LIGHTING BEST PRACTICES SERIES
Developed by the
California Lighting Technology Center, UC Davis

2019

RESIDENTIAL LIGHTING

A guide to meeting or exceeding
California's 2019 Building Energy Efficiency Standards

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STATE OF CALIFORNIA ENERGY COMMISSION

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CHAPTER 1

INTRODUCTION

THE BENEFITS OF EFFICIENCY

California's Title 24, Part 6 Building Energy Efficiency Standards (Energy Code) are effective January 1, 2020. Updates enhance and simplify previous requirements.

Overall, the Energy Code aims to reduce energy use for lighting, heating, cooling, ventilation and water heating. Single family homes built under the 2019 Energy Code will use about 7% less energy due to energy efficiency measures as compared to homes built under the 2016 Energy Code. Once rooftop solar electricity generation is factored in, homes built under the 2019 Energy Code will use an estimated 53% less energy than those under the 2016 Energy Code. This will reduce greenhouse gas emissions by an estimated 700,000 metric tons in three years, equivalent to removing 115,000 fossil-fueled cars off the road.

California is making strong efforts to address climate change. The state's Energy Code and Appliance Efficiency Regulations (Title 20), along with utility programs that promote efficiency, are vital means of reducing electricity use and lowering statewide greenhouse gas emissions.

CALIFORNIA'S TITLE 24, PART 6 BUILDING ENERGY EFFICIENCY STANDARDS (ENERGY CODE)
www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf

California's Energy Code is updated on an approximately three-year cycle. The 2019 Energy Code improves upon the 2016 Energy Code for New Construction, Additions and Alterations to residential and nonresidential buildings.

The 2019 Energy Code is effective starting on January 1, 2020.

2019 ENERGY CODE

California's Energy Code has saved Californians billions in reduced electricity bills since 1977.

To view the Energy Code online, visit **www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards**.

ENERGY CODE ACE
EnergyCodeAce.com

The Energy Code Ace website is provided by the California Statewide Codes & Standards Program, which offers free training, tools and resources for those who need to understand and meet the requirements of the Energy Code and the Appliance Efficiency Regulations.

Energy Code Ace™
HELPING YOU PLAY YOUR CARDS RIGHT

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 Energy Code. This guide 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 Energy Code in New Construction, Addition or Alteration projects.

All seven guides can be found on the Energy Code Ace website: **EnergyCodeAce.com**.

COMPLIANCE PROCESS OVERVIEW

Chapter 1 provides 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 AND PRINCIPLES

Chapter 2 is devoted to lighting concepts and principles, including color rendering metrics, correlated color temperature, light output and lamp life. These concepts are vital for making informed decisions about lamps, luminaires and controls.

TECHNOLOGY, SYSTEMS AND CONTROL STRATEGIES

Chapter 3 explores today's technology, systems and control strategies appropriate for residential applications. Selecting the right type of light source and lighting controls means comparing a variety of factors that are detailed in this chapter.

COMPLIANCE REQUIREMENTS

Chapter 4 starts with an overview of new requirements and important updates to the Energy Code for residential lighting. Recommendations for putting the Energy Code into practice are also included.

REQUIREMENTS AND RECOMMENDATIONS: IN PRACTICE

Chapter 5 covers the lighting requirements set forth under the Energy Code for the most common residential space types. Recommendations for implementing best practices are provided, along with a floor plan and example of compliant lighting design for a single family residence.

NOTE: This guide is not intended to be used in lieu of California's Energy Code, and it is not a substitute for the Energy Code itself. Please visit **www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency** to obtain the official 2019 Energy Code, Reference Appendices and Residential Compliance Manual.

Application Guide	What's Covered
Nonresidential Envelope and Solar-Ready Areas	• Climate-specific design • Insulation • Cool Roofs • Solar zone • Fenestration • Compliance documentation details
Nonresidential Lighting and Electrical Power Distribution	• Lighting design strategies • Controls • Electrical power distribution
Nonresidential HVAC and Plumbing	• Mechanical systems and plumbing systems • Commissioning, HERS process and acceptance testing
Process Equipment and Systems	• Process loads • Applicable products and systems such as kitchen hoods, parking garage ventilation, laboratory fume hoods, elevators, escalators and compressors
Residential Envelope, Solar Ready and PV	• Single family homes • Duplexes • Climate-specific design • Insulation • Cool Roofs • Solar PV (Photovoltaics) • Fenestration • Compliance documentation details • Battery Storage
Residential Lighting	• Lighting design strategies • Compliant products • Controls
Residential HVAC and Plumbing	• HVAC terminology • Heating and cooling system types • Hot water system types

THE COMPLIANCE PROCESS

The following is an overview of the compliance process for residential lighting. Additional information and resources, including the 2019 Residential Compliance Manual and forms, are found on the California Energy Commission website: **www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards**.

STEP 1: DISCUSS AND DEFINE ENERGY-RELATED PROJECT GOALS

Designers, project owners and builders have the greatest 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, as well as to 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 the Energy Code. 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 only need to comply with Mandatory Measures.

STEP 3: PREPARE AND SUBMIT PERMIT APPLICATION

Once the design requirements in the Energy Code 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 local authority having jurisdiction, often the building department, at the same time as a building permit application. There are some exceptions when Certificate of Compliance forms are not required, and these can be found in **Section 10-103** of the Energy Code. For all low-rise residential buildings that require Home Energy Rating System (HERS) Verification for compliance, Certificates of Compliance must be registered with a HERS provider prior to permit application.

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 a plan check is required, a plans examiner must check that the design satisfies Energy Code 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 Code, 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)

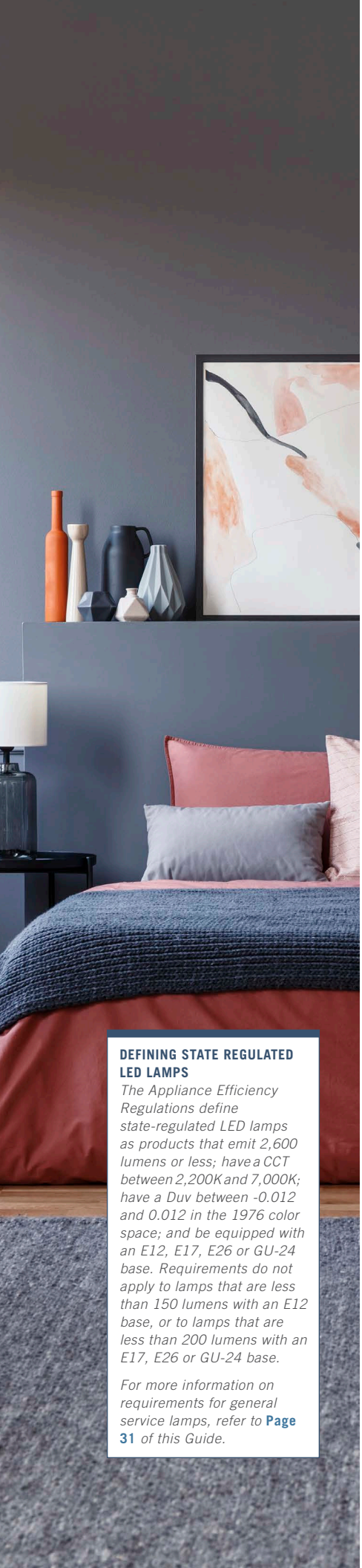
All compliance documentation must be registered with a HERS provider for New Construction, or Additions and Alterations to an existing home that has HERS measures included in the compliance package. This registration process includes lighting compliance documents (details provided on **page 11**). Lighting 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 multifamily dwellings

A list of providers approved by the Energy Commission can be found on their website at: **www.energy.ca.gov/HERS**.

STEP 7: PASS BUILDING INSPECTION

The local authority having jurisdiction, often the building department, likely will require an inspection before finalizing the permit. Building inspections often are 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 authority having jurisdiction.



DEFINING STATE REGULATED LED LAMPS

The Appliance Efficiency Regulations define state-regulated LED lamps as products that emit 2,600 lumens or less; have a CCT between 2,200K and 7,000K; have a Duv between -0.012 and 0.012 in the 1976 color space; and be equipped with an E12, E17, E26 or GU-24 base. Requirements do not apply to lamps that are less than 150 lumens with an E12 base, or to lamps that are less than 200 lumens with an E17, E26 or GU-24 base.

For more information on requirements for general service lamps, refer to **Page 31** *of this Guide.*

NEW IN 2019: AN OVERVIEW OF UPDATES

Those familiar with the Energy Code for residential lighting will find several changes to the requirements in the 2019 iteration. California's new residential Energy Code is effective starting January 1, 2020. The Energy Code focuses on several key areas to improve the energy efficiency of New Construction, Additions and Alterations to existing buildings. Below is an overview of the most significant lighting updates.

NEW LIGHT SOURCE CATEGORIES ADDED

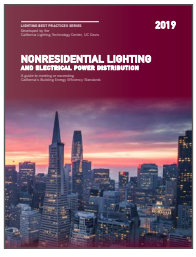
Step lights and path lights are now included in the same category as night lights. Light sources integral to drawers, cabinets and linen closets are now regulated by the Energy Code. If these light sources are greater than 5 watts or emit more than 150 lumens, they must comply with the high-efficacy requirements of **Table 150.0-A** and be controlled by a vacancy sensor; otherwise, the light sources are exempt. Additionally, light sources in drawers, cabinets and linen closets must be equipped with controls that automatically turn the light off when the drawer, cabinet or linen closet is closed.

MARKING UPDATE

Light sources meeting the new 2019 JA8 performance requirements must mark the light source itself with 'JA8-2019,' or 'JA8-2019-E' for products that also have passed the ENERGY STAR® Product Specification Version 2.1 Elevated Temperature Life Test and/or Rated Life Test. Products certified to JA8-2016 do not need to be retested or recertified to remain compliant with JA8-2019/JA8-2019-E. These products may be marked with JA8-2019/JA8-2019-E. Additionally, products marked with JA8-2016/JA8-2016-E may be installed in permitted construction.

COLOR QUALITY

JA8 now aligns with the **Appliance Efficiency Regulations** for color rendering index (CRI) requirements of state-regulated LED lamps. In addition, the 2019 JA8 now requires that all light sources be capable of providing a correlated color temperature (CCT) of 4,000 Kelvin or less.



MULTIFAMILY RESIDENTIAL BUILDINGS

In low-rise multifamily residential buildings where the total interior common area is more than 20% of the floor area, the permanently installed lighting for the interior common areas must adhere to the nonresidential requirements. In high-rise residential buildings, all common areas must meet the nonresidential lighting and controlled receptacle requirements. Lighting in the dwelling units must meet the residential lighting requirements discussed in this guide.

Detailed updates for nonresidential requirements are provided in the **Nonresidential Lighting & Electrical Power Distribution Guide**.

COMPLIANCE DOCUMENTS

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

CF2R – LTG – 01 – E

CF1R: Certificate of Compliance
CF2R: Certificate of Installation

LTG: Lighting

01: Single family Dwelling
02: Multifamily Dwelling

E: Verified by Enforcement Authority

CERTIFICATES OF INSTALLATION

There are two versions of the residential lighting Certificate of Installation. See **Page 8** of this Guide to learn where to access forms and how compliance documents are used in the compliance process.

The **CF2R-LTG-01-E** primarily is used for demonstrating compliance with the residential lighting requirements for single family dwellings. The **CF2R-LTG-01-E** also is 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 or 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, as well as 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 multifamily dwellings. The primary difference between the **CF2R-LTG-02-E** and **CF2R-LTG-01-E** is that the **CF2R-LTG-02-E** includes additional requirements for demonstrating compliance with residential outdoor lighting and common areas associated with low-rise multifamily dwelling units. Additionally, nonresidential lighting forms may be required based on the scope of your multifamily residential lighting project.

STATE OF CALIFORNIA
LIGHTING – MULTI FAMILY DWELLINGS
CEC-CF2R-LTG-02-E (Revised 01/20) CALIFORNIA ENERGY COMMISSION

CERTIFICATE OF INSTALLATION		CF2R-LTG-02-E
Lighting – Multi-Family Dwellings		(Page 1 of 4)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

	A. Installed Lighting and Controls Select Yes or No according to whether your work on the project includes each of the following types of lighting and controls. See Section B. thru N. for applicable compliance requirements.	**Y or N**
01	High efficacy luminaires installed in any interior rooms. (See Section B.)	
02	JA8 compliant luminaires and controls installed in any interior rooms. (See Section B.)	
03	Recessed downlight luminaires in ceilings in any interior rooms. (See Section C.)	
04	Screw-based luminaires installed in any interior rooms. (See Section D.)	
05	Enclosed or recessed luminaires installed in any interior rooms. (See Section D.)	
06	Lighting and controls in bathrooms. (See Section E.)	
07	Lighting and controls in laundry rooms. (See Section E.)	

RESIDENTIAL LIGHTING COMPLIANCE FORMS

As part of the Energy Code compliance process, the installer must prepare and submit documents, like the CF2R-LTG-02-E form on the left, to verify compliance (see Step 6).

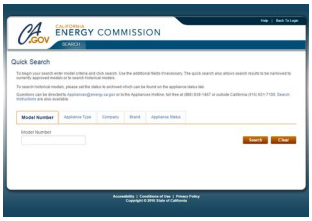
The Energy Commission has made these compliance documents, or examples of these documents, available at **www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency**.

FINDING COMPLIANT PRODUCTS

Certain devices must be certified to the Energy Commission as meeting California's Appliance Efficiency Regulations. Others are regulated under the Energy Code.

APPLIANCE EFFICIENCY DATABASE
cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

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 name.



APPLIANCE EFFICIENCY REGULATIONS
www.energy.ca.gov/sites/default/files/2019-11/Regulatory-Advisory-GSLs_ADA.pdf

Starting January 1, 2020, general service lamps (GSLs) with an efficacy less than 45 lumens per watt cannot be sold or offered for sale in California. General service lamps include, but are not limited to, general service incandescent lamps, compact fluorescent lamps, general service light emitting diode lamps and general service organic LED lamps.

CERTIFICATION TO THE ENERGY COMMISSION

Select lighting products installed to bring a building into compliance with the Energy Code must meet minimum, specific device requirements contained in the Appliance Efficiency Regulations. In addition, many products must also meet enhanced performance requirements contained in the Energy Code.

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	Product Requirements Provided Under the Energy Code
• Lamps **(including General Service Lamps (GSLs) and Small Diameter Directional Lamps (SDDLs))** • Ballasts • Torchieres • Metal-halide luminaires • Portable luminaires • Undercabinet luminaires • Luminaires with GU-24 socket and base configurations and GU-24 adaptors	• JA8 high-efficacy light sources • Track lighting current limiters and overcurrent protection devices • Time-switch lighting controls • Daylighting controls • Dimmers • Occupant sensing controls

Section 150.0(k)

ENERGY STANDARDS

ELECTRONIC BALLASTS FOR FLUORESCENT LAMPS

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

PHOTO: SYLVANIA

RECESSED DOWNLIGHT LUMINAIRES

Under the Energy Code, 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 high-efficacy requirements **(Table 150.0-A)**
- 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
- Listed for zero-clearance insulation contact (IC): Luminaires must be IC rated with a nationally-recognized testing lab, such as UL

PHOTO: CREE

- Certified airtight per ASTM E283-04 (2012). The product label must specify ASTM E283 certification
- 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
- Building occupants must be able to readily access ballasts or drivers for maintenance or replacement from below the ceiling without needing to cut holes in the ceilings

PHOTO: CLTC, UC DAVIS

SOCKETED LUMINAIRES

Under the Energy Code, all hard-wired or permanently installed indoor luminaires that utilize a socket (i.e., pin with non-fluorescent light source, GU24 and screw-base) — excluding hardwired ballasted HIDs — must contain lamps that are certified to the Energy Commission as meeting JA8 high-efficacy requirements. These lamps must be marked as "JA8-2019" or "JA8-2019-E", where the "E" signifies that the lamp is appropriate for applications with elevated temperatures. All enclosed socketed luminaires must utilize a compliant lamp rated for elevated temperatures. For more information on these requirements, see **Section 150.0(k)1G** and the Residential Compliance Manual, **Chapter 6**.

PHOTO: CLTC, UC DAVIS

NIGHT LIGHTS, STEP LIGHTS AND PATH LIGHTS

Night lights, step lights and path lights rated 5 watts or less of power and emit no more than 150 lumens are not required to be high-efficacy or controlled by vacancy sensors. If the light sources are greater than 5 watts or emit more than 150 lumens, they must adhere to the high-efficacy requirements defined in **Table 150.0-A** and be controlled by vacancy sensors.

LIGHT SOURCES IN DRAWERS, CABINETS AND LINEN CLOSETS

Light sources in drawers, cabinets and linen closets that are 5 watts or less, emit no more than 150 lumens and are equipped with controls that automatically turn the light source off when the drawer, cabinet or linen closet is closed do not need to adhere to the high-efficacy performance requirements defined in **Table 150.0-A** or be controlled by vacancy sensors. These light sources do not need to be paired with a sensor as long as it is paired with a control that automatically turns off the light source when the drawer, cabinet or closet is closed. Closets less than 70 square feet are always exempt from the sensor and dimming control requirements.

If the light sources are greater than 5 watts, emit more than 150 lumens or not equipped with controls to automatically shut the light off when the drawer, cabinet or linen closet closes, they must adhere to the high-efficacy requirements defined in **Table 150.0-A** and be controlled by vacancy sensors.

CHAPTER 2

CONCEPTS AND PRINCIPLES

LAYERS OF LIGHT

Adding task and accent lighting to the lighting system 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 typically thought to be 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 closer to 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. It also 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.

Spectrally 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.

LIGHT OUTPUT, EFFICACY AND 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.

LIGHT OUTPUT

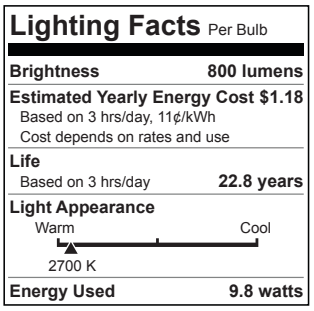
The amount of visible light emitted by a light source is measured in lumens (lm). The more lumens, the more light emitted, but other factors also affect visibility and perception of brightness, such as contrast ratios and color characteristics. In addition, the type of fixture or housing can greatly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

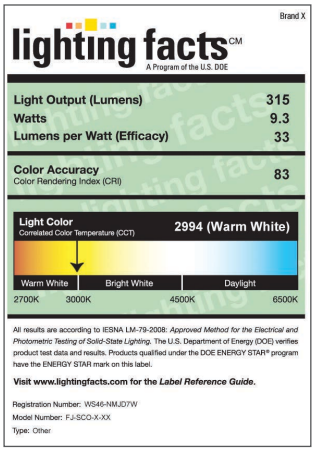
RECOMMENDATIONS

- Compare the light output, not the power, 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.

LIGHTING FACTS LABEL

The Lighting Facts Label helps consumers understand lamp performance and compare products. Information also can 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.





Light Source Efficiency Chart

LAMP TYPE	60 watt Incandescent	13 watt CFL	9.5 watt LED
Light Output (lm)	850	800	800
Watts (W)	60	13	9.5
Efficacy (lm/W)	14	62	84
Life Span (hr)	1,000	8,000	25,000
Price per Lamp	$0.50	$5.00	$10.00

Source: Greater Cincinnati Energy Alliance, March 24, 2015. https://greatercea.org/lightbulb-efficiency-comparison-chart/

LUMINOUS EFFICACY

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

Luminous Efficacy = Lumens / Watts

Different source technologies provide different efficacy levels. For example, a 60W A19 incandescent lamp, a 13W A19 CFL lamp and a 9.5W A19 LED lamp use different amounts of power to produce the same amount of light (approximately 800 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 also is important to compare long-term energy and maintenance costs, longevity and lifetime performance.

LIFE

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

Incandescent lamps typically last 1,000–2,000 hours and lose about 10–15% of their initial light output before burning out. CFL lamps last about 12,000 hours and lose about 10–15% of their light output before burning out. Linear fluorescent lamps typically last 25,000–40,000 hours, losing 5–10% of their original light output before they fail.

LEDs do not burn out suddenly in the same way as incandescent or CFL light sources. Their light 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. Recent testing indicates the LEDs 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 reach their end of useful life. For these reasons, basing LED product life on lumen depreciation (e.g., L70 or 70% of initial light output) 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:

RECOMMENDATIONS

- 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.

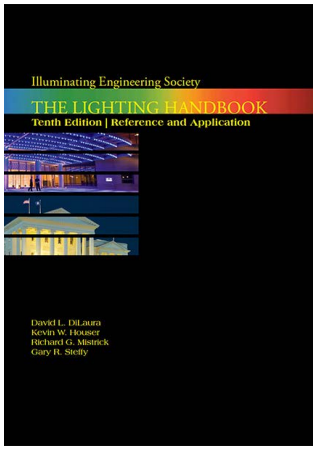
VISION NEEDS CHANGE WITH AGE

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 younger than 25 years old. These illumination requirements double for those ages 26–65 and quadruple for those older than age 65.*

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

NOTE:

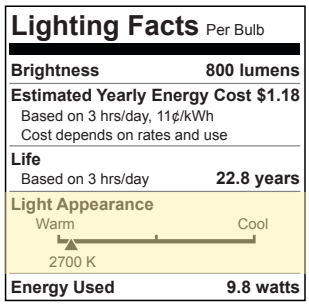
Life and lumen maintenance information presented here comes from The Lighting Handbook, Tenth Edition (sec. 7), published by the Illuminating Engineering Society (IES) in 2011.



COLOR CHARACTERISTICS

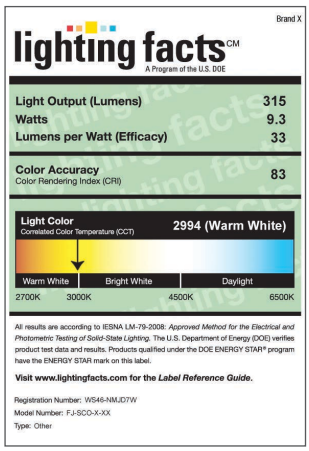
LIGHTING FACTS LABEL

The basic lighting facts label can be found on the packaging for a light source and provides valuable information on the light source's color characteristics, including the Correlated Color Temperature.



COLOR LIGHTING FACTS LABEL

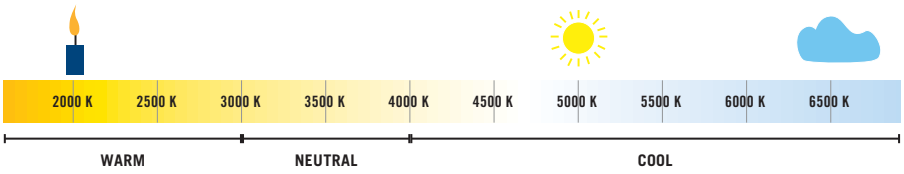
The full-color Lighting Facts label issued by the Department of Energy includes CRI, but the black-and-white Federal Trade Commission label does not.



CORRELATED COLOR TEMPERATURE (CCT)

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

Selecting light sources with consistent CCTs helps maintain consistency in the appearance of various light sources. Check the Lighting Facts label for information on CCT, as well as light output, power (W) and efficacy.



COLOR RENDERING INDEX (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.

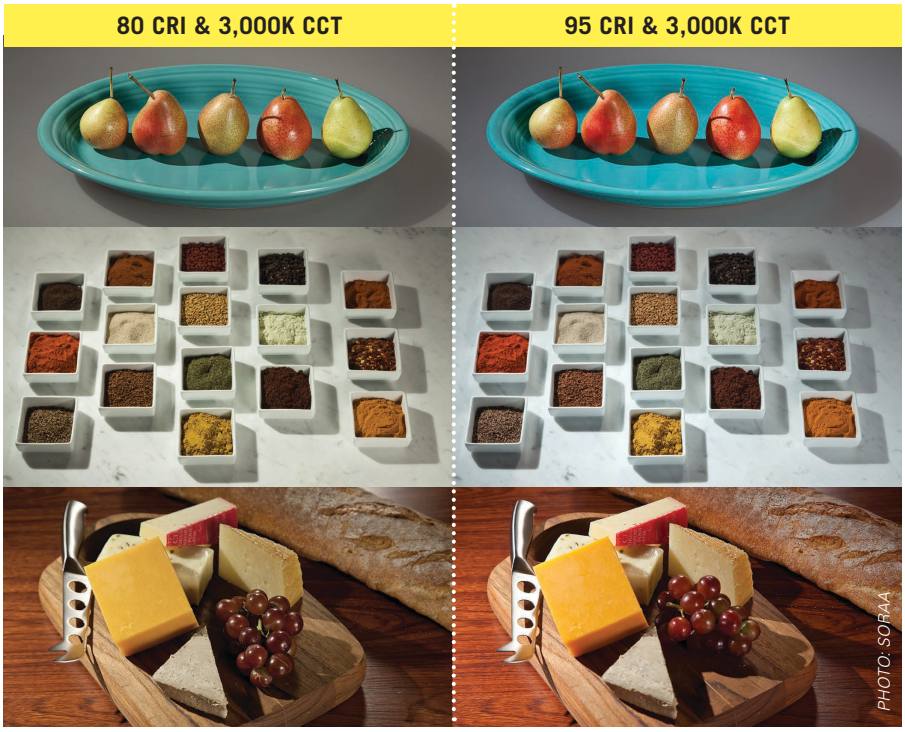
Specifying lamps and luminaires with similar color rendering properties helps ensure wall color, carpeting and other materials have a consistent appearance, especially in adjoining spaces. The full-color Lighting Facts label issued by the Department of Energy includes CRI, but the black-and-white Federal Trade Commission label does not. Most manufacturers can supply information on CRI if it is not immediately available on product packaging or literature.

INDIVIDUAL COLORS (R1–R15)

Individual color palettes (R1–R8) are used in the calculation of the average CRI metric. Collectively, there are 15 individual color pallets known as R1–R15. The Appliance Efficiency Regulations reference R1–R8, and the Energy Code JA8 references R9. R10–R15 are not included in any metrics today, but are typically provided in IES LM-79-08 test reports for lighting products.

R9 is the saturated red color palette and is not included in the average CRI metric. The CRI metric does not capture rendering of saturated reds well since it is calculated based on R1–R8 colors only.

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.



INDIVIDUAL COLOR PALETTES

COMPARING COLOR QUALITY

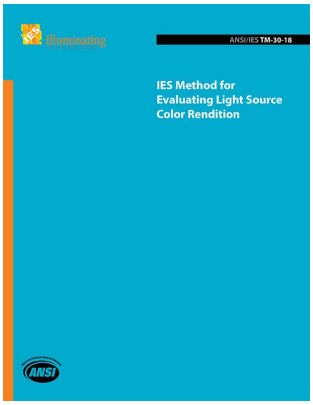
The LED MR16 lamps used for these photos both have a CCT of 3,000K and were produced by the same manufacturer. The difference is that the first-generation lamp on the left has a CRI of 80 while the lamp on the right has a CRI of 95.

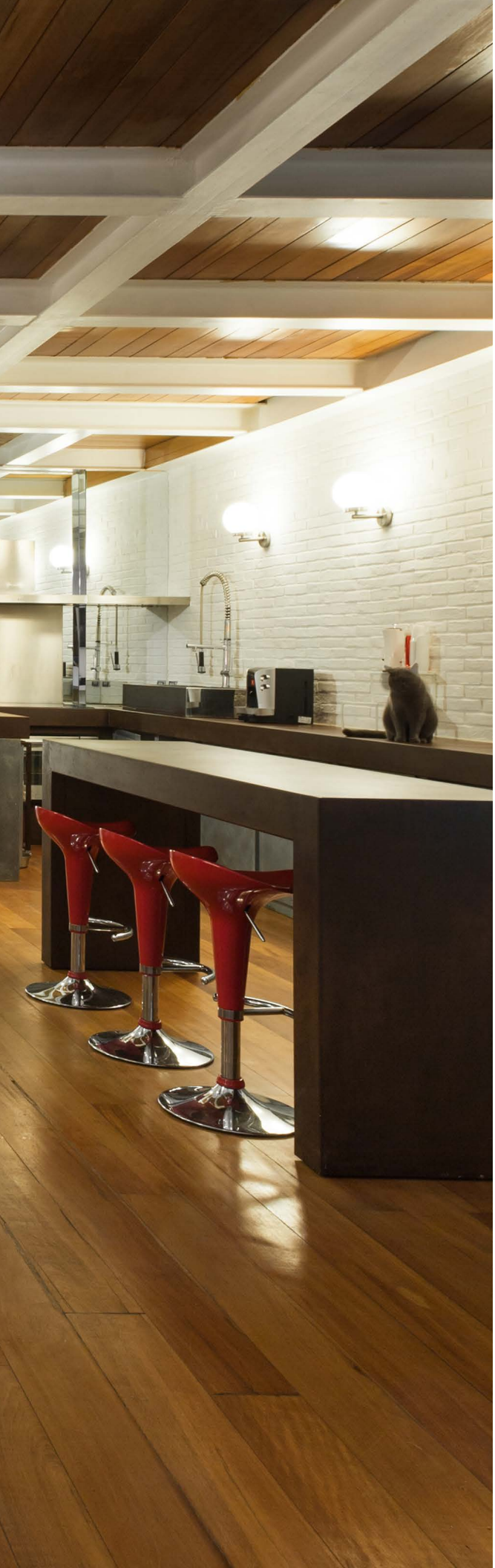
IES TM-30-18

In 2018, the Illuminating Engineering Society (IES) developed a new method for evaluating light source color rendition, known as TM-30-18. Since then, the new color fidelity has become more widely referenced in the lighting industry. TM-30-18 takes an objective and statistical approach to color rendition, quantifying the fidelity (closeness to a reference) and gamut (increase or decrease in chroma) of a light source.

TM-30-18
www.ies.org/product/ies-method-for-evaluating-light-source-color-rendition/

The TM-30-18 metric is calculated for a light source by using the spectral power distribution data acquired during an LM-79 test and an Excel-based calculator tool available from IES.





CHAPTER 3

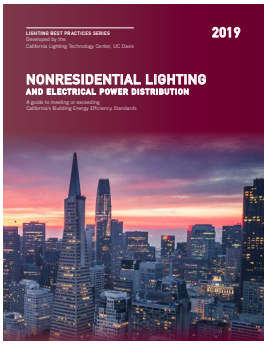
TECHNOLOGY, SYSTEMS AND COMPLIANCE STRATEGIES

CHOOSING THE RIGHT LIGHT

An effective indoor lighting system combines the appropriate light source technology with the application-appropriate luminaire and the 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 residential lighting needs means comparing a variety of factors, such as:

- Light output
- System wattage
- Efficacy
- Distribution
- Color qualities
- Controls compatibility
- Product life
- Manufacturer warranties
- Long-term energy and cost savings



2019 NONRESIDENTIAL LIGHTING AND ELECTRICAL POWER DISTRIBUTION GUIDE
cltc.ucdavis.edu/publication/nonresidential-lighting-and-electrical-power-distribution-guide-2019-building-energy

Curious about the Energy Code for nonresidential projects? The 2019 Nonresidential Energy Code focuses on several key areas to improve the energy efficiency of New Construction, Additions and Alterations to existing buildings. This guide offers an overview of important updates contained in the 2019 nonresidential lighting Energy Code and compliance strategies to meet or exceed requirements.

LIGHT SOURCES

PHOTO: BROAN GARAGE LIGHTING

A single luminaire often can accommodate different types of light sources. For example, screw-base lamps are designed to accept incandescent, CFL or LED sources. Selecting the best source type for a particular application means considering several factors, including light quality, intensity, luminous efficacy and longevity.

PERMANENTLY INSTALLED LUMINAIRES

Permanently installed luminaires are attached to the home or other structures on the property. These luminaires may have either screw-in or hardwired connections to the light source, except for recessed downlights which must be hardwired or use a quick connect. 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.

PHOTO: METEOR ELECTRIC LIGHTING

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 design and manufacturing of the LED chip.

PHOTO: SYLVANIA

- Installing long-life LED luminaires in difficult to reach spaces can reduce maintenance costs and reduce time spent changing failed lamps.
- Color-tunable, or spectrally-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 an incandescent lamp replacement. An electronic ballast in the base of the CFL activates the lamp and regulates the electrical current. Not all CFLs are dimmable and some can have delayed start times, which can be problematic in some applications.

PHOTO: CLTC, UC DAVIS

INCANDESCENT

Incandescent lamps are highly inefficient. These lamps have excellent color but burn out quickly compared to other sources, which increases maintenance costs through time. In addition, incandescent light sources can 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

Linear fluorescent lamps provide uniform levels of illumination, making them appropriate 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 32W 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.

Section 150.0(k)2

CONTROL STRATEGIES

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

SWITCHES

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

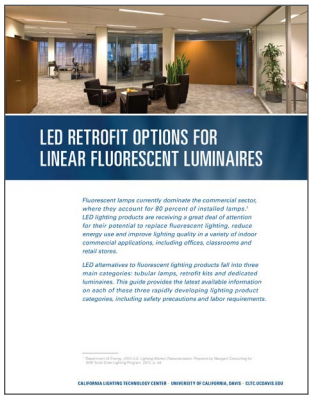
COMPLIANCE REQUIREMENTS

1. **Separate switching:** Lighting systems such as undercabinet lighting and exhaust fans must be switched separately from ceiling-installed lighting. Lights that are integral to exhaust fans must have independent manual controls, allowing them to be turned ON or OFF without affecting the exhaust fan, yet can be on the same switch. Ceiling fans are allowed to use a remote to fulfill this functionality.
2. **Manual control:** All installed luminaires must be switched with readily accessible wall-mounted manual ON/OFF controls.
3. **No bypassing:** No controls may bypass a dimmer, occupancy sensor or vacancy sensor function if the dimmer or sensor is used to comply with the Energy Code.

LED RETROFIT OPTIONS FOR LINEAR FLUORESCENT LUMINAIRES
cltc.ucdavis.edu/publication/led-retrofit-options-linear-fluorescent-luminaires

LED lighting products receive a great deal of attention for their potential to replace fluorescent lighting, reduce energy use and improve lighting quality.

LED alternatives to fluorescent lighting products fall into three main categories: linear LED replacement lamps, retrofit kits and dedicated luminaires. This guide provides information on each of these three rapidly developing lighting product categories, including safety precautions, photometric performance considerations and labor requirements.



MODERNIZED APPLIANCE EFFICIENCY DATABASE (MAEDBS)
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.

Visit the Appliance Efficiency Database at:
cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

DIMMERS

Dimmers give occupants more control over their lighting and reduce energy use. With the exception of small closets 70 ft^2 or less, cabinets, drawers, night lights, path lights, step lights and hallways, dimmers or sensors must be used with any JA8 light source.

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

COMPLIANCE REQUIREMENTS

Compliant dimmers must meet the criteria in **Section 110.9(b)3** of the Energy Code. These requirements include:

1. **65% power reduction:** Dimmers must be capable of reducing power consumption by at least 65% when the dimmer is at its lowest level.
2. **Full OFF:** Dimmers must include an OFF position with zero lumen output.
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, per **Section 150.0(k)2A**.

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 (Watts) or early equipment failure may occur.
3. **Fluorescent lamps:** Dimmers may be used with fluorescent lamps, but many fluorescent lamps cannot be dimmed properly 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.

OCCUPANT SENSING CONTROLS

Occupant sensing controls include occupancy sensors, motion sensors and vacancy sensors. This includes sensors with Partial-ON or Partial-OFF functionality. To be compliant with **Section 110.9(b)4**, occupant sensing controls must provide:

- A maximum time out of 20 minutes
- A visible status signal that indicates if the device is operating properly (this signal may have an override if the occupant prefers it OFF)

- A 15–30 second grace period to automatically turn lighting ON after the sensor has timed out

Occupant sensing control systems can consist of a combination of single- or multi-level occupancy, motion or vacancy sensors, as long as the components are configured to manual-ON operation.

Bathrooms, garages, laundry rooms and utility rooms must pair at least one luminaire in the space with a vacancy sensor or occupancy sensor commissioned to operate as a manual-ON, auto-OFF control. Dimmers or sensors must control all luminaires equipped with JA8 compliant sources except for luminaires in closets less than 70 ft^2, luminaires in hallways, cabinets, drawers, night lights, path lights and step lights.

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.

◀ *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*

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:** Sensors must be configured to operate as manual-ON, auto-OFF devices. No auto-ON function is allowed from the sensor at the time of inspection.

RECOMMENDATIONS

1. **Safety first:** Avoid using sensors that use a ground wire for the operating current. This method presents safety hazards.
2. **Full sensor coverage:** Be sure sensors are positioned for full coverage of the area where lighting will be controlled. For example, passive infrared (PIR) sensors 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.

DAYLIGHTING CONTROLS

Daylighting controls, such as photo controls, measure relative light levels and adjust electric lighting accordingly. **Section 110.9(b)2** of the Energy Code requires that daylighting controls must be able to:

- Automatically return to its most recent time delay settings within 60 minutes of the last received input when left in calibration mode
- Have a set point control that easily distinguishes settings to within 10% of full scale adjustment

▲ *Outdoor photocell sensor: Leviton*

- Provide a linear response within 5% accuracy over the range of illuminance measured by the light sensor
- Be capable of being calibrated in a manner that the person initiating the calibration is remote from the sensor during calibration to avoid influencing calibration accuracy. For example, by having a light sensor that is physically separated from where the calibration adjustments are made.

Some common outdoor photo controls 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 photo controls paired with dimming ballasts or drivers to automatically and dynamically adjust light levels in response to daylight availability.

AUTOMATIC TIME-SWITCH AND ASTRONOMICAL TIME-SWITCH CONTROLS

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 residential outdoor lighting requirements of the Energy Code if the lighting is also controlled by photo controls.

Astronomical time switches, which also include programming features based on sunrise, sunset and geographic location, may be used to comply with the residential outdoor lighting controls requirements when outdoor lights are also controlled by photo controls.

ASTRONOMICAL TIME-SWITCH CONTROLS

The Energy Commission defines astronomical time-switch control as "an automatic time-switch control device capable of controlling lighting based on the time of day and astronomical events, such as sunset and sunrise, accounting for geographic location and date of the year".

▲ *Electronic astronomic time-switch: Intermatic*

COMPLIANCE REQUIREMENTS

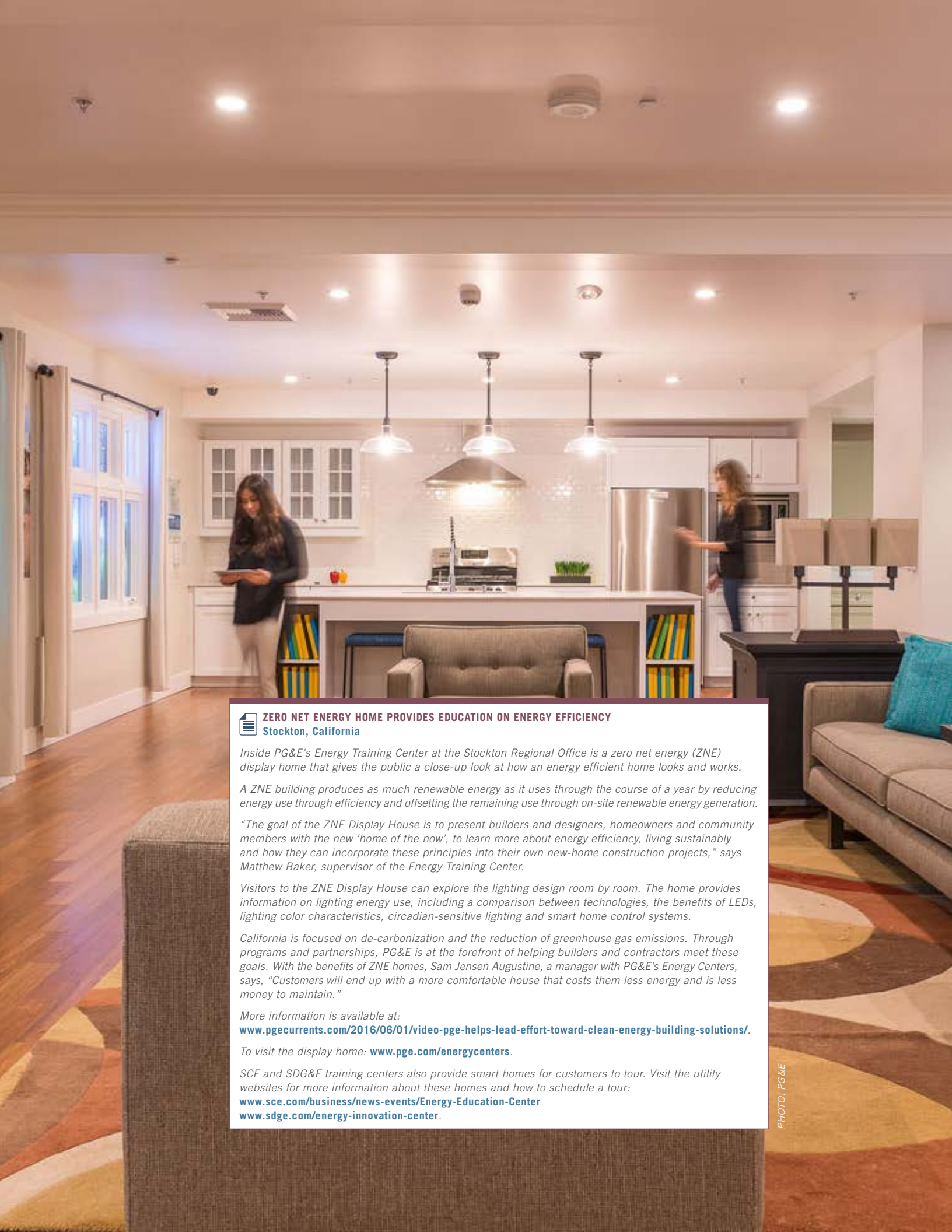
Under the Energy Code, astronomical time-switch controls are required to:

1. Accurately predict sunrise and sunset +/- 15 minutes and have timekeeping accuracy +/- 5 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 90 minutes before and after sunrise or sunset.

Additionally, automatic time switch controls for residential lighting must have program backup capabilities that prevent the loss of device schedule for at least 7 days and device date and time for at least 72 hours if power is interrupted.

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. EMCS must provide the same control functionality as the individual devices it replaces, meet the installation certificate requirements of **Section 130.4** and meet the EMCS requirements of **Section 130.0(e)**.



ZERO NET ENERGY HOME PROVIDES EDUCATION ON ENERGY EFFICIENCY
Stockton, California

Inside PG&E's Energy Training Center at the Stockton Regional Office is a zero net energy (ZNE) display home that gives 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 through 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 is focused on de-carbonization and the reduction of greenhouse gas emissions. Through programs and partnerships, PG&E is at the forefront of helping builders and contractors meet these goals. With the benefits of ZNE homes, Sam Jensen Augustine, a manager with PG&E's Energy Centers, says, "Customers will end up with a more comfortable house that costs them less energy and is less money to maintain."

More information is available at:
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**.

SCE and SDG&E training centers also provide smart homes for customers to tour. Visit the utility websites for more information about these homes and how to schedule a tour:
www.sce.com/business/news-events/Energy-Education-Center
www.sdge.com/energy-innovation-center.

PHOTO: PG&E

CHAPTER 4

COMPLIANCE REQUIREMENTS

COMPLIANCE PROCESS

There are two basic steps required to comply with the Energy Code.

1. Meet all Mandatory requirements by installing required systems, equipment and devices and ensuring that they perform all functions required by the Energy Code.
2. 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 for the entire project.

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 sensors in select spaces.

QUICK REFERENCE GUIDES FOR 2019

In addition to the guides for residential and nonresidential lighting in the Energy Code, the "What's New" series provides a summary of major changes to the Energy Code in a simplified format.

Residential:
cltc.ucdavis.edu/publication/residential-lighting-whats-new-2019-title-24-part-6-energy-code


WHAT'S NEW IN THE 2019 CODE?

RESIDENTIAL LIGHTING

Changes to mandatory lighting requirements in California's 2019 Building Energy Efficiency Standards

California's new residential Building Energy Efficiency Standards (Energy Standards) are effective starting January 1, 2020. The 2019 Energy Standards focus on several key areas to improve the energy efficiency of newly constructed buildings, additions and alterations to existing buildings. Significant changes in the 2019 Energy Standards address photovoltaic systems, walls, gas furnaces and lighting. Single-family homes built under the 2019 Energy Standards will use about 7 percent less energy due to energy efficiency measures as compared to homes built under the 2016 Energy Standards. Once rooftop solar electricity generation is factored in, homes built under the 2019 Energy Standards will use an estimated 53 percent less energy than those under the 2016 Energy Standards. This will reduce greenhouse gas emissions by an estimated 700,000 metric tons over three years, equivalent to removing 115,000 fossil-fueled cars off the road.

MAJOR CHANGES

NEW LIGHT SOURCE CATEGORIES ADDED

Step lights and path lights are now included in the same category as night lights. Light sources integral to drawers, cabinets and linen closets are now regulated by the Energy Standards. If these light sources are greater than 5 watts or emit more than 150 lumens, then they must comply with the high efficacy requirements of Table 150.0-A and be controlled by a vacancy sensor. Otherwise, the light sources are exempt. Additionally, light sources in drawers, cabinets and linen closets must be equipped with controls that automatically turn the light off when the drawer, cabinet or linen closet is closed.

MARKING UPDATE

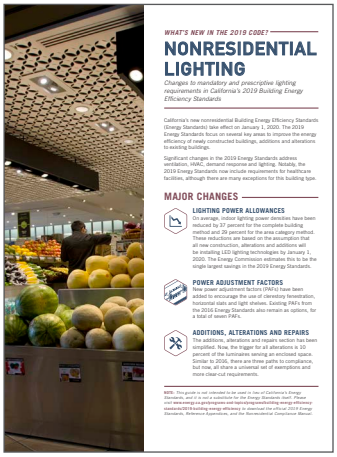
Light sources meeting the new 2019 JA8 performance requirements must mark the light source itself with "JA8-2019," or "JA8-2019-E" for products that have also passed the ENERGY STAR® Product Specification Version 2.1 Elevated Temperature Life Test and/or Rated Life Test.

COLOR QUALITY

JA8 now aligns with the Appliance Efficiency Regulations for color rendering index (CRI) requirements of state-regulated LED lamps. In addition, the 2019 JA8 now requires that all light sources be capable of providing a correlated color temperature (CCT) of 4,000 Kelvin or less.

NOTE: This guide is not intended to be used in lieu of California's Energy Standards, and it is not a substitute for the Energy Standards itself. Please visit www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency to download the official 2019 Energy Standards, Reference Appendices and the Residential Compliance Manual.

Nonresidential:
cltc.ucdavis.edu/publication/nonresidential-lighting-whats-new-2019-title-24-part-6-energy-code


WHAT'S NEW IN THE 2019 CODE?

NONRESIDENTIAL LIGHTING

Changes to mandatory and prescriptive lighting requirements in California's 2019 Building Energy Efficiency Standards

California's new nonresidential Building Energy Efficiency Standards (Energy Standards) take effect on January 1, 2020. The 2019 Energy Standards focus on several key areas to improve the energy efficiency of newly constructed buildings, additions and alterations to existing buildings.

Significant changes in the 2019 Energy Standards address ventilation, HVAC, demand response and lighting. Notably, the 2019 Energy Standards now include requirements for healthcare facilities, although there are many exceptions for this building type.

MAJOR CHANGES

LIGHTING POWER ALLOWANCES

On average, indoor lighting power densities have been reduced by 37 percent for the complete building method and 29 percent for the area category method. These reductions are based on the assumption that all new construction, alterations and additions will be installing LED lighting technologies by January 1, 2020. The Energy Commission estimates this to be the single-largest savings in the 2019 Energy Standards.

POWER ADJUSTMENT FACTORS

New power adjustment factors (PAFs) have been added to encourage the use of clerestory fenestration, horizontal slats and light shelves. Existing PAFs from the 2016 Energy Standards also remain as options, for a total of seven PAFs.

ADDITIONS, ALTERATIONS AND REPAIRS

The additions, alterations and repairs section has been simplified. Now, the trigger for all alterations is 10 percent of the luminaires serving an enclosed space. Similar to 2016, there are three paths to compliance, but now, all share a universal set of exemptions and more-clear-cut requirements.

NOTE: This guide is not intended to be used in lieu of California's Energy Standards, and it is not a substitute for the Energy Standards itself. Please visit www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency to download the official 2019 Energy Standards, Reference Appendices, and the Nonresidential Compliance Manual.

NEW CONSTRUCTION, ADDITIONS AND ALTERATIONS

NEW CONSTRUCTION

New Construction refers to construction of entirely new structures. New residential construction must comply with the Mandatory lighting measures contained in **Section 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 Code. Additions also are any change that increases the illuminated area of an outdoor lighting application regulated by the Energy Code. New residential Additions must comply with the Mandatory lighting measures contained in **Section 150.0(k)** and **Table 150.0-A.**

ALTERATIONS

Alterations involve replacing any lighting component, system or equipment regulated by the Energy Code. Alterations to existing residential lighting systems must comply with the Mandatory lighting measures contained in **Section 150.0(k)** and **Table 150.0-A**. Repairs, such as changing a light bulb in a socket-based luminaire, are not regulated by the Energy Code and do not need to meet JA8 requirements.

Table 150.0-A: Classification of High-Efficacy Light Sources

HIGH-EFFICACY LIGHT SOURCES **Light sources shall comply with one of the columns below:**	
Light sources in this column other than those installed in ceiling recessed downlight luminaires are classified as high efficacy and are not required to comply with Reference Joint Appendix JA8.	**Light sources in this column are only considered to be high efficacy if they are certified to the Commission as High-Efficacy Light Sources in accordance with Reference Joint Appendix JA8 and marked, as required by JA8.**
1. Pin-based linear fluorescent or compact fluorescent light sources using electronic ballasts. 2. Pulse-start metal halide light sources. 3. High pressure sodium light sources. 4. Luminaires with hardwired high frequency generator and induction lamp. 5. LED light sources installed outdoors. 6. Inseparable SSL luminaires containing colored light sources that are installed to provide decorative lighting.	7. All light sources installed in ceiling recessed downlight luminaires. Note that ceiling recessed downlight luminaires shall not have screw bases regardless of lamp type, as described in Section 150.0(k)1C. 8. Any light source not otherwise listed in this table.

MANDATORY MEASURES

HIGH-EFFICACY LIGHTING

Mandatory Measures require that lighting in permitted projects, such as New Construction, Additions or Alterations, be high efficacy. Some light sources are automatically considered high efficacy. Others must be certified to the Energy Commission as high efficacy per Joint Appendix JA8 requirements. 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 automatically includes linear fluorescent, pin-based compact fluorescent with electronic ballasts, pulse-start metal halide, HID and induction light sources.

Any luminaire can qualify as high efficacy as long as it meets the requirements of **Section 150.0(k)** and, if applicable, JA8.

Appendix JA8: Qualification Requirements for High-Efficacy Light Sources—Partial List

Specification	Requirement
Initial Efficacy	≥ 80 lm/W for state regulated LED lamps[1], or ≥ 45 lm/W for all other light source types
Power factor at Full Rated Power	≥ 0.90
Correlated Color Temperature (CCT)	≤ 4,000 Kelvin
Color Rendering Index (CRI)	≥ 82 for state regulated LED lamps[1], or ≥ 90 for all else
R1–R8, R9	R1–R8 ≥ 72 for state regulated LED lamps, or R9 ≥ 50 for all else
Rated Life	≥ 15,000 hours
Minimum Dimming Level	≤ 10% light output
Flicker	< 30% for frequencies of 200 Hz or below, at 100% and 20% light output

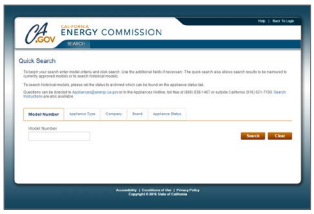
Full list is provided in the Appendix of this guide **(Page 50)**

[1] *Small diameter directional lamps may have an initial efficacy of at least 80 lm/W or a minimum compliance score of at least 165 for products with a minimum efficacy of 70 where compliance is determined by the equation: Compliance Score = Efficacy + CRI.*

JA8 CERTIFICATION FOR PRODUCTS

For products to gain JA8 certification, manufacturers must test their products at an accredited test laboratory and submit the results to the California Energy Commission. A list of certified products may be found at the Appliance Efficiency Database.

Visit the Appliance Efficiency Database at: **cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx**



COMPARING JA8 TO THE APPLIANCE EFFICIENCY REGULATIONS

For lamps that are regulated by California's Appliance Efficiency Regulations, 2019 JA8 requirements align with the Appliance Efficiency Regulations for initial efficacy and color rendering metrics.

For a full comparison of the differences and overlapping areas between JA8 and the Appliance Efficiency Regulations, visit Energy Code Ace's Fact Sheet on this topic: **energycodeace.com/download/33588/file_path/fieldList/resHELight.T20.JA8**.

HIGH-EFFICACY REQUIREMENTS APPLIED

PHOTO: SORAA

▲ *Example of JA8 marking*

MANUFACTURER REQUIREMENTS

For a light source to qualify as high efficacy under JA8, it must be certified and marked as either JA8-2019 or JA8-2019-E. These markings mean the light source meets the requirements of Joint Appendix JA8, and that the product is listed in the Energy Commission product database. Requirements ensure 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 "JA8-2019-E" indicates that the light source has been tested to provide long life at elevated temperatures in addition to the requirements listed for JA8-2019. Only "JA8-2019-E" light sources may be used in enclosed and recessed luminaires.

Products certified to JA8-2016/JA8-2016-E do not need to be retested or recertified to remain compliant with JA8-2019/JA8-2019-E. These products may be marked with JA8-2019/JA8-2019-E. Additionally, products marked with JA8-2016/JA8-2016-E may be installed in 2019 permitted construction.

BUILDER REQUIREMENTS

For New Construction and Additions, all luminaires except ceiling recessed that utilize a screw-base socket, excluding hardwired ballasted HID, must contain light sources that comply with JA8 high-efficacy requirements. All enclosed luminaires must utilize a compliant light source rated for elevated temperatures. For New Construction, ceiling recessed downlight luminaires with screw-based sockets are not permitted.

For Alterations, if a screw-base socket is present in a ceiling recessed luminaire, it does not have to be removed as part of the Alteration. Instead, if the socket is kept, the Alteration must use a JA8 compliant light source.

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 are installed when they take

possession of a new home. It is recommended to include the specification sheet along with the lighting schedule.

BUILDING INSPECTION

The Mandatory efficacy requirements, paired with the manufacturer marking and builder-provided lighting schedule and CF2R form requirements, make lighting inspections straightforward as all luminaires are high efficacy and there is a completed luminaire schedule for the owner.

INDOOR CONTROL REQUIREMENTS APPLIED

In nearly all cases, control requirements are based on the type of lamp or luminaire installed. In some cases, control requirements are based on the location of where the lamp or luminaire is installed in the home.

PHOTO: WATTSTOPPER

Any JA8-compliant light source must be controlled by a vacancy sensor, occupancy sensor configured to operate as manual-ON/auto-OFF 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 ceiling-mounted lighting.

At least one luminaire in the bathroom, garage, laundry room and utility room must be controlled by a vacancy sensor or occupancy sensor configured to operate as manual-ON/auto-OFF.

PHOTO: LUTRON

Preset scene controllers or EMCS can take the place of dimmers as long as the functionality meets Energy Code requirements.

Step lights, path lights and light sources integral to drawers, cabinets and linen closets that are greater than 5 watts or emit more than 150 lumens must comply with the high-efficacy requirements of **Table 150.0-A** and be controlled by a vacancy sensor. If less than 5 watts or 150 lumens, the light sources are exempt.

Additionally, light sources in drawers, cabinets and linen closets must be equipped with controls that automatically turn the light off when the drawer, cabinet or linen closet is closed.

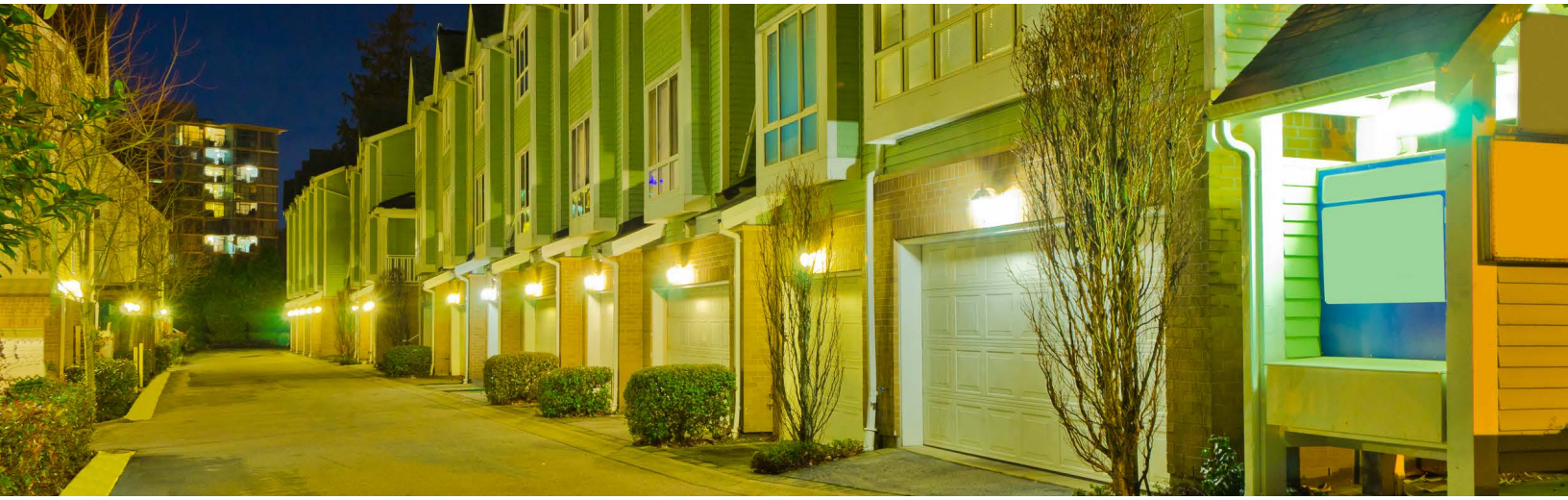


PHOTO: TORK

OUTDOOR LIGHTING REQUIREMENTS

All outdoor lighting must be high efficacy. For single family homes, lighting permanently mounted to any building on the lot must be controlled by one of the following control combinations and a manual ON/OFF switch that does not override the chosen combination:

1. Photocell and motion sensor
2. Photocell and automatic time switch
3. Astronomical time clock
4. EMCS meeting these requirements:
    - Having features of an astronomical time clock
    - Does not allow the luminaire to be ON during the day
    - May be programmed to automatically turn lighting OFF at night

PHOTO: RAB ELECTRIC LIGHTING

For low-rise multifamily residential buildings with four or more dwelling units, outdoor lighting for private patios, balconies, entrances and porches also must meet these requirements or comply with the applicable nonresidential standards. If the low-rise multifamily residential building has three or less dwelling units, only residential requirements can be used.

For high-rise multifamily residential buildings, lighting controlled from within the dwelling unit must meet residential requirements only. Lighting controlled from a location other than the dwelling unit must comply with nonresidential requirements.

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. Parking areas with seven or fewer spaces may comply with either the residential or nonresidential standards.

2019 Indoor Residential Lighting Requirements: Permanent Luminaires

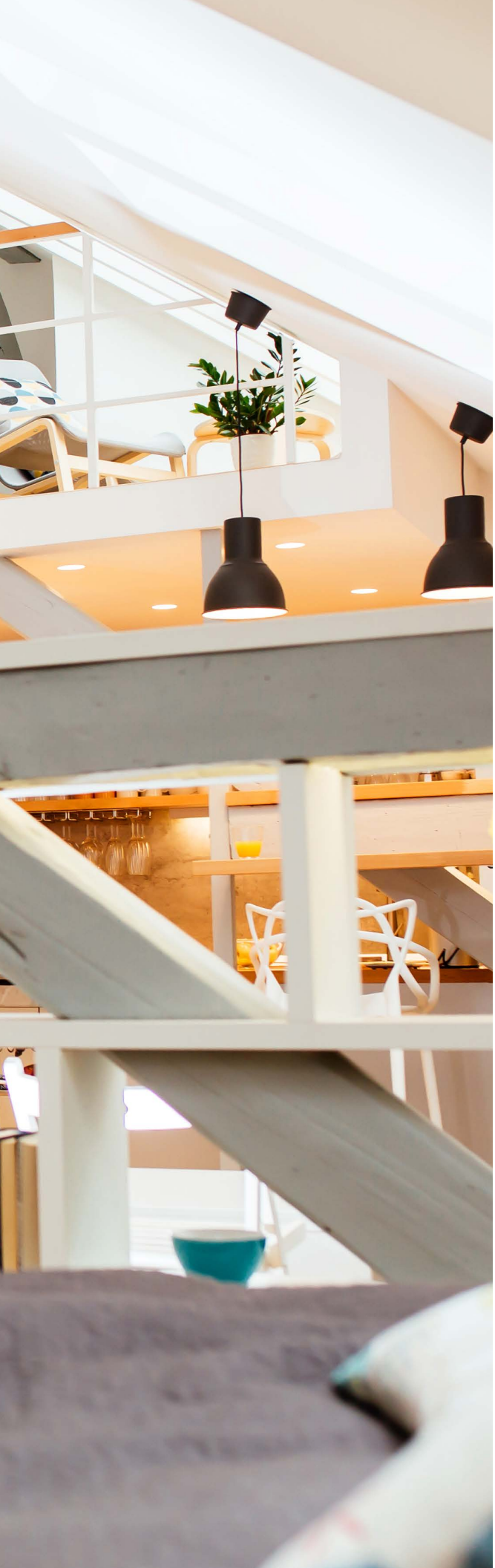
Mandatory Measure	Screw-Base Luminaire	Pin-Base[1] Luminaire	Recessed Downlight	Inseparable[4] SSL Luminaire (LED)	Night Lights, Path Lights, Step Lights, Lights in Drawers, Cabinets and Linen Closets	All Other
High Efficacy (required)	Yes—All	Yes—All	Yes—All	Yes—All	All, except those that are 5 watts or less and emit 150 lumens or less	Yes—All
High-Efficacy Qualification via JA8 lamps and luminaires[2]	All, excluding hardwired ballasted HID	Recessed downlight applications	All types, and certified compliant for elevated temperatures	All, except colored-decorative	Yes	Yes—All
Automatic Qualification as High Efficacy: Listed in Table 150.0-A, Column 1 *(JA8 Compliance not required)*	Hardwired, ballasted HID only	Linear fluorescent and compact fluorescent light sources using electronic ballasts only	—	Colored-decorative	No	—
Dimmer, Sensor or EMCS[3]	Yes—All	Yes, if installed to meet §150.0(k)2I requirements[5] or if a JA8 light source and not controlled by a vacancy/occupancy sensor	Yes—All	All, except colored-decorative	All, except those that use 5 watts or less and emit 150 lumens or less	Yes—All
Other Requirements	Cannot be a recessed downlight	Fluorescent lamps must use an electronic ballast	Airtight, IC-rated and maintenance per §150(k)1C	—	—	—

[1] Excludes recessed downlights.
[2] Enclosed luminaires must use JA8 lamps certified for use at elevated temperatures.
[3] Excludes luminaires in closets less than 70 ft² and hallways.
[4] Solid-state lighting such as LED where the LED source is permanently attached to the luminaire.
[5] Per Section 150.0(k)2I: In bathrooms, garages, laundry rooms and utility rooms, at least one luminaire in each of these spaces shall be controlled by an occupant or vacancy sensor providing automatic-OFF functionality.

2019 Indoor Residential Lighting Requirements: Spaces and Lighting Controls

Type of Lighting Control	Hallways and Closets[2, 3]	Kitchens	Bathrooms	Laundry Rooms or Utility Rooms	Garage	All Other
Manual ON / OFF Controls	Required for all spaces					
Sensor or Dimmer[1]	Not required	Based on installed luminaire or lamp type[4]	At least one luminaire controlled by an occupancy or vacancy sensor that provides manual-ON/auto-OFF functionality, and all other based on installed lamp or luminaire type[5]			Based on luminaire type[4]
Separate Switching: Exhaust Fans	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.					
Separate Switching: Undercabinet Lighting	Undercabinet lighting must be switched separately from ceiling-mounted lighting.					
Auto-Shut Off: Drawers, Cabinets and Linen Closets	Lighting in drawers, cabinets and linen closets less than 5 watts and 150 lumens must be equipped with controls that automatically turn off when the drawer, cabinet or linen closet is closed.					
Blank Electrical Boxes	Blank electrical boxes must be connected to a dimmer, vacancy sensor or fan speed control.					

[1] May be achieved with an EMCS or programmable scene controller with required functionality.
[2] Closets less than 70 ft². For all other closets, requirements based on installed lamp or luminaire type.
[3] Light sources in linen closets must be high efficacy and be controlled by vacancy sensors if they use more than 5 watts, emit more than 150 lumens and are not equipped to automatically turn the light off when the light closes.
[4] See '2019 Indoor Residential Lighting Requirements: Luminaires' table (above) for a list of requirements by lamp and luminaire type.
[5] No sensor is required if the light source is automatically classified as high efficacy, according to Table 150.0-A.



CHAPTER 5

REQUIREMENTS AND RECOMMENDATIONS

DESIGNING TO THE ENERGY CODE

The Energy Code allows designers and builders to choose from a variety of lighting strategies and technologies. Options are available across a broad range of price points and aesthetics. The sample lighting design presented in this chapter represents one possible compliant design available in the market today.

Section 100.1

SPACE TYPE DEFINITIONS

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

LIGHTING PLANS

The lighting plan in this section provides an example of a compliant lighting design. It includes descriptions of the luminaires and lamps used in the plan, including lamp types, power (W) and lamp efficacy.

CALCULATING EFFICACY

When calculating efficacy, it is important to use system power, also known as the luminaire's rated input power (W).

LIGHTING RECOMMENDATIONS

The example lighting plan includes recommendations for lighting in each space. These tips are intended to optimize occupants' comfort while meeting or exceeding the Energy Code.

INDOOR REQUIREMENTS AND RECOMMENDATIONS

Indoor lighting in residences are required to meet compliance requirements, regardless of the space type. This section summarizes the compliance requirements common to all indoor space types, as well as provides additional space-specific requirements and recommendations on how to meet or exceed these requirements. Additionally, luminaires permanently installed in indoor spaces of residences must adhere to the requirements listed in the **Finding Compliant Products section of Chapter 1**.

Compliance requirements common to all indoor space types include:

1. **High efficacy:** All luminaires that are permanently installed must be high efficacy. Step lights, path lights, night lights, lights in drawers, lights in cabinets and lights in linen closets that are less than 5 watts or emit less than 150 lumens are exempt from this requirement and do not need to be controlled by vacancy sensors. Additionally, non-permanent lighting, such as kitchen exhaust hoods, are exempt.
2. **Undercabinet lighting:** Undercabinet lighting must be switched separately from ceiling-mounted lighting.
3. **Light sources in drawers, cabinets and linen closets:** Light sources integral to drawers, cabinets or linen closets are not required to comply with **Table 150.0-A** or be controlled by vacancy sensors, provided that they are not greater than 5 watts of power, emit no more than 150 lumens and are equipped with controls that automatically turn off when the drawer, cabinet or linen closet is closed.
4. **Blank electrical boxes for future installations:** The total number of electrical boxes with a blank cover located more than five feet above the finished floor can be no greater than the number of bedrooms in the residence. The blank electrical boxes must be connected to a dimmer, vacancy sensor or fan speed control.
5. **Manual control:** All lighting must have readily accessible wall-mounted manual controls with ON/OFF functionality, giving occupants control of lighting in the space. Ceiling fans are allowed to use a remote to fulfill this functionality.
6. **Dimmer or sensors:** Sensors or dimmers are required for all JA8 light sources.

KITCHENS

Kitchens must adhere to the compliance requirements common to all indoor spaces. This section provides recommended best practices specific to kitchen lighting designs.

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

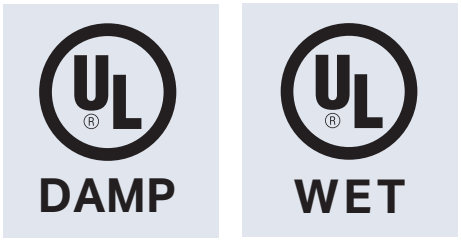
In bathrooms, laundry rooms, utility rooms and garages, vacancy sensors — or occupancy sensors configured as vacancy sensors — are required for at least one luminaire in the space, with controls for all other luminaires being based on the installed lamp or luminaire type. For all other luminaires, sensors or dimmers are required for all light sources required to comply with JA8. Otherwise, a manual ON/OFF switch is compliant.

Additionally, exhaust fans must be switched separately from lighting or utilize a device where lighting can be turned OFF while the fan is running.

Best practices specific to bathroom, laundry room, utility room and garage lighting designs that exceed compliance requirements are provided in this section.

RECOMMENDATIONS

1. **Choose UL rating — damp or wet:** Use lamps and luminaires that are rated appropriate for use in damp or wet areas. See examples of UL markings below.



◀ *Examples of UL damp and UL web markings.*

2. **Consider barriers:** Use a damp-rated recessed downlight over the shower when a shower curtain or door limits ambient lighting.
3. **Prevent shadows:** Position vanity lighting bath bars or sconces vertically (parallel with the sides of mirrors as opposed to overhead) to distribute light more evenly. Consider using mirrors with an integrated light source.
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 sensors, consider installing a dual-technology device to make sure the sensor can detect occupants at all times. If possible, do not pair the luminaires in the bath or shower area with a sensor. Instead, pair the vanity or general illumination luminaire with the sensor and pair the bath/shower luminaire with either a manual ON/OFF switch or a dimmer if the luminaire complies with JA8.

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^2 and larger

Sensors or dimmers are required for all space types when using a source regulated by JA8. Exceptions to this are closets that are less than 70 ft^2 and hallways. If a linen closet is less than 70 ft^2 with a light source that is 5 watts or greater, emits 150 or more lumens or is not equipped with a control that automatically turns off the lighting when the door is closed, it must be controlled by a vacancy sensor.

Best practices specific to these spaces that exceed compliance requirements follow below.

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. Remote fan controls are compliant so long as they meet the same requirements.
4. For hallways, install three-way switching to all entrances and exits for lighting to be controllable from all points of entrance.

OUTDOOR REQUIREMENTS AND RECOMMENDATIONS

This section summarizes the compliance requirements for outdoor lighting attached to residential buildings. The compliance requirements for outdoor lighting attached to residential buildings are as follows:

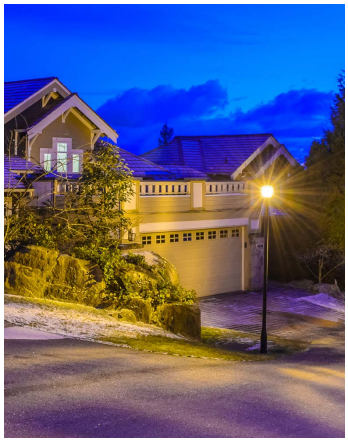
1. **High efficacy**: For single family residential buildings, all lighting attached to the exterior of the building or to other buildings on the same lot must be classified as high efficacy per **Table 150.0-A**.
2. **Controls:** All lighting attached to the exterior of a single family residential building or to other buildings on the same lot must be controlled by a manual ON/OFF switch that permits automatic lighting control AND must utilize one of the following control strategies:
    - Photocell and motion sensor
    - Photocell and automatic time switch
    - Astronomical time clock
    - EMCS with features of 1) astronomical time clock, 2) does not allow the luminaire to be ON during the day and 3) may be programmed to automatically turn lighting OFF at night
3. **Temporary overrides:** Automatic lighting controls 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:** For buildings with four or more dwelling units, outdoor lighting for private patios, entrances, balconies and porches may comply with requirements for single family residences or meet applicable nonresidential requirements.

    If the low-rise multifamily residential building has three or less dwelling units, only residential requirements can be used.
5. **For high-rise multifamily residential buildings:** Lighting controlled from within the dwelling unit must meet residential requirements only. Lighting controlled from a location other than the dwelling unit must comply with nonresidential requirements.
6. **Requirements for parking lots and carports:** These vary based on their size. See the following table for complete details.

2019 Residential Outdoor Lighting Requirements

Space Type	Single family	Low-Rise Multifamily		High-rise Multifamily and Hotels[2]
		1 to 3 Dwelling Units	4 or More Dwelling Units[1]	
Outdoor lighting mounted to building	Residential Standards	Residential Standards	Nonresidential Standards	Nonresidential Standards
Private patios, entrances, balconies and porches	Residential Standards	Residential Standards	Residential Standards or Nonresidential Standards for fixtures not controlled from within the dwelling unit (builder's option)	Residential applies to the dwelling unit; Nonresidential applies to lighting not controlled from within the dwelling unit
Parking lots and carports with less than 8 vehicles per site	Residential Standards	Residential Standards	Residential Standards or Nonresidential (builder's option)	Nonresidential Standards
Parking garages, lots and carports with 8 or more vehicles	Residential Standards	Nonresidential Standards when not controlled from within the dwelling unit	Nonresidential Standards when not controlled from within the dwelling unit	Nonresidential Standards

[1] *Outdoor lighting not mounted to the building with 4 or more dwelling units must meet Nonresidential Standards, per Section 150.0(k)3C.*
[2] *Refer to Section 130.0(b) and Section 150.0(k)3 in the Energy Standards for more information.*



RECOMMENDATIONS

OUTDOOR LIGHTING

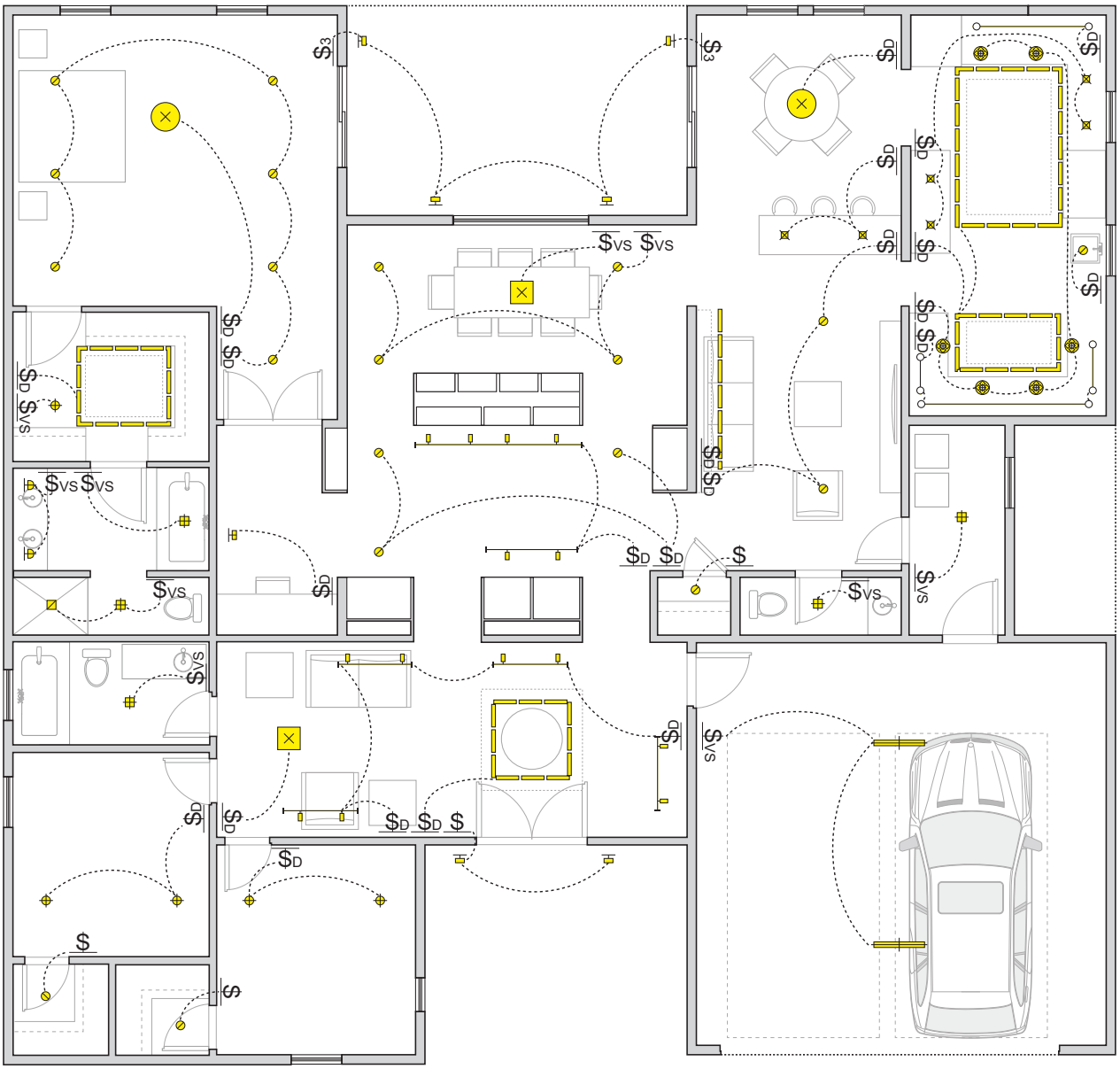
1. Ground-level lighting placed strategically along pathways and area perimeters gives occupants a sense of their surroundings without over-lighting the space.
2. Where switches are less accessible, use a motion sensor.
3. Adjust motion sensor coverage to avoid unwanted triggers from street traffic or neighbors' movements. Most sensors have DIP switches or turn-pots that allow for such adjustments.
4. Control landscape lighting and other luminaires not permanently attached to building exteriors with a time clock or photo control. 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. This avoids causing glare or light trespass.
6. During the Design Phase, select luminaires with a CCT of no more than 3,000K to minimize discomfort glare and circadian disruption at night.

PORCH LIGHTING

1. 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 neighbors' homes.
3. Select LED sources for colder outdoor environments.

LIGHTING IN PRACTICE: APPLYING REQUIREMENTS TO A SINGLE FAMILY HOME

The floorplan below is a representative, single family home. The lighting schedule on the following pages is an example of an Energy Code-compliant lighting design.



▲ *Single family home with compliant lighting design for the Energy Code.*

LIGHTING SCHEDULE

Symbol	Luminaire Type	Lamp	Quantity	CRI	CCT	Watts	Total Watts	Efficacy (lm/W)	JA8 Certified
KITCHEN									
	LED undercabinet	Dedicated LED	21'	94	2,150K	1.4W/ft.	29.4	84	Yes
	LED tape light	Dedicated LED	41'	90	2,200K	4W/ft.	164	230	Yes
	Pendant	Dedicated LED	4	90	2,700K	15	60	60	Yes
	Recessed downlight	Dedicated LED	1	90	2,700K	13	13	54	Yes
	Cabinet light (with auto shut-OFF when door is closed)	Dedicated LED	6	90	2,700K	4	24	47.5	Yes
MASTER BEDROOM									
	Ceiling mount	Dedicated LED	1	90	2,700K	13	13	64	Yes
	Recessed downlight	Dedicated LED	7	90	2,700K	13	91	54	Yes
MASTER BATHROOM									
	Ceiling mount	Dedicated LED	2	90	3,000K	30	60	62.5	Yes
	Indoor wall sconce	Dedicated LED	2	90	2,700K	15	30	60	Yes
	Recessed downlight	Dedicated LED	1	90	2,700K	10	10	54	Yes
POWDER ROOM/WALK-IN CLOSET									
	Ceiling mount	Dedicated LED	1	90	3,000K	30	30	62.5	Yes
	LED tape light	Dedicated LED	22'	90	2,200K	4W/ft.	88	230	Yes
BEDROOM 1									
	Ceiling mount	Dedicated LED	2	90	2,700K	13	26	64	Yes
	Recessed downlight	Dedicated LED	1	90	2,700K	13	13	54	Yes
BEDROOM 2									
	Ceiling mount	Dedicated LED	2	90	2,700K	13	26	64	Yes
	Recessed downlight	Dedicated LED	1	90	2,700K	13	13	54	Yes
BATHROOM 1									
	Ceiling mount	Dedicated LED	1	90	3,000K	30	30	62.5	Yes
BATHROOM 2									
	Ceiling mount	Dedicated LED	1	90	3,000K	30	30	62.5	Yes

Controls $ Switch $VS Switch with vacancy sensor $D Dimmer switch $3 3-way switch

Symbol	Luminaire Type	Lamp	Quantity	CRI	CCT	Watts	Total Watts	Efficacy (lm/W)	JA8 Certified
DINING ROOM									
	Chandelier	Dedicated LED	1	90	2,700K	13	13	64	Yes
	Recessed downlight	Dedicated LED	4	90	2,700K	13	52	54	Yes
LIVING ROOM									
	Ceiling mount	Dedicated LED	1	90	2,700K	13	13	64	Yes
	Pendant	Dedicated LED	2	90	2,700K	15	30	60	Yes
	Recessed downlight	Dedicated LED	2	90	2,700K	13	26	54	Yes
	LED tape light	Dedicated LED	11'	90	2,200K	4W/ft.	44	230	Yes
LIBRARY									
	Recessed downlight	Dedicated LED	3	90	2,700K	13	39	54	Yes
	LED track light	Dedicated LED	1-4' track 1-8' track 6 luminaires	90	3,000K	12	72	79	Yes
	Indoor wall sconce	Dedicated LED	1	91	2,700K	7	7	71	Yes
FOYER									
	LED tape light	Dedicated LED	22'	90	2,200K	4W/ft.	88	230	Yes
	LED track light	Dedicated LED	4-4' tracks 8 luminaires	90	3,000K	12	96	79	Yes
	Chandelier	Dedicated LED	1	90	2,700K	13	13	64	Yes
LAUNDRY									
	Ceiling mount	Dedicated LED	1	90	3,000K	30	30	62.5	Yes
UTILITY									
	Recessed downlight	Dedicated LED	1	90	2,700K	13	13	54	Yes
GARAGE									
	Garage pendant	Dedicated LED	2	90	3,500K	15	30	53	Yes
FRONT PORCH									
	Outdoor wall sconce (with photocell and motion sensor)	Dedicated LED	2	90	2,700K	13	26	64	Yes
PATIO									
	Outdoor wall sconce (with photocell and motion sensor)	Dedicated LED	4	90	2,700K	13	52	64	Yes

Controls $ Switch $VS Switch with vacancy sensor $D Dimmer switch $3 3-way switch

APPENDIX

GLOSSARY

A

Accent or display 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 easily for operation, repair or inspection. Accessible components still may require removal or opening of access panels, doors or similar obstructions.

Ambient or general lighting: Lighting provided by non-directional light sources to provide low-level illumination for comfortable navigation through spaces. Ambient lighting is generally supplemented by **task lighting** and **accent lighting**.

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 specified times of the day or at times relative to astronomical events, such as sunset and sunrise. These devices can account for geographic location and calendar date and are commonly used in daylight harvesting applications.

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^2 are exempt from many requirements in the Energy Code.

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 (2,700–3,000K) have a warmer, more reddish appearance than those with higher CCT values (4,000–6,500K, for example), which appear cooler, or more bluish, in color. Incandescent lamps are an example of a light source with low CCT.

D

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

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 used. 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 energy use by supporting monitoring and control of the operation of one or more building systems, such as lighting and HVAC. An EMCS can also be programmed to provide automated control based on signals from sensors or utilities.

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 mercury ultraviolet energy 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: An electric discharge lamp in which the light-producing arc is stabilized by bulb wall temperature. HID lamps include groups of lamps known as **mercury**, **metal halide** and **high pressure sodium**.

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

High-efficacy luminaires include linear fluorescent, pin-based compact fluorescent, GU-24 base CFL, HID and induction lighting and also include 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 or motel, of Occupancy Group R-2 or R-4 with four or more habitable stories. Occupancy Groups are defined in the Energy Code **(Title 24, Part 2, Chapter 3)**.

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 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 clothes dryer.

Light output: The rate at which a light source emits visible light. This "flow rate" of light is measured as lumens as time progresses. It is also referenced to as **'luminous flux'**.

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.

Light-emitting diode (LED) luminaire: A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light-emitting elements and to connect the unit 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 the Energy Code.

Low-efficacy luminaire: Per **Table 150.0-A** of the Energy Code, 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 and mercury vapor lamps.

Low-rise residential building: A building, other than a hotel or motel, that is of Occupancy Group R-2, multifamily 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: A light source consisting of a housing for lamp(s) and optics for specific light distributions.

Luminance (L): The intensity of light emitted from a light source or reflected off a surface, normalized by the area of the light source or the reflecting surface, projected on a plane vertical to the direction of view towards the light source or the surface (i.e., intensity or lumens per solid angle) per area. The units are Nit (cd/m^2) and FootLambert (cd/ft^2).

Luminous flux: The rate at which a light source emits visible light. This "flow rate" of light is measured as lumens as time progresses. It is also referred to as **'light output'**.

M

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

Multi-level lighting control: A lighting control device that adjusts the output of electric lighting sources in multiple discrete steps.

Multifamily building: A building containing multiple dwelling units that share common walls and also may share common floors or ceilings. Examples include apartments, duplexes, townhomes 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 the Energy Code, lighting in kitchen nooks is counted as separate from kitchen lighting if it is switched separately.

O

Occupancy sensor: A device that detects occupants, using motion or noise sensing as a proxy.

Other rooms: Any room or area that is not a kitchen, bathroom, garage, closet 70 ft^2 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^2)

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

P

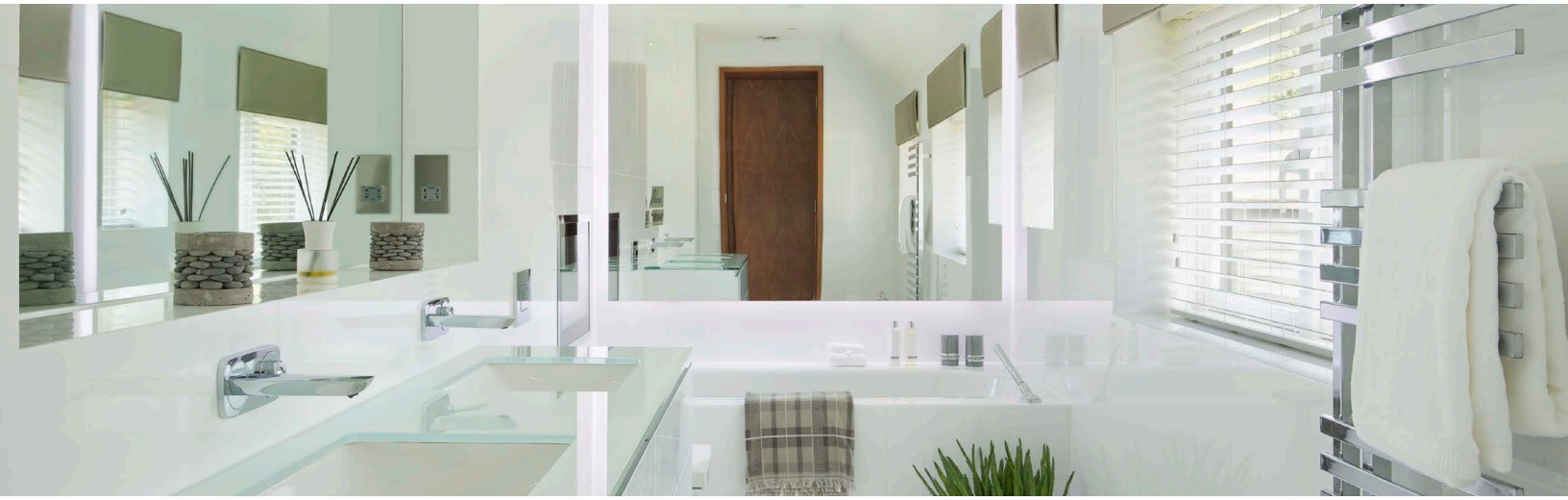
Parking area: The area of a parking garage used for parking and maneuvering vehicles on a single floor and which is not the roof of a parking structure.

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 luminaire that is suspended from the ceiling.

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: Automated lighting controls based on the signal of one or more photo sensors, usually used for daylight harvesting.

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 hardwired 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) Requirements for portable lighting are covered by the 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 Energy Code.

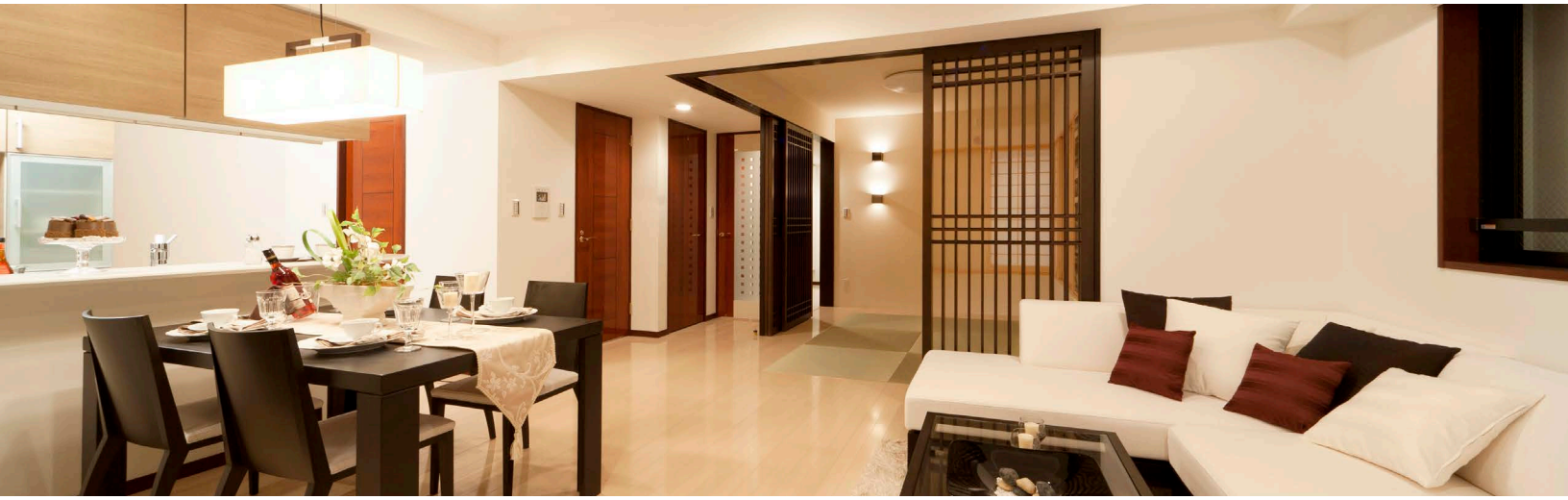
Residential occupancy types:

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; and congregate residences.



Group R-4: Residential occupancies, including buildings arranged for occupancy as residential care or assisted living facilities, including more than six ambulatory clients but 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 designed to meet specific illumination needs for specific tasks.

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 occupancy 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.

APPENDIX

TABLES

The original version of the tables in this section can be found in the **2019 Energy Standards for Residential and Nonresidential Buildings**.

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

Required Information	Permissible Answers	Compliance Threshold
MANUFACTURER, MODEL NUMBER, DESCRIPTION		
Light Source Type	LED, OLED, Fluorescent, HID, Incandescent, Other	
Product Type	Omnidirectional lamp, Directional lamp, Decorative lamp, LED light engine, Inseparable SSL luminaire, Other	
Lab accredited by NVLAP or accreditation body operating in accordance with ISO / IEC 17011	Yes/No	Yes
Initial Efficacy	Value (lumens/watt)	≥ 80 lm/W for state regulated LED lamps[1], or 45 lm/W for all other light source types
Power Factor at Full Rated Power	0–1 Fraction	≥ 0.90
Start Time	Value (seconds)	≤ 0.5 sec
Correlated Color Temperature (CCT)	Number (Kelvin)	≤ 4,000 Kelvin
Color Rendering Index (CRI)	0–100	≥ 82 for state regulated LED lamps[1], or ≥ 90 for all else
Color Rendering R1–R8, R9 (red)	0–100 or below 0	R1–R8 ≥ 72 for state regulated LED lamps, or R9 ≥ 50 for all else
Ambient or elevated temperature test for rated life, lumen maintenance and survival rate	Ambient or Elevated	
Lumen Maintenance	Value (percent), N/A	≥ 86.7% after final testing, or 93.1 if reporting interim data
Interim or Final Reporting	Interim or Final	
Rated Life	Value (hours)	≥ 15,000 hours
Survival Rate	Value (percent)	≥ 90%
Minimum Dimming Level	Value (percent)	≤ 10%
Dimming Control Compatibility	Forward phase cut control, reverse phase cut, powerline carrier, digital, 0–10 VDC, Other	At least one type must be listed
NEMA SSL 7A Compatible	Yes or N/A	If compatible with forward phase cut dimmer control, "Yes." If not, "N/A."

[1] *Small diameter directional lamps may have an initial efficacy of at least 80 lm/W or a minimum compliance score of at least 165 for products with a minimum efficacy of 70 where compliance is determined by the equation: Compliance Score = Efficacy + CRI.*

Table JA8, Continued

Required Information	Permissible Answers	Compliance Threshold
FLICKER		
See JA10 Table 10-1 for flicker data requirements and permissible answers		< 30% for frequencies of 200 Hz or below, at 100% light output
See JA10 table 10-1 for flicker data requirements and permissible answers		< 30% for frequencies of 200 Hz or below, at 20% light output
AUDIBLE NOISE		
100% Light Output: Audible Noise	Value (dBA)	≤ 24 dBA
20% Light Output: Audible Noise	Value (dBA)	≤ 24 dBA
MARKING		
Marked in Accordance with JA8.5	Yes/No	Yes

From Appendix JA8 — Qualification Requirements for High-Efficacy Light Sources in the Energy Code

APPENDIX

RESOURCES

COMPLIANCE RESOURCES

CALIFORNIA ADVANCED LIGHTING CONTROLS TRAINING PROGRAM (CALCTP)

calctp.org

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

CALIFORNIA ENERGY COMMISSION MODERNIZED APPLIANCE EFFICIENCY DATABASE SYSTEM

cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

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

The California Lighting Technology Center (CLTC) 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 the Energy Code.

ENERGY CODE ACE

energycodeace.com

This site developed by the California Statewide Codes & Standards Program provides free tools, trainings and resources to help users meet the latest Energy Code and Appliance Efficiency Regulations requirements. Visitors can download fact sheets, trigger sheets, checklists and information on classes (online or in-person) and workshops.

ENERGY CODE HOTLINE

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

title24@energy.ca.gov

The Energy Code Hotline is a resource for any questions regarding the Energy Code. The hotline is available Monday through Friday, 8 A.M.–12 P.M. and 1–4:30 P.M.

BUILDING ENERGY EFFICIENCY STANDARDS

www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards

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

The California Energy Commission created the 2019 Residential Compliance Manual to supplement the Energy Code. The Residential Compliance Manual clarifies issues not addressed in the Energy Code.

CLASSES

CALIFORNIA CENTER FOR SUSTAINABLE ENERGY (CCSE) EVENTS AND WORKSHOPS

energycenter.org/events

BUILDING OWNERS AND MANAGERS ASSOCIATION ONLINE EDUCATION SCHEDULE

boma.org/education

BUILDING OPERATOR CERTIFICATION CALIFORNIA TRAINING SCHEDULE

theboc.info/ca/ca-schedule.html

CALIFORNIA ASSOCIATION OF BUILDING ENERGY CONSULTANTS

cabec.org/title-24

MANUFACTURER TRAINING CENTERS

ACUITY BRANDS ACUITY ACADEMY

Berkeley, CA

www.acuitybrands.com/acuityacademy

EATON'S COOPER LIGHTING BUSINESS

Online Design Center

cooperindustries.com/content/public/en/resources/education.html

LUTRON

Experience Center

Irvine, CA

lutron.com/en-US/Experience-Light-Control/Pages/Inspiration/ExperienceCenter.aspx

UTILITY EDUCATION AND DEMONSTRATION CENTERS

All or most of these California utility centers host lighting classes for Energy Code compliance. 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

Pacific Energy Center (PEC), San Francisco

Energy Training Center, Stockton

SACRAMENTO MUNICIPAL UTILITY DISTRICT

smud.org

Energy & Technology Center, Sacramento

SAN DIEGO GAS & ELECTRIC

sdge.com

Energy Innovation Center, San Diego

SOUTHERN CALIFORNIA EDISON (SCE)

sce.com

Energy Education Centers

Irwindale, Tulare and on-location in other cities

UCDAVIS
California Lighting Technology Center

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

For more information and resources about the Energy Code, visit the CLTC website at ***cltc.ucdavis.edu***.

3/2020