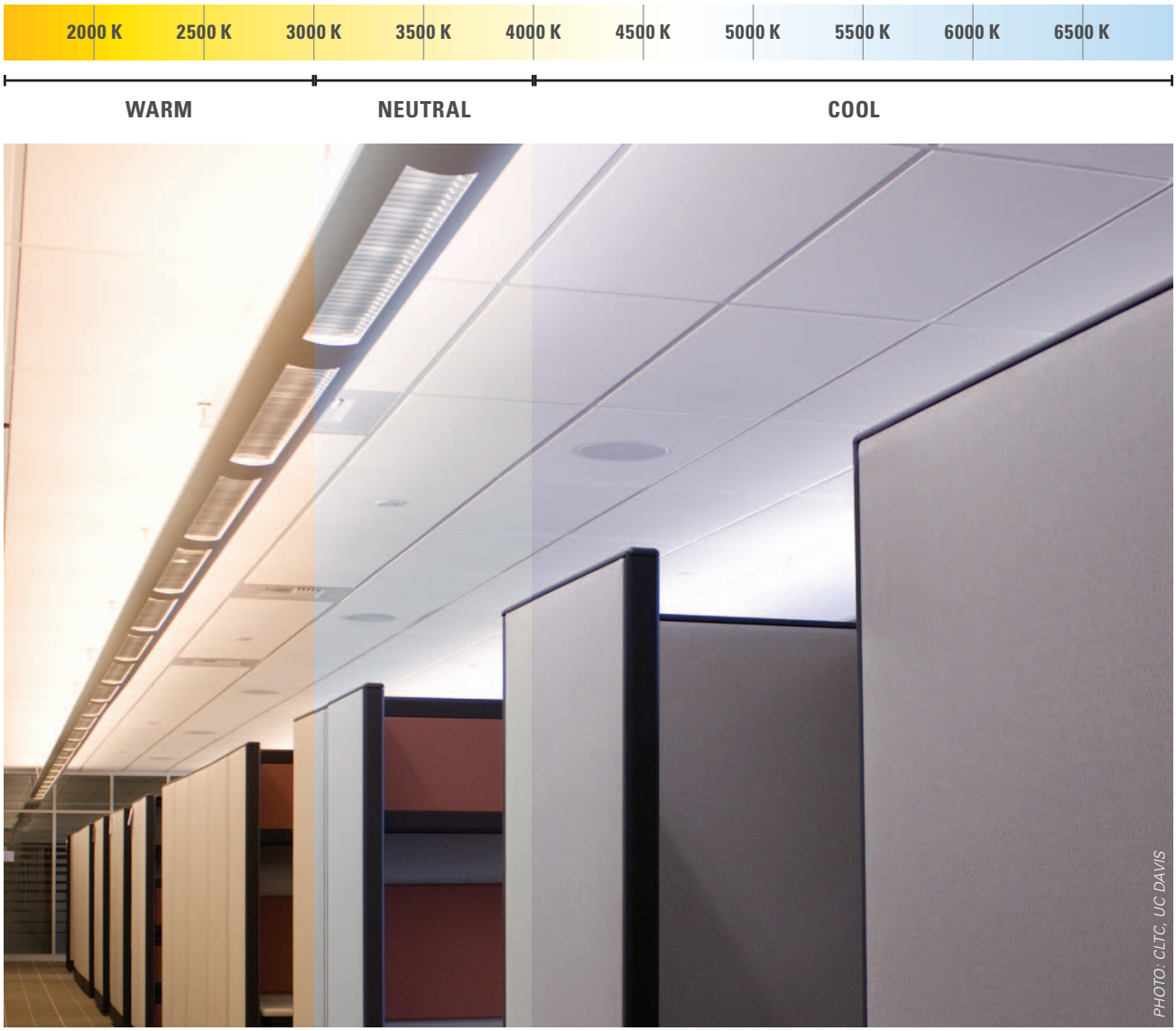
Manufacturers offer competitive warranties for lighting products. Energy Star requires that luminaires and LED lamps carry a warranty of at least three years. LED replacement lamps must come with a minimum five-year free replacement warranty in order to meet the Voluntary California Quality LED Lamp Specification and qualify for utility rebates.

NOTE: Life and lumen maintenance information presented here comes from the The Lighting Handbook, Tenth Edition (sec. 7), published by the IES in 2011.

Color Temperature (CCT)

Correlated color temperature (CCT) indicates the warmth or coolness of the light emitted by a given source. CCT is measured on the Kelvin scale (K). Light sources with a low CCT (2,700–3,000 K) give off light that is warm in appearance. Sources with higher CCT values (4,000–6,500 K) provide light with a cooler color appearance.

Selecting light sources with consistent CCTs helps maintain some consistency in the appearance of various light sources. Check specification sheets for information on CCT (or "light color"), lumen output, power consumption (watts), and efficacy.



Color Rendering (CRI)

The color rendering index (CRI) is the current industry standard for measuring how accurately a light source renders the colors of the objects it illuminates. The maximum CRI value is 100. Office lighting should have a minimum CRI of 80. In settings where color discrimination is important, such as in an architecture, advertising or graphic design firm, light sources with a CRI of 90 or higher provide even better color rendering.

Specifying lamps and luminaires with similar color rendering properties helps ensure wall color, carpeting and other materials have a consistent appearance, especially in adjoining spaces. Most manufacturers can supply information on CRI if it is not on product packaging or literature.

Comparing Color Quality

The LED MR16 lamps used for these photos both have a CCT of 3000 K and were produced by the same manufacturer. The difference is that the first-generation lamp on the left has a CRI of 80 while the lamp on the right has a CRI of 95.

Tunable Lighting

Advances in LED luminaires have opened up new possibilities to control lighting in office environments. Emerging products allow for the independent tuning of brightness and spectral content of individual luminaires. Research is being conducted on workplace preferences and the connection between spectral content and circadian health. The results will lead the way in workplace adoption of luminaires that can shift from warm to cool depending on the preferences of the building operator or employee.

LIGHT SOURCES

A single luminaire can often accommodate different lighting technologies. For example, most screw-based lamp types are available using incandescent, CFL or LED sources. Selecting the best source type for a particular application means considering several factors, including light quality, intensity, efficiency, and longevity.

Incandescent

Incandescent lamps are highly inefficient. Initial costs for incandescent lamps are low and they do have excellent color. However, incandescent lamps fail quickly compared to other sources. This can increase maintenance costs over time.

Halogen

Halogens lamps burn hotter and longer than standard incandescent lamps, producing a brighter, whiter light. Halogen lamps are also about 25% more efficacious than standard incandescent lamps.

CFL

With CFLs, the linear tube design of traditional fluorescent lights has been curved into a more compact shape, facilitating incandescent lamp replacement. An electronic ballast in the base of the CFL activates the lamp then regulates the electrical current. Not all CFLs are dimmable and some can have delayed start times.

PHOTO: CLTC, UC DAVIS

Linear Fluorescent

Linear fluorescent lamps provide uniform levels of illumination for long periods of time, making them ideal in spaces that require bright, uniform ambient lighting. Linear fluorescent lamps also work well in break rooms, bathrooms, storage spaces, and other more utilitarian areas. In addition, these lamps are relatively inexpensive and can provide excellent color rendering.

- Linear fluorescent lamps are available in different wattages and sizes; the 32W T8 is the most common.
- Not all fluorescent lamps are compatible with dimmable ballasts — make sure the products selected are able to dim in accordance with the requirements in **Table 130.1-A** of Title 24, Part 6.

LED

LEDs are solid-state light sources capable of emitting colored light, white light or color-tunable light. The color quality of white light LEDs depends on the phosphors used in manufacturing the LED chip.

- Installing long-life LED luminaires in hard-to-reach spaces reduces maintenance costs and time spent changing failed lamps
- LEDs' dimmability and compatibility with cold temperatures make them an excellent choice for pairing with occupancy-based controls
- Color-tunable LEDs introduce a new element of flexibility and fascination into display lighting

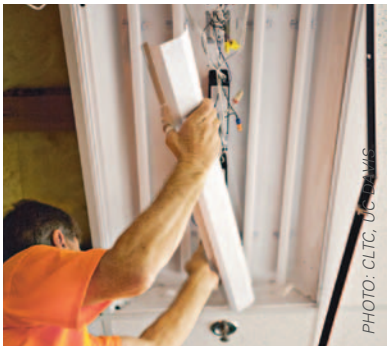


PHOTO: CLTC, UC DAVIS

Metal Halide (MH)

Metal halide lamps are a HID light source. They are commonly used in warehouse lighting, particularly high-bay and low-bay applications. MH lamps are three to five times more efficient than incandescent lamps and last about 15–20 times as long. Full light output can take up to 10 minutes to achieve.

PHOTO: PHILIPS

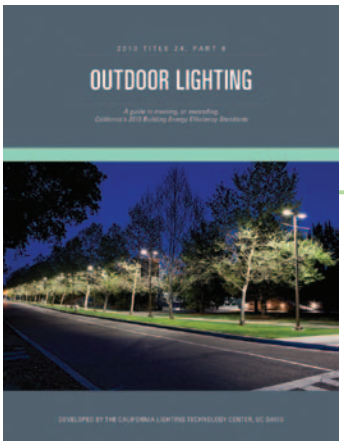
Ceramic Metal Halide (CMH)

CMH lamps are a newer variation of MH technology commonly used in spot and track lighting applications. CMH lamps can produce white light with a CRI as high as 96, making them suitable for color-critical applications. Similar to standard MH lamps, CMH can take up to 10 minutes to reach maximum light output.

Induction

Induction lamps operate similarly to fluorescent lamps, but without the electrodes and filaments. Induction sources have long lifetimes and seldom need replacing. These lamps are very efficient and compatible with many types of lighting controls and its long life (60,000–100,000 hours) means minimal maintenance. Induction lamps are often used in high bay, low bay and outdoor applications.

PHOTO: CLTC, UC DAVIS



2013 Title 24, Part 6 Outdoor Lighting Guide

CLTC's 2013 Outdoor Lighting Guide for Title 24, Part 6 compliance is designed to help builders, lighting industry professionals, and others navigate the nonresidential outdoor lighting portion of the Building Energy Efficiency Standards. The new standards, which took effect July 1, 2014, include updated requirements for retrofit standards, lighting controls, and uplight and glare limits.

Find the guide here: ***cltc.ucdavis.edu/article/2013-title-24-part-6-outdoor-lighting-guide***

Tubular LED Lamp

LED Retrofit Kit

Dedicated LED Luminaire

REPLACEMENT OPTIONS FOR LINEAR FLUORESCENTS

Tubular fluorescent lamps comprise 80 percent of the lamp inventory in the commercial sector, or about 1.7 billion lamps, according to a U.S. Department of Energy report. LED alternatives to fluorescent lighting products fall into three main categories: tubular lamps, retrofit kits and dedicated luminaires. These LED replacement options have different labor installation times, costs and safety precautiions.

Tubular LED Lamps

Replacing existing linear fluorescent lamps with similarly shaped tubular LED (TLED) lamps requires minimal new hardware, but this strategy also presents challenges that should be understood before purchase or installation.

Based on the particular LED replacement lamp product being considered, this approach typically requires changing the electrical wiring, replacing the ballast with an external driver, or altering the existing lamp holders (or "tombstones") to accommodate the new lamp.

The Building Energy Efficiency Standards allow TLED lamps to be installed as replacements for linear fluorescent lamps in existing luminaires. TLEDs that replace the lamp only and do not require any wiring alterations can be considered a repair and do not trigger the code compliance process. An existing linear fluorescent luminaire with TLED lamps is not recognized as an LED lighting system for compliance purposes. For luminaire modifications-in-place, **Section 141.0(b)2Ii** requires luminaires to be classified, and power to be determined, according to **Section 130.0(c)**.

LED Retrofit Kits

An LED retrofit kit provides the required electrical components, optical elements and light sources in a prepackaged kit. This replacement option provides an efficient retrofit solution for the majority of troffers in today's building stock.

When updating existing troffers, it is critical to make sure they can accommodate the retrofit kit selected since not all retrofit kits are universally accepted by troffers. Any retrofit option should preserve the safety rating of the existing luminaire.

Dedicated LED Luminaires

Dedicated LED luminaires can often easily replace existing linear fluorescent luminaires. While typically higher in cost, this option often provides the LED technology in a well-designed package with a straightforward electrical installation.

For more information, see "LED Retrofit Options for Linear Fluorescent Lighting": ***cltc.ucdavis.edu/publication/led-retrofit-options-linear-fluorescent-lighting***

CONTROL STRATEGIES

Sensors and controls can achieve significant energy savings by automatically adjusting lighting based on time of day, available task needs, daylight, occupancy, and electricity supply or cost. The 2013 Title 24 standards introduce many new requirements for lighting controls in non-residential buildings, including office spaces.

Tuning

Tuning Controls (left to right): Leviton Renoir II dimming control, Leviton Sapphire LCD Touch Screen

Tuning, also known as high-end trim or institutional dimming, reduces the level of general lighting in an area. Luminaire layouts are designed using a light loss factor, so initial designed light levels are often brighter than necessary. Tuning allows the luminaires to be dimmed to the recommended light level initially and, later, restored to full output when lumen output has degraded. This strategy saves energy, maintains more consistent light levels over the life of the luminaire, and extends lamp life.

Occupancy and Vacancy Sensors

Occupancy Sensors (top row, left to right): Leviton OSSMT Occupancy Sensor, Lighting Control & Design xCella Wireless Occupancy Sensor, Lutron Radio Powr Savr Wireless Occupancy Sensor

Vacancy Sensors (bottom row, left to right): Leviton Provolt Vacancy Sensor, WattStopper CU-250 Ultrasonic Multi-way Wall Switch Vacancy Sensor

These sensors automatically dim or switch lighting OFF when the field of view has been vacant for a period of time. Occupancy sensors automatically turn lights ON when an occupant is present in the sensor's field of detection. Occupancy sensors can often be programmed to turn only a portion of the controlled lights ON or OFF. This strategy is called Partial-ON or Partial-OFF control. Lights controlled by vacancy sensors, or manual-ON occupant sensors, must be turned on manually. The occupant makes a conscious decision to add electric lighting. This strategy can result in significant energy reductions when general lighting subsequently remains off for the majority of the day.

What features are required for occupancy sensors?

To be in compliance, an occupancy sensor must provide:

- *A maximum time out of 30-minutes*
- *A 15–30 second grace period to automatically turn lighting ON after the sensor has timed out*
- *No override switch that disables the sensor*
- *A visible status signal that indicates if the device is operating properly (this signal may have an override if the occupant prefers it OFF)*

Devices vs. Systems

Self-contained lighting control devices are defined in the standards as "unitary lighting control modules that require no additional components to be fully functional lighting controls." Self-contained devices that are required to be certified to the Energy Commission will be listed in the appliance database.

Networked lighting control systems provide a way to link devices together and have many benefits in building-wide energy management. Systems are not listed in the appliance database and do not need to be certified.

Read more in chapter 5.2.2 of the Nonresidential Compliance Manual.

Daylight Harvesting

◀ Daylight Harvesting Controls (left to right): Leviton ODC05-MDW, WattStopper LMS-600, Lutron Radio Powr Savr Wireless Daylight Sensor

Also called photocontrols, these devices utilize daylight sensors (photocells) to adjust lighting loads based on ambient light levels. Daylight controls are now required in all spaces that have skylights, windows or other daylight sources and at least 120 watts of electric lighting and 24 ft^2 of glazing.

Time Clocks

◀ Time Clocks (left to right): Leviton EZ-MAX Plus 8 Relay Panel, WattStopper LP8 Peanut Lighting Control Panels

Time clocks, commonly used in indoor and outdoor applications, switch lights ON or OFF based on daylight hours and geographical location. Some time clocks and curfew dimming controls can automatically adjust dimmable sources, such as LEDs or CMH lamps, to operate at different levels according to a schedule. Dimming lights during the least active hours of operation reduces energy waste and light pollution.

What is the ATT looking for?

The ATT ensures that the following indoor lighting control devices and systems are installed and functioning properly before the building is occupied:

- *Automatic daylighting controls*
- *Automatic time switch controls*
- *Occupancy sensor*
- *Demand response controls*

Automatic Demand Response

◀ Demand Response Controls (left to right): Leviton GreenMax Relay Panel, WattStopper Digital Lighting Management

Utilities initiate demand response events for a variety of reasons. Commercial electricity customers may choose to participate in utility demand response programs in exchange for financial incentives. Often, these events are issued when demand for electricity is expected to exceed generation capacity. Title 24 now requires all commercial buildings at least 10,000 ft^2 in size be capable of receiving and automatically responding to DR signals by reducing lighting energy use to a level at least 15% below the building's maximum lighting power.

CONTROL ARCHITECTURES

Control systems can be as simple as an ON/OFF switch or as complex as a building-level networked control system that integrates daylight harvesting, occupancy sensing, scheduling, and demand response. There are four control architectures most commonly used in commercial spaces: self-contained lighting control, luminaire-integrated control, circuit-level control and networked control.

Self-Contained Lighting Controls

This is the simplest category of control. This category includes ON/OFF switches, dimmers, photocontrols, and occupancy sensors. In the standards, each task area is required to be served by controls that allows occupants to adjust the lighting based on their needs.

Luminaire-Integrated Controls

Also known as on-board controls, these come integrated into the luminaire direct from the manufacturer. They can control individual lights locally. Luminaires can come with occupancy AND/OR daylight harvesting controls.

Circuit-Level Control

This control strategy automatically engages shut-off controls to circuits serving lighting and certain plug loads when those loads are not needed, typically based on a programmed schedule or area occupancy.

The strategy is implemented through a timer, or time-clock feature, that enables ON/OFF control based on a schedule defined by hours of building operation.

Networked Control Systems

Interconnected lighting control systems can control select groups of luminaires or lighting for whole buildings, facilities, or campuses. There are centralized, panel-based wired systems and distributed intelligence systems (available in both wired and wireless forms). The number of lighting control networks and systems on the market has increased in recent years. Interfaces are increasingly user-friendly. These systems can integrate daylight harvesting, advanced scheduling, occupancy-based control, demand response, and data monitoring.

Lighting can also be controlled as part of a computerized building management system (BMS) or energy management control system (EMCS) that can address HVAC and other systems in addition to lighting. Networked control systems may not override manual controls under Title 24.

Adaptive Corridors at Latham Square
Oakland, California

Energy savings can be achieved in corridors and other secondary spaces with an occupancy-based adaptive lighting system. Such a system is generally composed of occupancy sensors, dimmable ballasts and a communication platform. The system automatically lowers light levels during vacancy and raises light output to the recommended level for occupant comfort during occupied periods. The adaptive lighting system installed at the Latham Square office building is based on Lutron's Energi TriPak solution, a stand-alone platform for adaptive lighting that employs cost-effective wireless control devices and programmable dimming ballasts.

The new 64 W light fixtures installed for this project used dimmable ballasts. Lutron occupancy sensors were installed throughout the corridors to provide adequate passive infrared sensor coverage for the corridor areas and each point of entry. The wireless sensors work in tandem with dimming modules, which control the light level of the fixtures.

A case study is available at: ***cltc.ucdavis.edu/publication/adaptive-corridors-latham-square***


PHOTO: CLTC, UC DAVIS

Bright Ideas at Lakeland Community College
Kirkland, Ohio

The college's Holden University Center, a two-story, 40,000-square-foot facility, was designed as an educational and technological atmosphere to enhance student learning. The college installed 483 RT Series luminaires from Lithonia Lighting with Sensor Switch nLight controls in the center, including classrooms, hallways, lounge and study areas, conference rooms, offices, and science labs. The new LED luminaires accounted for more than 95% of the indoor lighting. A factor in achieving the college's priority performance and efficiency objectives was the ability to introduce easy-to-use digital controls already integrated in the luminaires. The controls solved several issues including the need to adjust lighting levels in classrooms. Reduced maintenance was another benefit from using LEDs.

A case study is available at: ***acuitybrands.com/solutions/inspire-me/case-studies/lakeland-community-college***

PHOTO: ACUITY BRANDS

CHAPTER 3

COMPLIANCE REQUIREMENTS

There are three basic steps to comply with Title 24, Part 6:

1. **Meet all mandatory requirements** by installing required devices, including controls, and ensuring that they perform all functions required by the standards.
2. **Select your method** of compliance by choosing either the **Performance Approach** or the **Prescriptive Approach**.
3. **Meet lighting power density requirements** by ensuring that the actual lighting power installed in a space is less than or equal to the allowed lighting power for that space.

Mandatory Requirements

All nonresidential buildings must meet a set of mandatory standards for equipment efficiency and the use of lighting controls.

Performance Approach

The Performance Approach allows energy allotments to be traded between building systems, such as lighting, HVAC or the building envelope. There is no benefit to using this approach for projects that only involve lighting. This compliance approach requires using energy analysis software that has been approved by the Energy Commission.

Prescriptive Approach

As an alternative to the Performance Approach, Title 24 provides office applications with three methods of compliance under the Prescriptive Approach: the **Complete Building Method**, the **Area Category Method**, and the **Tailored Method**.

COMPLETE BUILDING METHOD

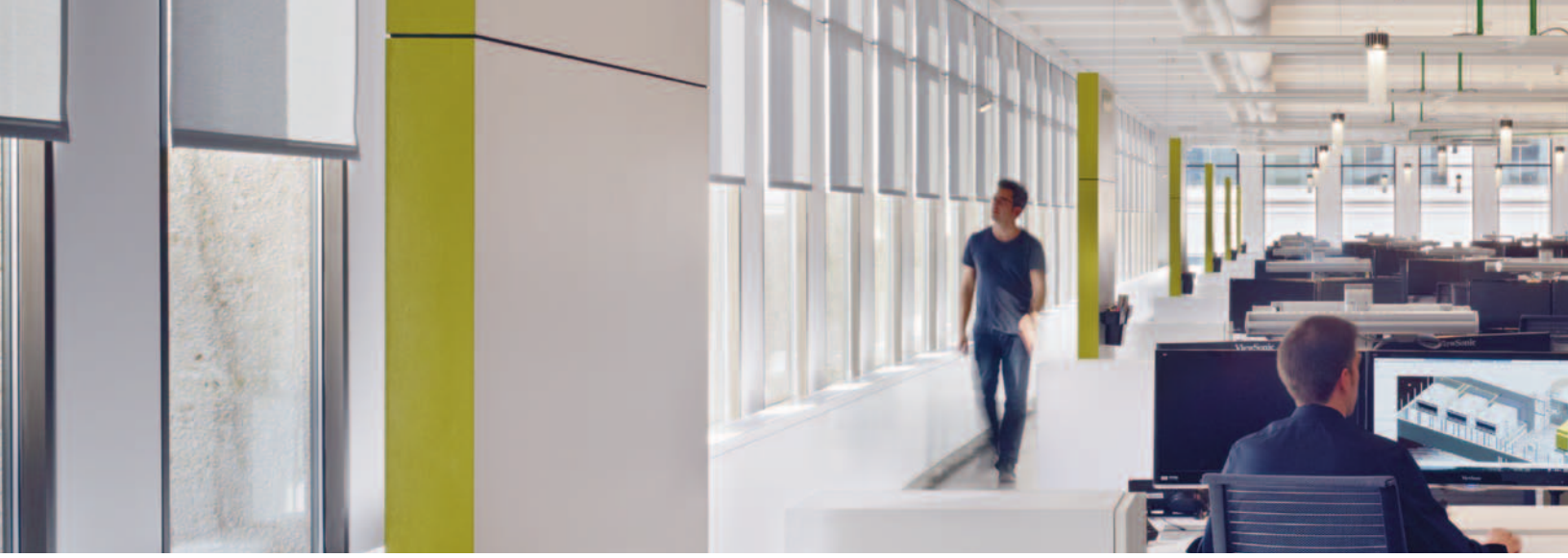
The Complete Building Method is useful for projects involving entire buildings with one primary type of use or in mixed-use buildings or tenant spaces where 90% of the spaces have one primary use. This method can be used for building types listed in **Table 140.6-B**.

AREA CATEGORY METHOD

With this option, lighting power values are assigned to each of the major areas of a building (e.g. offices, lobbies, conference rooms, etc.) listed in **Table 140.6-C**, with some tasks areas qualifying for higher lighting power allotments. This method can be used for any type of project, including alterations and modifications-in-place.

TAILORED METHOD

The Tailored Method allows for additional lighting design flexibility for accommodating specialized tasks in small zones within larger areas. Advanced calculations involving illuminance levels and room dimensions are required. It is typically used for space types listed in **Table 140.6-D**.



NAVIGATING TITLE 24, PART 6

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
ADDITIONS, ALTERATIONS AND REPAIRS	§141.0(b)2F– §141.0(b)2K	§141.0(b)2F– §141.0(b)2K	—
Additions	—	§141.0(a)1	§141.0(a)2
Alterations	§141.0(b)2Iii §141.0(b)2Iv Table 141.0-E	§141.0(b)2Iii §141.0(b)2Ivi §140.6	§141.0(b)3A Table 141.0-D
Luminaire Modifications-in-Place	§141.0(b)2Iiii Table 141.0-F	§140.6 §141.0(b)2Iiii §141.0(b)2Ivi Table 141.0-F	—
Light Wiring Alterations	§130.1 §130.4 §141.0(b)2Iiv	—	—
Repairs	§110.9(c)	—	—
GENERAL LIGHTING CONTROLS AND EQUIPMENT	§130.0	—	—
Manual Area Controls	§130.1(a)	—	—
Multi-level Controls	§130.1(b)	—	—
Automatic Shut-Off Controls (Occupant-Sensing Controls)	§130.1(c)	—	—


PHOTO: LUTRON

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
Automatic Daylighting Controls	§130.1(d) Skylit and Primary Sidelit Zones	§140.6(d) Secondary Sidelit Zones	—
Automated Demand Response	§130.1(e) Buildings over 10,000 ft²	§140.6(a)2K Table 140.6-A PAFs for demand response buildings < 10,000 sq ft	—
DAYLIGHTING / GLAZING REQUIREMENTS	—	§140.3	—
Fenestration: Minimum U-factor, Solar Heat Gain Coefficient (SHGC), Visible Transmittance	—	§140.3(a)5	—
Skylights: Maximum skylight to gross roof area, minimum SHGC, Visible Transmittance	—	§140.3(a)6	—
Minimum Daylight Requirements, spaces > 5,000 square feet with ceiling heights > 15 feet	—	§140.3(c)	—
CONTROL DEVICES AND SYSTEMS, BALLASTS, AND LUMINAIRES	§110.9	—	—
Time-Switch Lighting Controls	§110.9(b)1	—	—
Daylight Controls	§110.9(b)2	—	—
Dimmers	§110.9(b)3	—	—
Occupant-Sensing Controls	§110.9(b)4	—	—
Track Lighting Integral Current Limiter	§110.9(c)	—	—
Track Lighting Supplementary Overcurrent Protection Panel	§110.9(d)	—	—

PHOTO: STAFFORD KING WIESE

ADDITIONS, MAINTENANCE / REPAIRS, ALTERATIONS & MODIFICATIONS-IN-PLACE

Section 141.0

When starting the Title 24 compliance process, the first step is to determine what sections of the standards apply to the project. For new construction and additions, the requirements are easier to determine: most, if not all, sections of standards will apply. It becomes more challenging to determine what applies with retrofits. For lighting retrofits, code-triggering projects will either be alterations or modifications-in-place, a new category for the 2013 standards. Once the project is declared an alteration or a modification-in-place, certain rules can be applied. Maintenance and repair activities can occur outside of the compliance process.

EnergyCode Ace™
Helping you play your cards right

Help with Forms

energycodeace.com

Energy Code Ace offers tools to support compliance with the 2013 Title 24 requirements. Select the forms tool and follow the instructions for a summary of the forms required for your specific project. Energy Code Ace fact sheets, checklists and other resources are also available.

Maintenance & Repairs

No compliance measures required: Routine maintenance and repairs of lighting components, systems or equipment already installed in an existing building do not trigger Title 24.

The standards define maintenance tasks and repairs as:

- Replacement of lamps of the same technology type
- Replacement of lamp holders or lenses
- Replacement of a ballast or driver that is no longer functioning properly
- Maintenance measures that do not increase energy consumption of the equipment being serviced
- Alterations caused directly by the disturbance of asbestos
- Medium screw-based lamp replacements
- Tubular LED lamps that replace fluorescent lamps by changing the lamp only, and not any of the wiring (including the ballast)
- When less than 40 luminaires are upgraded or modified-in-place within a 12-month period in a building space, it is treated as a repair rather than an alteration. Refer to **Table 141.0-F** for a section-specific definition of "building space" to use for modifications-in-place.

Additions

Section 141.0(a)

New construction requirements apply: Lighting plans for building additions must meet the same mandatory and prescriptive or performance standards as lighting installed for a new construction project. If the performance approach is followed, the LPD for the general lighting systems may be traded off with other prescriptive building features.

Alterations

Section 141.0(b)2Iii, Table 141.0-E

Replacing any lighting component, system, or equipment regulated by Title 24 is considered an alteration, not a repair.

The following are considered lighting system alterations:

- Luminaire replacement
- Luminaire removal and reinstallation
- Luminaire relocation
- Wiring alterations
- Connecting luminaires to switches, relays, branch circuits, and other controls

Alterations do not always require compliance with all of Title 24, Part 6. For certain types of alterations, compliance is required for only specific sections.

LIGHTING SYSTEM ALTERATIONS

Lighting system alterations that do not change the area of the enclosed space they are located in trigger certain compliance requirements, based on the quantity of existing affected luminaires.

Only areas involved in the lighting alteration must comply with the standards. Areas that are untouched are not required to be changed.

SPACE CHANGES

Any renovations or alterations that increase lighting energy use, change the space function type as a part of the retrofit project (e.g. converting a conference room to private offices), or an adjustment to the area of the enclosed space will trigger the following compliance requirements for lighting in the entire space:

- LPD maximum limits under the Area Category Method (**Section 140.6**)
- Manual area controls (**Section 130.1(a)**)
- Automatic shut-off controls (**Section 130.1(c)**)
- Automated demand response (in buildings over 10,000 ft^2) (**Section 130.1(e)**)

LPD increases and space changes also trigger the following requirements — for the altered luminaires only:

- Multi-level lighting controls (**Section 130.1(b)**)
- Daylight controls (**Section 130.1(d)**)

New to Title 24, Part 6: Electrical Power Distribution Systems

Section 130.5 *addresses electrical power system requirements, which are distinct from lighting control system requirements. The electrical power distribution systems chapter applies to all non-residential projects and is part of the mandatory measures. Not all projects will trigger compliance with all measures. A careful reading of the exceptions will help to determine which sections apply.*

It includes measures for the disaggregation of loads, service metering and 120-volt receptacle controls. Some requirements for demand response systems and energy management control systems (EMCS) are also found in this chapter and other sections of the standards.

Voltage drop limits have migrated to ***Section 130.5*** *from recommendations in Title 24, Part 3.*

Compliance Requirements for Lighting Alterations

Type of Change to Existing Lighting	Total Portion of Existing Luminaires Affected by Alterations per Enclosed Space	Resulting Lighting Power	Mandatory Control Provisions for Each Enclosed Space	Multi-level Lighting Control Requirements for Each Altered Luminaire
	LESS THAN 10%	Lowered or unchanged	No changes required for compliance	
Luminaire Replacement **Luminaire removal and reinstallation**	**10% OR MORE**	85% or less of allowed lighting power under the Area Category Method **Section 140.6**	Area Controls Section 130.1 (a) Automatic Shut-off Controls **Section 130.1 (c)**	Multi-level controls **Section 130.1 (b)** OR Bi-level controls with at least one step at 30–70% of design lighting power
Luminaire relocation		86%–100% of allowed lighting power under the Area Category Method **Section 140.6**	Area Controls **Section 130.1 (a)** Automatic Shut-off Controls **Section 130.1 (c)** Automatic Daylighting Controls **Section 130.1 (d)**	Multi-level controls **Section 130.1 (b)**

Based on Table 141.0-E in the standards

NOTE:
- Bi-level lighting controls must provide reasonably uniform illumination.
- Controls and equipment must comply with applicable mandatory requirements (per **Section 110.9**) and be installed according to manufacturers' instructions, per **Section 130.0(d)**.

Luminaire Modifications-in-Place

This new category allows lighting retrofit projects to take place with fewer requirements than alterations. If fewer than 40 luminaire modifications-in-place are undertaken within one year in a building space as defined by this section of the standards, then no changes are required for compliance. For luminaire modifications-in-place, a "building space" is defined as any of the following:

- A single-story building
- A complete floor of a multi-floor building
- The entire space in a building with a single tenant under a single lease
- All of the common, not leasable space in a single building

When more than 40 luminaire modifications-in-place are done in the course of a year, then areas where at least 10% of the luminaires are affected must comply with the applicable lighting requirements. Any areas that do not change 10% or more of the luminaires are not required to comply with **Table 141.0-F**.

Title 24, Part 6 defines the following as luminaire modifications-in-place:

- One-to-one luminaire replacements (disconnecting old and reconnecting new)
- Lamp and ballast replacements that preserve the original luminaire type and listing
- Whole-fixture retrofit kit installations
- Reflector or optical system modifications
- Changes to the number or type of light source used by a luminaire, including: socket renewal, removal or relocation of sockets/lamp holders, changes to wiring internal to the luminaire

The benefit of classifying a project as a modification-in-place is that 39 luminaires can be modified-in-place without triggering additional requirements. To qualify as luminaire modifications-in-place, lighting alterations cannot result from any general remodeling of the enclosed space in which they are located and cannot involve changes to panelboard or branch circuit wiring.

Compliance Requirements for Luminaire Modifications-in-Place

Type of Change to Existing Lighting	Total Portion of Existing Luminaires Affected by Modifications-in-Place, per Building, per Year	Resulting Lighting Power	Mandatory Control Provisions for Each Enclosed Space	Multi-level Lighting Control Requirements for Each Altered Luminaire
	FEWER THAN 40	Lowered or unchanged	No changes required for compliance	
Group lamp and ballast change-outs **Reflector or optical system modifications**	**40 OR MORE**	85% or less of allowed lighting power under the Area Category Method **Section 140.6**	Area Controls **Section 130.1 (a)** Automatic shut-off controls **Section 130.1 (c)**	Multi-level controls **Section 130.1 (b)** OR Bi-level controls with at least one step at 30–70% of design lighting power
Installation of whole-fixture retrofit kits		86–100% of allowed lighting power under the Area Category Method **Section 140.6**	Area Controls **Section 130.1 (a)** Automatic shut-off controls **Section 130.1 (c)** Daylight controls **Section 130.1 (d)**	Multi-level controls **Section 130.1 (b)**

Based on Table 141.0-F in the standards

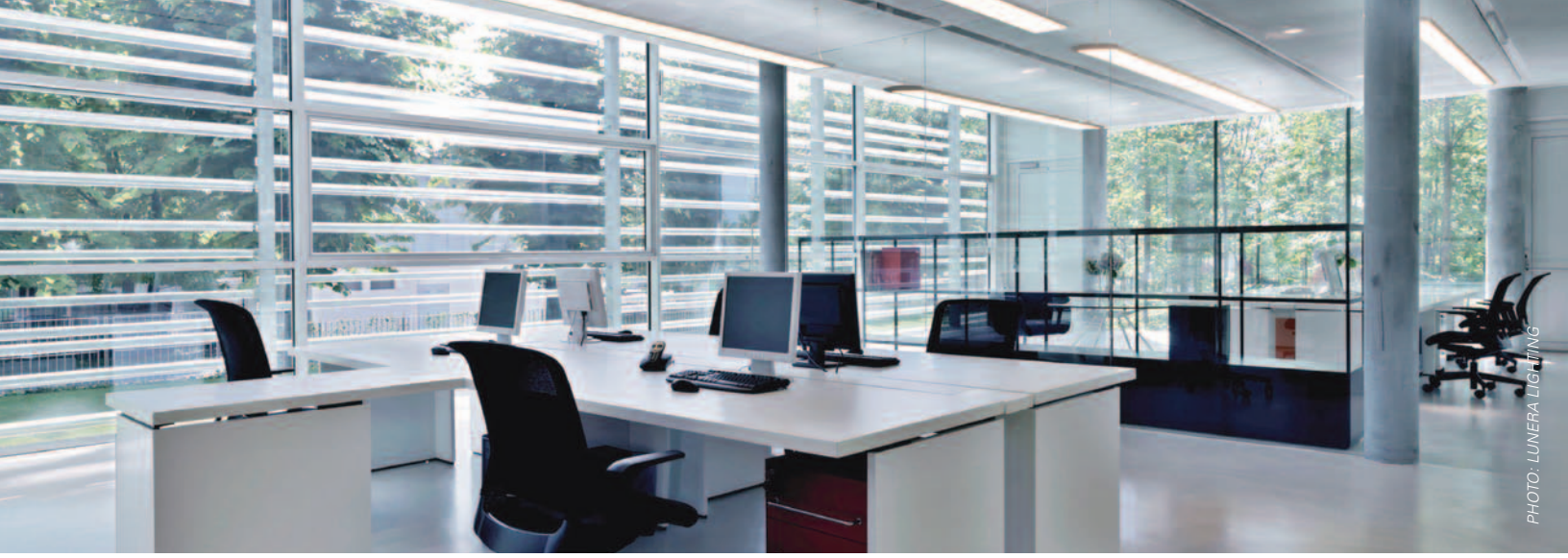


PHOTO: LUNERA LIGHTING

MANDATORY LIGHTING CONTROL MEASURES

New requirements for lighting controls constitute one of the biggest changes to the Title 24, Part 6 standards. The requirements for indoor lighting controls are included in **Section 130.1**. For new construction projects, including additions, all subsections within **Section 130.1** must be considered. Both alterations and modifications-in-place trigger controls requirements as well. However, not all measures will be implemented in every project.

Determining what controls measures will be required is connected to quantity of luminaires affected by the project, per enclosed space, and the actual lighting energy use calculations. Some measures may be bypassed if the lighting power density of a space is 85% or less than the maximum allowed. While most requirement triggers are based on a percentage of affected luminaires or a percentage of an allowed LPD, the demand response controls requirements are triggered by reaching an affected square footage threshold. Alterations that involve less than 10,000 ft^2 within a single building are not required to comply with **Section 130.1(e)**. To determine which measures affect a project, review **Table 141.0-E** for alterations and **Table 141.0-F** for modifications-in-place. These two tables are a valuable tool in this process.

All lighting equipment and control devices specified to meet the requirements must be installed according to manufacturer's instructions and lighting controls should following the performance and certification requirements listed in **Section 110.9**.

Ace Reference™

energycodeace.com/content/reference-ace

The Reference Ace™ tool helps users navigate the Title 24, Part 6 Standards documents. Keyword search capabilities along with hyperlinks allow users to jump directly to related sections.

The current 2013 version of the Reference Ace links the relevant sections of the Building Energy Efficiency Standards, Reference Appendices and the Residential and Nonresidential Compliance Manuals.

CALIFORNIA ENERGY COMMISSION
BLUEPRINT

energy.ca.gov/efficiency/blueprint

The Energy Commission's Blueprint Newsletter is published by the Standards Implementation Office. Each edition offers information that is helpful in interpreting the Building Energy Efficiency Standards in professional practice. Topics are selected based on needs identified by the energy standards hotline staff.

MANUAL AREA LIGHTING CONTROLS

Section 130.1(a)

Separate Manual Control of Different Areas

The luminaires in each area must be independently controlled from luminaires in other areas by manual lighting controls that provide:

- **ON / OFF functionality** AND
- **Dimming or multi-level control steps** for dimmable luminaires

This section of the standards calls for a manual switch to be located in the same room or area as the lighting it controls. Although lighting control software applications for mobile devices are increasing in availability and lighting may be controllable through these points, it is still necessary to install a switch.

Specific requirements for continuous dimming or multi-level control steps apply to general lighting and are based on luminaire type, per **Table 130.1-A**.

Public Restrooms

Restrooms with two or more stalls are not required to have a manual switch accessible to the public. An ON/OFF control should still be readily accessible to authorized personnel, and all other applicable lighting controls are still required.

Offices and Workstations

Manual area lighting controls for offices and workstations must be:

- **Readily accessible** to authorized personnel
- **Located so users can monitor the controls' effect**, either by looking directly at the area OR using a device such as the interface of a lighting management system to monitor light levels and lighting loads

Other installed controls may not override manual controls.

Separate Control of Different Lighting Systems

Within each area enclosed by ceiling-height partitions:

- **General lighting** must be controlled separately from all other lighting systems.
- **Ornamental and display lighting**, including lighting for floor and wall displays, window displays, case displays, and special effects lighting, must each be separately controlled on circuits of 20 amps or less.

Egress Lighting

Up to 0.2 watts per square foot of lighting may remain on during occupied hours for emergency egress, but only in building spaces designated for emergency egress on building plans. Control switches for the egress lighting must not be accessible to unauthorized personnel. Egress lighting that is part of the general illumination must be shut off along with other lighting when the building is not occupied.

Office buildings are also permitted to have 0.05 W/ft^2 illuminated in any area provided it is designated on the building plans as an emergency egress area. This exception is in **Section 130.1(c)** and applies only to office buildings, and not other applications such as retail stores, schools or manufacturing facilities.

MULTI-LEVEL CONTROLS FOR GENERAL LIGHTING

Section 130.1(b)

✓ ***EXCEPTION: Multi-level Controls for General Lighting***

An area with only one luminaire that has just one or two lamps is exempt from the requirements for multi-level lighting controls.

This section of the standards sets the dimmability requirements, by source and socket type, for the general lighting in office applications.

Dimmable lighting provides the opportunity to reduce lighting energy use while allowing occupants to choose an appropriate light level for each area at any time. When compliance with this section is required and the lighting power density of the task area is greater than 85% of the allowed lighting power, the standards require the general lighting in any area over 100 ft^2 with a connected lighting load over 0.5 W/ft^2 meet all of the multi-level steps described in this section.

Requirements by Luminaire Type

Minimum control steps and illuminance uniformity requirements are based on luminaire type (see the facing-page table, based on **Table 130.1-A** of Title 24, Part 6).

All Luminaires Must Comply

Each luminaire must meet every step of the multi-level control requirements. Controlling alternating luminaires or rows of luminaires does not comply.

PHOTO: CREE, INC.

Connected Lighting with Integrated Controls

Cary, North Carolina

LORD Corporation, a diversified technology and manufacturing company, saw an opportunity in 2012 to move towards more energy-efficient lighting at its main headquarters. Their first LEED Certified Gold facility features all LED fixtures in its corridor and task lighting with lighting controls throughout the building. Fluorescent luminaires were replaced with 90+CRI Cree CR22 LED troffers with SmartCast™ Technology. The integrated controls enable users to program the network with a handheld configuration tool, decreasing the need to call technicians to re-commission the system.

When building the campus, considerable attention was given to the orientation of each building in relation to sun exposure. The increased level of natural daylight makes the daylight harvesting feature of the controls extremely important in maximizing energy savings. The SmartCast Technology allows occupants to utilize daylight harvesting features within individual offices, reducing energy usage in response to daylight.

A case study is available at: ***cree.com/Lighting/Applications/Indoor-and-Outdoor-Applications/Corporate-Campus/Lord-Corp***

Multi-level Lighting Controls and Uniformity Requirements for General Lighting

Luminaire Type	Minimum Required Control Steps (% of full rated power[1])	Uniform Level of Illuminance Achieved By:
Line-voltage sockets except GU-24	Continuous dimming 10–100%	
Low-voltage incandescent systems		
LED luminaires & LED source systems		
GU-24 rated for LED		
GU-24 sockets rated for fluorescent >20 W	Continuous dimming 20–100%	
Pin-based compact fluorescent >20 W[2]		
GU-24 sockets rated for fluorescent ≤20 W	Minimum one step between 30–70%	Stepped dimming; or continuous dimming; or switching alternate lamps in a luminaire.
Pin-based compact fluorescent ≤20 W[2]		
Linear & U-bent fluorescent ≤13 W		
Linear & U-bent fluorescent >13 W	Minimum one step in each range 20–40% 50–70% 80–85% 100%	Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of four lamps per luminaire, illuminating the same area and in the same manner.
Track Lighting	Minimum one step between 30–70%	Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.
HID >20 W	Minimum one step between 50–70%	Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of two lamps per luminaire, illuminating the same area and in the same manner.
Induction >25 W		
Other light sources		

Table 130.1-A in the standards

[1] Full rated input power of ballast and lamp, corresponding to maximum ballast factor
[2] Includes only pin-based lamps: twin tube, multiple twin tube, and spiral lamps

NOTE: Multi-level controls must not override the functionality of other controls required for compliance.

AUTOMATIC SHUT-OFF CONTROLS

Section 130.1(c)

Automatic shut-off controls turn lights off when a space is unoccupied. These controls are required in addition to manual area lighting controls and meeting the dimmability requirements in **Section 130.1(b)**. In this code cycle, more lighting will be off after hours in spaces that were typically left on all night, such as corridors and stairwells. Almost all lighting should be off when the building is unoccupied. Lighting must be controlled by one or more of the following types of automatic shut-off controls:

- Occupant-sensing control
- Automatic time clock
- Energy management system (EMS)
- Lighting control system or another type of control mechanism

✓ EXCEPTION: Separate Control of Different Lighting Systems

Buildings with lighting in continuous use (24 hours per day, 365 days per year) are not required to have automatic shut-off controls. Electrical equipment rooms are another exception.

Separate Control of Different Areas

Each area and every building floor must separately automatically shut OFF during unoccupied times. No more than 5,000 ft² of floor area may be covered by a single control.

Countdown Timer Switches

If countdown timer switches are selected to comply with the shut-off requirements, they may only be used in the following specific applications:

- **Single-stall restrooms smaller than 70 ft²**: Maximum setting: 10 minutes
- **Closets smaller than 70 ft²**: Maximum setting: 10 minutes
- **Aisles in server rooms smaller than 500 ft²**: Maximum setting: 30 minutes

As an alternative to countdown timer switches, these same spaces can also comply with the automatic shut-off requirements with occupancy sensors, automatic time clocks or through an energy management system.

Controlled Outlets in Office Applications

*The standards include mandatory measures for controlled receptacles in office applications. **Section 130.5(d)** describes the requirement for providing a controlled outlet within six feet of each uncontrolled outlet in open office areas, private offices, reception lobbies, conference rooms, staff kitchens, and copy rooms.*

The intent is for outlets serving task lighting and non-essential equipment to be turned off during unoccupied times, offering the opportunity for significant plug load energy use reductions. Outlets can be switched OFF from an occupancy sensor signal that typically serve lighting loads, or by a time-based control system.

If walls with electrical infrastructure are constructed or new outlets are added, this section will apply. If existing outlets are not affected by the project and remain unchanged, the measures do not apply.

Automatic Time-switch Control

Where time-switch controls are installed instead of occupant-sensing controls, occupants must have a manual override option that allows the lighting to remain ON outside the scheduled time for a maximum of two hours.

Occupant Sensing Controls Required

When the following rooms are unoccupied, the lighting should automatically be turned completely OFF:

- Offices 250 square feet or less
- Multipurpose rooms 1000 square feet or less
- Classrooms and conference rooms of any size

Adaptive Occupancy Controls Required in Secondary Spaces

In parking garages, corridors, stairwells, warehouse aisles and open areas, and some library book stacks, separate controls must automatically reduce lighting energy use at least 50% when no occupants are detected during building hours of operation:

CORRIDORS AND STAIRWELLS

- Each space must be separately controlled
- Sensors must be activated from all potential entrances
- Minimum automatic 50% reduction in lighting power when vacant

DAYLIGHTING CONTROLS

Section 130.1(d)

The standards address three types of daylit zones:

1. **Skylit zones:** Areas illuminated by one or more skylights
2. **Primary sidelit zones:** Daylit areas directly adjacent to one or more windows
3. **Secondary sidelit zones:** Areas not directly adjacent to a window but close enough to still receive some daylight

General Lighting in Daylit Zones

Automatic daylighting controls are required for luminaires that meet these criteria:

- Provide general lighting (as opposed to display lighting, decorative chandeliers or ornamental lighting)
- Are located at least partially in a skylit or primary sidelit zone
- Are installed in an area with a total installed general lighting power of 120 watts or more
- Are located in a room with at least 24 ft^2 of glazing
- Luminaires in skylit and primary sidelit zones must be controlled separately from each other. Luminaires installed where a skylit zone and primary sidelit zone overlap are controlled as part of the skylit zone, except for rooms with less than 24 ft^2 of glazing.

Daylighting Control Requirements

When compliance with this section is required, general lighting will be adjusted when enough daylight is available with automatic daylighting controls that must:

- Provide multi-level lighting in accordance with **Table 130.1-A** unless the lighting power density is less than 0.3 watts per square foot
- Maintain design light levels for each space, i.e., at or above those provided by electric lighting when no daylight is available
- Reduce general lighting power in a daylit zone at least 65% when the daylight contribution in that zone is more than 150% of the general lighting system's design light level at full power

In projects that qualify as alterations and modifications-in-place, the daylighting requirements in this section can often be bypassed if the actual lighting power is lower than 85% of the lighting power density required for that task area. Also, only altered luminaires need to comply with the daylight control requirements.

PRESCRIPTIVE REQUIREMENTS

When using the prescriptive compliance approach for a space, the requirements for automatic daylighting controls in primary sidelit zones also apply to general-lighting luminaires that are at least 50% in a secondary sidelit zone.

Floor plans for most buildings located in climate zones 2–15 that are over 5,000 ft^2 with a ceiling height of greater than 15 ft must have 75% of their total floor area in daylit zones, per **Section 140.3(c)**.

Daylight Commissioning

Proper calibration of daylighting controls enables these devices to maintain a proper balance between daylight and electric lighting contributions.

✓ EXCEPTION: Daylighting Control Requirements

General lighting in rooms with a total glazing area of less than 24 ft^2 are not required to meet the daylighting control requirements. Controlled lighting with a lighting power density less than 0.3 W/ft^2 does not have to meet the multi-level requirements.

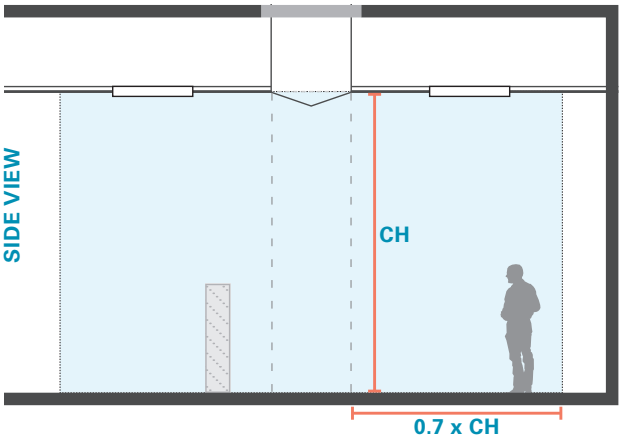
Determining Daylit Zones

All skylit zones and primary sidelit zones must be shown on building plans. The easiest way to determine the size of daylit zones is examining building plans.

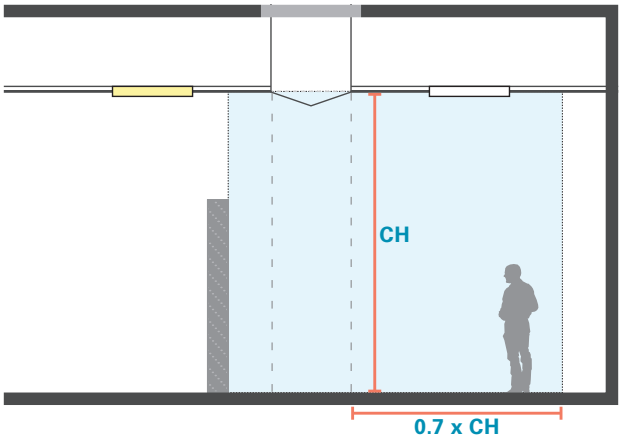
CALCULATING A SKYLIT ZONE

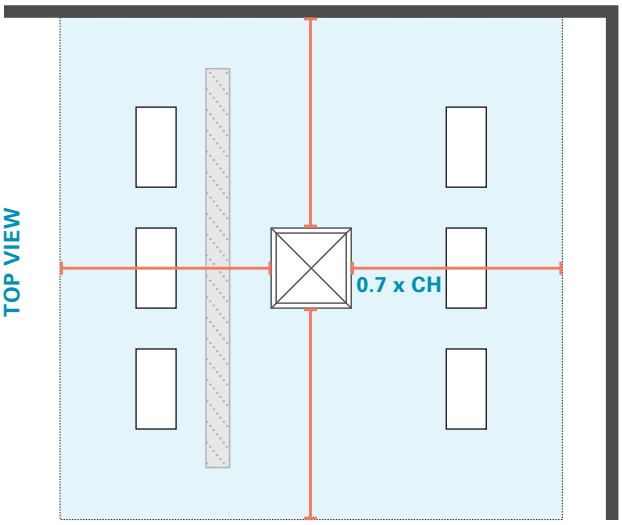
1. **Define the shape of the skylight.** A rectangular skylight produces a rectangular daylight zone, and a circular skylight produces a circular zone, etc.
2. **Determine the average ceiling height (CH) surrounding the skylight.** The ceiling height is the vertical distance from the finished floor level to the ceiling.
3. **Multiply the CH by 0.7**.
4. **Add the value determined in Step 3 in all directions around the skylight** (starting at the edges of the opening).
5. Subtract any area blocked from receiving daylight by a permanent obstruction taller than half the distance from the floor to the bottom of the skylight.

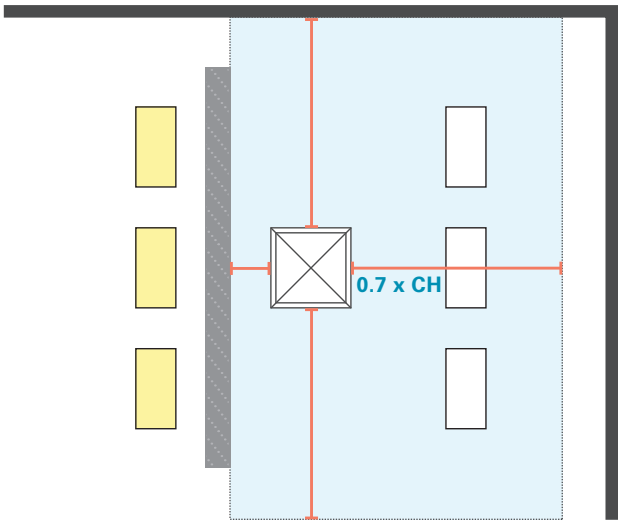
Obstruction height less than half the ceiling height



Obstruction height more than half the ceiling height

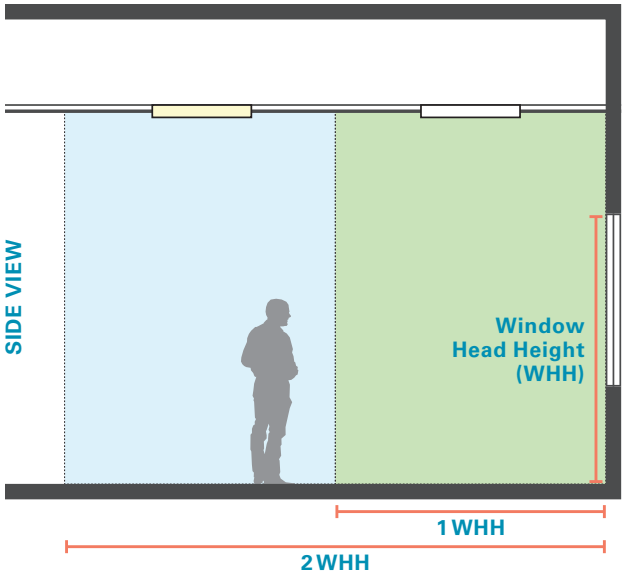






CALCULATING A PRIMARY SIDELIT ZONE

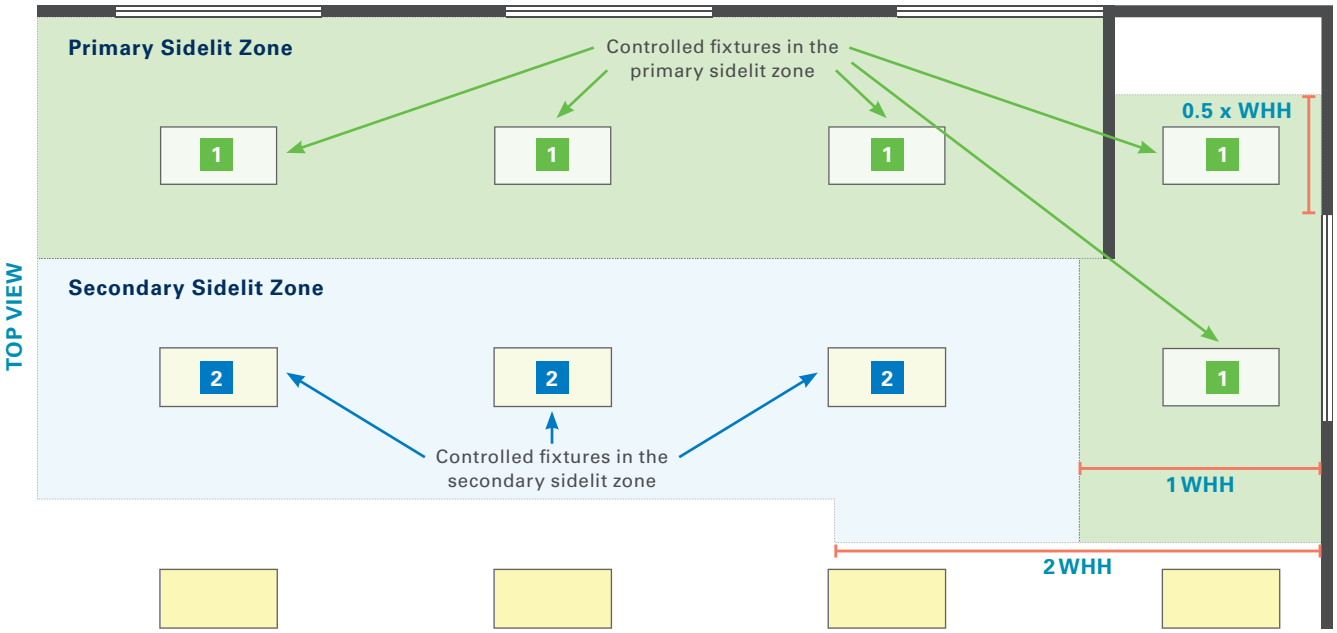
1. **Determine the window head height for each window.** The window head height (WHH) is the vertical distance from the finished floor level to the top of the glazing.
2. **Determine the depth of the zone.** The zone depth is one window head height into the area adjacent to the window.
3. **Calculate the width of the zone.** The zone width is the window's width added to half the window head height on each side of the window.
4. Subtract any area blocked from receiving daylight by a permanent obstruction that is six feet or taller. Modular furniture is not considered a permanent obstruction.



CALCULATING A SECONDARY SIDELIT ZONE

A secondary sidelit zone extends one additional window head height beyond the primary sidelit zone(s) adjacent to it.

1. Add one additional window head height to the same dimensions determined for primary sidelit zones, to determine the depth and width of the secondary sidelit zone.
2. Subtract any area that is blocked from receiving daylight by a permanent obstruction that is 6' or taller.



AUTOMATED DEMAND RESPONSE CONTROLS

Section 130.1(e)

Lighting Loads & ADR

Lighting is extremely well-suited to ADR, since peak demand periods typically overlap daylight hours. Research shows illuminance levels can be reduced by as much as 20% without occupants detecting the change. Optimal light levels are also easily, immediately restored after a DR event. Heating and cooling loads require time and additional energy.

Automated demand response (ADR) programs use energy management technologies and controls to respond to reduce peak demand and stabilize the grid more quickly and reliably than manual demand response (DR). An automated DR signal is sent from a utility, independent system operator or other power provider to energy management control systems enrolled in ADR programs. The automated systems then reduce electricity use temporarily, according to pre-programmed load shed strategies.

Buildings over 10,000 ft²

Project work areas larger than 10,000 ft² must be capable of automatically responding to a DR signal by:

- Reducing lighting power at least 15% below total installed lighting power AND
- Observing uniform level of illumination requirements consistent with the multi-level controls requirements listed in **Table 130.1-A**

A project work area can be comprised of various task areas and does not have to be continuous. If the total affected square footage of the project exceeds 10,000 ft², ADR compliance is likely required. It is important to note that per **Table 141.0-F** lighting retrofits that are classified as modifications-in-place will not trigger **Section 130.1(e)**, even if they exceed the square footage threshold.

Spaces Not Included in the ADR Plan for Compliance Purposes

Lighting load in the following space types is treated differently:

- Non-habitable spaces (such as storage closets) may not be counted toward the 15% reduction for compliance purposes, but they can be included in the DR plan when the facility is in operation for additonal reductions
- Spaces using a sum total of less than 0.5 W/ft² may not be counted in the building's ADR plan, as these spaces rarely have spare lighting load to shed

Designers are responsible for specifying controls compatible with the local utility company's protocol. The lighting control system must be programmed to automatically respond to DR signals in compliance with Title 24, Part 6 before the project is considered ready for the ATT and the building inspector. The ATT will verify that the ADR system is capable of the appropriate reduction as part of the acceptance testing process.

In Pursuit of Automated Demand Response

CLTC and Berkeley Lab partnered to test the ADR-readiness of commercially available networked lighting control systems. All three systems tested were configured for ADR communications, and all three successfully accessed the demand response automation server to retrieve demand response events. The research shows the potential for lighting control manufacturers to refine ADR software features in future product iterations. It also raises questions for discussion among utility leaders, regulators, rate payers, and others in the lighting industry and energy sectors.

More here: ***cltc.ucdavis.edu/publication/pursuit-automated-demand-response***

PHOTO: CREE, INC.

PERFORMANCE APPROACH

The Performance Approach to compliance is a software-based method that uses energy modeling to plan for an energy efficient building. This method is commonly used in new construction projects, rather than lighting retrofits.

System Trade-offs Allowed

In addition to meeting the mandatory requirements, actual lighting power may not exceed LPD limits set forth by the standards, unless traded with other energy features of the building using the Performance Approach. The Performance Approach to complying with these limits is recommended for professionals with experience using software modeling to manage energy budgets.

Under the Performance Approach, trade-offs may be made between different systems within a building. For example, energy-efficient lighting can allow more installed power for heating and cooling. There is no trade-off benefit to using the this method on projects that only affect the lighting system.

Approved Software Required

Those choosing the Performance Approach to compliance must use software to model building energy use, and that software must be approved by the Energy Commission. At the time this guide was created, two programs were approved for use with nonresidential building projects:

- **CBECC-Com V2b:** CBECC-Com uses EnergyPlus v8.0 to perform simulations and Sketchup (v8.0/Pro) with OpenStudio SketchUp Plugin for geometry input. Software can be downloaded at: **bees.archenergy.com/software.html**
- **IES Virtual Environment 2013 Title-24 Feature Pack 1 (VE2013 Title-24 FP1:** Integrated Environmental Solutions' VE Feature Pack works with SketchUp, Revit, DXF, gbXML, and IFC to import model geometry; data can be shared across all VE modules including the VE-Navigator for ASHRAE 90.1 (LEED Energy), Daylighting and Solar analysis modules. Software can be downloaded at: **iesve.com/software/title24**
- **EnergyPro Nonresidential:** This software was conditionally approved for demonstrating compliance with the nonresidential provisions of the standards until 03/31/2015. Software can be downloaded at: **energysoft.com/download/energypro-6**

Download the Title 24 Compliance Manuals

www.energy.ca.gov/title24/2013standards/2013_computer_prog_list.html

More information on "Approved Computer Compliance Programs" is available through the Energy Commission's website.

Find an Energy Consultant

*Professional energy consultants to assist with the Performance Approach and Title 24, Part 6 compliance can be located through the California Association of Building Energy Consultants. Visit **cabec.org**.*


PHOTO: STEELCASE

PRESCRIPTIVE APPROACH

When choosing the Prescriptive Approach to lighting power density compliance, choose one of the following methods to calculate the allowed indoor lighting power for each room or area of a building:

1. **Complete Building**
2. **Area Category Method**
3. **Tailored Method**

All three methods involve multiplying the area of a space (ft^2) by the allowed LPD (W/ft^2) for that space and adding special allowances for display lighting and decorative or ornamental lighting. Actual lighting power may not exceed this allotment.

With the Prescriptive Approach, trade-offs are limited to general lighting power and restricted to certain space types.

Under the Prescriptive Approach, the actual lighting power is compared to an allowed lighting power total. If the actual is less than or equal to the allowed, the project complies with the lighting power budget requirements.

The third method, the Tailored Method, is not frequently used for office buildings. However, it is an option for areas that utilize lighting to highlight unique features. In office applications, the Tailored Method may be used for a lobby or waiting area where awards or artwork is displayed.

Prescriptive Approach in Practice

At the end of this section are exercises for lighting power adjustments, Complete Building Method, and Area Category Method.


PHOTO: CREE, INC.

ACTUAL LIGHTING POWER

Section 140.6(a)

The actual indoor lighting power of the proposed building area is the total sum of all planned permanent and portable lighting systems, after any lighting power adjustments.

Lighting Power Adjustments

Exceeding the mandatory requirements for lighting controls (for example, by installing a control where it is not required) makes an installation eligible for a Power Adjustment Factor (PAF). This lowers the calculated lighting power use for the installed system.

Lighting Power Reduction = Controlled lighting power x PAF from Table 140.6-A

Lighting Power Density Adjustment Factors (PAF)

Type of Control		Type of Area		Factor
a. To qualify for any of the Power Adjustment Factors in this table, the installation will comply with the applicable requirements in **Section 140.6(a)2** b. Only one PAF may be used for each qualifying luminaire unless combined below c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF				
Partial-ON Occupant Sensing Control		Any area ≤ 250 ft² enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room		0.20
Occupant Sensing Controls in Large Open Plan Offices		In open plan offices > 250 ft²: One sensor controlling an area that is:	No larger than 125 ft²	0.40
			From 126 to 250 ft²	0.30
			From 251 to 500 ft²	0.20
Dimming System	**Manual Dimming**	Hotels/motels, restaurants, auditoriums, theaters		0.10
	Multiscene Programmable			0.20
Demand Responsive Control		All building types less than 10,000 ft² Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF		0.05
Combined Manual Dimming plus Partial-ON Occupant Sensing Control		Any area ≤ 250 ft² enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room		0.25

Table 140.6-A in the standards

Task Lighting Power Exclusions for Offices

An exception to **Section 140.6(a)** allows for up to 0.3 W/ft² of portable office lighting to be added without counting towards the LPD budget. If this option is used, **Form NRCC-LTI-01-E** has a section that must be completed as part of the compliance process.

Other Lighting Power Exclusions

The power used by certain lighting applications may be excluded from actual lighting power calculations. Selections from the list of exclusions including but not limited to:

- Equipment that is for sale and for demonstration
- Specialized studio lighting for video or photography that is installed in addition to general lighting
- Manufacturer-installed lighting in vending machines, refrigerated cases, walk-in freezers, and food preparation equipment

DETERMINING ALLOWED POWER UNDER THE COMPLETE BUILDING METHOD

Section 140.6(c)1

The Complete Building Method may only be used on projects involving buildings with one primary type of use or in mixed-use buildings or tenant spaces where 90% of the leased space has one primary use. This is the simplest way to determine if the office lighting plan complies with the standards.

This method can only be used for building types listed in **Table 140.6-B**. The lighting power allowance is calculated by multiplying the complete building area (ft²) by the allowed lighting power (W/ft²) for that building type.

Allowed Lighting Power = W / ft² from Table 140.6-B x floor area

When applying the Complete Building Method on a project where a parking garage is included, the parking structure and buildings should be calculated separately using the appropriate use type for each.

PHOTO: UC SANTA BARBARA

The Benefits of Networked Controls in Office Spaces

UC Santa Barbara

In 2013, UC Santa Barbara installed network controlled LED lighting in the Student Information Systems & Technology Office through the State Partnership for Energy Efficient Demonstrations (SPEED) program. The project reduced lighting energy use by 89%, based on an average measured occupancy rate of 28%.

Each of the open office's 58 T8 fluorescent luminaires were replaced with a recessed LED luminaire and dimmable LED driver. The new luminaires were equipped with wireless occupancy sensors and wireless network lighting control units so they dim automatically when spaces are vacant. The control system software tracks energy use for the entire system and the individual luminaires. The new control system also allows for dimming, so light levels can be adjusted for specific cubicles and occupants' needs.

The occupancy data collected through the system has also proven extremely valuable, informing occupancy rate studies and decision making for HVAC retrofits and for lighting retrofits in other spaces. The occupancy data collected has also garnered better utility incentives for the campus.

DETERMINING ALLOWED POWER UNDER THE AREA CATEGORY METHOD

Section 140.6(c)2

The Area Category Method provides a single lighting power allowance for each primary function area listed in **Table 140.6–C**. This exact value is calculated by multiplying the entire area (ft^2) of each function area (including floor space used by partitions) by the allowed lighting power (W/ft^2) for that function area.

Allowed Lighting Power = W/ft^2 from Table 140.6-C x entire floor area

The total allowed lighting power is the sum of the lighting power allotments for all the areas covered by the permit application.

Additional Lighting Power Allotments

Additional lighting energy use is allowed for some areas under the Area Category Method including but are not limited to:

- Adjustable or directional accent, display and feature lighting
- Decorative lighting
- Ornamental lighting

Office-specific Selections from the Allowed Lighting Power Table

Primary Function Area		Allowed General Lighting Power	Additional Power Allowances *(As listed in footnotes for Table 140.6-C)*
Classroom, Lecture, Training, Vocational Areas		1.2 W/ft^2	+5.5 W/ft^2 per linear foot of whiteboard or chalkboard
Convention, Conference, Multipurpose and Meeting Center Areas		1.4 W/ft^2	+0.5 W/ft^2 Ornamental Lighting
Lobby Area	**Hotel lobby**	1.1 W/ft^2	+0.5 W/ft^2 Ornamental Lighting
	Main entry lobby	1.5 W/ft^2	
Electrical, Mechanical, Telephone Rooms		0.7 W/ft^2	+0.5 W/ft^2 Specialized task work
Laboratory Area, Scientific		1.4 W/ft^2	+0.2 W/ft^2 Specialized task work
Waiting Area		1.1 W/ft^2	+0.5 W/ft^2 Ornamental Lighting
Office Area ≤ 250 ft^2		1.0 W/ft^2	
Kitchen, Food Preparation Areas		1.6 W/ft^2	
Commercial and Industrial Storage Areas (conditioned and unconditioned)		0.6 W/ft^2	
All other areas		0.6 W/ft^2	

Table 140.6-C: Area Category Method—Lighting Power Density Values

PHOTO: LUTRON

DETERMINING ALLOWED POWER UNDER THE TAILORED METHOD

Section 140.6(c)3

The Tailored Method is typically used for projects that include space types listed in **Table 140.6-D** of the standards. Within office applications, these space types may include:

- Auditorium Area
- Dining Areas
- Main Entry Lobby Area
- Lounge Area
- Waiting area

Space types, or "primary function areas," not listed in **Table 140.6-D** can refer to the Tenth Edition IES Handbook to apply the tailored method in other areas by obtaining an illuminance value appropriate for the tasks occurring in that area. See **Section 140.6(c)3H(i)(e)** for details.

General Lighting Power Allotments

Under the Tailored Method, general lighting power allotments are tailored to each space or area based on the dimensions of the space, including ceiling height and IES-recommended illumination levels. The process includes the following steps:

1. Determine the primary function area, and the illuminance value (listed in lux) per **Table 140.6-D**
2. Determine the room cavity ratio (RCR) according to **Table 140.6-F**
3. Use the illuminance value and the RCR to find the allowed LPD according to **Table 140.6-G**

Areas with high ceilings have a high RCR, making them more difficult to light. The Tailored Method allows greater LPD allowances as the RCR increases. The RCR trigger points for increased LPD allowances start at 2.0, then increase at 3.5 and 7.0.

GENERAL LIGHTING TRADE-OFFS

The Tailored Method allows for certain LPD trade-offs for general lighting only. Trade-offs must be documented using compliance forms and must be kept within conditioned areas or within unconditioned areas. Trade-offs are allowed:

- From one conditioned area using the Tailored Method to another conditioned area using either the Tailored or Area Category Method
- From one unconditioned area using the Tailored Method to another unconditioned area using either the Tailored or Area Category Method

Additional Lighting Power Allotments

In addition to general lighting power allotments, the Tailored Method provides lighting energy use allotments for special tasks that use lighting as a way to draw attention to an area, by providing visual contrast to what is contributed from the general lighting. The following is a sample selection of lighting power allotments in the standards. The complete list can be found in **Section 140.6(c)3** of the standards:

- **Wall display lighting:** Supplementary lighting required to highlight features such as artwork or awards, which is displayed on perimeter walls. It provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance.

- **Ornamental/special effects lighting:** Decorative indoor luminaires are typically chandeliers, sconces, theatrical projectors, dynamic or moving lighting or illuminated colored panels that are not providing general illumination.

- **Room Cavity Ratio**

The room cavity ratio describes the configuration of a room. Rooms with high ceilings are typically more difficult to illuminate and have a high RCR. Because luminaires are not as effective in areas with a high RCR, the standards allow a higher lighting power density.

The RCR must be calculated for any function area using the Tailored Method. **Section 140.6-F** of the standards provides the equations for the calculations.

The RCR is based on the entire space bounded by floor-to-ceiling partitions. If a task area with a larger space is not bounded by floor-to-ceiling partitions, the RCR of the entire space must be used for the task area.

Room Cavity Ratio (RCR) Equations

Determine the Room Cavity Ratio using one of the following equations

Room cavity ratio for rectangular rooms

$$RCR = \frac{5 \times H \times (L + W)}{L \times W}$$

Room cavity ratio for irregularly shaped rooms

$$RCR = \frac{2.5 \times H \times P}{A}$$

H = Vertical distance from the work plane to the center line of the lighting fixture
L = Length W = Width P = Perimeter A = Area of the room

Table 140.6-F in the standards

✓ EXCEPTION: Room Cavity Ratio

*RCR allows for imaginary or virtual walls when the boundaries are established by "high stack" elements (close to the ceiling structure and high storage (shelves) or high partial walls defined as "perimeter full height partitions" described in **Section 140.6(c) 3liv**.*

In-Person Codes and Standards Training

EnergyCodeAce offers training events at the investor owned utility energy education training centers and other locations throughout California.

Have a group of 20 or more attendees that need more help to apply the standards in practice? Training sessions can also be requested and scheduled to fulfill needs not covered by the scheduled sessions.

*Submit a request at **energycodeace.com/content/training-request***

EXAMPLE: CALCULATE ACTUAL & ALLOWED LIGHTING POWER

J.S.H. Associates 1,944 ft² office building

The following example will show the steps to determine whether the actual lighting power of a project will comply with the lighting power budget allowed by the standards using the Area Category Method:

1. Calculate the lighting power allowance
2. Calculate the total installed lighting power for all planned lighting from a lighting schedule
3. Exclude portable task lighting power for the office areas, using an option available under the Area Category Method
4. Apply control credits earned by specifying lighting controls that go beyond code requirements
5. Determine the adjusted lighting power using answers from steps one through four
6. Compare the adjusted installed lighting power to the allowed lighting power

This section concludes with an example calculation of allowed lighting power using the Complete Building Method to compare results with the Area Category Method.

The example offers notes on what sections of the Certificates of Compliance for Nonresidential Indoor Lighting are necessary to support the compliance process for this scenario.

Indoor Lighting Schedule

Symbol	Luminaire	Qty.	System Wattage	Total Watts	Efficacy *(Lumens / Watt)*
	2X2 LED RECESSED TROFFER Cree CR22	15	35	525	90 – 100
	1x4 1-LAMP FLUORESCENT RECESSED TROFFER Finelite HPR w/ Sylvania 32W T8 lamp; Sylvania Quicktronic Ballast	4	28	112	89
	2x4 2-LAMP FLUORESCENT RECESSED TROFFER Finelite HPR w/ Sylvania 32W T8 lamp; Sylvania Quicktronic Ballast	2	54	108	89
	8' LED SUSPENDED LUMINAIRE Lunera Lighting L7-G3	1	85	85	84
	8' LED LINEAR WALL MOUNT LUMINAIRE Finelite Muro-Oval	1	45.2	45.2	57.3
	6" LED RECESSED DOWNLIGHT Cree CR6	12	12	144	90
	LED WALL SCONCE Tech Lighting Mura	6	8	48	50
	LED PENDANT Philips Vetro	3	10	30	76
	LED SUSPENDED LUMINAIRE Philips Ledino Cinta Suspension Light	2	22.5	45	100
			Total Installed Lighting Watts : 1,142.2 W		
PORTABLE LIGHTING					
	45" LED UNDERCABINET TASK LIGHTING Finelite Edge Undercabinet	10	12.2	122	62.2
	LED TASK LIGHT Koncept Z Bar Mini Task Light	1	6.5	6.5	–
			Total Portable Lighting Watts: 128.5 W		

The schedule is used to fill in lighting schedule in Form NRCC-LTI-01-E

TOTAL WATTS: 1,270.7 W

NRCC-LTI-01-E: Indoor Lighting, "C. Indoor Lighting Schedule and Field Inspection Energy Checklist"

STATE OF CALIFORNIA
INDOOR LIGHTING
CEC-NRCC-LTI-01-E (Revised 06/14)
CALIFORNIA ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE	NRCC-LTI-01-E
Indoor Lighting	(Page 4 of 5)
Project Name:	Date Prepared:

A separate Lighting Schedule Must Be Filled Out for Conditioned and Unconditioned Spaces. Installed Lighting Power listed on this Lighting Schedule is only for:
☐ **CONDITIONED SPACE** ☐ **UNCONDITIONED SPACE**

C. INDOOR LIGHTING SCHEDULE and FIELD INSPECTION ENERGY CHECKLIST

Luminaire Schedule		Installed Watts				Location	Field Inspector [1]	
A	B	C	D		E	F	G	H	
Name or Item Tag	Complete Luminaire Description (i.e, 3 lamp fluorescent troffer, F32T8, one dimmable electronic ballast)	Watts per Luminaire	How wattage was determined: CEC Default from NA8	How wattage was determined: According to §130.0(c)	Number Luminaires	Total Installed Watts in this area (C x E)	Primary Function area in which these luminaires are installed	Pass	Fail
			☐	☐				☐	☐
			☐	☐				☐	☐
			☐	☐				☐	☐
			☐	☐				☐	☐

DETERMINING COMPLIANCE WITH THE AREA CATEGORY METHOD

The lighting plan complies if the total installed lighting power is less than or equal to the allowed lighting power. This example uses the Area Category Method to determine allowed lighting power. Area by area, the LPD of the spaces within the building is calculated. All areas in the project are added together. If the total LPD is greater than the standards allow, the lighting design does not comply and it will have to be revised to achieve a lower LPD. The Summary of Allowed Lighting Power, shown below, will be completed at the end of this example.

Summary of Allowed Lighting Power

Installed Lighting (NRCC-LTI-01-E)	**+**	
Portable Lighting (NRCC-LTI-01-E)	**+**	
Minus Lighting Control Credits (NRCC-LTI-02-E)	**–**	
Adjusted Installed Lighting Power	**=**	
Complies ONLY if Installed ≤ Allowed		
Allowed Lighting Power (NRCC-LTI-03-E)		

Adapted from "Summary of Allowed Lighting Power," Form NRCC-LTI-01-E: Indoor Lighting

NRCC-LTI-01-E: Indoor Lighting, "C. Indoor Lighting Schedule and Field Inspection Energy Checklist"

Summary of Allowed Lighting Power

Conditioned and Unconditioned space Lighting must not be combined for compliance

	Indoor Lighting Power for Conditioned Spaces		Watts	Indoor Lighting Power for Unconditioned Spaces		Watts
1.	**Installed** Lighting NRCC-LTI-01-E, page 4	+		**Installed** Lighting NRCC-LTI-01-E, page 4	+	
2.	PORTABLE ONLY FOR OFFICES NRCC-LTI-01-E, page 3	+				
3.	Minus Lighting Control Credits NRCC-LTI-02-E, page 2	-		Minus Lighting Control Credits NRCC-LTI-02-E, page 2	-	
4.	Adjusted **Installed** Lighting Power (row 1 plus row 2 minus row 3)	=		Adjusted **Installed** Lighting Power (row 1 minus row 3)	=	

CA Building Energy Efficiency Standards - 2013 Nonresidential Compliance June 2014

STATE OF CALIFORNIA
INDOOR LIGHTING
CEC-NRCC-LTI-01-E (Revised 06/14)
CALIFORNIA ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE	NRCC-LTI-01-E
Indoor Lighting	(Page 2 of 5)
Project Name:	Date Prepared:

5.	Complies ONLY if **Installed** ≤ **Allowed**		Complies ONLY if **Installed** ≤ **Allowed**		
6.	**Allowed** Lighting Power Conditioned NRCC-LTI-03-E, page 1		**Allowed** Lighting Power Unconditioned NRCC-LTI-03-E, page 1		

1 LIGHTING POWER ALLOWANCE

1. There are six primary function areas in this space. Determine the allowed lighting power of each area according to **Table 140.6-C**.
2. Determine the square feet of each area type.
3. Calculate the wattage allowance by multiplying the square feet of the each area type by the additional watts allowed.
4. Total the allowed watts.

Form NRCC-LTI-03-E: Indoor Lighting Power Allowance

C-2 Area Category Method General Lighting Power Allowance

Primary Function Area	Allowed Lighting Power	x	Area	=	Allowed Watts
Office Area >250ft²	0.75W/ft²		532ft²		399W
Office Area ≤250ft²	1.0W/ft²		222ft²		222W
Classroom, Lecture, Training, Vocational Area	1.2W/ft²		252ft²		302.4W
Lobby	1.5W/ft²		228ft²		342W
Kitchen, Food Prep Area	1.6W/ft²		156ft²		249.6W
Corridor, Restroom, Stair and Support Area	0.6W/ft²		470.02ft²		282W
				TOTAL	**1,797W**

Some of the areas in the example are eligible for an additional wattage allowance for specialized lighting. The footnotes in **Table 140.6-C** are used to determine how much can be allocated. This is a "use it, or lose it" allowance. If there is no lighting in the schedule that qualifies for the additional allowance, it cannot be used.

Additional Lighting Wattage Allowance

Form NRCC-LTI-03-E: Indoor Lighting Power Allowance

The suspended luminaire in the lobby is classified as "Ornamental lighting," as defined in **Section 100.1** and in accordance with **Section 140.6(c)2**. The whiteboard lighting in the conference room also qualifies for an additional lighting wattage allowance according to **Table 140.6-C**.

C-3 Area Category Method Additional Lighting Wattage Allowance

1. Determine the additional watts allowed according to the footnotes in **Table 140.6-C**.
   Ornamental Lighting: **0.5 W / ft²**
   Whiteboard Lighting: **5.5 W per linear foot**
2. Determine the square feet of the office primary function area.
   For white board lighting, determine the linear feet of whiteboard.
   Ornamental Lighting: **228 ft²**
   Whiteboard Lighting: **7 feet**
3. Calculate the wattage allowance by multiplying the square feet of the sales area by the additional watts allowed.
   Ornamental Lighting: **38.5 W**
   Whiteboard Lighting: **114 W**
4. Choose the smaller of either the newly calculated allowed watts or the total design watts of the luminaire.
   There are 38.5 W for ornamental lighting and 22.5 W for whiteboard lighting, totaling 61 W of additional allowed lighting wattage.

Total Lighting Power Allowances

C-1 Area Category Method Total Lighting Power Allowances

Calculate the adjusted installed lighting power by adding the additional lighting wattage allowance to the general lighting power allowance.

1,797W + 61W = 1,858 W

Allowed Lighting Power (NRCC-LTI-03-E)	-	**1,858 W**

INSTALLED LIGHTING POWER

2 Installed Lighting Power

The installed lighting power includes all planned permanent and portable lighting. Complete the lighting schedule in "C. Indoor Lighting Schedule and Field Inspection Energy Checklist" to determine the total to use for compliance purposes.

Installed Lighting (NRCC-LTI-01-E)	**+**	**1,270.7 W**

Form: NRCC-LTI-01-E: Indoor Lighting

C. Indoor Lighting Schedule and Field Inspection Energy Checklist

3 Installed Portable Luminaires in Offices

When calculating actual lighting power, there is an exception to **Section 140.6(a)** that states that up to 0.3 watts per square foot of portable lighting for office areas shall not be required to be included in the calculation of actual indoor Lighting Power Density. When calculating installed lighting power under the Area Category Method, planned portable luminaires should be calculated using "B. Installed Portable Luminaires in Offices — Exception to Section 140.6(a)" in **Form NRCC-LTI-01-E**. For the Complete Building Method, include the total wattage for portable lighting into the installed lighting total.

Using **Form NRCC-LTI-01-E**, calculate the wattage for installed portable luminaires in offices. This section should only be filled out for portable luminaires in offices as defined by **Section 100.1** All other planned portable luminaires should be documented on "C. Indoor Lighting Schedule and Field Inspection Energy Checklist." This section is used to determine if greater than 0.3 W of portable lighting is planned for any office.

There are two portable luminaires in the offices — LED undercabinet lighting for the cubicles in the open office and an LED task light in the private office.

1. Multiply the watts per luminaire by the number of luminaires to determine installed portable luminaire watts in this office.
   LED Undercabinet: **122 W** LED Task Light: **6.5 W**
2. Determine the square feet of each office primary function area.
   Open Office: **532 ft²** Private Office: **222 ft²**
3. Divide the installed portable luminaire watts by the square feet of the office to determine watts per square foot.
   LED Undercabinet: **122 W ÷ 532 ft² = 0.23 W/ft²**
   LED Task Light: **6.5 W ÷ 222 ft² = 0.03 W/ft²**
4. Determine accountable wattage by multiplying the square feet of the office primary function area by the watts per square feet. If the watts per square foot is ≤ 0.3, claim 0 W of accountable watts for installed portable luminaires.
   LED Undercabinet Task: **0 W** LED Task Light: **0 W**

B. Installed Portable Luminaires in Offices — Exception to Section 140.6(a)

Portable Lighting (NRCC-LTI-01-E)	**+**	**0 W**

The new Installed Lighting total with the exclusion of portable luminaire wattage is:

Installed Lighting (NRCC-LTI-01-E)	**+**	**1,142.2 W**

4 Lighting Control Credits

This lighting plan exceeds the mandatory requirements for lighting controls by including partial-ON occupant sensing controls in the restrooms and copy room. These controls comply with **§ 130.1(a)**, **§ 130.1(c)**, and **§ 140.6(a)2**. There is also a combined manual dimming and partial-ON occupancy sensor in the conference room. These controls comply with **§ 130.1(a)**, **§ 130.1(b)**, **§ 130.1(c)**, **§ 130.1(d)**, and **§ 140.6(a)2**.

This design is eligible for a PAF, which lowers the calculated lighting power use for the installed system. The lighting control credits are subtracted from the total installed lighting.

1. Determine the PAF using **Table 140.6-A**.
   Restrooms and Copy Room: **0.2**
   Conference Room: **0.25**
2. Calculate the watts of controlled lighting.
   Restroom #1: **28 W** Restroom #2: **28 W**
   Copy Room: **56 W** Conference Room (downlights & pendant): **133 W**
3. Multiply the watts of controlled lighting by the PAF to determine the control credit.
   Restroom #1: **28 W x 0.20 = 5.6 W**
   Restroom #2: **28 W x 0.20 = 5.6 W**
   Copy Room: **56 W x 0.20 = 11.2 W**
   Conference Room: **133 W x 0.25 = 33.25 W**
4. Total the control credits to determine how many lighting control credits are available for this space
   6.4 + 6.4 + 12.8 + 67.8 = 58.85 W of lighting control credits

Minus Lighting Control Credits (NRCC-LTI-02-E)	-	**55.65 W**

Form NRCC-LTI-02-E: Indoor Lighting — Lighting Controls

Mandatory and Prescriptive Indoor Lighting Control Schedule, PAF Calculation, and Field Inspection Checklist

5 Adjusted Lighting Power

Use the "Summary of Allowed Lighting Power" in **Form NRCC-LTI-01-E** to calculate the adjusted installed lighting power by adding the portable lighting and subtracting the lighting control credits from the total installed lighting.

1,142.2 W + 0 W – 55.65 W = 1,086.55 W of adjusted lighting power

6 Compare Adjusted Installed Lighting Power to Allowed Lighting Power

Use the "Summary of Allowed Lighting Power" in **Form NRCC-LTI-01-E** to determine if this lighting schedule is compliant.

Summary of Allowed Lighting Power

Installed Lighting (NRCC-LTI-01-E)	+	**1,142.2 W**
Portable Lighting (NRCC-LTI-01-E)	+	**0 W**
Minus Lighting Control Credits (NRCC-LTI-02-E)	–	**55.65 W**
Adjusted Installed Lighting Power	=	**1,086.55 W**
Complies ONLY if Installed ≤ Allowed		
Allowed Lighting Power (NRCC-LTI-03-E)	**1,858 W — This space complies.**	

Adapted from "Summary of Allowed Lighting Power," Form NRCC-LTI-01-E: Indoor Lighting

COMPLETE BUILDING METHOD

This method can be used for select building types, including office buildings. To evaluate whether the space complies, calculate the allowed lighting power by multiplying square footage by one lighting power density for the whole project and compare it to the actual lighting power.

Form NRCC-LTI-03-E: Indoor Lighting Power Allowance

B. Complete Building Method Lighting Power Allowance

Lighting Power Allowance

The Complete Building Method may only be used in projects involving entire buildings with one primary use, or in mixed-use buildings or tenant spaces where 90% of the spaces have one primary use.

The schedule includes portables, but under the Complete Building Method the total wattage used by the portables goes into total installed lighting power and no exemption can be applied.

According to **Table 140.6-B**, this space is classified as an office building.

1. Determine the allowed lighting power density of an office building according to **Table 140.6-B**
   Office Building: **0.8 W/ft²**
2. Multiply the allowed lighting power density by the area of the space.
   0.8 W/ft² X 1,944 ft² = 1,555.2 W allowed lighting power under the Complete Building Method

Determining Compliance Under the Complete Building Method

Use the "Summary of Allowed Lighting Power" in **Form NRCC-LTI-01-E** to determine if this lighting schedule is compliant under the Complete Building Method.

Summary of Allowed Lighting Power

Installed Lighting (NRCC-LTI-01-E)	**+**	**1,270.7 W**
Portable Lighting (NRCC-LTI-01-E)	**+**	**—**
Minus Lighting Control Credits (NRCC-LTI-02-E)	**–**	**55.65 W**
Adjusted Installed Lighting Power	**=**	**1,215.05 W**
Complies ONLY if Installed ≤ Allowed		
Allowed Lighting Power (NRCC-LTI-03-E)		**1,555.2 W — This space complies.**

Adapted from "Summary of Allowed Lighting Power," Form NRCC-LTI-01-E: Indoor Lighting

PHOTO: LUTRON

CHAPTER 5

DESIGNING TO CODE

MINIMIZE LIGHTING POWER DENSITY, MAXIMIZE CONTROL

Designing office buildings to meet or exceed Title 24, Part 6 requires implementing measures that maximize adaptive lighting controls to achieve the lowest lighting power density and reduce energy use. These energy efficiency steps are necessary for California to meet its ambitious goal for all new commercial buildings to be zero net energy (ZNE) by 2030. A ZNE building produces as much energy on-site as it consumes annually.

Office lighting should help workers perform their tasks effectively and comfortably. In most office applications, this involves maximizing illumination while minimizing the visibility of light sources to allow employees to focus on the workspaces being lit than the lighting itself. Energy savings can be achieved while maintaining the quality of lighting for occupants' comfort and satisfaction.

A critical step in lighting design is determining the visual needs of the space and identifying the type of lighting to use. That will help in deciding which energy efficient lighting technologies and control strategies to use.

This section discusses how the Title 24 requirements apply to ambient lighting, task lighting, daylighting, and transitional spaces and provides recommendations for designing with them for office applications.

PHOTO: ACUITY BRANDS

LAYERED LIGHTING FOR OFFICE SPACES

Office spaces traditionally rely on a lighting design approach referred to as general lighting, where ceiling-mounted luminaires provide an overall level of illumination intended to be sufficient for all space uses. This strategy results in the level of illumination being sufficient for tasks in all locations, regardless of whether tasks are being performed or not. Studies have shown that reducing ambient lighting and using localized light for specific visual tasks creates a more comfortable experience and can significantly reduce energy use.

In partnership with lighting manufacturers and the Energy Commission's Public Interest Energy Research (PIER) Program, CLTC evaluated the benefits of a layered lighting design for office applications. The studies found that including LED-based task lighting in the primary layer of lighting in offices resulted in a 50% savings in lighting energy and overwhelming user satisfaction. Following is a summary of some of the research conducted:

Integrated Office Lighting System

Task/ambient lighting, an effective strategy to illuminate office spaces, is a total systems approach. Dimmable overhead troffers or pendants provide the majority of the lighting, supplemented by vertical surface and task lighting. This approach achieves significant energy savings by reducing the overhead lighting load without sacrificing user comfort and visual acuity. Incorporating high quality task lighting makes this possible.

"Task/Ambient Lighting: Efficient, Stylish, and Portable":
energy.ca.gov/research/buildings/proj_lighting.html

The Benefits of LED Task Lighting

The "Portable Office Lighting Systems Final Report" summarized research to design, develop, and test prototype portable workstation luminaires and implemented lighting controls in these lamps to provide both workstation and office-level lighting control.

"Developing Lighting Technologies Integrated Office Lighting":
finelite.com/products/pls-overview

Zero Net Energy by 2030

In 2008, California set a goal to achieve zero net energy (ZNE) use in new commercial buildings by 2030. To reach this objective, new construction projects must combine highly efficient energy systems and distributed renewable energy generation to meet 100 percent of their annual energy need. Meeting the requirements of Title 24, Part 6 is a good start, but new buildings must go beyond code to meet these bold goals.

LOW AMBIENT LIGHTING, MEET OR EXCEED CODE

Compliance Requirements

Lighting power density maximums for most office-related areas are now below 1 W/ft^2. The required maximums or lower LPDs can be achieved by carefully using only what is needed and by using LED technologies where possible. Review **Table 140.6-C** for the allowed lighting power allowances in the Area Category Method primary function area.

The standards do not currently require occupancy-based controls in open office environments. Capturing savings that exceed code requirements is reachable by using networked systems or luminaires with integrated controls. The standards do require occupancy controls in private offices 250 ft^2 or smaller and conference rooms of any size. If occupancy controls shut off lighting in infrequently occupied spaces, the project is likely to comply. Refer to **Sections 130.1(a) and (c)** for the complete requirements.

Recommendations

Visual Comfort and Uniformity

When designing lighting for office spaces, use indirect lighting to minimize glare on computer screens and task lighting to provide users light when and where it is needed. Indirect lighting illuminates the ceiling, which in turn reflects light down to the vertical surfaces, task areas and floor. If the lighting design provides uniform distribution, the resulting illumination can be diffuse, soft and nearly shadow-free.

Vertical Illumination

Adding lighting for vertical surfaces where the task/ambient strategy is applied reduces contrast ratios and gives the space a softer and more appealing visual appearance. This additional effect also offers energy reduction opportunities when the luminaires illuminating the vertical surfaces are controlled in a separate lighting layer. This layer can be dimmed or shut off during typically vacant periods or during a demand response event.

Networked Controls

In an open office environment, overhead ambient lighting is typically controlled in large zones. As a result, large areas of a building may be illuminated for long periods of time, regardless of occupancy. Significant energy and maintenance savings can be achieved by using a combination of low ambient lighting, zonal controls for smaller areas and high-quality task lighting and personalized controls.

Many controls solutions involve connecting all light points into a network using either wired or wireless communication between sensor and luminaires, or from luminaire to luminaire if integrated controls are used. Not all networked systems accurately collect information about energy use. Some systems do not collect or store any information and are intended to function as a hardware-based system only.

The standards do not require that networked lighting controls be used to meet the mandatory measures. However, many current systems have standard features that meet and exceed the measures in **Section 130.1** and will help to comply with the new Electric Power Distribution Systems requirements in **Section 130.5**.


PHOTO: LUTRON

MANAGING DAYLIGHT

Compliance Requirements

The mandatory measures for automatic daylighting requires more controls in spaces that have more than 24 ft² of glazing and more than 120 W of general illumination in the combined sidelit and skylit zones. Not all buildings will realize the maximum benefit from adding daylighting controls because of the building's position or outside obstructions. Not all measures are required for all projects and there are many exceptions. Review **Section 130.1(d)** with **Table 141.0-E** or **Table 140.0-F** to determine what each project mandates. The standards consider controlled luminaires as providing general illumination and not accent or task lighting.

Recommendations

Daylighting in commercial buildings can reduce electricity use for lighting by up to 50% or more, but also presents complex challenges. The IES' Recommended Practice for Daylighting Buildings (RP-5-13) provides up-to-date technological solutions and data for addressing the challenges of daylighting while maximizing its benefits. The RP-5-13, which is the authoritative reference guide for architects, engineers and lighting designers, includes information on daylight design techniques, delivery methods, glazing systems, shading techniques, control strategies, and daylight performance simulation tools. More at:
cltc.ucdavis.edu/publication/ies-rp-5-13-recommended-practice-daylighting-buildings

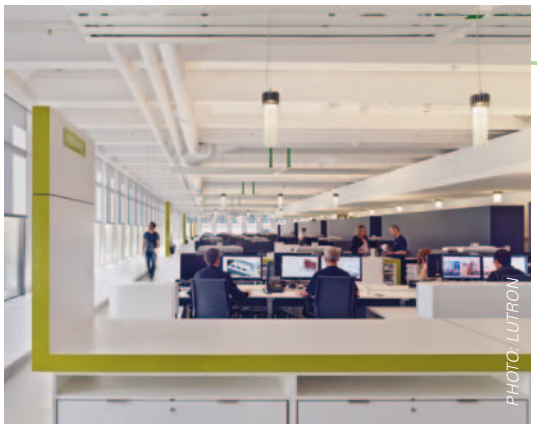


PHOTO: LUTRON

Balancing Daylight with Electronic Light
Glumac, Portland, Oregon

Glumac paired with Lutron to create a comfortable and energy-efficient area for their new office space in the Standard Insurance Center. Wireless vacancy sensors, total light management system controls, and preset controls were installed. The space was equipped with daylight sensing to respond to the natural window light. The system aims to reduce lighting power density by 47% of the Oregon allowance. In the first two months, lighting energy use was reduced to 0.24 W/ft², below the designed connected load of 0.68.

A case study is available at: **lutron.com/en-US/Residential-Commercial-Solutions/Pages/SolApp/Corporate/OpenOffice/Glumac/Glumac.aspx**

PHOTO: CLTC, UC DAVIS

TASK LIGHTING FOR PERSONAL CONTROL

Compliance Requirements

Task lighting can play a critical role to meet or exceed the 0.75 W/ft² maximum when using the Area Category Method. With a thorough design using LED luminaires, 0.5 W/ft² is achievable with current products at a reasonable cost.

In the standards, installing occupancy controls in small open office zones qualifies for a power adjustment factor. By utilizing power adjustment factors to apply control credits, this strategy can result in a lower claimed LPD when calculating for actual lighting power.

In office space projects that trigger the plug load control requirements in **Section 130.5**, energize task lighting from occupancy controlled outlets. Connect task lighting into networked controls to analyze energy use and occupancy patterns for maximum benefit.

Recommendations

Occupants of office spaces have varying lighting requirements. Different visual tasks demand variations in lighting to produce ideal lighting conditions. Computer monitors require diffuse, ambient light with low screen glare effects. Printed materials require more light directed to a specific task plane (typically a desk surface) to avoid eye fatigue caused by low light levels. These task requirements drive target illuminance levels. Personally controlled task lighting helps to meet visual task requirements and should be included in the lighting design.

Integrated Office Lighting System at California Department of Motor Vehicles
Sacramento, CA

The Department of Motor Vehicles (DMV) wanted to provide more uniform lighting and higher visual comfort as part of the renovation of its headquarters. The original design using fluorescent troffers and fluorescent undercabinet task lights fell short of those goals. The design changed to the Integrated Office Lighting System (IOLS), which used suspended indirect/direct pendants with zonal occupancy controls and LED task lighting systems from Finelite, Inc. Workstations were installed with LED undercabinet and task lights, and individual occupancy sensors. The project produced a 54% energy savings compared to baseline conditions. The IOLS, which is a lighting design approach, was a research project between CLTC, Finelite and the Energy Commission's PIER Program.

A case study is available at: **cltc.ucdavis.edu/publication/integrated-office-lighting-system-department-motor-vehicles-sacramento-ca**

PHOTO: ACUITY BRANDS

Luminaires with Integrated Controls

Occupancy-based lighting controls can save significant amounts of energy in areas, such as stock rooms, which are often characterized by highly intermittent occupancy patterns. Integrated, occupancy-based lighting controls offer the largest opportunity for energy and cost savings. Integrate dimming or multi-level stepped lighting controls that include a lower light setting for periods of inactivity to support safety and additional settings to provide light levels for different activities.

MAXIMIZE CONTROL IN TRANSITIONAL SPACES

Stairwells typically have very low occupancy rates and highly intermittent use patterns, so occupancy-based lighting controls can dramatically reduce energy use. Most of the light sources in stairwells operate all day, seven days a week. The lighting used for stairwells in office buildings includes either surface-mounted or recessed wall sconces that use CFL or linear T8 fluorescent lamps. These luminaires are often located at each stairwell landing.

Compliance Requirements

Lighting power for stairwell luminaires should be automatically reduced by at least 50% during vacant periods. Recommended light levels should be restored when occupants are detected from either direction. At 50% power, general lighting is often well above minimum levels required for egress lighting. After typical occupied hours, general lighting in stairwells should be shut off.

Recommendations

Retrofit Options

Bi-level luminaire retrofits are easy to implement and are designed to provide safe, reliable, and efficient lighting. If fluorescent luminaires are in good condition, a lamp-and-ballast retrofit with the addition of an external sensor technology will provide the bi-level functionality to meet the standards. Be sure to note whether the dimming range required by **Section 130.1(b)** is included in the technology plan. These luminaires will also need to be shut off after occupied times per **Section 130.1(c).**

LED Luminaires With Integrated Controls

There is an evolving product base of bi-level LED luminaires with integrated sensors made specifically for this application. Some have the ability to communicate between luminaires or back to a centralized system through a network. If luminaires are old and need replacing, the best long-term approach is installing new, dedicated LED strip luminaires with integrated dimming drivers. Installing new luminaires may be more cost-effective than retrofitting old luminaires.

Sensor Options

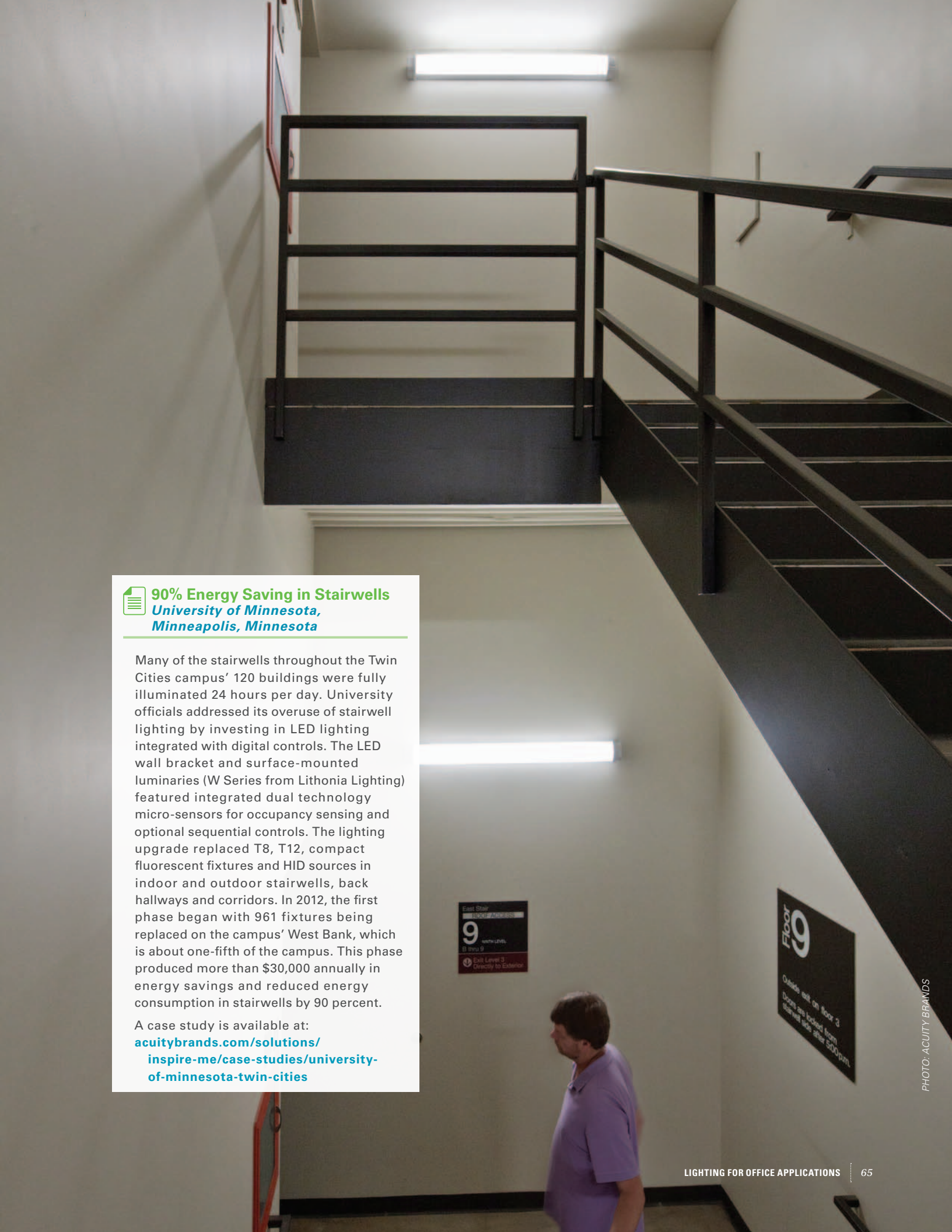
Ultrasonic sensors typically offer a better level of detection in constricted stairwell configurations compared to PIR sensors. PIR technology has proven effective when multiple sensors are integrated within the luminaire with different detection angles. In either case, make sure that the sensor technology is appropriately installed and commissioned for effective lighting control. An LED retrofit kit that supports bi-level functionality offers another option.

Stairwells are often located at the perimeter of buildings where large windows may offer a significant opportunity for daylight harvesting. Photosensors need to be carefully placed in stairwells. Luminaire-integrated photosensors provide lighting control on a per-luminaire basis. Alternatively, a single photosensor can be used to control multiple luminaires. Daylight harvesting systems can be cost-effective in spaces that receive enough daylight. But like most lighting controls, they require careful installation and proper calibration to function properly.

UC Davis Smart Lighting Initiative: Stairwells

sli.ucdavis.edu

As part of the Smart Lighting Initiative, a campaign to reduce lighting energy use by 50% in five years, 999 adaptive LED stairwell luminaires were installed in buildings throughout the campus. The luminaires feature two PIR occupancy sensors, one on each end, for maximum coverage. When the stairwells are vacant, the luminaire enters a low mode and uses only 5 watts. In occupied mode, the unit uses 22 watts. Based on previous studies, it is estimated the stairwells on campus are occupied only 20 percent of the day. The expected energy use reduction is 85 percent.



90% Energy Saving in Stairwells

University of Minnesota, Minneapolis, Minnesota

Many of the stairwells throughout the Twin Cities campus' 120 buildings were fully illuminated 24 hours per day. University officials addressed its overuse of stairwell lighting by investing in LED lighting integrated with digital controls. The LED wall bracket and surface-mounted luminaries (W Series from Lithonia Lighting) featured integrated dual technology micro-sensors for occupancy sensing and optional sequential controls. The lighting upgrade replaced T8, T12, compact fluorescent fixtures and HID sources in indoor and outdoor stairwells, back hallways and corridors. In 2012, the first phase began with 961 fixtures being replaced on the campus' West Bank, which is about one-fifth of the campus. This phase produced more than $30,000 annually in energy savings and reduced energy consumption in stairwells by 90 percent.

A case study is available at:
acuitybrands.com/solutions/inspire-me/case-studies/university-of-minnesota-twin-cities

PHOTO: ACUITY BRANDS

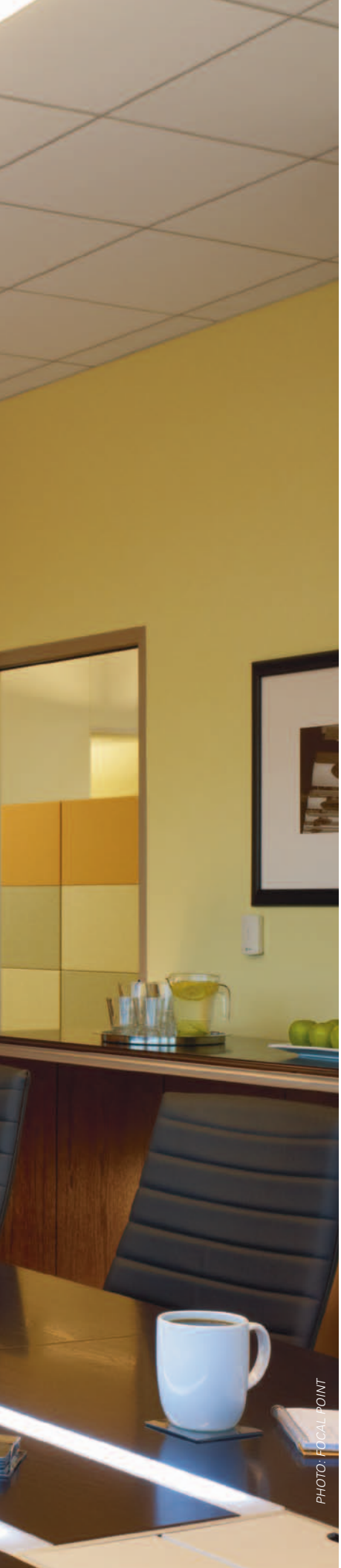


PHOTO: FOCAL POINT

GLOSSARY

A

Accent lighting: Also called **display lighting**, this is directional lighting designed to provide additional lighting on display merchandise, in contrast with lower ambient, or general, light levels. It can be recessed, surface mounted or mounted to a pendant, stem or track.

Ambient lighting: Also known as **general lighting**, this lighting is designed to provide fairly uniform illumination throughout a space. Ambient lighting is generally supplemented by task lighting and accent lighting.

Astronomical time-switch control: An automatic lighting control device that switches lights ON or OFF at specified times of the day, or during astronomical events such as sunset and sunrise, to prevent energy waste when daylight is available. These devices can account for geographic location and calendar date. **Multi-level astronomical time-switch controls** reduce lighting power in multiple steps between full light output and their off setting.

B

Beam angle: Also known as **beam spread**, the width of the cone of light emitted from a light source, defined from the center of the beam to the angle where the intensity of light is half of its maximum. Narrow beam angles create a spotlight effect while broader beam angles spread light more evenly across a larger area.

C

Candela (cd): Unit of measurement for luminous intensity. One candela (cd) is equal to one lumen per steradian (lm/sr). A candle flame emits light with a luminous intensity of approximately one candela.

Case lighting Lighting designed for enclosed cases, such as glass display cases, that display jewelry, electronics or other valuable items.

Center beam candlepower (CBCP): Luminous intensity at the center of the beam from a reflector lamp, such as a parabolic aluminized reflector (PAR) lamp. CBCP is measured in candelas (cd).

Ceramic metal halide (CMH): A type of high-intensity discharge (HID) lamp commonly used in retail lighting, particularly high- and low-bay applications. Like **metal halide** lamps, CMH lamps generate light using a mixture of argon, mercury and metal halide vapors. CMH lamps are a newer variation of MH capable of producing white light with a CRI as high as 96. Full light output takes about 2–10 minutes, making them less compatible with adaptive lighting controls. They can produce energy savings of up to 90% when replacing incandescent sources.

Chandelier: A ceiling-mounted or suspended decorative luminaire that typically uses many small lamps and incorporates glass, crystal, ornamental metals, or other reflective decorative materials.

Correlated Color Temperature (CCT): Measured in Kelvins (K), CCT indicates the warmth or coolness of light emitted from a lamp. Low CCT indicates a warmer (more red) hue while high CCT denotes a cooler (more blue) appearance. Sources with a CCT of 2700–3000 K emit incandescent-like light while lamps with cooler color temperatures, such as 5000–6500 K, are often chosen to approximate bright daylight on a clear afternoon.

Color Rendering Index (CRI): The current industry-standard scale used to measure how truly light sources can render the colors of the objects they illuminate. The maximum CRI value is 100. Lamps with a high CRI (at least 80) render colors more accurately.

Compact fluorescent lamp (CFL): A type of fluorescent lamp shorter than 9 inches in overall length with a T5 glass tube (or smaller diameter) folded, bent or bridged to create a compact shape.

Countdown timer switch: A device featuring one or more preset countdown time periods that turns lighting (or other loads) ON when activated and automatically switches OFF when the selected time period elapsed.

D

Daylight control: An automatic lighting control device that uses one or more photosensors to detect changes in daylight contribution and automatically adjust electric lighting levels accordingly. A **multi-level daylight control** adjusts the luminous flux of the electric lighting system in either a series of steps or by continuous dimming in response to available daylight.

Daylit Zone: The floor area under skylights or next to windows. Title 24 includes building and lighting control requirements for specific types of daylit zones, including Primary Sidelit, Secondary Sidelit, and Skylit zones.

Decorative Lighting: Luminaires installed only for aesthetic purposes that do not serve as general, display or task lighting.

Dimmer: A lighting control device that adjusts the light output (or luminous flux) of an electric lighting system by decreasing or increasing the power delivered to that system. **Step Dimmers** provide end-users with one or more distinct light level settings (or steps) between maximum light output and off. **Continuous Dimmers** offer finer, more subtle control over a continuous range between maximum light output and the off setting.

E

Efficacy: The amount of light produced by a lamp or luminaire relative to the amount of electrical power it consumes (lm/W). To calculate lamp efficacy, divide the lamp's rated initial lumens (lm) by the rated lamp power (watts) without including auxiliaries such as ballasts, transformers and power supplies.

Energy Management Control System (EMCS): A computerized control system designed to regulate energy consumption by controlling the operation of one or more building systems, such as lighting and HVAC. An EMCS can also monitor environmental and system loads, adjust system operations, optimize energy usage, and respond to demand response signals.

F

Fluorescent: A low-pressure mercury electric-discharge lamp in which a phosphor coating transforms some of the ultraviolet energy generated into visible light.

G

General lighting See **ambient lighting**.

GU24: A bi-pin (versus screw-base) lamp holder and socket configuration based on a coding system by the International Energy Consortium, where "G" stands for the broad type of two or more projecting contacts, "U" distinguishes between lamp and holder designs of similar but not interchangeable types, and "24" indicates 24 millimeters center-to-center spacing between the electrical contact posts or pins.

H

HID lamps: High-intensity discharge (HID) lamps, such as metal halide or high-pressure sodium, lamps.

I

Illuminance: A measure of the intensity of incident light illuminating a surface; measured in lux (lx) or lumens (lm) per unit of surface area (lm/ft^2 or lm/m^2, for example).

Illumination: Density of light incident at a point on a surface, measured in footcandles (fc), perpendicular to the surface.

Incandescent: A type of lamp with a filament that gives off light when heated by an electric current.

L

Lamp: An electric light source, such as a light bulb or fluorescent tube. This is the term used in the lighting industry to describe replacement bulbs or tubes consisting of an electric light source, a holder and a cover.

Lighting control system: Technology consisting of two or more components and capable of providing full functionality for lighting control compliance.

Luminaire: Also commonly referred to as a **light fixture**, this is the lighting industry term for a complete lighting unit. It consists of a housing, socket, one or more lamps, a base that connects the fixture to a power source, and any integrated lighting control elements.

Light-emitting diode (LED): A solid-state diode that is constructed to emit colored or white light. LED is often used to describe a component, device or package that incorporates an array of light emitting diodes.

LED lamp: An LED component, device, or package, and other optical, thermal, mechanical, and electrical (control circuitry) components with an integrated LED driver (power source) and a standardized base that is designed to connect to the branch circuit via a standardized base, lamp holder or socket.

LED luminaire: A complete LED lighting unit consisting of a light source, driver and other parts designed to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED component, package, device, array, module, source system, or lamp. The LED luminaire is intended to be connected directly to a branch circuit.

Lumen: The unit of measurement that describes the amount of light emitted from a light source. Higher lumen output indicates a brighter light source.

Luminaire: A complete lighting unit consisting of lamp(s) and the parts that distribute light, position and protect the lamp(s), and connect the lamp(s) to the power supply.

Luminance (L): The intensity of light reflected from a surface in a given direction. Measured in candelas per area unit (generally, cd/ft^2 or cd/m^2).

Luminous flux: The rate at which a light source emits visible light. This "flow rate" of light is measured as lumens over time and defines "light," generally, for purposes of lighting design and illuminating engineering.

M

Mandatory measures checklist: A form used by the building plan checker and field inspector to verify a building's compliance with the prescribed list of mandatory features, equipment efficiencies and product certification requirements. The documentation author indicates compliance by initialing, checking or marking N/A (for not applicable) in the boxes or spaces provided for the designer.

Metal halide (MH): A high-intensity discharge (HID) light source commonly used in retail, industrial and outdoor applications. MH lamps use a mixture of argon, mercury and metal halide. A hard outer glass covering absorbs much of the UV radiation emitted by MH lamps, thereby reducing their efficacy. MH lamps have CRI ratings of 60. Full light output takes about 2–10 minutes, making them less compatible with adaptive lighting controls. MH lamps produce more light than mercury vapor lamps and provide better color rendering, with CRI ratings of 60–96.

Motion sensor: A device that automatically turns lights OFF soon after an area is vacated. Motion sensor applies to outdoor lighting controls. When the device is used to control indoor lighting systems, it is called an occupant sensor, occupancy sensor, occupant-sensing device, or vacancy sensor.

Multi-level lighting control: A lighting control device that reduces power going to a lighting system, and the consequent light output of the system, in multiple discrete steps.

Multi-scene lighting control: In addition to all-OFF, this feature allows end-users to program or select pre-defined lighting settings for two or more groups of luminaires for multiple activities or displays within a space.

O

Occupant sensor: A device that automatically turns lights OFF soon after an area is vacated. The term occupant sensor applies to a device that controls indoor lighting systems. It is called a motion sensor when used to control outdoor lighting systems.

P

Pendant: A type of ceiling-mounted luminaire that is suspended from the ceiling, often above task surfaces.

Permanently installed lighting: All luminaires attached to the inside or outside of a building site, including: track and flexible lighting systems; lighting attached to walls, ceilings, or columns; inside or outside of permanently installed cabinets; internally illuminated case work; lighting mounted on poles, in trees, or in the ground; and lighting attached to ceiling fans and integral to exhaust fans other than exhaust hoods for cooking equipment. Portable lighting and lighting installed in appliances by the manufacturer is not considered permanently installed lighting.

Photocontrol: An electrical device that detects changes in illumination levels and controls lighting load at predetermined illumination levels. Automatically turns luminaires ON at dusk and turns OFF at dawn.

Pin-base luminaire: A luminaire, or fixture, that accepts lamps with a pin base, as opposed to a screw base. GU-24 pin-base luminaires prevent the use of low-efficacy lamps in high-efficacy luminaires.

Portable lighting: Lighting with plug-in connections for electric power, including: table lamps and freestanding floor lamps, lighting attached to modular furniture, workstation task lights, lights attached to workstation panels, movable displays, and other equipment that is not **permanently installed lighting.**

R

Readily accessible: Capable of being reached quickly for operation, repair or inspection. Readily accessible items must be accessible without the use of special equipment, removal of obstacles or need for climbing.

S

Screw-base luminaire: A luminaire, or fixture, with a socket that accepts screw-base lamps (e.g., incandescent, CFL or LED replacement lamps). Screw-base luminaires are considered low-efficacy under Title 24, Part 6 because they are compatible with low-efficacy lamps.

Skylight: A window (fenestration surface) installed in a roof and having a slope of less than 60 degrees from the horizontal plane.

PHOTO: FINELITE, INC.; JDN PHOTOGRAPHY

T

Task lighting: Lighting that is designed to meet the specific illumination needs of an area designated for specific tasks.

Time switch: Also called a **timer switch** or **timer**, this device is designed to automatically control lighting based on time of day.

Track lighting: A system that utilizes luminaires mounted to a track, rails or cables.

U

Utility room: A non-habitable room or building (not a bathroom, closet, garage, or laundry room) that contains only HVAC, plumbing or electrical controls, or equipment.

V

Vacancy sensor: An occupant sensor that requires occupants turn lights on manually but automatically switches lights off soon after an area is vacated. Also called a **manual-ON occupant sensor** or **manual-ON / automatic-OFF sensor**.

W

Watt: The unit of measure for the electric power used by a lamp or luminaire.

APPENDIX

TABLES

The original versions of the tables in this section can be found in the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. These tables are used for determining compliance what is required for compliance with Title 24, Part 6 and in the process of calculating lighting energy budgets.

Table 140.6-B: Complete Building Method Lighting Power Density Values (W/ft^2)

Type of Use	Allowed Lighting Power
Auditorium Building	1.5
Classroom Building	1.1
Commercial and Industrial Storage Buildings	0.6
Convention Center Building	1.2
Financial Institution Building	1.1
General Commercial Building / Industrial Work Building	1.0
Grocery Store Building	1.5
Library Building	1.3
Medical Buildings / Clinic Building	1.1
Office Building	0.8
Parking Garage Building	0.2
Religious Facility Building	1.6
Restaurant Building	1.2
School Building	1.0
Theater Building	1.3
All Other Buildings	0.6

Table: 141.0-E: Requirements for Luminaire Alterations

Quantity of existing affected luminaires per Enclosed Space[1]	Resulting lighting power for each enclosed space	Applicable mandatory control provisions for each enclosed space	Multi-level lighting control requirements for each altered luminaire
Alterations that do not change the area of the enclosed space or the space type (lighting alterations where enclosed space area or type has not changed and lighting wattage not increased)			
Sum total < 10% of existing luminaires	Existing lighting power is permitted	Existing provisions are permitted	Existing controls are permitted
Sum total ≥ 10% of existing luminaires	≤ 85% of allowed lighting power per §140.6 Area Category Method	§130.1(a), (c)	Two level lighting control[2] Or §130.1(b)
	> 85% of allowed lighting power per §140.6 Area Category Method	§130.1(a), (c), (d)[3]	§130.1(b)
Alterations that change the area of the enclosed space or the space type or increase the lighting power in the enclosed space (lighting alterations accompanying changes to the enclosed space area or space type or accompanying an increased in lighting power)			
Any number	Comply with §140.6	§130.0 (d)[3] §130.1(a), (c), (d)[3],(e)	§130.1(b)

[1] Affected luminaires include any luminaire that is changed, replaced, removed, relocated; or, connected to, altered or revised wiring, except as permitted by EXCEPTIONS 1 and 2 to §141.0(b)2Iii:

[2] Two level lighting control shall have at least one control step between 30 and 70% of design lighting power in a manner providing reasonably uniform illuminations

[3] Daylight controls in accordance with §130.0(d) are required only for luminaires that are altered.

Table 141.0-F: Requirements for Luminaire Modifications-in-Place

For compliance with this table, building space is defined as any of the following:

1. A complete single story building
2. A complete floor of a multi-floor building
3. The entire space in a building of a single tenant under a single lease
4. All of the common, not leasable space in single building

Quantity of affected luminaires per building space per annum	Resulting lighting power per each enclosed space where ≥10% of existing luminaires are luminaire modifications-in-place	Applicable mandatory control provisions for each enclosed space[1]	Applicable multi-level lighting control requirements for each modified luminaire[2]
Sum total <40 luminaire modifications-in-place	Existing lighting power is permitted	Existing provisions are permitted	Existing controls are permitted
Sum total ≥40 luminaire modifications-in-place	≤85% of allowed lighting power per §140.6 Area Category Method	§130.1(a), (c)	Two level lighting control[3] Or §130.1(b)
	>85% of allowed lighting power per §140.6 Area Category Method	§130.0(d)[4], §130.1(a), (c), (d)[4]	§130.1(b)

[1] Control requirements only apply to enclosed spaces for which there are luminaire modifications-in-place

[2] Multi-level controls are required only for luminaires for which there are luminaire modifications-in-place

[3] Two level lighting control shall have at least one control step between 30% and 70% of design lighting power in a manner providing reasonably uniform illuminations

[4] Daylight controls in accordance with §130.0(d) are required only for luminaires that are modified-in-place

Table 140.6-C: Area Category Method Lighting Power Density Values (W/ft²)

Primary Function Area	Allowed Lighting Power (W/ft²)	Primary Function Area		Allowed Lighting Power (W/ft²)
Auditorium Area	1.5[3]	Library Area	Reading Areas	1.2[3]
Auto Repair Area	0.9[2]		Stack Areas	1.5[3]
Beauty Salon Area	1.7	Lobby Area	Hotel lobby	1.1[3]
Civic Meeting Place Area	1.3[3]		Main entry lobby	1.5[3]
Classroom, Lecture, Training, Vocational Areas	1.2[5]	Locker/ Dressing Room		0.8
Commercial and Industrial Storage Areas (conditioned and unconditioned)	0.6	Lounge Area		1.1[3]
Commercial and Industrial Storage Areas (refrigerated)	0.7	Malls and Atria		1.2[3]
Convention, Conference, Multipurpose and Meeting Center Areas	1.4[3]	Medical and Clinical Care Area		1.2
Corridor, Restroom, Stair, and Support Areas	0.6	Office Area	>250 square feet	0.75
Dining Area	1.1[3]		≤ 250 square feet	1.0
Electrical, Mechanical, Telephone Rooms	0.7[2]	Parking Garage Area	Parking Area	0.14
Exercise-Center, Gymnasium Areas	1.0		Dedicated Ramps	0.3
Exhibit, Museum Areas	2.0		Daylight Adaptation Zones[9]	0.6

Table 140.6-C (continued)

Primary Function Area		Allowed Lighting Power (W / ft²)	Primary Function Area		Allowed Lighting Power (W / ft²)
Financial Transaction Area		1.2[3]	Religious Worship Area		1.5[3]
General Commercial and Industrial Areas	Low bay	0.9[2]	Retail Merchandise Sales, Wholesale Showroom Areas		1.2[6 and 7]
	High bay	1.0[2]	Theatre Area	Motion Picture	0.9[3]
	Precision	1.2[4]		Performance	1.4[3]
Grocery Sales Area		1.2[6 and 7]	Transportation Function Area		1.2
Hotel Function Area		1.5[3]	Video Conferencing Studio		1.2[8]
Kitchen, Food Preparation Areas		1.6	Waiting Area		1.1[3]
Laboratory Area, Scientific		1.4[1]	All Other Area		0.6
Laundry Area		0.9			

Footnotes for Table 140.6-C:

See Section 140.6(c)2 for an explanation of additional lighting power available for specialized task work, ornamental, precision, accent, display, decorative, and white boards and chalk boards, in accordance with the footnotes in this table. The smallest of the added lighting power listed in each footnote below, or the actual design wattage, may be added to the allowed lighting power only when using the Area Category Method of compliance.

Footnote number	Type of lighting system allowed	Maximum allowed added lighting power (W/ft² of task area unless otherwise noted)
1	Specialized task work	0.2 W/ft²
2	Specialized task work	0.5 W/ft²
3	Ornamental lighting as defined in Section 100.1 and in accordance with Section 140.6(c)2	0.5 W/ft²
4	Precision commercial and industrial work	1.0 W/ft²
5	Per linear foot of white board or chalk board	5.5 W per linear foot
6	Accent, display and feature lighting—luminaires shall be adjustable or directional	0.3 W/ft²
7	Decorative lighting—primary function shall be decorative and shall be in addition to general illumination	0.2 W/ft²
8	Additional Videoconferencing Studio lighting complying with all of the requirements in Section 140.6(c)2Gvii.	1.5 W/ft²
9	Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage	

Table 140.6-D: Tailored Method Lighting Power Allowances

Primary Function Area	General Illumination Level (Lux)	Wall Display Power (W/ft)	Allowed Combined Floor Display Power and Task Lighting Power (W / FT²)	Allowed Ornamental/ Special Effect Lighting
Auditorium Area	300	2.25	0.3	0.5
Civic Meeting Place	300	3.15	0.2	0.5
Convention, Conference, Multipurpose, and Meeting Center Areas	300	2.50	0.4	0.5
Dining Areas	200	1.50	0.6	0.5
Exhibit, Museum Areas	150	15.0	1.2	0.5
Financial Transaction Area	300	3.15	0.2	0.5
Grocery Store Area	500	8.00	0.9	0.5
Hotel Function Area	400	2.25	0.2	0.5
Lobby Area				
Hotel Lobby	200	3.15	0.2	0.5
Main Entry Lobby	200	0	0.2	0
Lounge Area	200	7.00	0	0.5
Malls and Atria	300	3.50	0.5	0.5
Religious Worship Area	300	1.50	0.5	0.5
Retail Merchandise Sales, and Showroom Area	400	14.00	1.0	0.5
Theater Area				
Motion picture	200	3.00	0	0.5
Performance	200	6.00	0	0.5
Transportation Function Area	300	3.15	0.3	0.5
Waiting Area	300	3.15	0.2	0.5

APPENDIX

RESOURCES

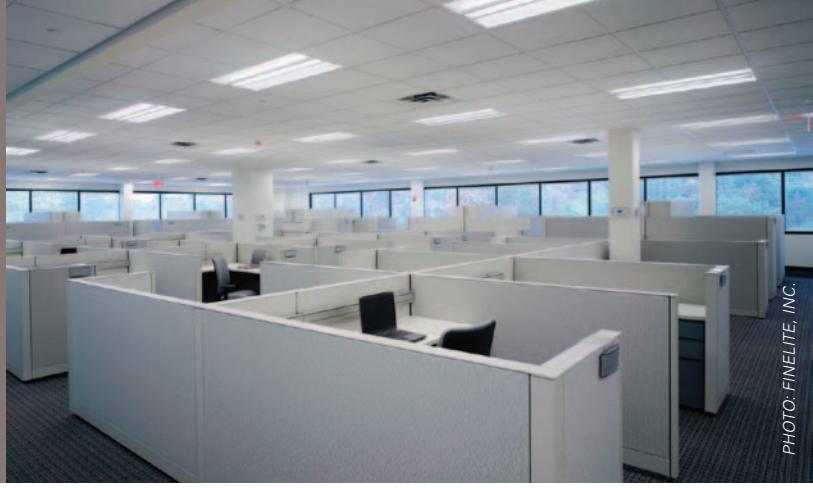


PHOTO: FINELITE, INC.

COMPLIANCE RESOURCES

2013 Title 24 Building Energy Efficiency Standards and Related Documents

energy.ca.gov/title24/2013standards

Visit the Energy Commission website to download the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. The nonresidential standards should be the first resource for any contractor, builder or designer with questions about Title 24 regulations. Supporting documents and information on how to obtain public domain software for complying with the 2013 commercial standards (CBECC-Com) are also available. The Nonresidential Compliance Manual and 2013 Nonresidential Alternative Calculation Method Reference Manual are among the related documents available.

Energy Standards Hotline

Toll-free in California: (800) 772-3300

Title24@energy.ca.gov

The Energy Standards Hotline is a resource for any questions regarding the 2013 Title 24, Part 6 standards. The hotline is available Monday through Friday, 8 a.m–12 p.m. and 1–4:30 p.m.

California Energy Commission Appliance Efficiency Database

appliances.energy.ca.gov

This online database features Quick Search and Advanced Search options that allow users to easily verify if lighting products have been certified to the Energy Commission as meeting applicable efficiency standards.

Title 20 Appliance Efficiency Regulations

energy.ca.gov/appliances

Energy efficiency and performance standards for appliances, including ballasts, lamps, luminaires, and lighting controls, are detailed in the 2012 Appliance Efficiency Regulations, which took effect February 1, 2013. This and other resources are available through the Energy Commission's website.

Energy Code Ace

energycodeace.com

This new site developed by the California Statewide Codes & Standards Program provides free tools, trainings and resources to help users meet the latest Title 24, Part 6 requirements. Visitors can download fact sheets, trigger sheets, checklists, and information on classes (online or in person) and workshops.

California Advanced Lighting Controls Training Program (CALCTP)

calctp.org

CALCTP educates, trains, and certifies licensed electrical contractors and state certified general electricians in the proper installation, programming, testing, commissioning, and maintenance of advanced lighting control systems.

California Lighting Technology Center

cltc.ucdavis.edu/title24

The Title 24 Office Lighting Design Guide was developed by the California Lighting Technology Center. CLTC was established through joint efforts by the Energy Commission and the University of California, Davis. CLTC develops and tests state-of-the-art, energy-saving lighting and daylighting innovations. CLTC also offers training and educational programs on energy-efficient lighting.

DesignLights Consortium Qualified Products List

designlights.org/qpl

This online database of quality, high-efficiency LED products for the commercial sector is maintained by the DesignLights Consortium, a project of the regional non-profit, Northeast Energy Efficiency Partnerships. It allows users to search for LED products by criteria (such as CRI and light output), categories (including display case lighting and track lighting), manufacturer, or keyword. Products listed may or may not qualify for certification to the Energy Commission.

CLASSES

California Association of Building Energy Consultants' Title 24 Resources

cabec.org/title24info.php

California Training Schedule for Building Operator Certification

theboc.info/ca/ca-schedule.html

Education Schedule for the Building Owners and Managers Association

boma.org/TrainingAndEducation/Pages/default.aspx

Workshop & Event Calendar for the Center for Sustainable Energy, California

energycenter.org/events

UTILITY EDUCATION & DEMONSTRATION CENTERS

All or most of these California utility centers host Title 24 lighting classes. They also house lighting technology demonstration spaces and tool lending libraries that can provide visitors with energy and light meters, data loggers, lighting design software, lighting design manuals, and other resources.

Online calendars list training events and workshops. Some websites offer virtual video tours of the demonstration centers and information on resources and services. Visitors and class participants can also learn about the utilities' rebate and incentive programs.

Pacific Gas and Electric Company (PG&E)

pge.com

Pacific Energy Center (PEC), San Francisco

Energy Training Center, Stockton

Sacramento Municipal Utility District

smud.org

Energy & Technology Center, Sacramento

San Diego Gas & Electric

sdge.com

Energy Innovation Center, San Diego

Southern California Edison (SCE)

sce.com

Energy Education Centers
Irwindale, Tulare and on-location in other cities

MANUFACTURER TRAINING CENTERS

Acuity Brands Center for Light&Space

Berkeley, CA

acuitybrands.com

Eaton's Cooper Lighting Business

Online Design Center

cooperindustries.com

Lutron

California Experience and Training Center
Irvine, CA

lutron.com

For more information and resources about Title 24, Part 6, visit the CLTC website at ***cltc.ucdavis.edu/title24****.*

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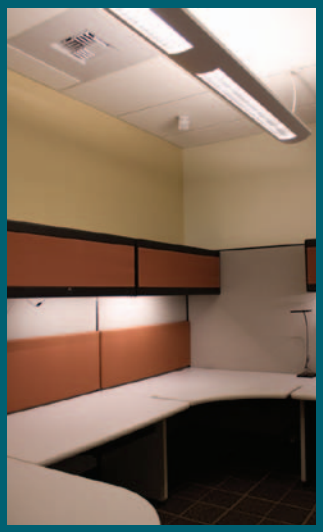

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