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# RESIDENTIAL LIGHTING

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*A guide to meeting or exceeding,  
California's 2016 Building Energy Efficiency Standards*



DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS

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Davis campus, California Lighting Technology Center

**Guide Prepared by:**

California Lighting Technology Center (CLTC)  
University of California, Davis  
633 Pena Drive  
Davis, CA 95618  
[cltc.ucdavis.edu](http://cltc.ucdavis.edu)

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# INTRODUCTION

## THE BENEFITS OF EFFICIENCY

California's 2016 Building Energy Efficiency Standards become effective January 1, 2017. These standards represent a major step towards meeting California's residential Zero Net Energy (ZNE) goal by the year 2020. Updates enhance and simplify previous requirements and lay the foundation for additional efficiency improvements slated for 2019 code.

The Energy Standards will lead to reduced energy use for lighting, heating, cooling, ventilation, and water heating. The California Energy Commission estimates that the 2016 Energy Standards will deliver approximately 385 gigawatt-hours of electricity savings annually and reduce statewide greenhouse gas emissions by 339,012 metric tons. This is enough electricity to power 685,000 California homes each year.

California is making strong efforts to address climate change. The state's building and appliance standards, along with utility programs that promote efficiency, are vital means of reducing electricity use and lowering statewide carbon emissions.

California's ambitious energy and climate goals include those legislated under the Lighting Efficiency and Toxics Reduction Act (AB 1109). This bill calls for a minimum 50 percent reduction in lighting energy use for interior residential lighting by 2018 as compared to 2007 levels. California's 2008 Long-Term Energy Efficiency Strategic Plan also set the goal that all new low-rise residential construction in the state be zero net energy (ZNE) by 2020.



PHOTO: TECH LIGHTING

## ABOUT THIS GUIDE

This is one of seven guides designed to help builders, designers, contractors, and others involved in the compliance process become more familiar with California's 2016 Energy Efficiency Building Standards. It is designed to serve as a resource for industry professionals involved in the design, construction or retrofit of California's buildings. The guides include compliance requirements and recommendations for implementing the Standards in new construction, addition or renovation projects.

All seven guides can be found on the Energy Code Ace website: [EnergyCodeAce.com](http://EnergyCodeAce.com)

Application Guide	What's Covered
<b>NONRESIDENTIAL ENVELOPE &amp; SOLAR-READY AREAS</b>	<ul style="list-style-type: none"> <li>• Climate specific design</li> <li>• Insulation</li> <li>• Cool Roofs</li> <li>• Solar Zone</li> <li>• Fenestration</li> <li>• Compliance documentation details</li> </ul>
<b>NONRESIDENTIAL LIGHTING &amp; ELECTRICAL POWER DISTRIBUTION</b>	<ul style="list-style-type: none"> <li>• Lighting design strategies</li> <li>• Controls</li> <li>• Electrical power distribution</li> </ul>
<b>NONRESIDENTIAL HVAC &amp; PLUMBING</b>	<ul style="list-style-type: none"> <li>• Mechanical Systems and Plumbing Systems</li> <li>• Commissioning, HERS Process &amp; Acceptance Testing</li> </ul>
<b>PROCESS EQUIPMENT &amp; SYSTEMS</b>	<ul style="list-style-type: none"> <li>• Process loads</li> <li>• Applicable products and systems such as kitchen hoods, parking garage ventilation, laboratory fume hoods, elevators, escalators, and compressors</li> </ul>
<b>RESIDENTIAL ENVELOPE &amp; SOLAR-READY AREAS (Low Rise and Single Family)</b>	<ul style="list-style-type: none"> <li>• Single Family Homes</li> <li>• Duplexes</li> <li>• Climate specific design</li> <li>• Insulation</li> <li>• Cool Roofs</li> <li>• Solar Zone</li> <li>• Fenestration</li> <li>• Compliance documentation details</li> </ul>
<b>RESIDENTIAL LIGHTING (Low Rise and Single Family)</b>	<ul style="list-style-type: none"> <li>• Lighting design strategies</li> <li>• Compliant Products</li> <li>• Controls</li> </ul>
<b>RESIDENTIAL HVAC &amp; PLUMBING (Low Rise and Single Family)</b>	<ul style="list-style-type: none"> <li>• HVAC terminology</li> <li>• Heating and cooling system types</li> <li>• Hot Water system types</li> </ul>

## Compliance Process Overview

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.

## Concepts & Principles

Chapter 2 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 regarding lamps, luminaires and controls.

## Compliance Requirements

Starting with an overview of new requirements and important updates to the Energy Standards, this portion of the guide examines the new requirements for luminaire efficacy classification and lighting controls. Recommendations for putting the Standards into practice are also included.

## Requirements & Recommendations

This guide section covers the lighting requirements set forth under the Energy Standards for the most common residential space types. Floor plans with examples of compliant lighting designs are also provided, along with recommendations for implementing best practices.

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**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](http://www.energy.ca.gov/title24) to download the official 2016 Building Energy Efficiency Standards, Errata, Reference Appendices, and the Residential Compliance Manual.



## THE COMPLIANCE PROCESS

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The following is an overview of the compliance process for residential lighting. Additional information and resources, including the 2016 Residential Compliance Manual and forms may be found on the California Energy Commission website: [energy.ca.gov/title24/2016standards](http://energy.ca.gov/title24/2016standards)

### **Step 1: Discuss and Define Energy-Related Project Goals**

Designers, project owners and builders have the most opportunity to identify and pursue energy savings strategies at the beginning of a project. Early coordination of project team members is recommended to clearly define energy related project goals and understand potential opportunities and constraints.

### **Step 2: Determine and Design for Applicable Mandatory Measures**

All residential buildings that are regulated occupancies must be designed and built to comply with the mandatory measures of Title 24, Part 6. Mandatory measures are discussed in Chapter 4 of this guide. Unlike requirements for other building systems, which vary based on the compliance path (prescriptive and performance approach to compliance), residential lighting systems need only comply with mandatory measures.



### Step 3: Prepare and Submit Permit Application

Once the design requirements in the Standards have been met, the permit applicant must ensure that the plans include all the documents that building officials will require to verify compliance. Plans, specifications and compliance forms are submitted to the enforcement agency at the same time as a building permit application. There are some exceptions when plans are not required, and these can be found in Section 10-103 of Title 24, Part 1. Certificates of Compliance must be registered with a Home Energy Rating System (HERS) Provider prior to permit application. For additions and alterations, if the project includes HERS verification measures, Certificates of Compliance must also be registered.

### Step 4: Pass Plan Check and Receive Permit

Depending on the permit type, the building department will issue a permit over the counter or require a plan check. If plan check is required, a plans examiner must check that the design satisfies Energy Standards requirements and that the plans contain the information to be verified during field inspection. A building permit is issued by the building department after plans are approved.

### Step 5: Perform Construction

The construction team must follow the approved plans, specifications and compliance forms during construction. Coordination is required between installers, designers, HERS Raters, and building inspectors to properly install and verify compliant installation.

### Step 6: Test and Verify Compliance (HERS)

When a HERS Rater is required by the Energy Standards, early coordination is encouraged to understand when inspections and testing are necessary during the construction process. These should be incorporated into the schedule. Many system inspections are time sensitive because they may be inaccessible after walls or other barriers are installed.

#### HOME ENERGY RATING SYSTEM (HERS)

All new homes, additions over 1,000 square feet, and alterations to an existing home that has HERS measures included in the compliance package must be registered with a HERS provider. This registration process includes lighting compliance documents, however lighting systems do not require HERS verification or testing. Applicable lighting compliance forms are:

- **CF2R-LTG-01-E** for single-family dwellings
- **CF2R-LTG-02-E** for multi-family dwellings

A list of providers approved by the California Energy Commission (CEC) can be found on their website at [energy.ca.gov/HERS/providers.html](http://energy.ca.gov/HERS/providers.html)

### Step 7: Pass Building Inspection

The local authority having jurisdiction (AHJ), often the building department, will likely require an inspection before finalizing the permit. Building inspections are often scheduled by the contractor on behalf of the building owner. Once all systems are installed and inspected, and completed compliance documentation has been verified, a Certificate of Occupancy will be issued by the local jurisdiction.

## NEW IN 2016: AN OVERVIEW OF UPDATES

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Those familiar with the Energy Standards for residential lighting will find several changes to the requirements in the 2016 iteration. Below is an overview of the most significant updates.

### All High-Efficacy Lighting Introduced

All luminaires installed in residential buildings must be high-efficacy. Certain types of high-efficacy lighting products must be certified to the California Energy Commission. In addition, more types of luminaires now qualify as high-efficacy. Outdoor lighting must comply with the same high-efficacy requirements.

This change reduces the complexity of residential lighting code compliance, which was previously attributed to variances in regulations based on space type and the presence of installed lighting controls.

### JA-8 Updated

Reference Joint Appendix JA8 regulations now set quality standards for certain types of high-efficacy lamps and luminaires installed in residences, regardless of source type. In addition, any light source used in recessed downlights as well other types of specific lighting products must be high-efficacy and comply with JA-8. In the 2013 Standards, JA-8 regulations only applied to LED sources. Indoor lighting must provide accurate color rendering (minimum CRI of 90) and a CCT of 4000K or less (specific CCT values vary by source type).

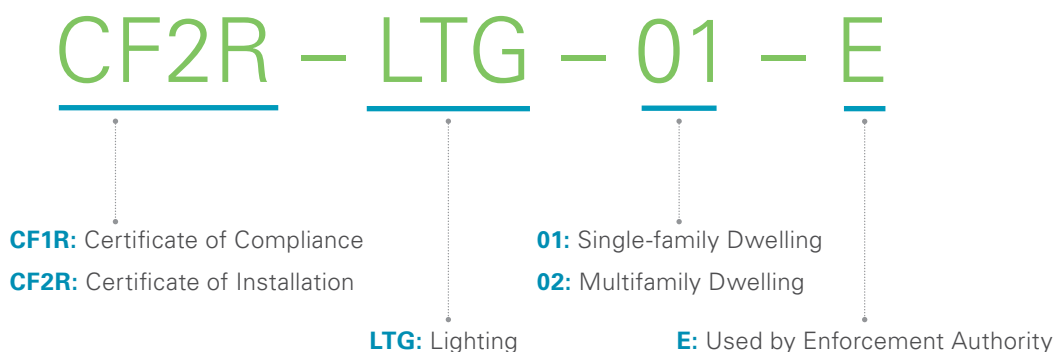
### Indoor Controls Requirements Simplified

Lighting control requirements for indoor spaces are now simpler. Control requirements are based, in nearly all cases, on the type of lamp or luminaire installed. Nearly all JA-8 compliant light sources must be controlled by a vacancy sensor or dimmer. In practice, this requirement translates to any screw-base luminaire, recessed downlight, dedicated non-decorative LED luminaire, or luminaire with an LED lamp. In addition, all undercabinet lighting must be switched separately from other lighting in the home.

Most space-specific indoor control requirements have been eliminated with one exception. At least one luminaire in the bathroom, garage, laundry room and utility room must be controlled by a vacancy sensor. Preset scene controllers and EMCS can take the place of sensors and dimmers as long as the functionality meets code requirements.

## COMPLIANCE DOCUMENTS

Instructions for completing compliance forms are provided in Chapter 2 of the Energy Commission's Residential Compliance Manual.



### Certificates of Installation

There are two versions of the residential lighting Certificate of Installation.

The **CF2R-LTG-01-E**, is primarily used for demonstrating compliance with the residential lighting Standards for single-family dwellings. The **LTG-01** is also used to demonstrate compliance with the residential lighting requirements for high-rise residential dwelling units; outdoor lighting that is attached to a high-rise residential or hotel/motel building, and is separately controlled from the inside of a dwelling unit or guest room; fire station dwelling accommodations; hotel and motel guest rooms; and, dormitory and senior housing dwelling accommodations. When using the **CF2R-LTG-01-E** to demonstrate compliance for lighting in high-rise residential dwelling units, compliance for lighting that is not in the dwelling units, such as lighting in common areas, shall be demonstrated using nonresidential lighting compliance documentation.

Form **CF2R-LTG-02-E** is used for demonstrating compliance with the residential lighting standards for low-rise multi-family dwellings. The primary difference between the **LTG-02** and **LTG-01** is that the **LTG-02** includes additional requirements for demonstrating compliance with residential outdoor lighting, and common areas associated with low-rise multi-family dwelling units.



## FINDING COMPLIANT PRODUCTS

Certain devices must be certified to the Energy Commission as meeting California’s Appliance Efficiency Regulations (Title 20, Section 1605 of the California Code of Regulations). Others are regulated under the Building Energy Efficiency Standards (Title 24, Part 6).

### Certification to the Energy Commission

The California Energy Commission maintains an appliance database that lists a variety of products that are certified as meeting the current Title 20 and Title 24 requirements. Nearly all lighting products installed to bring a building into compliance with the Energy Standards, must meet minimum, specific device requirements contained in the Appliance Efficiency regulations. In addition, multiple products must also meet enhanced performance requirements contained in the Energy Standards.

Lighting specifiers who wish to work with a product not yet listed in the database can encourage the manufacturer or a pre-approved, third-party certifier to submit appliance certification data to the Energy Commission.

Products Regulated Under the Appliance Efficiency Regulations	Additional Product Requirements Provided Under the Energy Standards
<ul style="list-style-type: none"> <li>▪ Lamps</li> <li>▪ Ballasts</li> <li>▪ Torchieres</li> <li>▪ Metal-halide luminaires</li> <li>▪ Portable luminaires</li> <li>▪ Undercabinet luminaires</li> <li>▪ Luminaires with GU-24 socket and base configurations and GU-24 adaptors</li> <li>▪ Lighting controls</li> <li>▪ LED lighting systems classified as high efficacy for compliance purposes</li> </ul>	<ul style="list-style-type: none"> <li>▪ JA8-high efficacy light sources</li> <li>▪ Occupancy sensors</li> <li>▪ Residential recessed luminaire ballasts</li> <li>▪ Track lighting current limiters and overcurrent protection devices</li> </ul>



## Recessed Downlight Luminaires

Under Title 24, Part 6, all downlight luminaires recessed in ceilings (not just those in insulated ceilings) must meet the following requirements:

- Shall not contain screw-base sockets
- Shall contain light sources that comply with JA8, including JA8's elevated temperature requirements
- Enclosed downlights, such as those often used in showers or over food preparation areas, must utilize a compliant lamp rated for use at elevated temperatures (see Screw-Base Luminaires section below; this is true for luminaires recessed in ceilings regardless of whether they are enclosed or not)
- Listed for zero-clearance insulation contact (IC): Luminaires must be IC rated with a nationally recognized testing lab (such as UL)
- Certified airtight per ASTM E283-04 (2012): The product label must specify ASTM E283 certification, or documentation is required to indicate the luminaire has been tested and certified in accordance with ASTM E283
- Sealed airtight with a gasket or caulking: Any space between the luminaire housing and ceiling must be sealed during installation to prevent airflow between conditioned and unconditioned spaces
- Recessed luminaires must also be certified to the Energy Commission for compliance with CFL ballast requirements, and building occupants must be able to readily access ballasts for maintenance or replacement without needing to cut holes in the ceilings

## Fluorescent Lamp Ballasts

Fluorescent lamps rated 13 W or more must have electronic ballasts with an output frequency no less than 20 kHz.

## Screw-Base Luminaires

Under the 2016 Energy Standards, all luminaires that utilize a screw-based socket, excluding hard-wired ballasted HIDs, must contain lamps that are certified to the Commission as meeting JA 8 high-efficacy requirements. These lamps must be marked as "JA8-2016" or "JA8-2016-E", where the "E" signifies that the lamp is appropriate for applications with elevated temperatures. All enclosed, screw-base luminaires, must utilize a compliant lamp rated for elevated temperatures. For more information on these requirements, see [Section 150.0\(k\)1.G](#). and the Residential Compliance Manual, [Chapter 6](#).

## Night Lights

Permanently installed night lights and night lights integral to installed luminaires or exhaust fans shall be rated to consume five watts or less of power per luminaire or exhaust fan. Night lights are also not required to be controlled by vacancy sensors.

## Lighting Control Devices

All control devices shall comply with Title 20 requirements. In addition, all forward phase cut dimmers used with LED light sources shall comply with NEMA SSL 7A.



### Appliance Efficiency Database

[appliances.energy.ca.gov](http://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.



### Energy Star®

All Energy Star-certified luminaires and Energy Star LED lamps carry a warranty of at least three years. The Voluntary California Quality LED Lamp Specification requires that LED replacement lamps come with a minimum five-year free replacement warranty in order to qualify for utility rebates.



# CONCEPTS & PRINCIPLES

## LAYERS OF LIGHT

Adding task and accent lighting to ambient lighting allows ambient lighting loads to be reduced without compromising safety or visual comfort. In fact, this layered approach to lighting improves visual comfort by reducing contrast. Lighting designs that include task and accent lighting are also more attractive, as they provide variety and visual interest.

### Ambient Lighting

Ambient lighting should provide a comfortable level of brightness without causing glare. Most rooms benefit from having a central ambient light source in the form of a ceiling-mounted luminaire, recessed lights, wall-mounted luminaires, or a chandelier. In certain spaces, such as laundry rooms and closets, ambient lighting may be the only source needed.

### Task Lighting

Task lighting supplements ambient lighting and maximizes efficiency by placing light directly where it is needed, allowing occupants to switch it on only when needed. A table lamp, for example, provides extra light for reading. Undercabinet lighting in the kitchen makes cooking and food preparation safer and easier.

Task lighting should be bright enough to prevent eye strain without causing glare. High-quality task lighting makes visual tasks easier, and it allows for lower ambient light levels, reducing energy use.

### Accent Lighting

Track lighting, cove lighting and wall-mounted luminaires are common choices for accent lighting. These luminaires can highlight architectural features, spotlight artwork, or illuminate interior design elements.

Color tunable LED products for the home are becoming more prevalent and more affordable, offering new options for accent lighting. For instance, with the press of a button, occupants can temporarily wash their walls with colored light.

◀ *Recessed downlights provide ambient lighting in this kitchen while undercabinet and pendant luminaires deliver task lighting where it is needed.*

## LUMEN OUTPUT, EFFICACY & LIFE

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 energy consumption, of existing and replacement light sources or luminaires to ensure adequate lighting is maintained.
- Consider other factors, such as contrast, distribution and color quality; 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, be sure to factor both 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			
↑ LESS EFFICIENT ↓ MORE EFFICIENT	 <b>Standard Incandescent</b>	40 W	60 W	75 W	100 W
	 <b>Halogen Incandescent</b>	29 W	43 W	53 W	72 W
	 <b>CFLs</b>	10 W	13 W	16 W	20 W
	 <b>LEDs</b>	5 W	10 W	15 W	19 W

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 consumed by 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 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.

## 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 they fail.

LEDs do not burn out suddenly in the same way as incandescents or CFLs. Their lumen output continues to decrease 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 reach their end of useful life. For these reasons, 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. Meanwhile, a few best practices can help 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 Illuminating Engineering Society (IES) in 2011.



### Lighting Facts Label

The Lighting Facts Label helps consumers understand lamp performance and compare products. Information can also be found through manufacturers' websites and in product specification sheets. A simplified, black and white version of this label is now required by the Federal Trade Commission for all general service, medium screw-base lamps.



### 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 are doubled for those ages 26–65 and quadrupled for those over age 65.

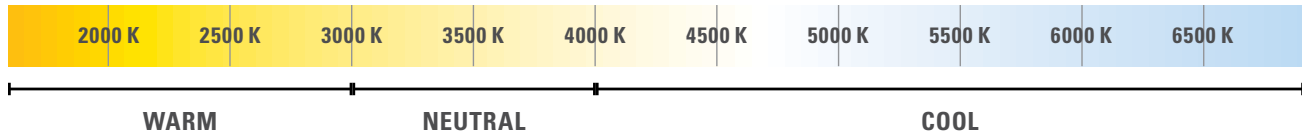
Adjustable lighting systems with scene settings and easily accessible controls can accommodate the needs of more occupants, across a broader age range and over time.

## COLOR CHARACTERISTICS

### 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 the Lighting Facts label for information on CCT (or “light color”), as well as 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. JA8 light sources must have a minimum CRI of 90.

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. The full-color Lighting Facts label issued by the Department of Energy includes CRI, but the black-and-white Federal Trade Commission label does not. Most manufacturers can supply information on CRI if it is not immediately available on product packaging or literature.

## R9

R9 is the saturated red color pallet not included in the average CRI metric. The CRI metric does not capture rendering of red well so the addition of the R9 requirement helps assure that sources will provide sufficient red content and that consumers will be satisfied with the light sources. High CRI and high R9 are important for accurately rendering skin tones, wood, food, and other natural materials.

### Voluntary California Quality LED Lamp Specification

LED replacement lamps must now meet certain performance criteria in order to qualify for utility incentive programs and rebates in California. These include:

- Minimum color accuracy (CRI) of 90
- R9 greater than 50
- CCT of 2700K or 3000K
- Color consistency



### Comparing Color Quality

The LED MR16 lamps used for these photos both have a CCT of 3000K 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.

PHOTO: SORAA





27 KEW GREEN  
27 MARYLEBONE  
27 NOTTINGHILL GATE  
27 PADDINGTON  
27 RICHMOND  
27 STAMFORD BROOK GARAGE  
27 TURNHAM GREEN  
27 WARREN STREET STN





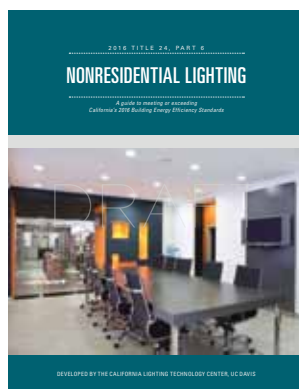
PHOTO: CLTC, UC DAVIS

# TECHNOLOGY, SYSTEMS & COMPLIANCE STRATEGIES

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. In many cases, a higher up-front investment in a more efficient, more functional lighting system yields a higher return in the long term.

Selecting the right type of light source and lighting controls for different residential 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



## 2016 Nonresidential Lighting Guide

### URL

*The 2016 Nonresidential Standards focus on several key areas to improve the energy efficiency of newly constructed buildings, additions and alterations to existing buildings. This guide offers an overview of important updates contained in the 2016 nonresidential lighting energy efficiency standards and compliance strategies to meet or exceed code.*

## LIGHT SOURCES

A single luminaire can often accommodate different types of light sources. For example, screw-base lamps are available with 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.

### Permanently Installed Luminaires

Permanently installed luminaires are attached to the home or other structures on the property. These luminaires may have either plug-in or hard-wired connections. This includes all luminaires that are:

- Attached to walls, ceilings and columns
- Inside cabinets
- Mounted under cabinets
- Attached to ceiling fans
- Integral to exhaust fans
- Integral to garage door openers
- Part of track lighting and flexible lighting systems
- Permanently installed luminaires do not include portable lighting or lighting installed in appliances by the manufacturer, like those in range hoods, refrigerators or microwave ovens.

### 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 difficult-to-reach spaces can reduce maintenance costs and reduces time spent changing failed lamps
- Color-tunable LEDs introduce a new element of flexibility and fascination into home accent lighting

### 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, which can be problematic in some applications.

### Incandescent

Incandescent lamps are highly inefficient. These lamps do have excellent color, but they burn out quickly compared to other sources, which increases maintenance costs over time. In addition, incandescents provide unwanted heat throughout the home.

### Halogen

Halogen 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.

### Linear Fluorescent Replacement Options

Linear fluorescent lamps provide uniform levels of illumination, making them a good choice for spaces like garages that require bright, uniform ambient lighting. Linear fluorescent lamps also work well in 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 32 W T8 is the most common.
- Not all fluorescent systems can dim—make sure selected products utilize dimming ballasts and lamps equipped for dimming. Often low-wattage or energy saving fluorescent lamps are not dimmable

# CONTROLS SYSTEMS & STRATEGIES

## Section 150.0(k)2

Lighting controls allow increased flexibility and control over the lighting systems in a home. The controls requirements of Title 24, Part 6 aim to maximize energy savings while ensuring occupants are comfortable.

Many lighting controls must be certified to the Energy Commission before they can be installed in lighting projects. This certification verifies that a device has the minimum functionality required by the Title 20 Appliance Efficiency Regulations and meets all state and federal standards for energy efficiency.

### Switches



◀ Switches (left to right):  
Lutron Claro, Lutron Skylark,  
WattStopper RD250  
PIR Dimming Multi-way  
Convertible Occupancy Sensor

#### ☑ Compliance Requirements

- 1. Separate Switching:** Lighting systems such as undercabinet lighting and exhaust fans must be switched separately from other lighting. Lights that are integral to fans must have independent manual controls, allowing them to be turned ON or OFF without affecting the fan, yet can be on the same switch.
- 2. Manual control:** All installed luminaires must be switched with readily accessible manual ON/OFF controls.
- 3. No bypassing:** No controls may bypass dimmer or vacancy sensor functions if the dimmer or sensor is used to comply with the standards.

### Permanently Installed Luminaires

Permanently installed luminaires are attached to the home or other structures on the property. These luminaires may have either plug-in or hard-wired connections. This includes all luminaires that are:

- Attached to walls, ceilings and columns
- Inside cabinets
- Mounted under cabinets
- Attached to ceiling fans
- Integral to exhaust fans
- Integral to garage door openers
- Part of track lighting and flexible lighting systems

Permanently installed luminaires do not include portable lighting or lighting installed in appliances by the manufacturer, like those in range hoods, refrigerators or microwave ovens.



### Residential Lighting: What's New in the 2016 Title 24, Part 6 Code?

[cltc.ucdavis.edu/  
publication/2016-title-24-  
code-changes-residential](http://cltc.ucdavis.edu/publication/2016-title-24-code-changes-residential)

California's new residential Building Energy Efficiency Standards take effect on January 1, 2017. The 2016 Standards focus on several key areas to improve the energy efficiency of newly constructed buildings, additions and alterations to existing buildings. This publication offers an overview of important requirements and major updates to the 2016 residential lighting energy efficiency code.

## Dimmers



◀ Dimmers (left to right):  
Lutron Maestro, Lutron Pico  
Wireless Control, Lutron Vierli

Dimmers give occupants more control over their lighting, and they reduce energy use. With the exception of small closets or hallways, dimmers or vacancy sensors must be used with any recessed ceiling downlight or other source that must be certified as JA8 compliant.

### ☑ Compliance Requirements

Compliant dimmers must meet the criteria in **Section 1605.3** of Title 20 and be certified to the Commission. These requirements include:

1. **65% power reduction:** Dimmers must be capable of reducing power consumption by at least 65%.
2. **Full OFF:** Dimmers must include an OFF position with zero lumen output, consuming no more than 1 W of power per lighting dimmer switch leg.
3. **Reduced flicker:** Dimmers must provide electrical outputs to lamps for reduced flicker operation through the dimming range (amplitude modulation less than 30% for frequencies less than 200 Hz) without causing premature lamp failure.
4. **Three-way circuits:** Wall box dimmers and associated switches designed for use in three-way circuits must be able to turn the lighting ON and OFF. When turning lights ON, these devices must restore the light level set by the dimmer before the lighting was last turned OFF.
5. **Forward phase-cut dimmers:** All forward phase-cut dimmers used with LED sources must comply with NEMA SSL 7A-2015.

### ★ Recommendations

1. **Multi-way switches and dimmers:** Install multi-way toggle switches with multi-way dimmers, so lights can be switched or dimmed from all room entrances and exits.
2. **Lighting load:** Be sure to correctly match the dimmer with the electrical lighting load or early equipment failure may occur.
3. **Fluorescent lamps:** Dimmers may be used with fluorescent lamps, but many fluorescent lamps cannot be properly dimmed with typical wall box devices used with incandescent lamps. A special control and dimming ballast must be used. Some CFLs cannot be dimmed at all; check the packaging to see if they are dimmable.



### Dimmer Compatibility

*It is important to correctly match the dimmer with the type of lighting load being dimmed. This prevents equipment failure, and it is especially critical with LED lighting. Among other criteria, a dimmer should be chosen according to the total wattage of the lighting it will control and forward-phase cut dimmers should comply with NEMA SSL 7A - 2015: Phase-Cut Dimming for Solid State Lighting - Basic Compatibility.*



## Vacancy Sensors



◀ Vacancy Sensors (left to right): WattStopper CS-50 PIR Wall Switch Vacancy Sensor; Lutron Maestro occupancy/vacancy sensor; WattStopper CS-350-N PIR Dual Relay Wall Switch Vacancy Sensor

Vacancy sensors require occupants to turn lights ON manually, but they enable lights to automatically turn OFF after a space has been vacated. To be in compliance, a vacancy sensor must provide:

- A maximum time out of 20 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)
- Vacancy sensors cannot incorporate DIP switches or other manual means to convert between manual and automatic functionality.

Bathrooms, garages, laundry rooms, and utility rooms must pair at least one luminaire in the space with a vacancy sensor. Dimmers or vacancy sensors must control all luminaires equipped with JA8 compliant sources except for luminaires in closets less than 70 square feet or luminaires in hallways.

### ☑ Compliance Requirements

1. **Manual control:** Occupants must be able to turn lights ON and OFF manually.
2. **Auto-OFF:** Sensors must be capable of automatically turning lights OFF within 20 minutes of a room being vacated.
3. **Manual-ON:** Occupants must turn lights ON manually. No auto-ON function is allowed from the sensor.

### ★ Recommendations

1. **Safety first:** Avoid using vacancy sensors that use a ground wire for the operating current, as this method presents safety hazards.
2. **Partial-OFF vacancy sensors:** Some vacancy sensors allow lights to be partially shut OFF before switching OFF completely. This is especially useful in spaces where safety may be a concern.
3. **Full sensor coverage:** Be sure sensors are positioned for full coverage of the area where lighting will be controlled. Passive infrared (PIR) vacancy sensors, for example, require a clear line of sight to detect occupants. This is not necessary for ultrasonic sensors. When using a two-way switch for one luminaire, it is recommended to use a ceiling-mounted occupancy sensor rather than a wall-switch sensor. Another option is to use a three-way vacancy sensor at both switch locations.

### What is the difference between a vacancy sensor and an occupancy sensor?

Occupancy sensors allow for both auto-ON and auto-OFF functionality. Vacancy sensors are a specific type of occupancy sensor.

Vacancy sensors require occupants to turn lights ON manually, but they enable lights to automatically turn OFF after a space has been vacated.

## Photosensors



◀ Photocontrols (Left to Right): Leviton Photocell ODCOP-W; SensorSwitch On/Off Photocell CM PC

Photosensors measure relative light levels and adjust electric lighting accordingly. Title 20 regulations prohibit photosensors from having a mechanical device that allows for their disabling.

Some common outdoor photocontrols simply turn lights ON or OFF at dusk or dawn, when light levels drop below or rise above a certain set point. More complex systems use advanced photosensors paired with dimming ballasts or drivers to automatically and dynamically adjust interior light levels in response to daylight availability.

## Automatic Time-Switch Controls

Automatic time-switch controls are capable of automatically controlling lighting based on time of day. This type of control device can be used to comply with the outdoor lighting requirements of the Energy Standards. Astronomical time clocks, which also include programming features based on sunrise, sunset and geographic location, may be used to comply with the residential outdoor lighting controls requirements.



▲ Leviton Programmable Timer Switch VPT24-1PZ

### ☑ Compliance Requirements

Under the 2015 Title 20 Appliance Efficiency Regulations, astronomical time-switch controls are required to:

1. Accurately predict sunrise and sunset +/- 15 minutes and have timekeeping accuracy +/- five minutes per year.
2. Be capable of displaying date, current time, sunrise time, sunset time, and switching times for each step during programming.
3. Automatically adjust for daylight savings time.
4. Be able to independently offset the ON/OFF times for each channel by at least 99 minutes before and after sunrise or sunset.

## Energy Management Control Systems

An energy management control system (EMCS) is a computerized control system designed to regulate a building's energy use by controlling the operation of energy-consuming systems such as lighting. EMS must provide the same control functionality as the individual devices it replaces.



▲ Leviton Lumina 44A00-1



## Zero Net Energy Home Provides Education on Energy Efficiency Stockton, CA

Inside PG&E's Energy Training Center at the new Stockton Regional Office is a zero net energy (ZNE) display home that is giving the public a close up look at how an energy efficient home looks and works.

A ZNE building produces as much renewable energy as it uses over the course of a year by reducing energy use through efficiency and offsetting the remaining use through on-site renewable energy generation.

"The goal of the ZNE Display House is to present builders and designers, homeowners and community members with the new 'home of the now', to learn more about energy efficiency, living sustainably and how they can incorporate these principles into their own new-home construction projects," says Matthew Baker, supervisor of the Energy Training Center.

Visitors to the ZNE Display House can explore the lighting design room by room. The home provides information on lighting energy use, including a comparison between technologies, the benefits of LEDs, lighting color characteristics, circadian-sensitive lighting and smart home control systems.

California has set a goal for all new homes to be built as ZNE by 2020, and for all new commercial construction to be built as ZNE by 2030. Through programs and partnerships, PG&E is at the forefront of helping builders and contractors meet these goals.

With the benefits of ZNE homes, says Sam Jensen Augustine, a manager with PG&E's Energy Centers: "customers will end up with a more comfortable house that costs them less energy and is less money to maintain."

More information is at: [www.pgecurrents.com/2016/06/01/video-pge-helps-lead-effort-toward-clean-energy-building-solutions/](http://www.pgecurrents.com/2016/06/01/video-pge-helps-lead-effort-toward-clean-energy-building-solutions/)

To visit the display home: [www.pge.com/energycenters](http://www.pge.com/energycenters)





# COMPLIANCE REQUIREMENTS

## COMPLIANCE PROCESS

### There are two basic steps to comply with the Energy Standards

- Meet all mandatory requirements by installing required systems, equipment and devices, and ensuring that they perform all functions required by the Standards.
- Select your method of compliance by choosing either the Performance Approach or the Prescriptive Approach.

Residential lighting requirements consist of mandatory measures only, regardless of whether the prescriptive or performance approach is taken during the design process.

### Mandatory Requirements

All residential buildings must meet a set of mandatory requirements for lighting system efficiencies and lighting controls. Examples of lighting components addressed by mandatory measures include minimum light source efficacy, switching separation for certain light loads, and use of vacancy sensors in various spaces.



PHOTO: HINKLEY LIGHTING



## NAVIGATING TITLE 24, PART 6

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
<b>NEW CONSTRUCTION RESIDENTIAL LIGHTING</b>	§ 150.0(k)	—	—
<b>Luminaire Requirements</b>	§ 150.0(k)1	—	—
<b>Interior Lighting Switching Devices and Controls</b>	§ 150.0(k)2	—	—
<b>Outdoor Lighting</b>	§ 150.0(k)3	—	—
<b>Internally-illuminated Address Sign</b>	§ 150.0(k)4	—	—
<b>Garages for 8 or More Vehicles</b>	§ 150.0(k)5	—	—
<b>Interior Common Areas of Low-rise Multifamily Residential Buildings</b>	§ 150.0(k)6	—	—
<b>ADDITIONS AND ALTERATIONS</b>	§ 150.2	—	—
<b>Additions</b>	§ 150.2(a)	—	—
<b>Alterations</b>	§ 150.2(b)	—	—

## NEW CONSTRUCTION, ADDITIONS & ALTERATIONS

### New Construction

New construction refers to construction of entirely new structures. New residential construction must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.

### Additions

Additions are any change that increases the floor area and volume of a building of an occupancy group or type regulated by the Energy Standards. Additions are also any change that increases the illuminated area of an outdoor lighting application regulated by the Standards. New residential additions must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.

### Alterations

Alterations involve replacing any lighting component, system, or equipment regulated by the Standards. Alterations to existing residential lighting systems must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.

## MANDATORY MEASURES

### High Efficacy Lighting

Mandatory measures require that lighting in new homes be high efficacy. Some light sources are automatically considered high efficacy. Others must be certified to CEC as high efficacy. Luminaires which are subject to JA8's requirements must include elements of efficiency and lighting quality. The high efficacy definition is applicable to all lighting technology types and includes linear fluorescent, pin based compact fluorescent, GU-24 base CFL, HID, and induction.

Any luminaire can qualify as high efficacy as long as it meets the requirements of [Section 150.0 \(k\)](#) and, if applicable, Joint Appendix JA8.

### Appendix JA8: Qualification Requirements for High Efficacy Light Sources – Partial List

Specification	Requirement
Initial Efficacy	≥ 45 lumens/Watt
Power Factor at Full Rated Power	≥ 0.90
Correlated Color Temperature (CCT)	For inseparable SSL luminaires, LED light engines and GU24 LED lamps, ≤4000 Kelvin. For all other sources, ≤3000 Kelvin.
Color Rendering Index (CRI)	≥90
R9	≥50
Rated Life	≥ 15,000 hours
Minimum Dimming Level	≤ 10%
Flicker	<30% for frequencies of 200 Hz or below, at 100% and 20% light output.

**2016 Indoor Residential Lighting Requirements: Luminaires**

Mandatory Measure	Screw-Base Luminaire	Pin-Base <sup>1</sup> Luminaire	Recessed Downlight	Inseparable SSL <sup>5</sup> Luminaire (LED)	Night Lights <sup>2</sup>	All Other
<b>High Efficacy (required)</b>	Yes—All	Yes—All	Yes—All	Yes—All	Yes—All	Yes—All
<b>High Efficacy Qualification via JA8 lamps and luminaires<sup>3</sup></b>	All, excluding hard-wired ballasted HID	Only GU-24 LED lamps	All types, and certified compliant for elevated temperatures	All, except colored-decorative	Yes	All types
<b>Automatic Qualification as High Efficacy: Listed in Table 150.0-A, Column 1 (JA8 compliance not required)</b>	Hard-wired, ballasted HID only	All types, excluding GU-24 LED	None	Colored-decorative	No	None
<b>Dimmer, Vacancy Control or EMCS<sup>4</sup></b>	Yes—All	Not mandatory, except for GU-24 LED	Yes—All	All, except colored-decorative	Yes—All	All
<b>Other Requirements</b>	Cannot be a recessed downlight	Must use an electronic ballast	Airtight, IC-rated and maintenance per § 150(k)1C	None	Must consume 5W or less	None

<sup>1</sup> Excludes recessed downlights  
<sup>2</sup> Permanently installed or integral to luminaire or exhaust fan  
<sup>3</sup> Enclosed luminaires must use JA8 lamps certified for use at elevated temperatures  
<sup>4</sup> Excludes luminaires in closets less than 70 ft<sup>2</sup> and hallways  
<sup>5</sup> Solid-state lighting such as LED where the LED source is permanently attached to the luminaire

Manufacturers must test their products at an accredited test laboratory and submit the results to the California Energy Commission to gain JA8 certification. A list of compliant products may be found at <https://cacertappliances.energy.ca.gov>

long life at elevated temperatures in addition to the requirements listed for JA8-2016. Only “JA8-2016-E” light sources may be used in enclosed and recessed luminaires.

**Efficacy Requirements Applied**

**MANUFACTURER REQUIREMENTS**

For a light source to qualify as high efficacy under JA8, it must be certified and marked as either JA8-2016 or JA8-2016-E. These markings mean the light source meets the requirements of Joint Appendix JA8, and the product is listed in the Energy Commission product database. Requirements assure lamps and luminaires provide high color quality, have a long life and are energy efficient.

JA8 compliance markings are located on the lamp bulb or base. The marking “JA8-2016-E” indicates that the light source has been tested to provide

**BUILDER REQUIREMENTS**

All luminaires that utilize a screw-based socket, excluding hard-wired ballasted HID, must contain lamps that comply with JA8 high efficacy requirements. All enclosed luminaires, must utilize a compliant lamp rated for elevated temperatures. Recessed downlight luminaires with screw based sockets are not permitted.

The builder must provide new homeowners with a luminaire schedule that includes a list of installed lamps and luminaries. This ensures that homeowners know what lighting products they are entitled to when they take possession of a new home.



## 2016 Indoor Residential Lighting Requirements: Spaces & Lighting Controls

Residential Space	Manual ON/OFF Controls	Vacancy Sensor or Dimmer <sup>1</sup>	Separate Switching: Exhaust Fans	Separate Switching: Undercabinet Lighting
Hallways & Closets <sup>2</sup>	Required for all spaces	Not required	Exhaust fans must be switched separate from lighting or utilize a device where lighting can be turned OFF while the fan is running. Excludes kitchen exhaust hoods.	Undercabinet lighting must be switched separate from all other lighting.
Kitchens		Based on installed luminaire or lamp type <sup>3</sup>		
Bathrooms		At least one luminaire controlled by a vacancy sensor and all other based on installed lamp or luminaire type		
Laundry Rooms / Utility Rooms				
Garage				
All Other		Based on installed luminaire or lamp type <sup>3</sup>		

<sup>1</sup> May be achieved with an EMCS or programmable scene controller with required functionality.

<sup>2</sup> Closets less than 70ft<sup>2</sup>. For all other closets, requirements based on installed lamp or luminaire type.

<sup>3</sup> See page 3 for a list of requirements by lamp and luminaire type.

### BUILDING INSPECTION

The mandatory efficacy requirements paired with the manufacturer marking and builder provided lighting schedule requirements make lighting inspections straight forward as all luminaires are high efficacy and there is a completed luminaire schedule for the owner.

### Indoor Control Requirements Applied

Control requirements are based, in nearly all cases, on the type of lamp or luminaire installed. Any JAB-compliant light source must be controlled by a vacancy sensor or dimmer. In practice, this requirement translates to any screw-base luminaire, ceiling recessed downlight, enclosed luminaire, dedicated LED luminaire, or luminaire with an LED lamp.

Additionally, all undercabinet lighting must be switched separately from other lighting in the home.

At least one luminaire in the bathroom, garage, laundry room and utility room must be controlled by a vacancy sensor.

Preset scene controllers and EMCS can take the place of dimmers as long as the functionality meets code requirements.

### Outdoor Lighting Requirements

All outdoor lighting must be high efficacy.

In addition, for single family homes, lighting permanently mounted to any building on the lot must be controlled by one of the following combinations and a manual ON/OFF switch that does not override the chosen combination:

1. Photocell and motion sensor
2. Photocell and time switch
3. Astronomical time clock
4. EMCS with features of an astronomical time clock, does not allow the luminaire to be ON during the day, and may be programmed to automatically turn lighting OFF at night.

For low-rise, multifamily residential buildings, outdoor lighting for private patios, balconies, entrances, and porches must also meet these requirements or comply with the applicable nonresidential standards.

Requirements for carports and parking lots vary based on the number of parking spaces they contain. Carports, parking garages and parking lots with eight or more spaces must comply with the nonresidential standards. Smaller parking areas may comply with either the residential or nonresidential standards.



# REQUIREMENTS & RECOMMENDATIONS

## DESIGNING TO CODE

The Energy Standards allow designers and builders to choose from a variety of lighting strategies and technologies. Options are available across a broad range of price points and can suit a variety of aesthetics. The sample lighting designs presented here represent just some of the many possibilities on the market today.

### Space Type Definitions

#### Section 100.1

Definitions for each residential space type within a home are provided in the Energy Standards (under **Residential Space Type**). These definitions are also provided in the glossary of this guide. Some open plans blend space types. When working on a home that blends spaces, check the code for definitions to be sure plans are in compliance.

### Lighting Plans

Each plan in the following section provides an example of a compliant lighting design. Each includes descriptions of the luminaires and lamps used in the plan, including lamp types, power consumption (watts), and lamp efficacy.

### Calculating Efficacy

Use system power, the luminaire's rated input power (watts), for efficacy calculations.

### Lighting Recommendations

Each plan includes recommendations for lighting each space. These tips are intended to optimize occupants' comfort while meeting or exceeding the 2016 Title 24, Part 6 standards for energy efficiency.



## REQUIREMENTS & RECOMMENDATIONS BY SPACE TYPE

### INDOOR

#### Kitchens

All permanently-installed kitchen luminaires shall be high-efficacy. Additionally, luminaires shall adhere to requirements listed in the Finding Compliant Products section of Chapter 1.

Manual on/off controls are required for all luminaires. Undercabinet lighting must be switched separate from all other lighting. Since most lights in kitchens are either recessed or enclosed, in practice, most kitchen luminaires must be on either a vacancy sensor, or dimmer.

#### Compliance Requirements

- 1. High-Efficacy:** All installed luminaires in kitchens shall be high-efficacy that are permanently installed or integral to a luminaire/exhaust fan. Night lights are required to be high efficacy, but are not expected to meet the specifications of JA-8. If something unusual is being installed, there is a chance it will not meet one of the items in Table 150.0-A and may need to go through JA-8 certification.
- 2. Undercabinet lighting:** Undercabinet lighting must be switched separate from all other lighting.
- 3. Blank electrical boxes for future installations:** The total number of electrical boxes with a blank cover located five feet or higher above the finished floor in the whole building shall be no greater than the number of bedrooms in the building.
- 4. Manual control:** All lighting must have readily accessible manual controls, allowing occupants easy control of lighting in the space.
- 5. Dimmer or Vacancy controls:** Vacancy switches or dimmers are required for all light sources required to comply with JA-8. If the kitchen luminaire is an enclosed or recessed luminaire, you must use a dimmer or vacancy sensor.

#### Recommendations

- 1. Separate switching:** Switch nooks, dining areas and other adjacent spaces separately from the kitchen. This adds flexibility to the lighting design and reduces lighting energy use.
- 2. Sink task lighting:** Install a luminaire over the sink on a separate switch to provide task lighting for this frequently used area of the kitchen.





- 3. Low-glare countertops:** Select light-colored, matte-finish countertops if you want to increase light reflectance while minimizing glare. For dark or highly reflective countertops, be sure to choose downlights and undercabinet luminaires with optics that reduce glare.
- 4. Clean ceiling lines:** Minimize the number of luminaires extending below the ceiling to reduce visual clutter.

## Bathrooms, Laundry Rooms, Utility Rooms and Garages

All installed luminaires in bathrooms, laundry rooms, utility rooms and garages shall be high efficacy. Exhaust fans must be switched separate from lighting or utilize a device where lighting can be turned OFF while the fan is running. Additionally, luminaires shall adhere to requirements listed in the Finding Compliant Products section of Chapter 1.

Manual ON/OFF controls are required for all luminaires. Undercabinet lighting must be switched separate from all other lighting. Vacancy sensors are required for at least one luminaire in the space, and controls for all other luminaires are based on the installed lamp or luminaire type. In practice, this means all remaining luminaires except non-LED pin base luminaires, and colored-decorative dedicated LED luminaires, must also be paired with a vacancy sensor or dimmer. Any enclosed luminaire must also be paired with a vacancy sensor or dimmer.

### Compliance Requirements

- 1. High-Efficacy:** All installed luminaires shall be high-efficacy that are permanently installed or integral to a luminaire/exhaust fan. Night lights are required to be high efficacy.
- 2. Undercabinet lighting:** Undercabinet lighting must be switched separate from all other lighting.
- 3. Blank electrical boxes for future installations:** The total number of electrical box with a blank cover located five feet or higher above the finished floor in the whole building shall be no greater than the number of bedrooms in the building.
- 4. Manual control:** All lighting must have readily accessible manual controls, allowing occupants easy control of lighting in the space.
- 5. Separate switching:** Exhaust fans must be switched separate from lighting or utilize a device where lighting can be turned OFF while the fan is running.
- 6. Dimmer or Vacancy controls:** Vacancy sensors or dimmers are required for at least one luminaire in the space, with controls for all other luminaires being based on the installed lamp or luminaire type.





### ★ Recommendations

1. **Choose UL rating — damp or wet:** Use luminaires that are rated appropriate for use in damp areas.
2. **Consider barriers:** Use a recessed downlight over the shower when a shower curtain or door limits ambient lighting.
3. **Prevent shadows:** Position bath bars or sconces vertically (parallel with the sides of mirrors as opposed to overhead) to distribute light more evenly.
4. **Make storage spaces more functional:** Use surface-mounted lights in deep cabinets and closets to spread light evenly on shelving and supplement lower ambient light levels.
5. **Design for safety:** If luminaires in bath or shower areas are controlled by vacancy sensors, consider installing a dual-technology device to make sure the sensor can detect occupants at all times.

### Other Indoor Space Types

This category covers any residential space type that is not a kitchen, bathroom, laundry room, garage, or utility room. These include:

- Bedrooms
- Living rooms
- Home offices
- Dining rooms, if switched separately from kitchens
- Nooks, if switched separately from kitchens
- Hallways
- Attic spaces
- Closets 70 ft<sup>2</sup> and larger

### ☑ Compliance Requirements

1. **High-Efficacy:** All installed luminaires shall be high-efficacy that are permanently installed or integral to a luminaire/exhaust fan.
2. **Undercabinet lighting:** Undercabinet lighting must be switched separate from all other lighting.
3. **Blank electrical boxes for future installations:** The total number of electrical box with a blank cover located five feet or higher above the finished floor in the whole building shall be no greater than the number of bedrooms in the building.



4. **Manual control:** All lighting must have readily accessible manual controls, allowing occupants easy control of lighting in the space.
5. **Separate switching:** Exhaust fans must be switched separate from lighting or utilize a device where lighting can be turned OFF while the fan is running.
6. **Dimmer or Vacancy controls:** For all space types except hallways and closets that are 70 square feet or smaller, vacancy sensors or dimmers are required when using a source regulated by JA8.

### ★ Recommendations

1. In large living rooms and dining rooms, layer ambient, task and accent lighting to reduce shadows and create visual interest.
2. Provide separate switches, preferably dimmers, for different layers of lighting to allow residents control and reduce energy use.
3. When using ceiling fans with light kits, be sure the fan and light can be switched separately. Select a dimmable fan light and be sure the dimmer switch is compatible and compliant with NEMA SSL 7A if the light source is LED.
4. For hallways, install three-way switching, lighting should be controllable from all points of entrance.
5. Combine high-efficacy luminaires with vacancy sensors to maximize efficiency in hallways and closets.



## OUTDOOR

All outdoor lighting in single family residential buildings must be high efficacy. In addition, lighting mounted to any building on the lot must adhere to mandatory control requirements pairing manual ON/OFF with one of the following combinations:

1. Photocell and motion sensor,
2. Photocell and time switch
3. Astronomical time clock
4. EMCS with features of astronomical time clock, does not allow the luminaire to be ON during the day, and may be programmed to automatically turn lighting OFF at night.

For low-rise, multifamily residential buildings, outdoor lighting for private patios, balconies, entrances, and porches must also meet these requirements or comply with the applicable nonresidential standards.

Requirements for carports and parking lots vary based on the number of parking spaces they contain. Carports, parking garages and parking lots with eight or more spaces must comply with the nonresidential standards. Smaller parking areas may comply with either the residential or nonresidential standards.

### Compliance Requirements

1. **High efficacy:** For single family residential buildings, all lighting attached to the exterior of the building or to other buildings on the same lot must be classified as high efficacy.
2. **Controls:** All lighting attached to the exterior of a single family residential building or to other buildings on the same lot must be controlled by a manual ON/OFF switch that is not capable of turning on any lighting that has been shut off by an automatic lighting control AND utilize one of the following control strategies:
  - Photocell and motion sensor,
  - Photocell and time switch
  - Astronomical time clock
  - EMCS with features of astronomical time clock, does not allow the luminaire to be ON during the day, and may be programmed to automatically turn lighting OFF at night.
3. **Temporary motion sensor overrides:** Motion sensors may have a temporary override function that allows luminaires to stay switched ON regardless of motion detection, but the motion sensor must automatically reactivate within six hours.





4. **For low rise multifamily residential buildings:** Outdoor lighting for private patios, entrances, balconies, and porches may comply with requirements for single family residences, or meet applicable nonresidential requirements.
5. **Requirements for parking lots and carpports:** These vary based on their size. See the following table for complete details.

### 2016 Residential Versus Nonresidential Outdoor Lighting Requirements

Space Type	Single Family	Low-Rise Multifamily		High-rise Multifamily and Hotels <sup>1</sup>
		1 to 3 Dwelling units	4 or More Dwelling units	
<b>Outdoor Lighting Mounted to Building</b>	Residential Standards	Residential Standards for lighting not regulated by Section 3B or 3D	Nonresidential Standards	Nonresidential Standards
<b>Private patios, entrances, balconies and porches</b>	Residential Standards	Residential Standards or Nonresidential (builder's option)	Residential Standards or Nonresidential (builder's option)	Residential Standards applies to the dwelling units; Nonresidential applies to areas outside the dwelling units
<b>Parking lots and carpports with 8 or LESS vehicles per site</b>	Residential Standards	Residential Standards or Nonresidential (builder's option)	Residential Standards or Nonresidential (builder's option)	Nonresidential Standards
<b>Parking garages, lots and carpports with 8 or More vehicles</b>	Residential Standards	Nonresidential Standards	Nonresidential Standards	Nonresidential Standards

<sup>1</sup> Residential Lighting Standards applies to the dwelling units; Nonresidential Lighting Standards applies to areas outside the dwelling units..

## ★ Recommendations

### OUTDOOR LIGHTING

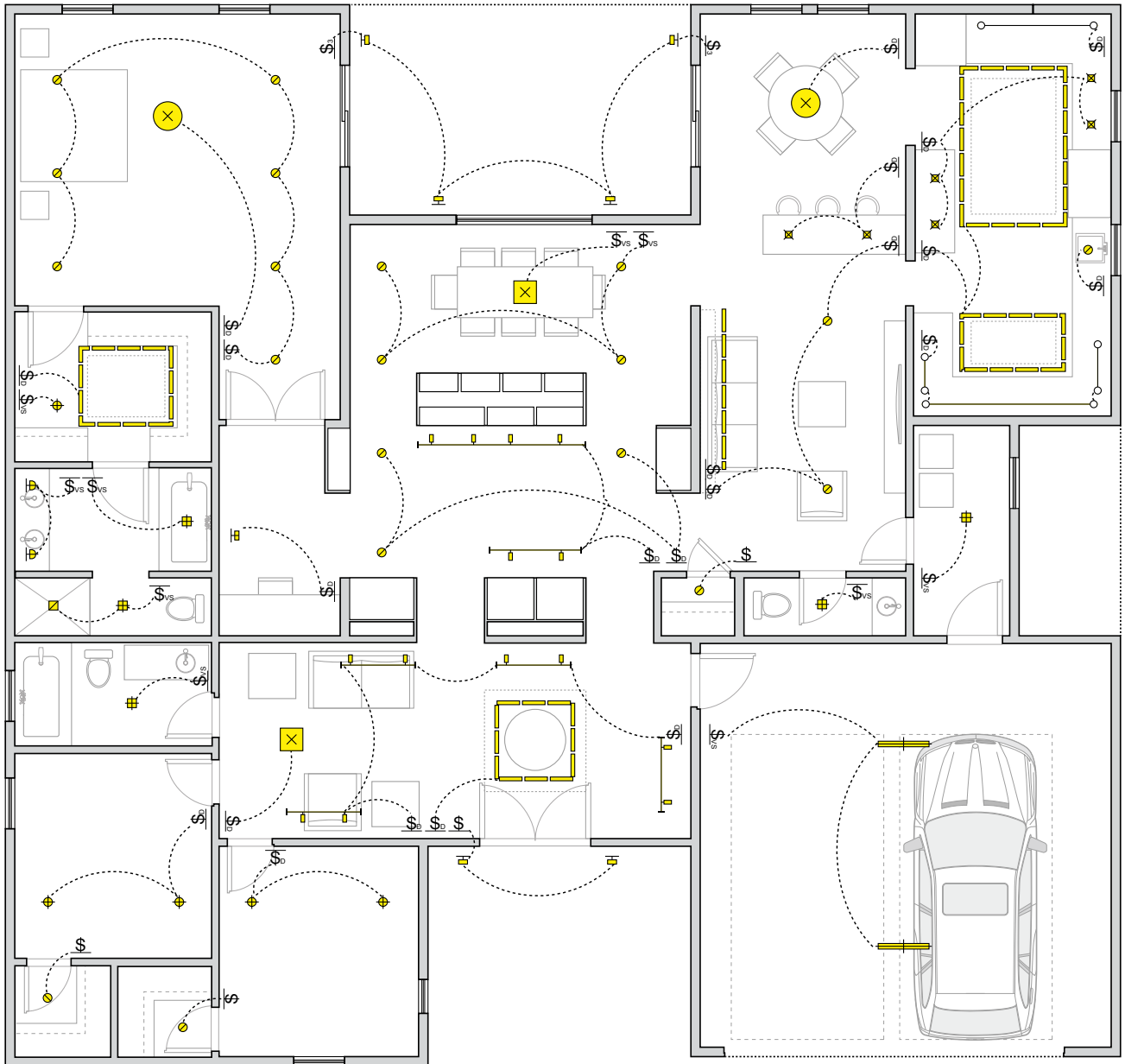
1. Sparse ground-level lighting placed strategically along pathways and area perimeters gives occupants a sense of their surroundings without over-lighting the space.
2. Where switches are less accessible, use a motion sensor.
3. Adjust motion sensor coverage to avoid unwanted triggers from street traffic or neighbors' movements. Most sensors have controls that allow for such adjustments.
4. Control landscape lighting and other luminaires not permanently attached to building exteriors with a time clock or photocontrol. It will save energy and extend lamp life by automatically turning lights OFF during daylight hours.
5. Position adjustable heads to aim light on the objects they are meant to highlight, so as to avoid causing glare or light trespass.
6. During the design phase, select luminaires with a CCT of no more than 3000 K to minimize discomfort glare and circadian disruption at night.

### PORCH LIGHTING


















1. Install a motion sensor to automatically reduce energy use and light pollution when spaces are vacant. Position and adjust motion sensors so they provide light as occupants approach but are not triggered too easily.
2. Shield outdoor lighting near bedroom windows to minimize light trespass into your home and your neighbor's homes.
3. Use a photocell or programmable timer to ensure that lights operate when desired for safety and security, but are not left on all day.
4. Select LED sources for colder outdoor environments.







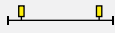














# LIGHTING IN PRACTICE: APPLYING REQUIREMENTS TO A SINGLE-FAMILY HOME



## Lighting Schedule

Symbol	Luminaire Type	Lamp	Quantity	CRI	CCT	Watts	Total Watts	Efficacy (lm / W)
<b>KITCHEN</b>								
	<b>LED undercabinet</b>	Dedicated LED	21'	94	2,150K	1.4W/ft.	29.4	84
	<b>LED tape light</b>	Dedicated LED	41'	90	2,200K	4W/ft.	164	230
	<b>Pendant</b>	Dedicated LED	4	90	2,700K	15	60	60
	<b>Recessed downlight</b>	Dedicated LED	1	90	2,700K	13	13	54
<b>MASTER BEDROOM</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	2,700K	13	13	64
	<b>Recessed downlight</b>	Dedicated LED	7	90	2,700K	13	91	54
<b>MASTER BATHROOM</b>								
	<b>Ceiling mount</b>	Dedicated LED	2	90	3,000K	30	60	62.5
	<b>Indoor wall sconce</b>	Dedicated LED	2	90	2,700K	15	30	60
	<b>Recessed downlight</b>	Dedicated LED	1	90	2,700K	10	10	54
<b>POWDER ROOM / WALK-IN CLOSET</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	3,000K	30	30	62.5
	<b>LED tape light</b>	Dedicated LED	22'	90	2,200K	4W/ft.	88	230
<b>BEDROOM 1</b>								
	<b>Ceiling mount</b>	Dedicated LED	2	90	2,700K	13	26	64
	<b>Recessed downlight</b>	Dedicated LED	1	90	2,700K	13	13	54
<b>BEDROOM 2</b>								
	<b>Ceiling mount</b>	Dedicated LED	2	90	2,700K	13	26	64
	<b>Recessed downlight</b>	Dedicated LED	1	90	2,700K	13	13	54
<b>BATHROOM 1</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	3,000K	30	30	62.5
<b>BATHROOM 2</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	3,000K	30	30	62.5

Symbol	Luminaire Type	Lamp	Qty.	CRI	CCT	Watts	Total Watts	Efficacy (lm / W)
<b>DINING ROOM</b>								
	<b>Chandelier</b>	Dedicated LED	1	90	2,700K	13	13	64
	<b>Recessed downlight</b>	Dedicated LED	4	90	2,700K	13	52	54
<b>LIVING ROOM</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	2,700K	13	13	64
	<b>Pendant</b>	Dedicated LED	2	90	2,700K	15	30	60
	<b>Recessed downlight</b>	Dedicated LED	2	90	2,700K	13	26	54
	<b>LED tape light</b>	Dedicated LED	11'	90	2,200K	4W/ft.	44	230
<b>LIBRARY</b>								
	<b>Recessed downlight</b>	Dedicated LED	3	90	2,700K	13	39	54
	<b>LED Track Light</b>	Dedicated LED	1-4' track 1-8' track 6 luminaires	90	3,000K	12	72	79
	<b>Indoor wall sconce</b>	Dedicated LED	1	91	2,700K	7	7	71
<b>FOYER</b>								
	<b>LED tape light</b>	Dedicated LED	22'	90	2,200K	4W/ft.	88	230
	<b>LED Track Light</b>	Dedicated LED	4-4' tracks 8 luminaires	90	3,000K	12	96	79
	<b>Chandelier</b>	Dedicated LED	1	90	2,700K	13	13	64
<b>LAUNDRY</b>								
	<b>Ceiling mount</b>	Dedicated LED	1	90	3,000K	30	30	62.5
<b>UTILITY</b>								
	<b>Recessed downlight</b>	Dedicated LED	1	90	2,700K	13	13	54
<b>GARAGE</b>								
	<b>Garage pendant</b>	Dedicated LED	2	90	3,500K	15	30	53
<b>FRONT PORCH</b>								
	<b>Outdoor wall sconce</b>	Dedicated LED	2	90	2,700K	13	26	64
<b>PATIO</b>								
	<b>Outdoor wall sconce</b>	Dedicated LED	4	90	2,700K	13	52	64

**CONTROLS**     Switch     Switch with vacancy sensor     Dimmer switch     3-way switch



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# GLOSSARY

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## A

**Accent lighting:** Directional or localized light used to focus attention on a specific architectural or design element of a building's interior or exterior.

**Accessible:** Capable of being reached fairly easily for operation, repair or inspection. Accessible components may still require removal or opening of access panels, doors or similar obstructions.

**Ambient lighting:** Also known as **General lighting**. Lighting designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect.

**Approval by the Commission:** Approval by the California Energy Commission under Section 25402.1 of the Public Resources Code.

**Astronomical time switch control:** An automatic lighting control device that switches lights on or off at dusk or dawn, or at specified times of the day, to prevent energy waste during periods when daylight is available.

## B

**Bathroom:** A room or area containing a toilet, a sink used for personal hygiene, a shower or a tub.

## C

**California Energy Commission:** The California State Energy Resources Conservation and Development Commission.

**Carport:** A covered, open-sided structure used solely for the purpose of parking vehicles, consisting of a roof over the parking area. Carports typically are free standing or projected from the side of the building and one or two car lengths deep.

**Chandelier:** A ceiling-mounted luminaire that uses glass, crystal, ornamental metals, or other decorative materials. A chandelier may be mounted close to the ceiling or suspended. Typically used as a significant element of interior architecture.



**Closet:** A non-habitable room used to store linens, household supplies, clothing, or non-perishable food items, which is not a hallway or passageway. Closets smaller than 70 ft<sup>2</sup> are exempt from many Title 24, Part 6 requirements.

**Color Rendering Index (CRI):** The current industry standard for measuring how accurately a light source renders the colors of the objects it illuminates when compared to an ideal light source. The maximum CRI value is 100.

**Common areas:** Common areas include interior hallways, pool houses, reading rooms, and laundry rooms.

**Correlated Color Temperature (CCT):** Expressed in Kelvin (K), CCT indicates the warmth or coolness of light emitted from a particular source. Light sources with a low CCT (2700–3000K) have a warmer, more reddish appearance than those with higher CCT values (4000–6500K, for example), which appear cooler, or more bluish, in color.

## D

**Dimming, continuous:** Also known as full-range dimming. A lighting control method that is capable of varying the light output of lamps over a gradual range from full light output to OFF (zero lumen output).

**Dimming, stepped:** A lighting control method that varies the light output of lamps in one or more predetermined discrete levels between full light output and OFF.

**Dining area:** An area or room where meals are eaten. May be attached to the kitchen or in a separate space.

## E

**Electrical box:** Also called a junction box or electrical junction box. A plastic or metal container for electrical circuits where the main electrical service from the grid is distributed throughout the building.

**Efficacy, lamp:** Lamp efficacy indicates how much light is produced by a lamp or lighting system for the amount of electrical power consumed. The quotient of rated initial lamp output (lumens) divided 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 the energy consumption of a building by controlling the operation of an energy-consuming system. An EMCS is capable of monitoring environmental and system loads, adjusting operations to optimize energy usage, and responding to demand response signals.

**Exhaust fan:** A fan in a wall or ceiling that moves air from within a building to outside the building. Commonly located in bathrooms and kitchens.

## F

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

## G

**Garage:** A non-habitable building or portion of a building, attached to or detached from a residential dwelling unit, in which motor vehicles are parked.

**Glare:** The uncomfortable or visually impairing effect of stray light, often resulting from a light source placed directly in an occupant's field of view.

**GU-24:** A lamp holder and socket configuration, based on the International Energy Consortium coding system, where "G" stands for the broad type of two or more projecting contacts (pins or posts), "U" distinguishes between lamp and holder designs of similar but not interchangeable types, and "24" indicates 24 millimeters between the center points of the electrical contact posts.

## H

**High intensity discharge (HID) lamp:** A point-source, electric-discharge lamp in which the arc producing light is contained within a secondary bulb. HID lamps are typically used in exterior lighting applications such as parking areas. Examples include metal halide and high-pressure sodium lamps.

**High-efficacy luminaires:** To qualify as JA8 high efficacy light source for compliance with the residential lighting Standards in Section 150.0(k), a residential light source shall be certified to the Energy Commission according to Reference Joint Appendix JA-8 Luminaires installed with only the lighting technologies in Table 150.0-A. High-efficacy luminaires include light sources identified as efficient in 2013 (linear

fluorescent, pin based compact fluorescent, GU-24 base CFL, HID, and induction lighting), and now also includes any luminaire that contains a JA8 compliant lamp or other light source that is appropriately marked. JA8 contains requirements that ensure that light sources, including lamps and luminaires, provide sufficient color quality, life, and energy efficiency.

**High-rise residential building:** A building, other than a hotel/motel, of Occupancy Group R-2 or R-4 with four or more habitable stories.

## I

**Incandescent lamp:** An electric lamp in which a filament gives off light when heated by an electric current.

## K

**Kitchen:** A room or area with cooking facilities and/or an area where food is prepared.

## L

**Lamp:** The lighting industry term for a light source, such as a light bulb or fluorescent tube.

**Laundry room:** A non-habitable room or space that contains plumbing and electrical connections for a washing machine and/or clothes dryer.

**Light-emitting diode (LED):** A solid-state diode that is constructed to emit colored or white light. The acronym LED is often used to refer to an LED component, device, or package.

**Hybrid LED luminaire:** A

complete lighting unit consisting of both an LED light source and a non-LED light source.

**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 and driver together with parts 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.

**Light trespass:** A form of light pollution that occurs when light spills into areas where it is not useful or wanted, for example, when outdoor lighting spills into neighboring interior spaces.

**Line-voltage socket:** Line-voltage sockets pair with a variety of screw, pin and bayonet bases (also called holders). Line-voltage sockets do not include a transformer, ballast or power supply between the wires connected to the luminaire and the lamp. Only GU-24 line-voltage luminaires can qualify as high efficacy under Title 24, Part 6.

**Low-efficacy luminaire:** Per Table 150.0-A of Title 24, Part 6, a low-efficacy luminaire is one manufactured or rated for use with: a line-voltage or low-voltage lamp holder (socket) capable of

accepting a low-efficacy lamp, such as an incandescent lamp; track lighting and similar flexible lighting systems; conversions between screw-base and pin-base sockets; electrical boxes used for a luminaire or ceiling fan; uncertified LED light sources; mercury vapor lamps.

**Low-rise residential building:** A building, other than a hotel/motel, that is of Occupancy Group R-2, multi-family with three or fewer habitable stories; or a single-family residence of Occupancy Group R-3; or a U-building located on a residential site.

**Lumen:** Unit of measurement for the amount of light emitted by a light source.

**Luminaire:** Also commonly referred to as a light fixture. A complete lighting unit consisting of a lamp and the parts designed to distribute the light (lens, reflector), to position and protect the lamp (housing), and to connect the lamp to the power supply (ballast, transformer).

**Luminance (L):** The term used to describe the intensity of light (flux) reflected from a surface in a given direction. It is measured in candelas per square foot (cd/ft<sup>2</sup>) or candelas per square meter (cd/m<sup>2</sup>).

**Luminous flux** The rate at which a light source emits visible light. This “flow rate” of light is measured as lumens over time.

## M

**Motion sensor:** A device that automatically controls outdoor lighting systems based on occupancy. Devices used to control indoor lighting systems are called occupant sensors. Also often called occupancy sensors, occupant-sensing devices or vacancy sensors.

**Multi-level lighting control:** A lighting control device that reduces lighting power in multiple steps while maintaining a reasonably uniform level of illuminance throughout the area controlled.

**Multi-family building:** A building containing multiple dwelling units that share common walls and may also share common floors or ceilings. Examples include apartments and dormitories.

**Multi-scene programmable switch:** A lighting control device that is capable of setting light levels at pre-established settings throughout a continuous range.

## N

**Nook:** A small, often recessed section of a room, such as a corner area adjacent to a kitchen (“breakfast nook”). Under Title 24, Part 6 lighting in kitchen nooks is counted as separate from kitchen lighting if it is switched separately.

## O

**Occupancy sensor:** Also known as an occupancy-sensing device, occupant sensor, or vacancy sensor. A device that automatically turns indoor lighting off, and sometimes on, based on occupancy or vacancy. Vacancy

sensors are a type of occupancy sensor that automatically turns lights off within 20 minutes of vacancy but requires lights be turned on manually. Motion sensors control outdoor lighting systems.

**Other rooms:** Any room or area that is not a kitchen, bathroom, garage, closet 70 ft<sup>2</sup> and larger, laundry room, or utility room, e.g., dining rooms, family rooms, home offices, bedrooms, attic spaces, hallways, and closets smaller than 70 ft<sup>2</sup>.

**Outdoor lighting, residential:** Permanently installed luminaires that provide lighting for private patios, entrances, balconies, and porches.

## P

**Parking area:** The area of a parking garage used for parking and maneuvering vehicles on a single floor, and which is not the roof of a parking structure.

**Parking garage:** A covered building or structure for the purpose of parking vehicles. Consists of at least a roof over the parking area enclosed with walls on all sides. May have fences, rails, partial walls, or other barriers in the place of walls. Parking garages have entrances and exits, and include space for vehicle maneuvering to reach the parking spaces. If the roof of a parking structure also is used for parking, the section without an overhead roof is considered a parking lot instead of a parking garage.

**Parking lot:** An uncovered area used for parking vehicles. Includes some parking structure roofs.

**Pendant:** A ceiling-mounted luminaire that is suspended, either close to the ceiling or closer to task surfaces. Pendant luminaires are generally a less formal choice than a chandelier.

**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, columns, inside or outside of permanently installed cabinets, internally illuminated case work, mounted on poles, in trees, or in the ground; lighting attached to ceiling fans; and lighting integral to exhaust fans other than exhaust hoods in cooking equipment. Does not include portable lighting or lighting that is installed by the manufacturer in appliances.

**Photocontrol:** An electric device that detects changes in illumination levels then automatically controls lighting load accordingly, e.g., turning luminaires on at dusk or off at dawn.

**Pin-base luminaire:** A luminaire, or fixture, that accepts lamps with a pin base. The pin base performs the same function as the screw base, but with greater efficiency. GU-24 pin-base luminaires are meant to prevent the use of low-efficacy lamps in high-efficacy luminaires.

**Portable lighting:** Lighting that is not permanently installed or hard-wired but uses a plug-in connection for electric power, e.g., freestanding floor or table lamps, luminaires attached to modular furniture, workstation task lights, lights attached to workstation panels, movable displays, and other impermanent luminaires. Code requirements for portable lighting are covered by Title 20 Appliance Efficiency Regulations.

## R

**Readily accessible:** Capable of being reached quickly for operation, repair, or inspection, without climbing or removing obstacles, or resorting to using portable access equipment.

**Residential compliance manual:**

The Residential Compliance Manual was developed by the California Energy Commission, under Section 25402.1 of the Public Resources Code, to aid designers, builders and contractors in meeting the California Building Energy Efficiency Standards.

**Residential occupancy types:**

**Group R-1:** Residential occupancies containing sleeping units where the occupants are primarily transient, including: boarding houses, hotels, motels, and efficiency dwelling units.

**Group R-2:** Residential occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent, including: apartments, boarding houses, convents, dormitories, fraternities and sororities, hotels, live/work units, monasteries, motels, and vacation timeshare properties.

**Group R-2.1:** Occupancy group including buildings, structures, or parts thereof that house clients who live in a supervised residential environment that provides personal care services. This includes: assisted living facilities, residential care facilities, retirement facilities, halfway houses, correctional centers, and recovery or treatment facilities.

**Group R-3:** Residential occupancies with primarily permanent occupants and not classified as Group R-1, R-2,

R-2.1, R-3.1, R-4 or I. This includes: buildings containing fewer than two dwelling units; adult care facilities that provide accommodations for six or fewer clients of any age for less than 24 hours (adult day programs); child care facilities that provide accommodations for six or fewer clients of any age for less than 24 hours; congregate residences.

**Group R-4:** Residential occupancies including: buildings arranged for occupancy as residential care/assisted living facilities, including more than six ambulatory clients, excluding staff.

**Group U:** Buildings and structures not classified in any specific occupancy that must adhere to fire and safety regulations. Examples include: barns, carports, greenhouses, livestock shelters, private garages, sheds, and stables.

## S

**Sconce:** A wall-mounted ornamental luminaire.

**Screw-base luminaire:** A luminaire, or fixture, that accepts lamps with a screw base, e.g., incandescent, CFL or LED replacement lamps.

**Stairs:** A series of steps providing passage from one level of a building to another.

**Storage building:** A non-habitable detached building used to store tools, garden equipment, or miscellaneous items.

## T

**Task lighting:** Lighting that is designed specifically to illuminate a task location, and that is generally confined to the task area.

## U

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

## V

**Vacancy sensor:** An occupant sensor that requires occupants to turn lights on manually but automatically turns the lights off soon after an area is vacated. Also called a manual-on occupancy sensor or manual-on/Automatic-off sensor.

## W

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

# TABLES

**Table JA8. Data to be Recorded and Submitted to the California Energy Commission**

Required Information	Permissible Answers	Compliance Threshold
<b>MANUFACTURER, MODEL NUMBER, DESCRIPTION</b>		
<b>Light Source Type</b>	LED, OLED, Fluorescent, HID, Incandescent, Other	
<b>Product Type</b>	Omnidirectional lamp, Directional lamp, Decorative lamp, LED light engine, Inseparable SSL luminaire, Other	
<b>Lab accredited by NVLAP or accreditation body operating in accordance with ISO/IEC 17011</b>	Yes/No	Yes
<b>Initial Efficacy</b>	Value (lumens/watt)	$\geq 45$ lumens/watt
<b>Power Factor at Full Rated Power</b>	0–1 Fraction	$\geq 0.90$
<b>Start Time</b>	Value (seconds)	$\leq 0.5$ sec
<b>Correlated Color Temperature (CCT)</b>	Number Kelvin	For inseparable SSL luminaires, LED light engines and GU24 LED lamps, $\leq 4,000$ Kelvin.  For all other sources, $\leq 3,000$ Kelvin.
<b>Duv</b>	Number Duv	$\geq -0.0033$ and $\leq +0.0033$
<b>Color Rendering Index (CRI)</b>	0–100	$\geq 90$
<b>Color Rendering R9 (red)</b>	0–100 or below 0	$\geq 50$
<b>Ambient or elevated temperature test for rated life, lumen maintenance, and survival rate</b>		"Ambient" allowed only for omnidirectional lamps $< 10W$ , and decorative lamps, or labeled "not for use in enclosed fixtures," lamps and light engines that are labeled "not for use in recessed fixtures," and "inseparable SSL luminaires." All others must report "Elevated."
<b>6,000 Hour Lumen Maintenance</b>	Value (percent), N/A	$\geq 86.7\%$ or N/A for integral luminaires providing TM-21 L70 projections based on light source LM80 data.





Required Information	Permissible Answers	Compliance Threshold
<b>LM-80 and TM-21 Projected Time to L70</b>	Value (hours), N/A	≥ 25,000 hours, or N/A for light sources providing 6,000 hour lumen maintenance testing
<b>Rated Life</b>	Value (hours)	≥ 15,000 hours
<b>6,000 Hour Survival Rate</b>	Value (percent)	≥ 90% or N/A for integral luminaires whose lumen maintenance/rated life is evaluated using light source LM80 data.
<b>Minimum Dimming Level</b>	Value (percent)	≤ 10%
<b>Dimming Control Compatibility</b>	Forward phase cut control, reverse phase cut, powerline carrier, digital, 0–10VDC, Other	At least one type must be listed
<b>NEMA SSL 7A Compatible</b>	Yes/No	If compatible with forward phase cut dimmer control, "Yes." If not, "No."
<b>FLICKER</b>		
<b>See JA10 Table 10-1 for flicker data requirements and permissible answers</b>		< 30% for frequencies of 200Hz or below, at 100% and 20% light output
<b>AUDIBLE NOISE</b>		
<b>100% Light Output: Audible Noise</b>	Value (dBA)	≤ 24 dBA
<b>20% Light Output: Audible Noise</b>	Value (dBA)	≤ 24 dBA
<b>MARKING</b>		
<b>Marked in Accordance with JA8.5</b>	Yes/No	Yes. "No" allowed only for lamps and LED light engines with diameter less than 1.0" and decorative lamps with a diameter less than 2.0".

From Appendix JA8—Qualification Requirements for High Efficacy Light Sources in the Standards

# RESOURCES

## COMPLIANCE RESOURCES

### California Advanced Lighting Control Training Program (CALCTP)

[calctp.org](http://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 Energy Commission Appliance Efficiency Database

[appliances.energy.ca.gov](http://appliances.energy.ca.gov)

The Appliance Efficiency Database contains all fixtures, systems, lamps, and devices currently certified to the California Energy Commission by their manufacturers as meeting applicable efficiency standards. The database allows users to search by category for each appliance type listed in the database.

### California Lighting Technology Center

[cltc.ucdavis.edu/title24](http://cltc.ucdavis.edu/title24)

The California Lighting Technology Center at UC Davis conducts research, development and demonstrations of state-of-the-art outdoor lighting systems. CLTC was established with support from the California Energy Commission. The center offers training programs on energy-efficient lighting solutions that meet or exceed Title 24, Part 6.

### Energy Code Ace

[energycodeace.com](http://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.

### Energy Standards Hotline

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

[Title24@energy.ca.gov](mailto:Title24@energy.ca.gov)

The Energy Standards Hotline is a resource for any questions regarding the Building Energy Efficiency Standards. The hotline is available Monday through Friday, 8 a.m.–12 p.m. and 1–4:30 p.m.

### Building Energy Efficiency Standards

[energy.ca.gov/title24/2016standards](http://energy.ca.gov/title24/2016standards)

The 2016 Building Energy Efficiency Standards (Title 24, Part 6) are available as a PDF on the Energy Commission website. This includes the standards for residential lighting, along with standards for all other residential applications. The standards should be the first resource for any contractor, builder, or designer seeking information on Title 24, Part 6 regulations.

The California Energy Commission created the 2016 Building Energy Efficiency Standards Residential Compliance Manual to supplement Title 24, Part 6. The Residential Compliance Manual clarifies issues not addressed in the standards.



PHOTO: LUTRON

## CLASSES

**California Center for Sustainable Energy (CCSE) Events and Workshops**  
[energycenter.org/events](http://energycenter.org/events)

**Building Operator Certification California Training Schedule**  
[theboc.info/ca/ca-schedule.html](http://theboc.info/ca/ca-schedule.html)

**Building Owners and Managers Association Online Education Schedule**  
[boma.org/education/Pages/default.aspx](http://boma.org/education/Pages/default.aspx)

**California Association of Building Energy Consultants Title 24 Resources**  
[cabec.org/title24info.php](http://cabec.org/title24info.php)

## MANUFACTURER TRAINING CENTERS

**Acuity Brands Center for Light&Space**  
Berkeley, CA  
[acuitybrands.com](http://acuitybrands.com)

**Eaton's Cooper Lighting Business**  
Online Design Center  
[cooperindustries.com](http://cooperindustries.com)

**Lutron**  
California Experience and Training Center  
Irvine, CA  
[lutron.com](http://lutron.com)

## 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, and some websites offer virtual video tours of the demonstration centers, as well as information on resources, services and more. Visitors and class participants can also learn about utilities' rebate and incentive programs.

**Pacific Gas and Electric Company (PG&E)**  
[pge.com](http://pge.com)

Pacific Energy Center (PEC), San Francisco  
Energy Training Center, Stockton

**Sacramento Municipal Utility District**  
[smud.org](http://smud.org)

Energy & Technology Center, Sacramento

**San Diego Gas & Electric**  
[sdge.com](http://sdge.com)

Energy Innovation Center, San Diego

**Southern California Edison (SCE)**  
[sce.com](http://sce.com)

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

For more information and resources about Title 24, Part 6,  
visit the CLTC website at [cltc.ucdavis.edu/standards-regulations](http://cltc.ucdavis.edu/standards-regulations).

CALIFORNIA LIGHTING TECHNOLOGY CENTER  
UNIVERSITY OF CALIFORNIA, DAVIS  
633 Pena Drive  
Davis, CA 95618  
Phone: (530) 747-3838  
Fax: (530) 747-3812  
Email: [cltc@ucdavis.edu](mailto:cltc@ucdavis.edu)

**UCDAVIS**  
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CALIFORNIA LIGHTING TECHNOLOGY CENTER

