2022 ENERGY CODE

RESIDENTIAL LIGHTING

Best practices in lighting design to comply with California's Building Energy Efficiency Standards (Title 24)

MARTIN VU
RMS PRINCIPAL | J.D., MBA, PMP®, CWEP
IN PARTNERSHIP WITH UC DAVIS CLTC

UCDAVIS California Lighting Technology Center

RMS Energy Consulting, LLC

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LEARNING OBJECTIVES

- Effectively apply the **mandatory residential** California Building Energy Efficiency Standards (Energy Code) specific to lighting for the 2022 cycle
- Understand the **lighting-related requirements** in the 2022 Energy Code
- **Identify current lighting technologies**, including LED luminaires, that are available to fulfill Energy Code requirements
- **Access resources** through utility and lighting technology training centers for continued professional development
- Understand **how to participate in the 2025 Energy Code** code and standards enhancement process.

2022 RESIDENTIAL LIGHTING DESIGN GUIDE

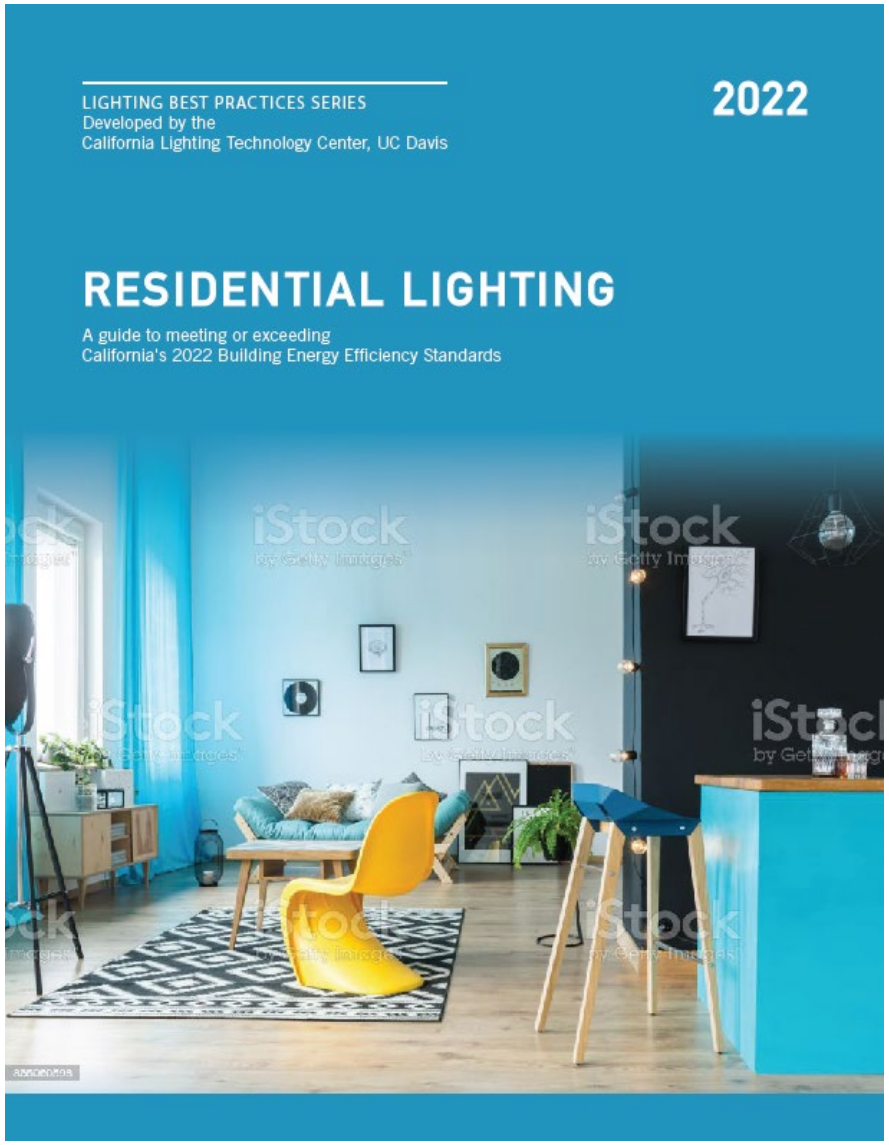
Provides a simplified and practical approach to lighting standards compliance and design.

Topics include:

- Explanation of the code
- Technical guidelines
- Steps to compliance
- Lighting design examples

Coming soon online for download!

cltc.ucdavis.edu



2019 LIGHTING EDUCATION VIDEOS

CLTC developed a series of lighting education videos in support of the 2019 Energy Code.

Videos cover four key topics:

- Lighting Controls Technologies & Requirements
- Lighting Alterations
- Lighting Controls Acceptance Testing
- High Efficacy Lighting

Videos were funded by Southern California Edison in collaboration with RMS Energy Consulting, LLC and the California Energy Commission.

Available online! cltc.ucdavis.edu

2022 updates in progress

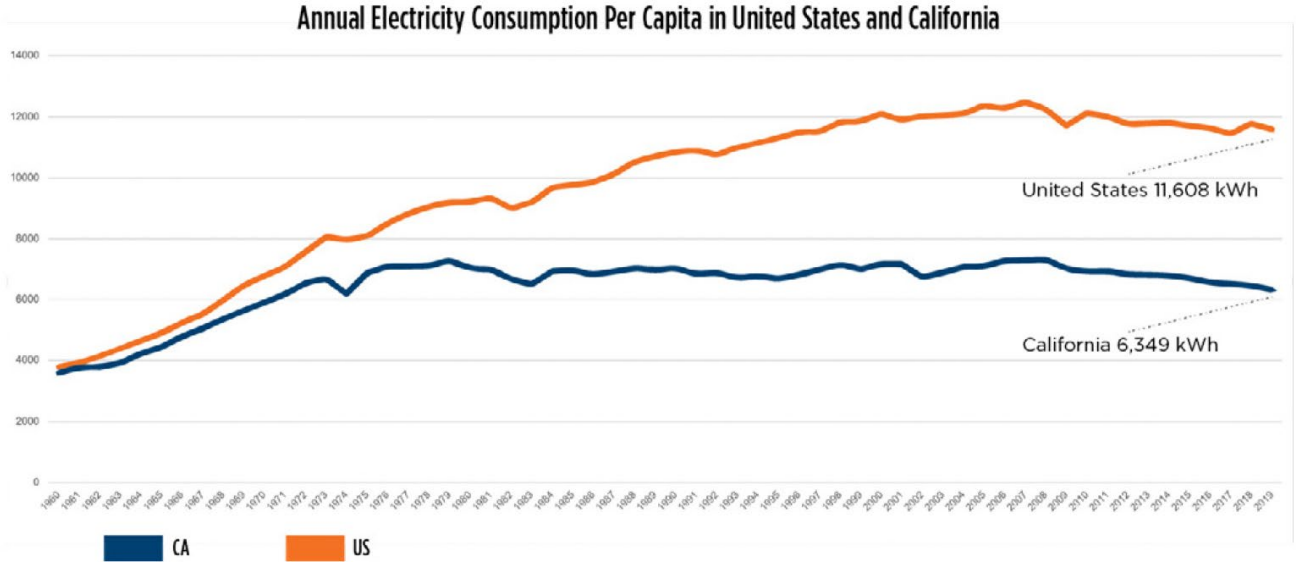
BACKGROUND & POLICY

WHY THE ENERGY CODE?

EFFICIENCY BEFORE GENERATION

The California Energy Commission has found energy efficiency and demand response as the preferred means of meeting the energy needs of a growing population.

As a result, Californians use 31 percent less energy compared to the average American.




WARREN-ALQUIST
STATE ENERGY BUILDING

WARREN-ALQUIST ACT – ENERGY CODE DEVELOPMENT OBLIGATIONS

- Technically feasible
- Cost-effective
- Performance-based and prescriptive compliance path

ENERGY CODE TIMELINE

The *2022 Energy Code* is effective now! Any application for a Building Permit submitted on or after January 1, 2023 must meet the 2022 Energy Code.

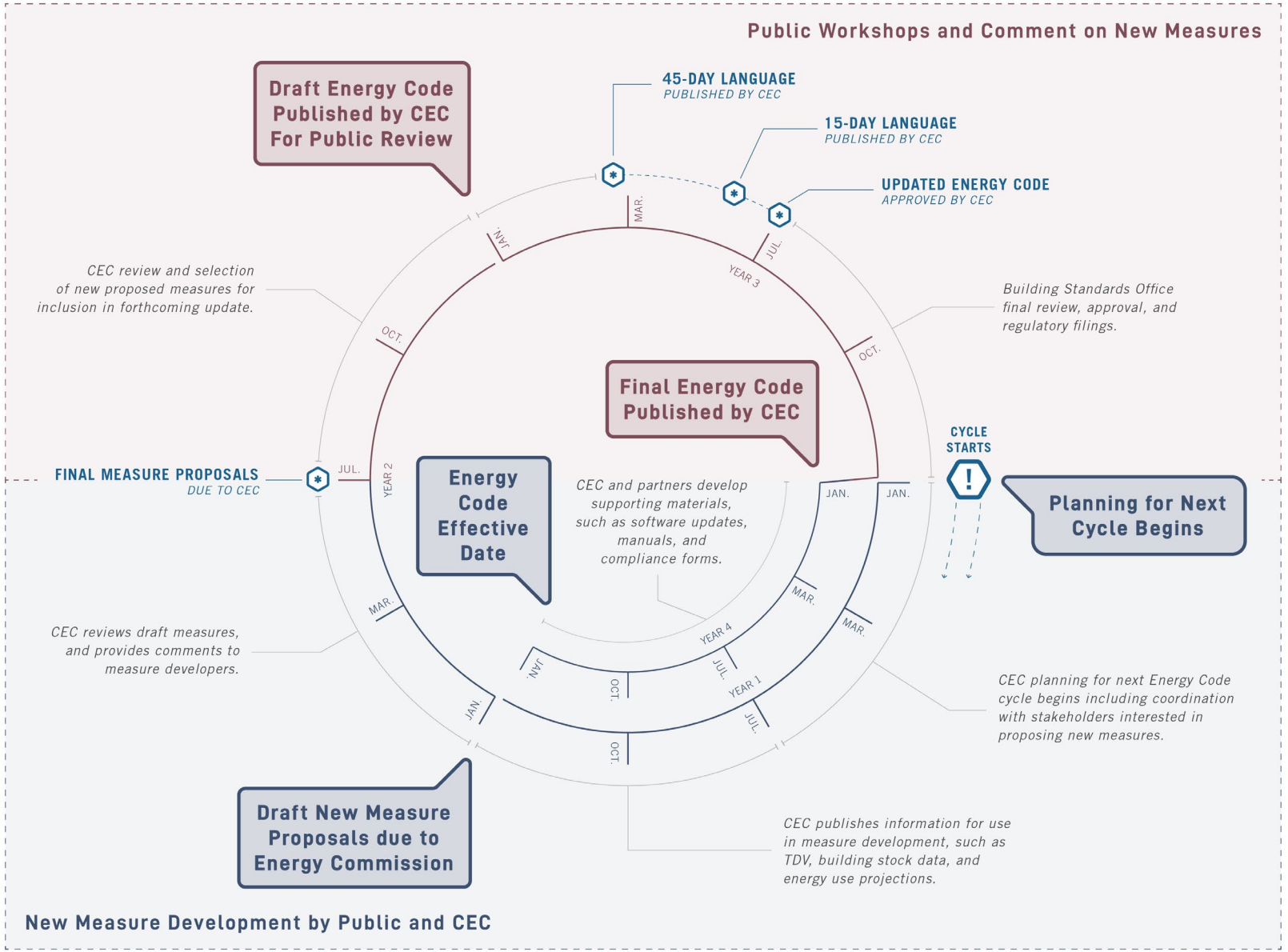
The *2025 Energy Code* is currently being researched and developed. If you are interested in following the Codes and Standards Enhancement (CASE) process please participate in public events and docketing of comments on the California Energy Commission's website.

http://www.energy.ca.gov/title24/2022standards/

http://title24stakeholders.com/

https://caenergyalliance.org/2022-title-24/

Note: This presentation is not intended to be used in lieu of California's *Building Energy Efficiency Standards*. Please visit www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency to download the official *2022 Energy Code,* Reference Appendices and Residential Compliance Manual.


Public Workshops and Comment on New Measures
Draft Energy Code Published by CEC For Public Review
45-DAY LANGUAGE
PUBLISHED BY CEC
15-DAY LANGUAGE
PUBLISHED BY CEC
UPDATED ENERGY CODE
APPROVED BY CEC
CEC review and selection of new proposed measures for inclusion in forthcoming update.
Building Standards Office final review, approval, and regulatory filings.
Final Energy Code Published by CEC
CYCLE STARTS
FINAL MEASURE PROPOSALS
DUE TO CEC
Energy Code Effective Date
CEC and partners develop supporting materials, such as software updates, manuals, and compliance forms.
Planning for Next Cycle Begins
CEC reviews draft measures, and provides comments to measure developers.
CEC planning for next Energy Code cycle begins including coordination with stakeholders interested in proposing new measures.
Draft New Measure Proposals due to Energy Commission
CEC publishes information for use in measure development, such as TDV, building stock data, and energy use projections.
JAN.
MAR.
JUL.
OCT.
YEAR 1
YEAR 2
YEAR 3
YEAR 4
New Measure Development by Public and CEC

WHAT'S NEW FOR 2022?

The proposed 2022 Energy Code update focuses on four key areas in new construction of homes and businesses:

- Encouraging electric heat pump technology and use
- Establishing electric-ready requirements when natural gas is installed
- Expanding solar photovoltaic (PV) system and battery storage standards
- Strengthening ventilation standards to improve indoor air quality

2022 Energy Code: Better for the Environment and You

Heat pumps use less energy and produce fewer emissions than traditional HVACs and water heaters.

Electric-ready building sets up owners to use cleaner electric heating, cooking, and electric vehicle (EV) charging when they're ready to invest in those technologies.

Using battery storage allows onsite energy to be available when needed and reduces the grid's reliance on fossil fuel power plants.

Better ventilation can reduce illness from poor air quality and reduce disease transmission.

COMPLIANCE REQUIREMENTS

DOES MY PROJECT TRIGGER CODE?

NEW CONSTRUCTION

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

ADDITIONS

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

ALTERATIONS

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

THE COMPLIANCE PROCESS

DESIGN

Architects, engineers and designers must understand both the requirements and the underlying intent of the Energy Code if they are to design buildings and systems that are inherently energy efficient and cost effective.

PERMIT APPLICATION

Design teams must make sure that the plans contain all the information that the building official will need to verify that the building or system satisfies the requirements.

PLAN CHECK

The plans examiner of the local building department must verify that the building or system satisfies the requirements of the standards and that the plans (not just the compliance forms) contain the information to be verified during field inspection.

THE COMPLIANCE PROCESS

CONSTRUCTION

Contractors must carefully follow the approved plans and specifications, and the building department field inspector(s) must verify that the building is constructed according to the plans and specifications.

ACCEPTANCE COMMISSIONING

After completion of construction, the contractor and/or the design team must properly commission the building and its systems and provide information and/or training to the building operators on maintenance and operation of the building and its equipment.

OPERATION

After occupancy, the building and its systems must be correctly operated and properly maintained. The building must provide new homeowners with a luminaire schedule that includes a list of installed lamps and luminaires. This ensures that homeowners know what lighting products they are entitled to when they take possession of a new home.

LOCAL ORDINANCES

Local governmental agencies, primarily cities and counties, may adopt and enforce standards for newly constructed and existing buildings that are more stringent than the Energy Code. These can include:

- Shorter timeframes
- Additional energy conservation measures
- More stringent energy budgets
- CALGreen or GreenPoint Rated

It is critical to check with your local building agency for additional requirements.

Current local ordinances, or "reach codes," are listed on the Energy Commission website: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency-2

2022 APPROVED LOCAL ORDINANCES

Local Ordinances	Date Approved	Topic	Ordinance Number
Encinitas	January 25, 2023	Residential Retrofit Efficiency Improvements; PV for High-Rise and Nonresidential Additions	2022-13
Piedmont	January 25, 2023	All-Electric SF NC, Residential Retrofit Efficiency Improvements, PV for Some Additions	766 N.S.

PRESCRIPTIVE VS. PERFORMANCE STANDARDS

PRESCRIPTIVE STANDARDS

- Simpler, but does not allow as much flexibility in design
- Each individual component of the proposed building must meet a prescribed minimum energy requirement
- Applicant needs only to show that a building meets each minimum or maximum level prescribed in the set of requirements contained in a package

"Which technology is appropriate for my project?"

PERFORMANCE STANDARDS

- Allows the builder more freedom, but the standards are more complex and involved
- Detailed accounting of energy trade-offs between measures is possible
- Uses Energy Commission-approved computer software to calculate energy trade-offs based on Energy Code guidelines

"What is available, and how can I piece together the building I want while complying with the Energy Code?"

2022 APPROVED COMPLIANCE PROGRAMS

Program Name	Compliance Software Versions	Contact Information	Additional Information
California's Building Energy Code Compliance Software – Residential (CBECC-Res)	CBECC-Res 2022.2.0 was approved 10/12/22 for demonstrating performance compliance with the single-family residential provisions of the 2022 Energy Code. Permit applications made on or after 1/16/23 must use CBECC-Res 2022.2.0. **Latest Version** • Download CBECC-Res 2022.2.0 **Non-Current Version** • Download CBECC-Res 2022.1.0 **CBECC-Res 2022 Resolutions/Approvals** • CBECC-Res 2022.2.0 Resolution • CBECC-Res 2022.1.0 Resolution	California Energy Commission Building Standards Office 715 P Street, MS 37 Sacramento, CA 95814 ATTN: Michael Shewmaker 916-931-9770 cbecc.res@energy.ca.gov	See the CBECC-Res Website for: • Quick Start Guide and User Manual (packaged with software) • FAQs • Software Archive • ACM Tests • Reference Documents • 2022 Compliance Software Approval and Expiration Dates. Support: cbecc.res@energy.ca.gov
EnergyPro	EnergyPro 9.0 was approved 12/14/22 for demonstrating performance compliance with the single-family residential provisions of the 2022 Energy Code. **EnergyPro 2022 Resolutions/Approvals** EnergyPro 9.0 Resolution	EnergySoft, LLC 1025 5th Street, Suite A Novato, CA 94945-2413 415-897-6400	See the EnergySoft website for: • Software Download • Training and FAQ's • Support: support@energysoft.com 2022 Compliance Software Approval and Expiration Dates

https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency-1

MANDATORY MEASURES

Mandatory measures required by both prescriptive and performance approaches include the following areas:

- Building envelope
- Space conditioning, water heating and plumbing
- Ducts and fans
- Pools and spas
- Fireplaces
- **Indoor & Outdoor Lighting**
- Energy Storage System Ready (New in 2022!)
- Heat Pump Ready (New in 2022!)
- Electric Cooktop Ready (New in 2022!)
- Electric Clothes Dryer Ready (New in 2022!)

WHAT FORMS APPLY?

CF2R-LTG-01-E
for single-family dwellings

DOWNLOAD 2022 FORMS HERE:
https://energycodeace.com/ResidentialForms/2022

The appropriate CF2R form must be posted on site and provided to the home owner **once the lighting project has been completed.**

2022-CF2R-ADD-02-E: Prescriptive Additions - Simple Non-HERS	CEC Website
2022-CF2R-ALT-05-E: Prescriptive Alterations Simple Non-HERS	CEC Website
2022-CF2R-ELC-01-E: Electrical Power Distribution	HERS Required
2022-CF2R-ENV-01-E: Fenestration Installation	CEC Website
2022-CF2R-ENV-03-E: Insulation Installation	CEC Website
2022-CF2R-ENV-04-E: Roofing Radiant Barrier	CEC Website
2022-CF2R-ENV-20-H: Envelope-HERS Building Leakage Diagnostic Test	HERS Required
2022-CF2R-ENV-21-H: Envelope-HERS QII - Framing Stage	HERS Required
2022-CF2R-ENV-22-H: Envelope-HERS QII - Insulation Installation Stage	HERS Required
2022-CF2R-LTG-01-E: Lighting Single Family Dwellings	CEC Website
2022-CF2R-MCH-01-E: Mechanical-NonHERS Space Conditioning Systems	HERS Required
2022-CF2R-MCH-02-E: Whole House Fan	CEC Website

LIGHTING – SINGLE FAMILY DWELLINGS

CALIFORNIA ENERGY COMMISSION CEC-CF2R-LTG-01-E

SAMPLE FORM – NOT VALID FOR SUBMISSION TO BUILDING DEPARTMENTS

CERTIFICATE OF INSTALLATION

Note: This table completed by HERS Registry.

Project Name:	Enforcement Agency:
Dwelling Address:	Permit Number:
City and Zip Code:	Permit Application Date:

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 Sections B through J for applicable requirements.

01	High Luminous Efficacy luminaires installed in any interior rooms. (See Section B.)	
02	JA8 compliant luminaires installed in any interior rooms. (See Section B.)	
03	Recessed downlight luminaires in ceilings in any interior rooms. (See Section C.)	
04	Light Sources in Enclosed or Recessed Luminaires. (See Section D.)	
05	Lighting controls in bathrooms. (See Section E.)	
06	Lighting controls in laundry rooms. (See Section E.)	
07	Lighting controls in utility rooms. (See Section E.)	
08	Lighting controls in garage. (See Section E.)	
09	Lighting controls in walk-in closets. (See Section E.)	
10	Lighting controls in interior rooms except bathrooms, laundry rooms, utility rooms, and garages. (See Section F)	
11	Screw based luminaires. (See Section G.)	
12	Internally illuminated address signs. (See Section H.)	
13	Outdoor lighting and controls. (See Section I.)	
14	Parking Garages for eight or more Vehicles. (See Section J)	
15	Blank Electrical Boxes installed more than 5 feet from finished floor. (See Section K.)	

B. High Luminous Efficacy Luminaires

01	150.0(k)1A and Table 150.0-A: All luminaires are installed with: • Light sources of one of the lighting technologies specified under the "High Luminous Efficacy" column of Table 150.0-A; or • JA8 compliant light sources and the light sources are marked with "JA8-2022" or "JA8-2022-E". Exception 1: Integrated device lighting: Lighting integral to exhaust fans, kitchen range hoods, bath vanity mirrors, and garage door openers, and non-removable lighting attached to ceiling fans. Exception 2: Navigation Lighting: Night lights, step lights, path lights less than 5 watts. Exception 3: Cabinet Lighting: Lighting internal to drawers, cabinetry, and linen closets with an efficacy of 45 lumens per watt or greater
02	• Lighting shall have readily accessible wall-mounted controls that allow the lighting to be manually turned ON and OFF

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

C. Recessed Downlight Luminaires in Ceilings

01	150.0(k)1Ci: Do not contain screw based lamp sockets.
02	The luminaire is marked with "JA8-2022".
03	150.0(k)1Cii: Has label certifying the luminaires are air tight with air leakage less than 2.0 cfm at 75 Pascals when tested in accordance with ASTM E283. Exception: Recessed luminaires marked for use in fire-rated installations, and recessed luminaires installed in non-insulated ceilings.
04	150.0(k)1Ciii: Sealed with a gasket or caulk between the luminaire housing and ceiling, and all air leakage paths between conditioned and unconditioned spaces are sealed with a gasket or caulk, or be installed per manufacturer's instructions to maintain airtightness between the luminaire housing and ceiling. Exception: Recessed luminaires marked for use in fire-rated installations, and recessed luminaires installed in non-insulated ceilings.
05	150.0(k)1Civ: Meet the following requirements (California Electrical Code Section 410.116). • A recessed luminaire that is not identified for contact with insulation shall have all recessed parts spaced not less than 1/2 inch from combustible materials. The points of support and the trim finishing off the openings in the ceiling shall be permitted to be in contact with combustible materials. • A recessed luminaire that is identified for contact with insulation, Type IC, shall be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through or finishing off the opening in the building structure. • Thermal insulation shall not be installed above a recessed luminaire or within 3 inches of the recessed luminaire's enclosure, wiring compartment, ballast, transformer, LED driver, or power supply unless the luminaire is identified as Type IC for insulation contact.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

D. Light sources in enclosed or recessed luminaires (other than recessed downlight luminaires in ceilings)

01	150.0(k)1D: **Light Sources in Enclosed or Recessed Luminaires** that are not marked with "JA8-2022-E", should not be installed in enclosed or recessed luminaires.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

E. Lighting Controls in bathrooms, garages, laundry rooms, utility rooms, and walk-in closets

01	150.0(k)2Ei: In **bathrooms, garages, laundry rooms, utility rooms, and walk-in closets,** at least one installed luminaire is controlled by an occupancy or vacancy sensor providing automatic-off functionality.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

F. Lighting Controls in any interior rooms

01	150.0(k)2Eii: For lighting internal to drawers and cabinetry with opaque fronts or doors, the lighting has controls to turn light off when the drawer or door is closed are provided.
02	150.0(k)2F: Lighting in habitable spaces, including but not limited to living rooms, dining rooms, kitchens, and bedrooms, have readily accessible wall-mounted dimming controls that allow the lighting to be manually adjusted up and down. Forward phase cut dimmers controlling LED light sources in these spaces comply with NEMA SSL 7A.. EXCEPTION 1: Ceiling fans may provide control of integrated lighting via a remote control. EXCEPTION 2: Luminaires connected to a circuit with controlled lighting power less than 20 watts or controlled by an occupancy or vacancy sensor providing automatic-off functionality. EXCEPTION 3: Navigation lighting such as night lights, step lights, and path lights less than 5 watts, and lighting internal to drawers and cabinetry with opaque fronts or doors or with automatic off controls.
03	150.0(k)2A: Lighting has readily accessible wall-mounted controls that allow the lighting to be manually turned ON and OFF.
04	150.0(k)2B: No controls bypasses a dimmer, occupant sensor or vacancy sensor function where that dimmer or sensor is installed to comply with Section 150.0(k)
05	150.0(k)2C: Lighting controls comply with the applicable requirements in Section 110.9.
06	150.0(k)2D: An Energy Management Control Systems (EMCS) or a multiscene programmable control can be used to comply with dimming, occupancy, and lighting control requirements in Section 150.0(k)2 if it provides the functionality of the specified control in accordance with Section 110.9, and the physical controls (readily accessible wall-mounted controls that allow the lighting to be manually turned ON and OFF).
07	150.0(k)2G: Independent controls • Integrated lighting of exhaust fans is controlled independently from the fans. • Undercabinet lighting, undershelf lighting, interior lighting of display cabinets, and switched outlets are controlled separately from ceiling installed lighting.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

G. Screw Based luminaires

01	150.0(k)1B: Screw based luminaires shall contain lamps that are marked with "JA8-2022" or "JA8-2022-E".

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

H. Address Signs

01	150.0(k)4: Internally illuminated address signs. Internally illuminated address signs shall either: • Comply with Section 140.8. Applicable nonresidential sign lighting compliance forms shall also be submitted; or • Consume no more than 5 Watts of power.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

I. Outdoor Lighting and Controls

01	150.0(k)1A and Table 150.0-A: High efficacy outdoor lighting or LED light sources are installed.
02	150.0(k)3A: Outdoor lighting is controlled by a manual ON and OFF switch that permits one of the following automatic actions: • Controlled by a photocell and either a motion sensor or an automatic time switch control; or • Controlled by an astronomical time clock control. Controls that override to ON shall not be allowed unless the override automatically returns the automatic control to its normal operation within 6 hours. An energy management control that provides the specified lighting control functionality and complies with all requirements applicable to the specified controls may be used to meet the above requirements.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

J. Lighting for Residential Garages for Eight or More Vehicles

01	150.0(k)5: Lighting complies with the applicable requirements for nonresidential garages in Sections 110.9, 130.0, 130.1, 130.4, 140.6, and 141.0. Applicable LTG forms shall also be submitted.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

K. Blank Electrical Boxes

01	150.0(k)1E: The number of electrical boxes that are more than 5 feet above the finished floor and do not contain a luminaire or other device shall be no greater than the number of bedrooms. These electrical boxes must be served by a dimmer, vacancy sensor control, low voltage wiring or fan speed control.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT

1. I certify that this Certificate of Compliance documentation is accurate and complete.

Documentation Author Name:	Documentation Author Signature:
Documentation Author Company Name:	Date Signed:
Address:	CEA/HERS Certification Identification (If applicable):
City/State/Zip:	Phone:

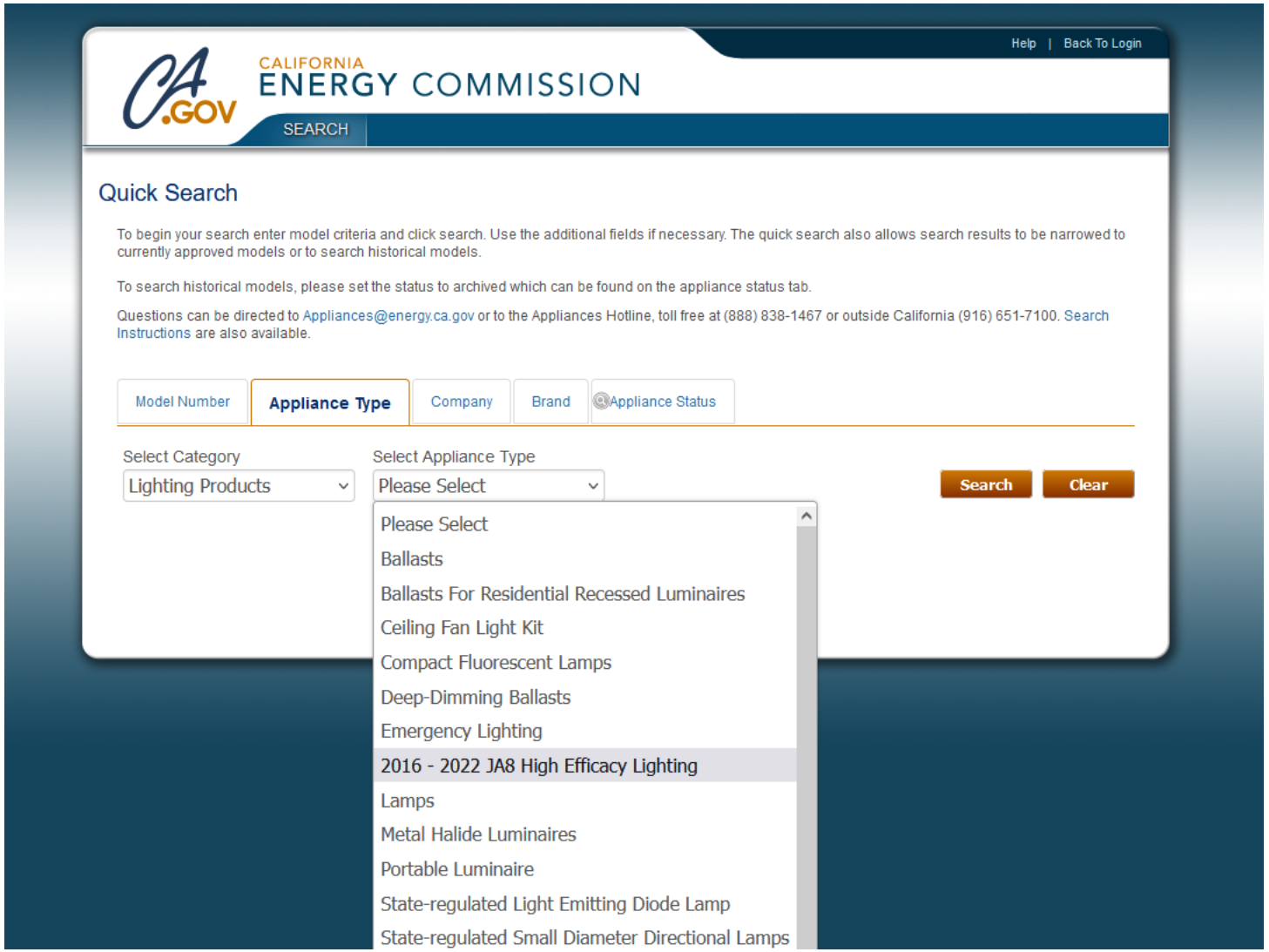
RESPONSIBLE PERSON'S DECLARATION STATEMENT

2. I certify the following under penalty of perjury, under the laws of the State of California:
    1. The information provided on this Certificate of Installation is true and correct.
    2. I am either: a) a responsible person eligible under Division 3 of the Business and Professions Code in the applicable classification to accept responsibility for the system design, construction, or installation of features, materials, components, or manufactured devices for the scope of work identified on this Certificate of Installation, and attest to the declarations in this statement, or b) I am an authorized representative of the responsible person and attest to the declarations in this statement on the responsible person's behalf.
    3. The constructed or installed features, materials, components or manufactured devices (the installation) identified on this Certificate of Installation conforms to all applicable codes and regulations and the installation conforms to the requirements given on the Certificate of Compliance, plans, and specifications approved by the enforcement agency.
    4. I understand that a registered copy of this Certificate of Installation shall be posted or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections, and I will take the necessary steps to ensure this requirement is accomplished.
    5. I understand that a registered copy of this Certificate of Installation is required to be included with the documentation the builder provides to the building owner at occupancy, and I will take the necessary steps to ensure this requirement is accomplished.

Responsible Builder/Installer Name:	Responsible Builder/Installer Signature:	
Company Name: (Installing Subcontractor or General Contractor or Builder/Owner)	Position With Company (Title):	
Address:	CSLB License:	
City/State/Zip:	Phone:	Date Signed:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

MODERNIZED APPLIANCE EFFICIENCY DATABASE SYSTEM (MAEDBS)



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

CONSTRUCTION & INSPECTION

Builder must provide new homeowners with a luminaire schedule that includes a list of installed lamps and luminaires.

Lighting inspections are made easier since all luminaires are high efficacy and there is a completed luminaire schedule for the owner.

Section 10-103(b)2

Photo: CLTC, UC Davis

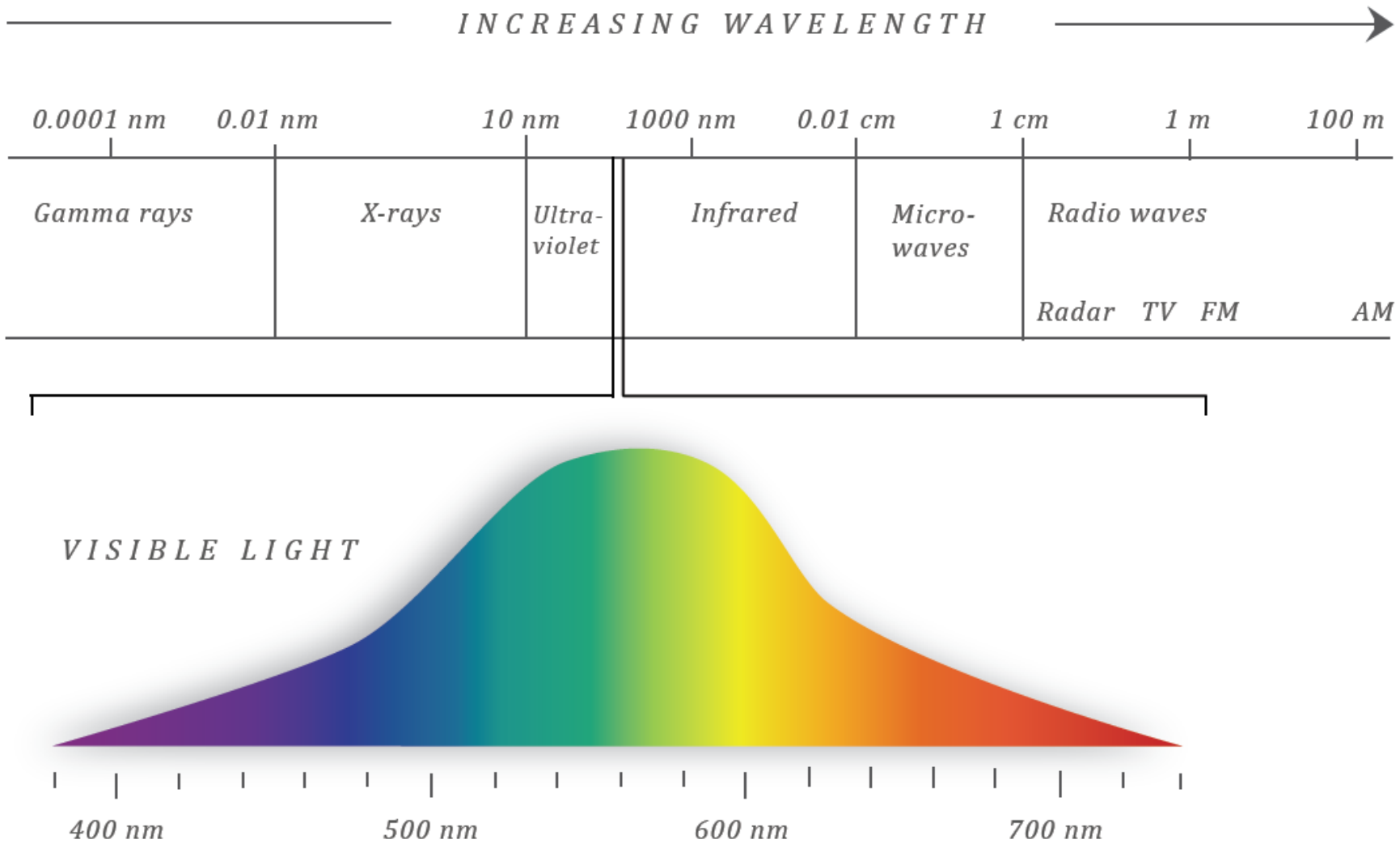
CONCEPTS & PRINCIPLES

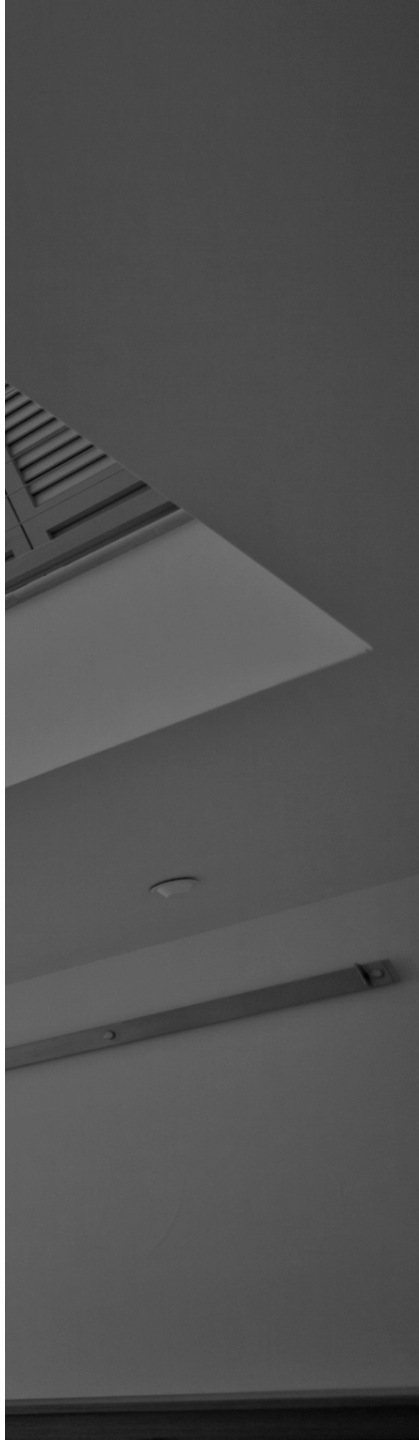
Photo: CLTC, UC Davis

LIGHTING & ENERGY EFFICIENCY

- Light Sources
  - One-time, long-term change
  - Reduction of baseline
    - Light source efficacy
    - Luminaire efficacy
    - Application efficacy
- Light Controls
  - Continuous, real-time change
  - Fluctuations from baseline
    - Dimming
    - Occupancy/vacancy

ELECTROMAGNETIC RADIATION



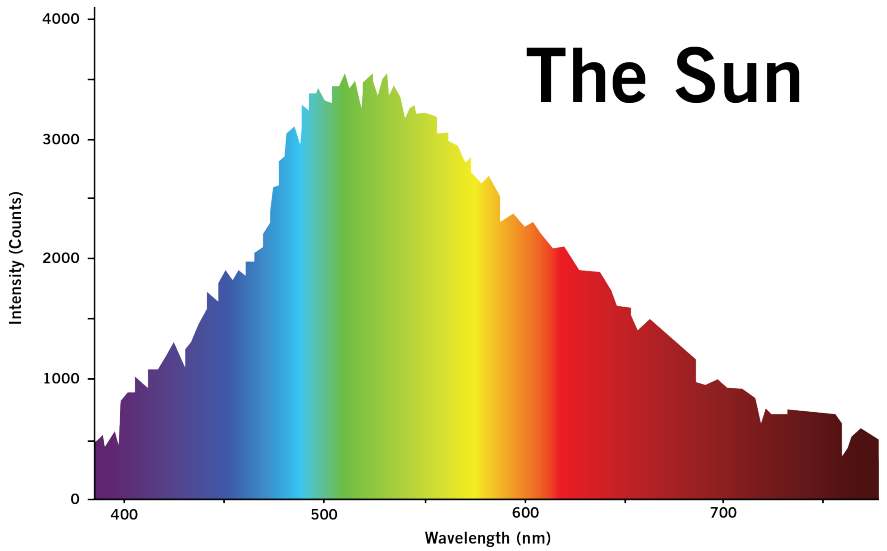


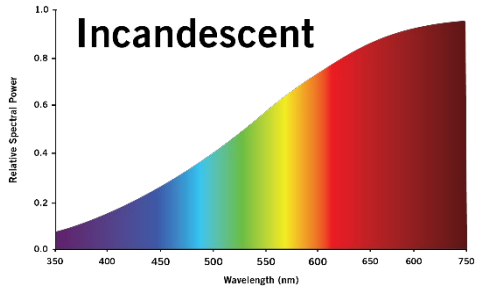
SPECTRAL POWER DISTRIBUTION

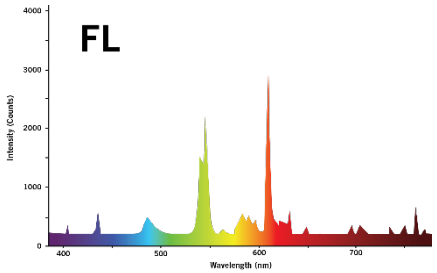
SPD: The radiant power emitted by a light source over a range of specified wavelengths, typically the visible range (approximately 360 nm to 830 nm)

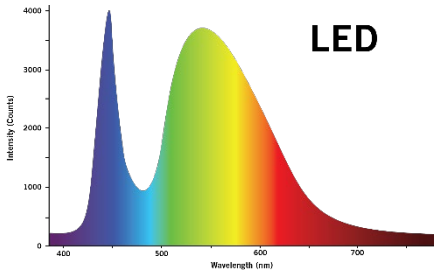
Which electric light source's spectral power distribution (SPD) is most similar to the sun's SPD?

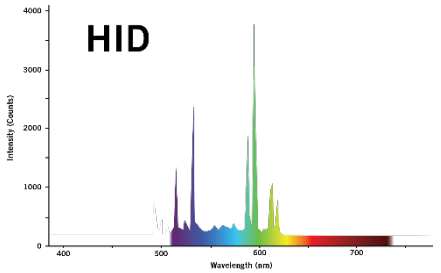
Why does this matter?











INTEGRATING SPHERE

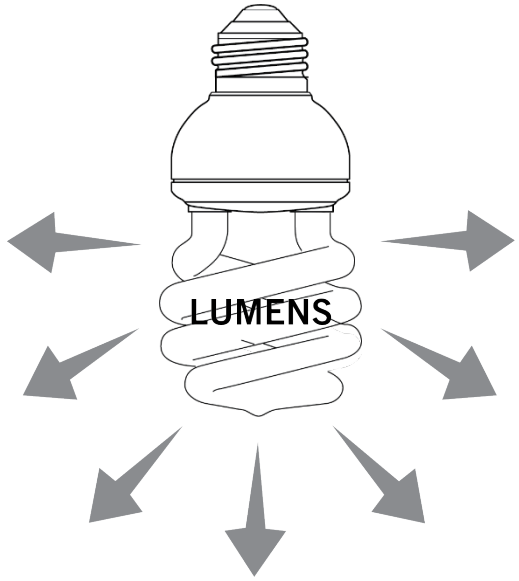
TERMINOLOGY

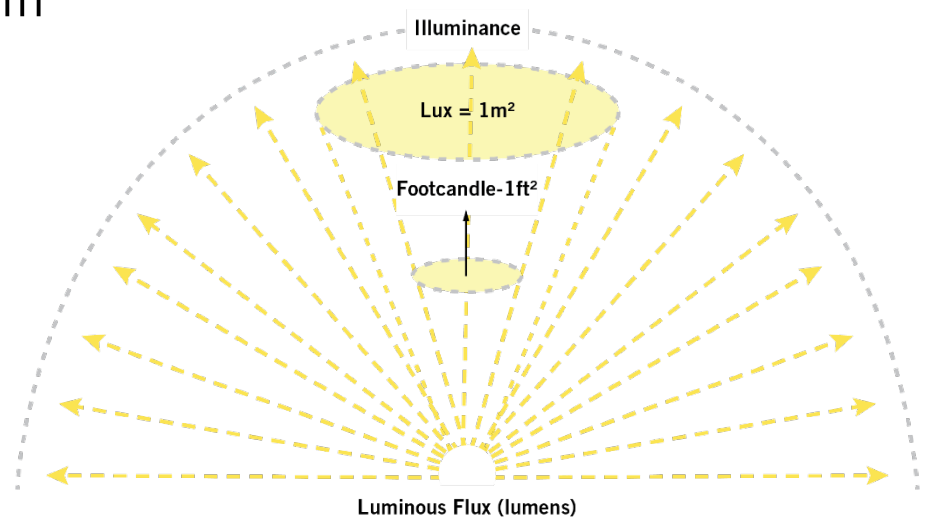
Luminous flux: rate of flow of visible light emitted from a light source over time, measured in lumens (lm).

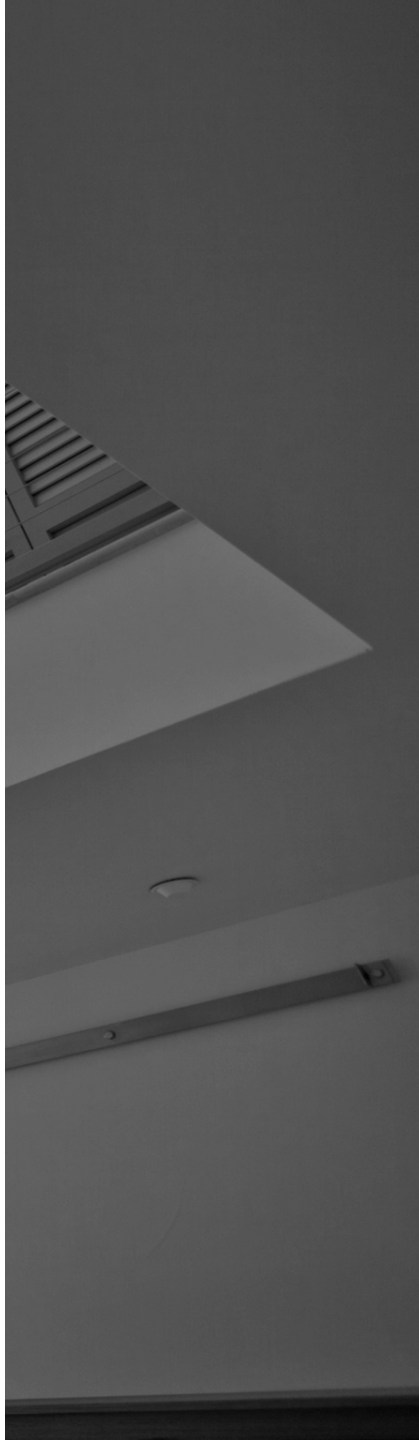
Luminous intensity of the measured solid angle (lm), where:
1 lumen = 1 candela * 1 steradian

Illuminance: the amount of luminous flux that covers a surface (measured in lux or footcandles).

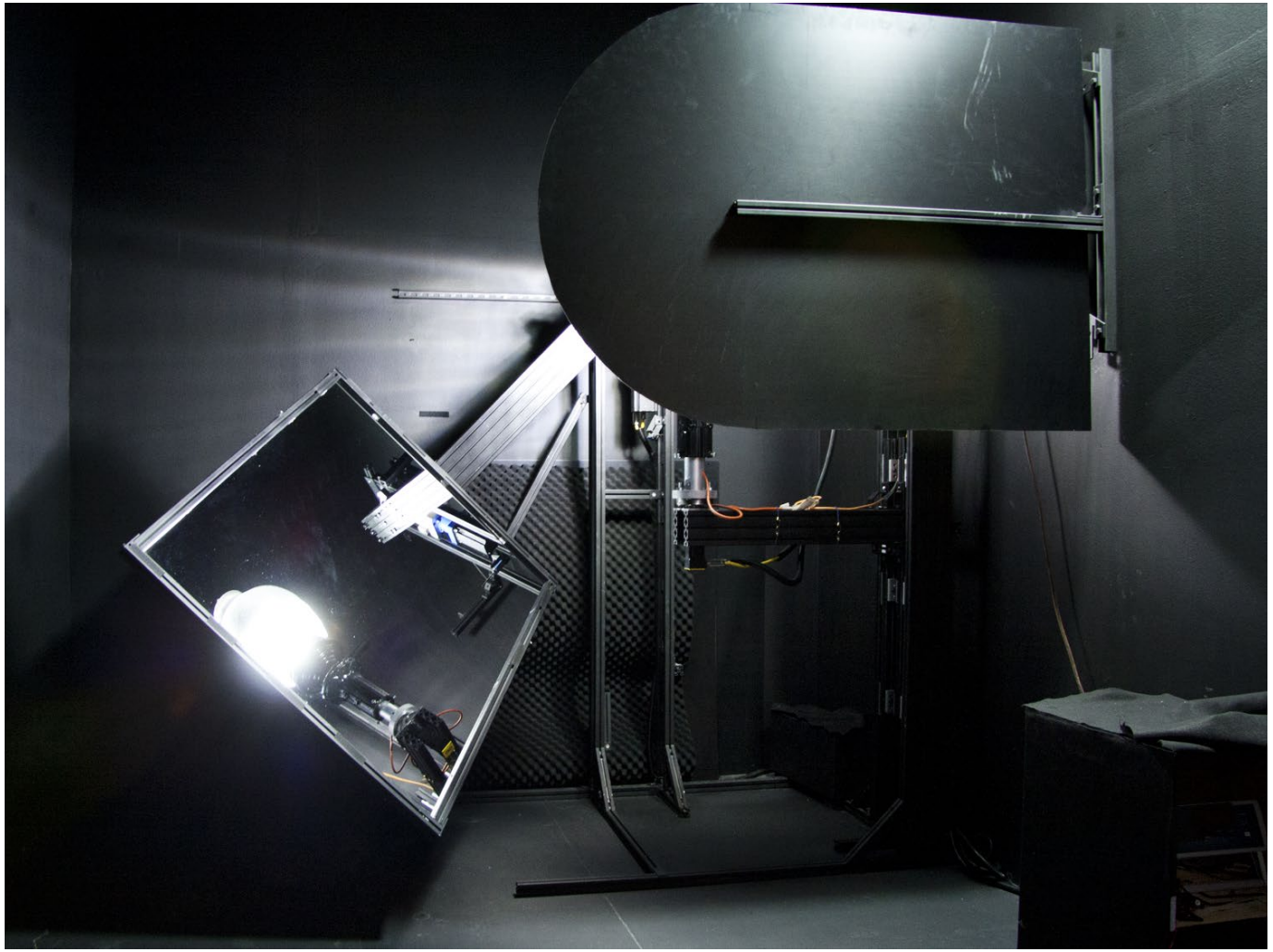
Footcandle: equal to one lumen per square foot **(1 footcandle = 10 lux)**.





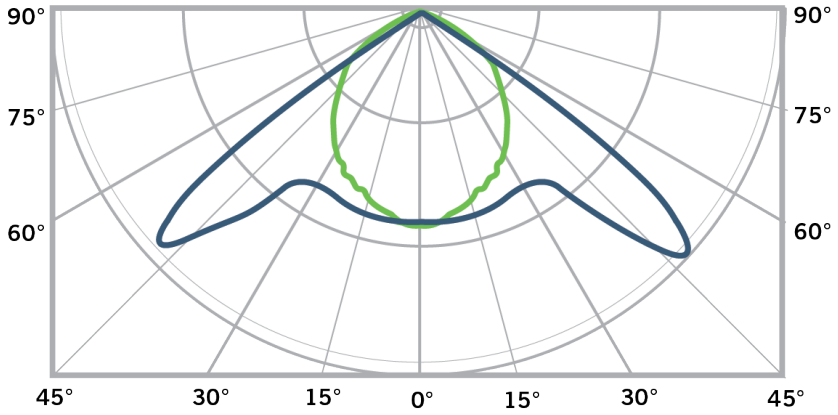


GONIOPHOTOMETER

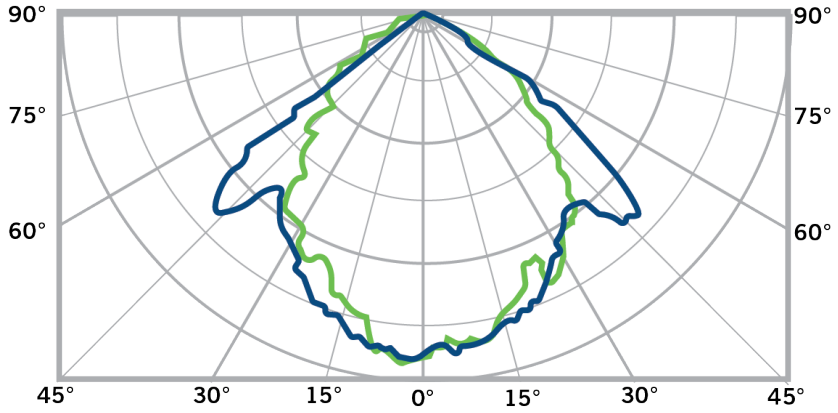


LUMINOUS INTENSITY (CANDELA)

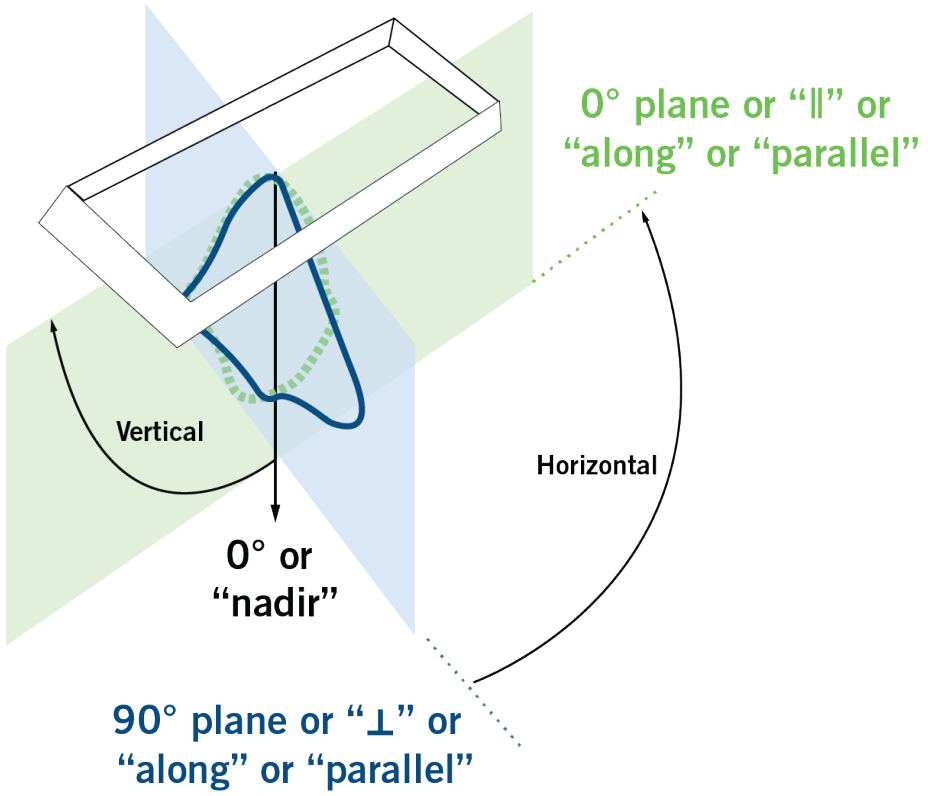
A: LED tube with diffuser



B: LED tube using high-intensity LEDS

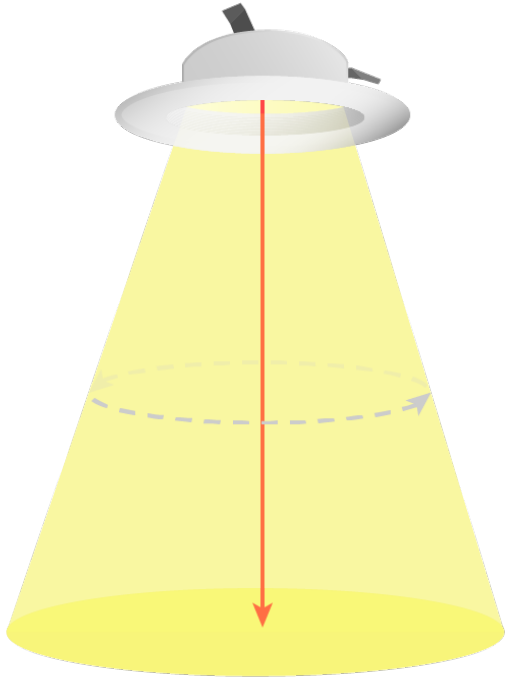


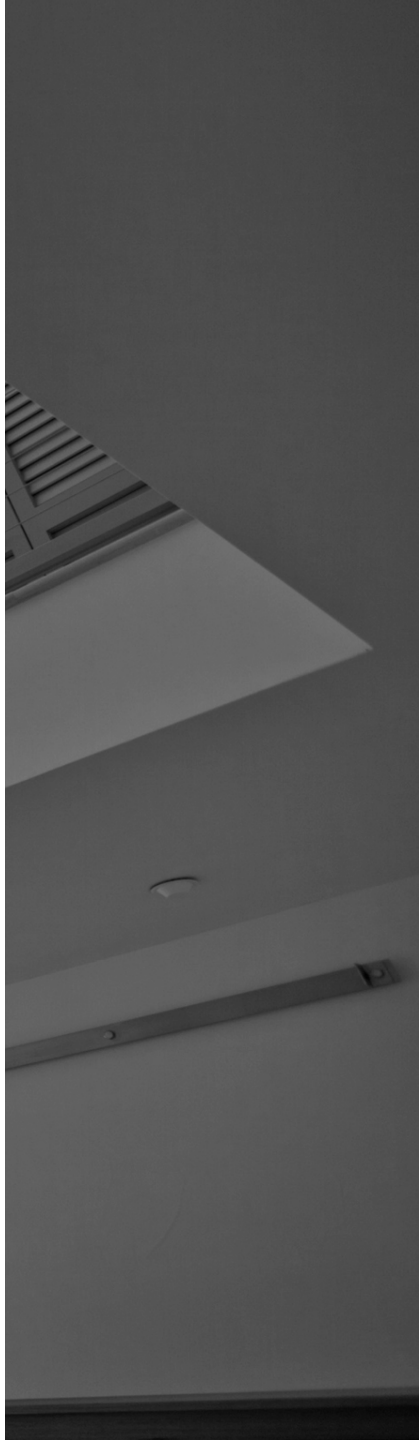
The green and blue lines represent light intensity distribution patterns in the axial and traverse planes, respectively.



LUMINOUS INTENSITY (CANDELA)

- Intensity of light emitted in a specific direction
- Unit is candela (cd)
- Used to rate the output of directional lamps and light distribution of luminaires
- The luminous intensity of a source expressed in candelas is called its candlepower (cp)



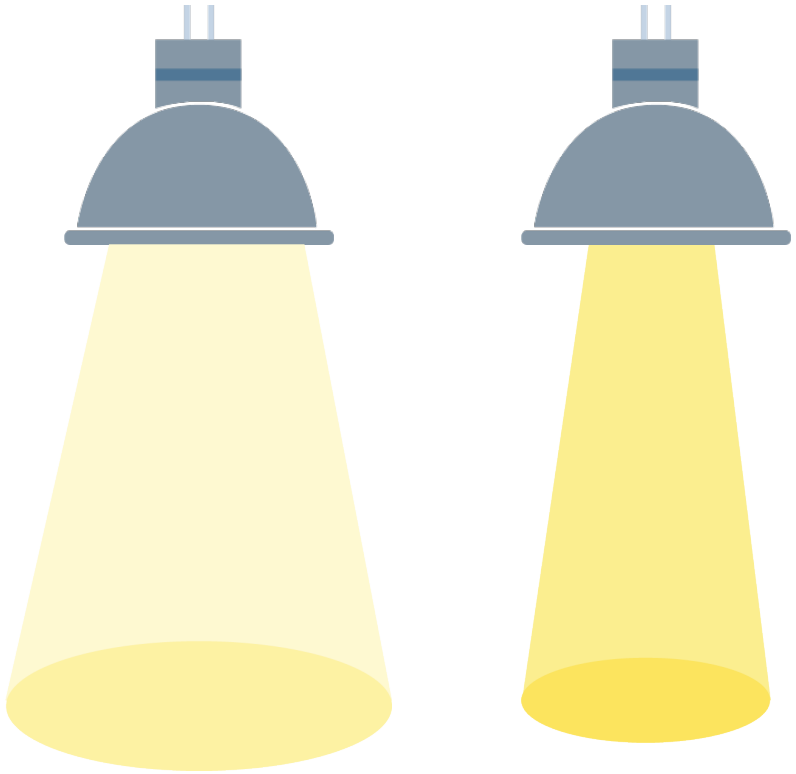


TERMINOLOGY

Luminous Intensity: the concentration of light emitted from a given source in a particular direction, measured in candela (cd) (1 cd = 1 lm per steradian).

LED MR16

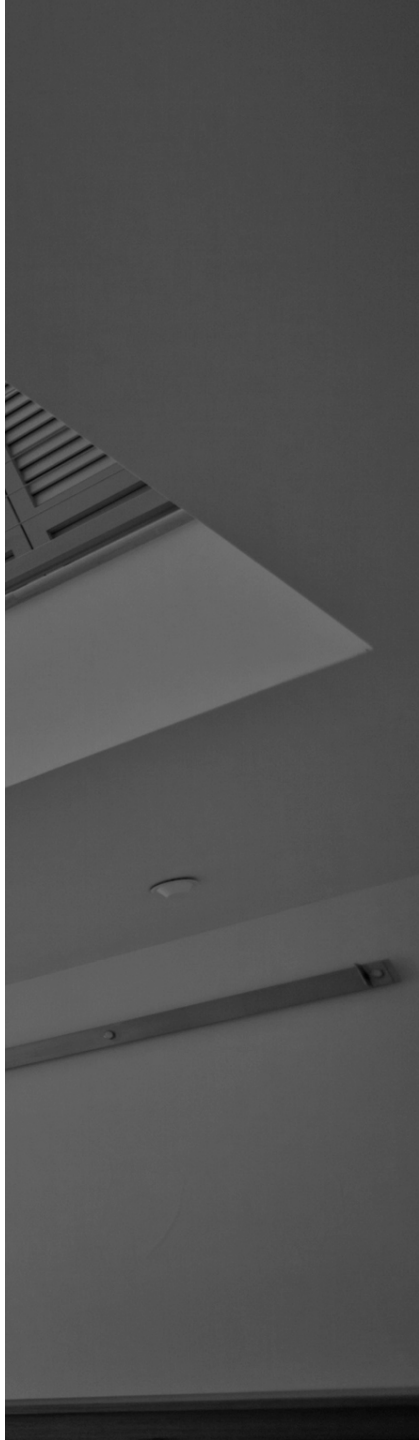
4 watts | 12 volts
Beam Angle: 25°
CBCP: 760 cd
Brightness: 190 lm



LED MR16

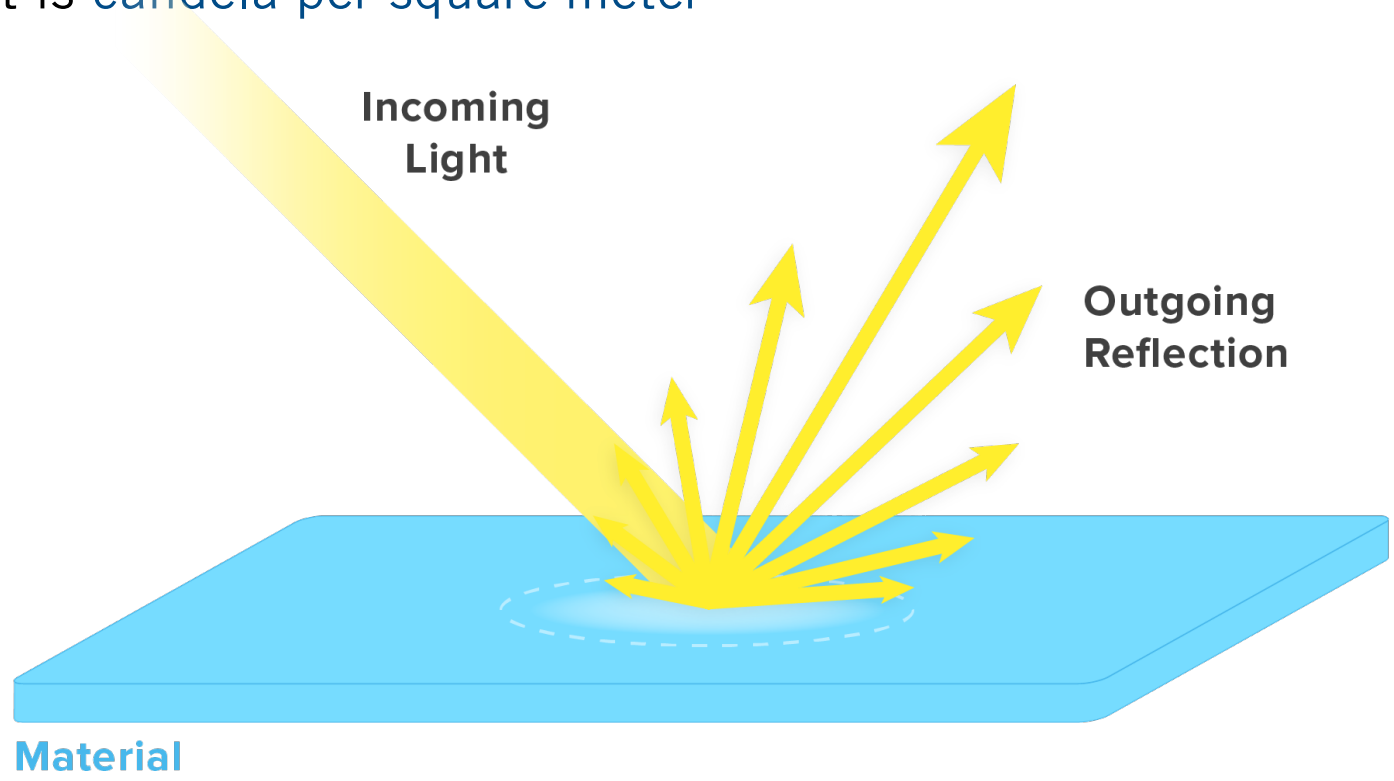
4 watts | 12 volts
Beam Angle: 15°
CBCP: 1550 cd
Brightness: 190 lm

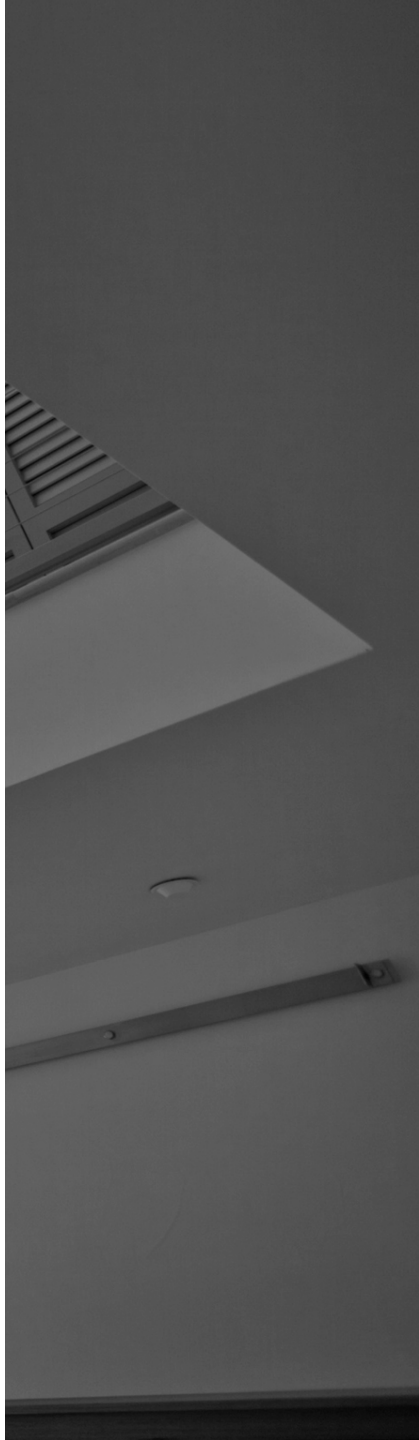
*Note: color represents intensity, not CCT or CRI



LUMINANCE (CANDELA PER METER^2)

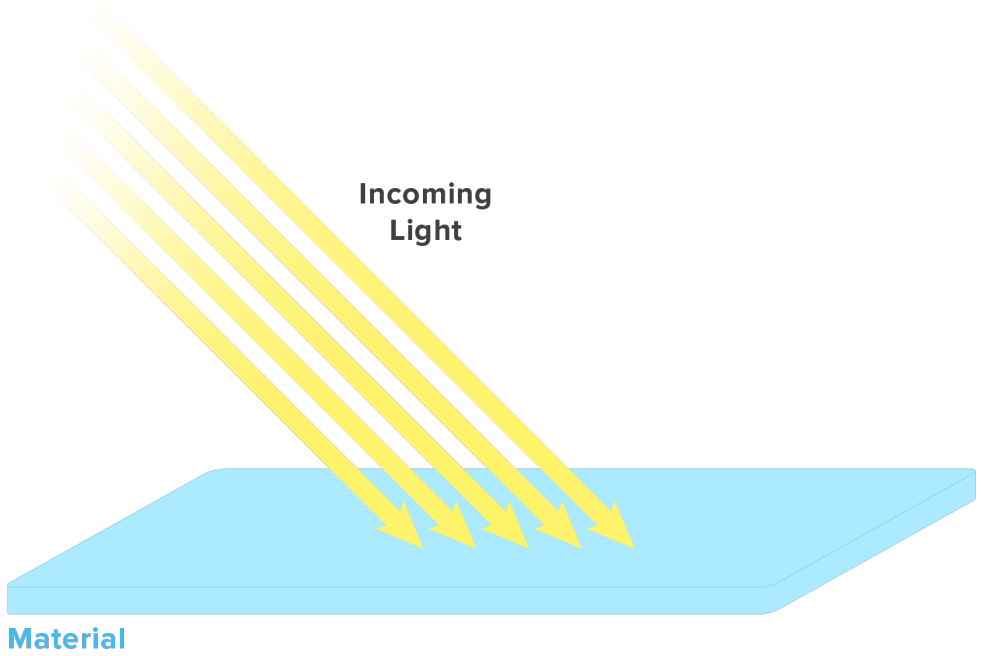
- Light emitted, reflected, or transmitted from or through a surface from a solid angle
- Specific to the direction of travel of the light
- US Unit is candela per square foot
- SI Unit is candela per square meter



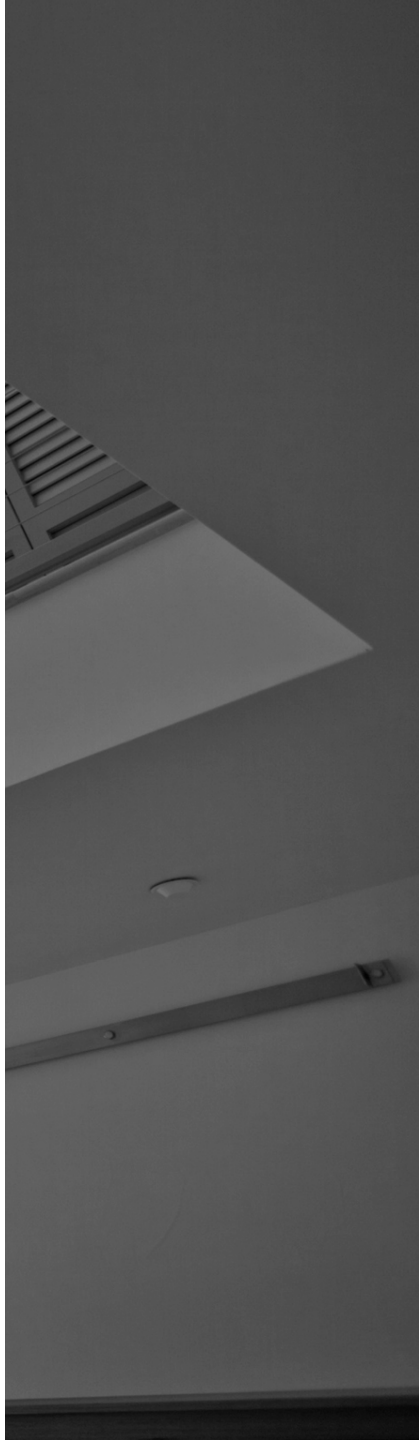


ILLUMINANCE (FOOTCANDLE OR LUX)

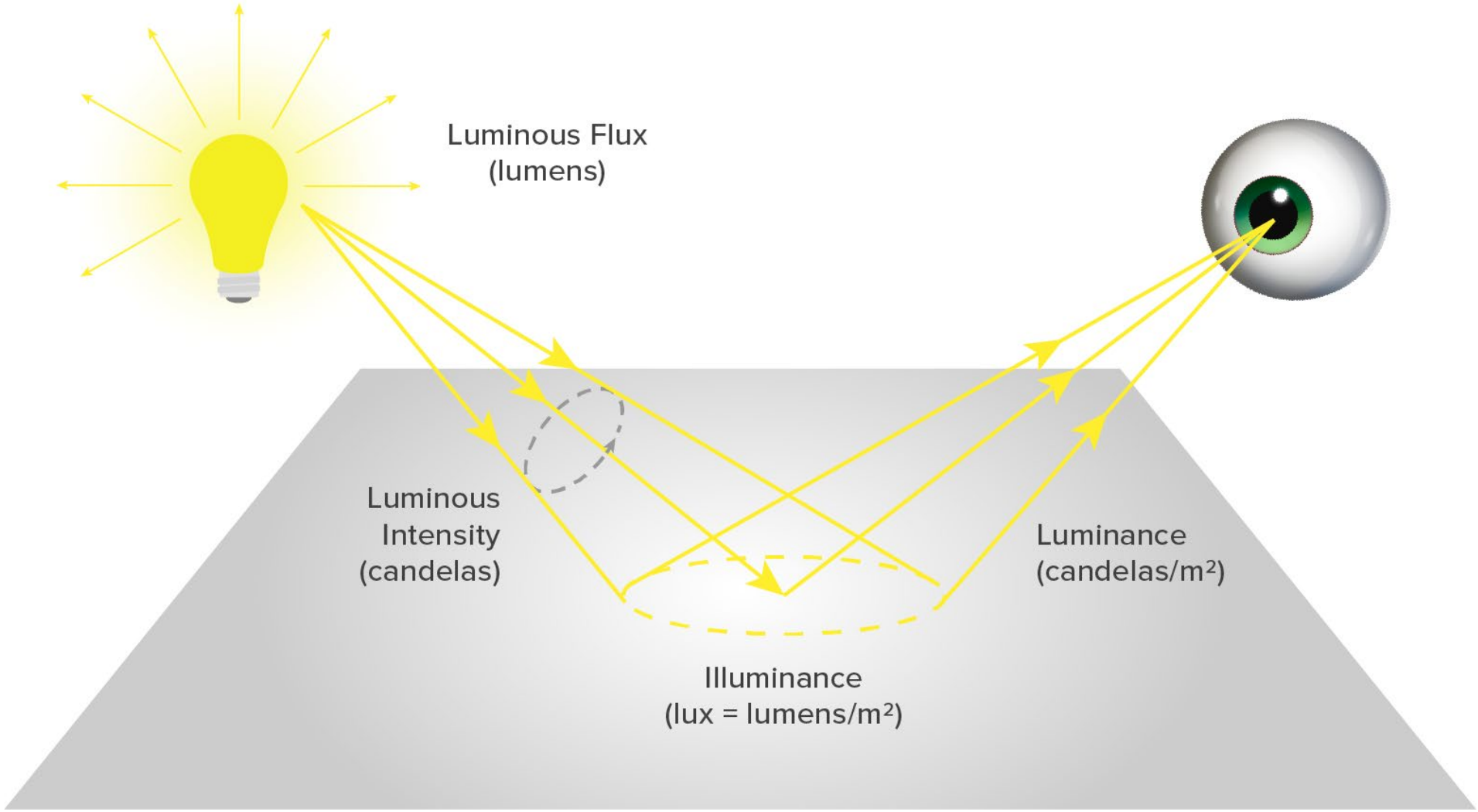
- Density of light striking a material surface
- Surface can be real or imaginary
  - A plane or a point in space
- US Unit is footcandle (fc)
  - One Lumen per one square foot
- SI Unit is lux (lx)
  - One lumen per one square meter
- Horizontal and/or vertical levels may be critical depending on the application and type of task



10.76 lux = 1 foot-candle,
~10 lux = 1 foot-candle

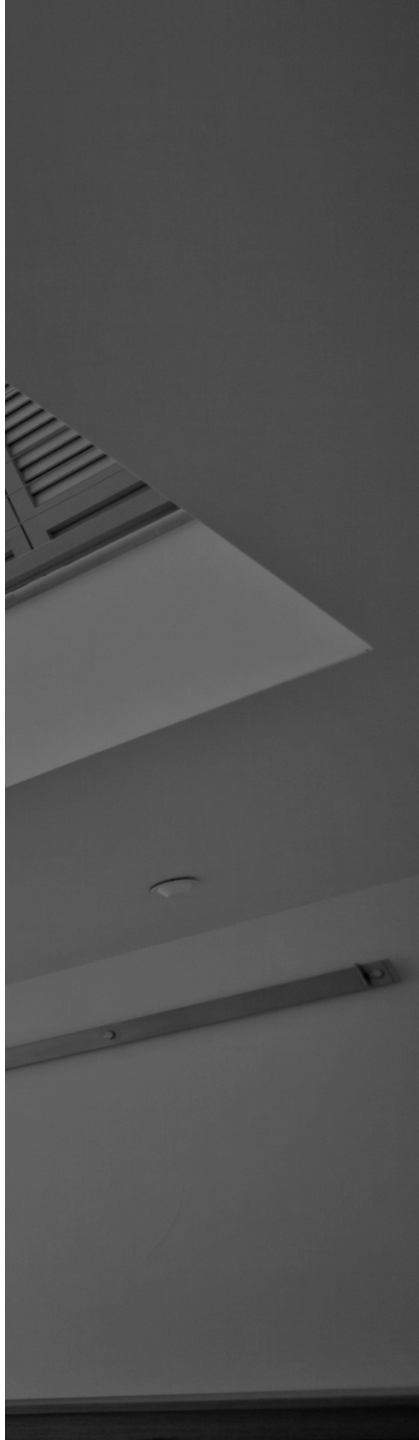


MEASUREMENT OF LIGHT



IES ILLUMINANCE RECOMMENDATIONS

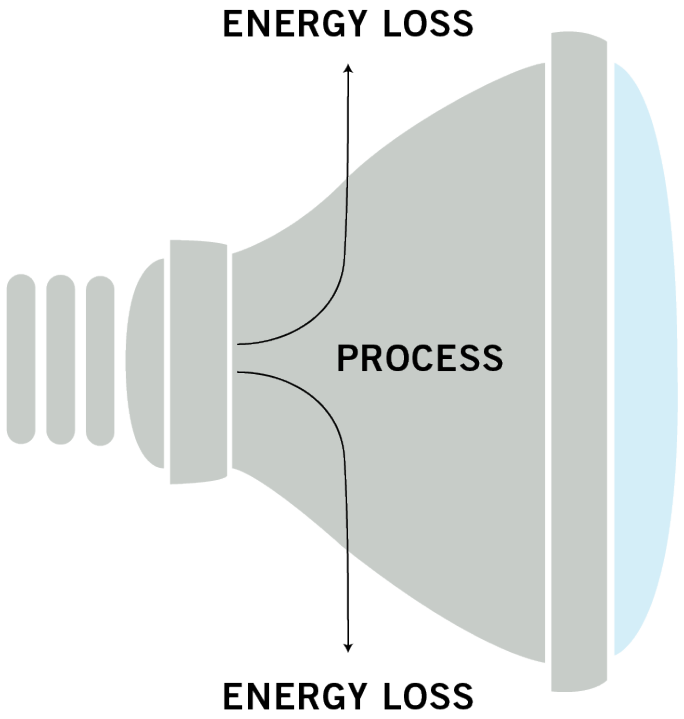
Category	Building Types
A (3fc)	**Public spaces** (Movie theater, observatory)
B (5fc)	**Orientation for short visits** (Public auditorium, night club, arcade)
C (10fc)	**Working spaces for simple visual tasks** (Art gallery, restaurant, parking garage, public restroom)
D (30fc)	**Performance of visual tasks of high contrast and large size** (Coliseum/arena, school gymnasium, chapel, grocery store, commercial building)
E (50fc)	**Performance of visual tasks of high contrast and small size or tasks of low contrast and large size** (School, medical laboratory, computer processing office, vehicle repair center)
F (100fc)	**Performance of visual tasks of low contrast and small size** (Hospital facilities, veterinary clinic)
G (800fc)	**Performance of visual tasks near threshold** (Operating table)

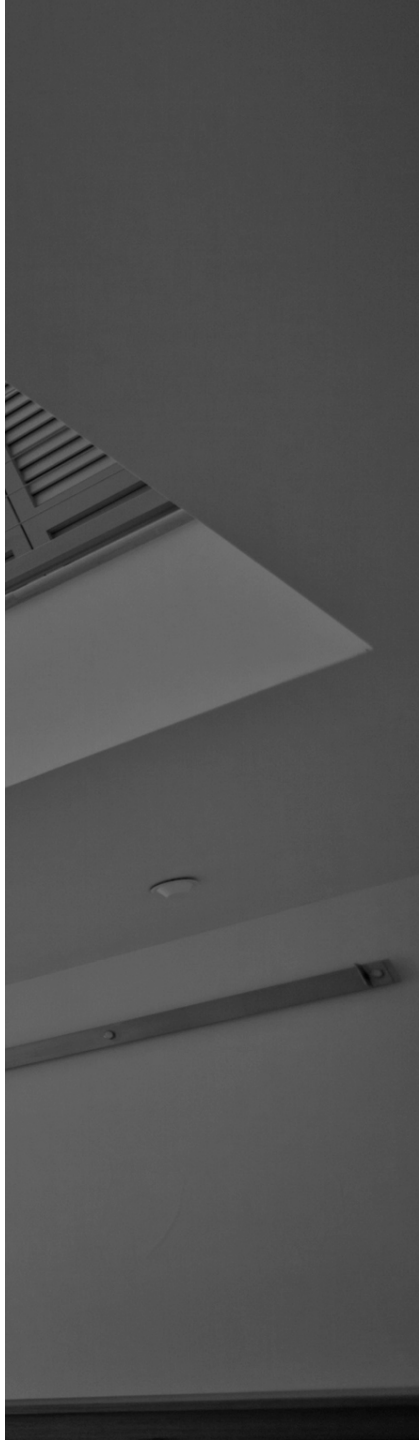


ELECTRICAL CHARACTERISTICS

Efficiency: the ratio between the useful output of energy and the input of energy.

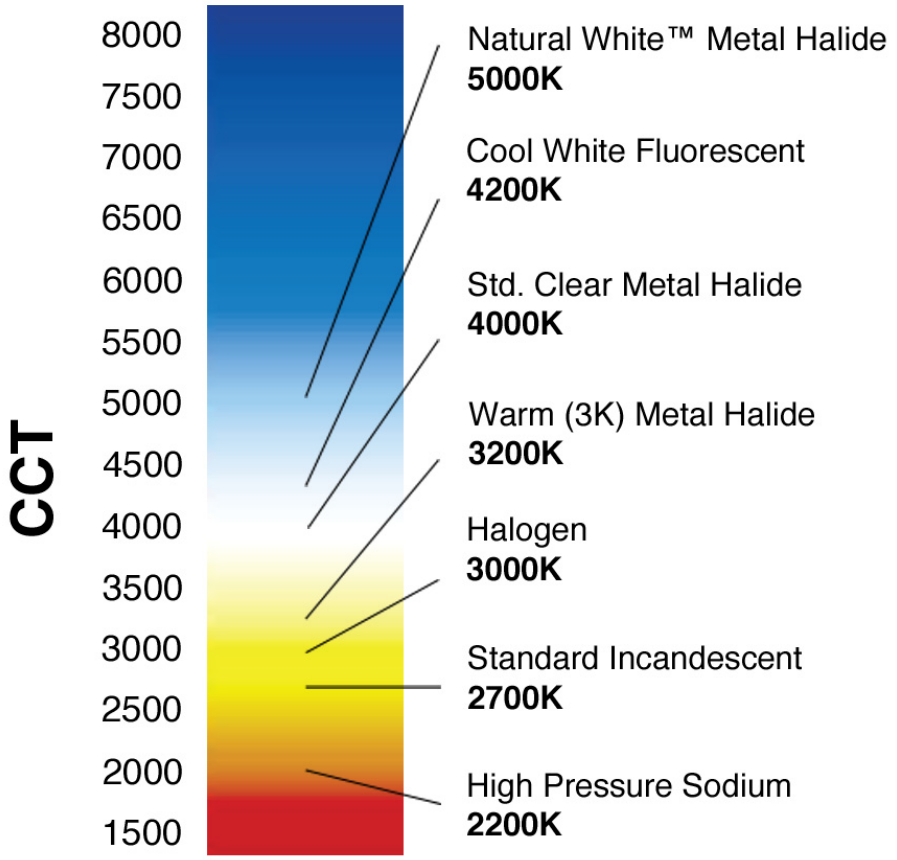
Luminous Efficacy compares the amount of light produced by a lamp (lumens), to amount of power consumed to produce it (watts).

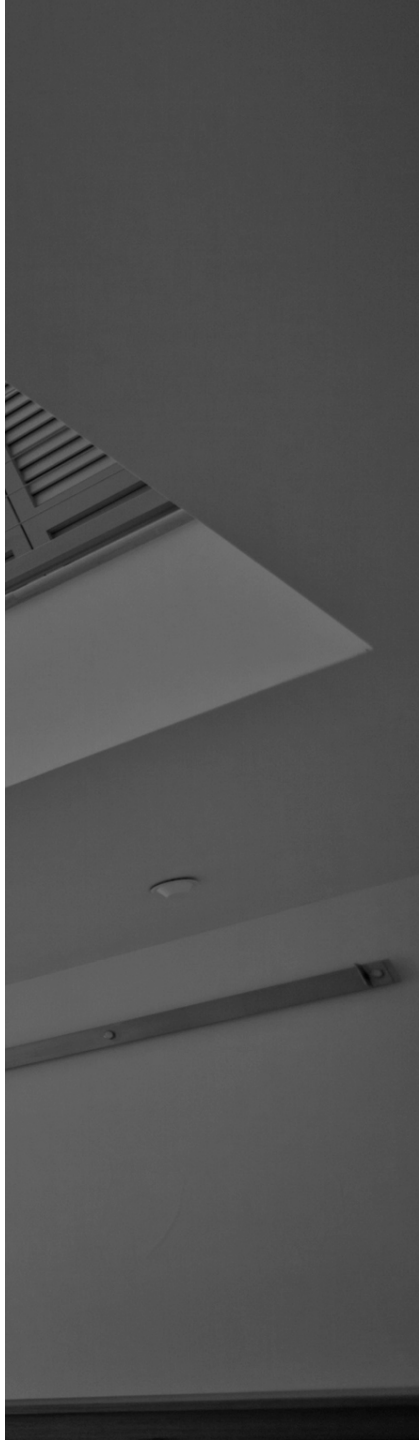




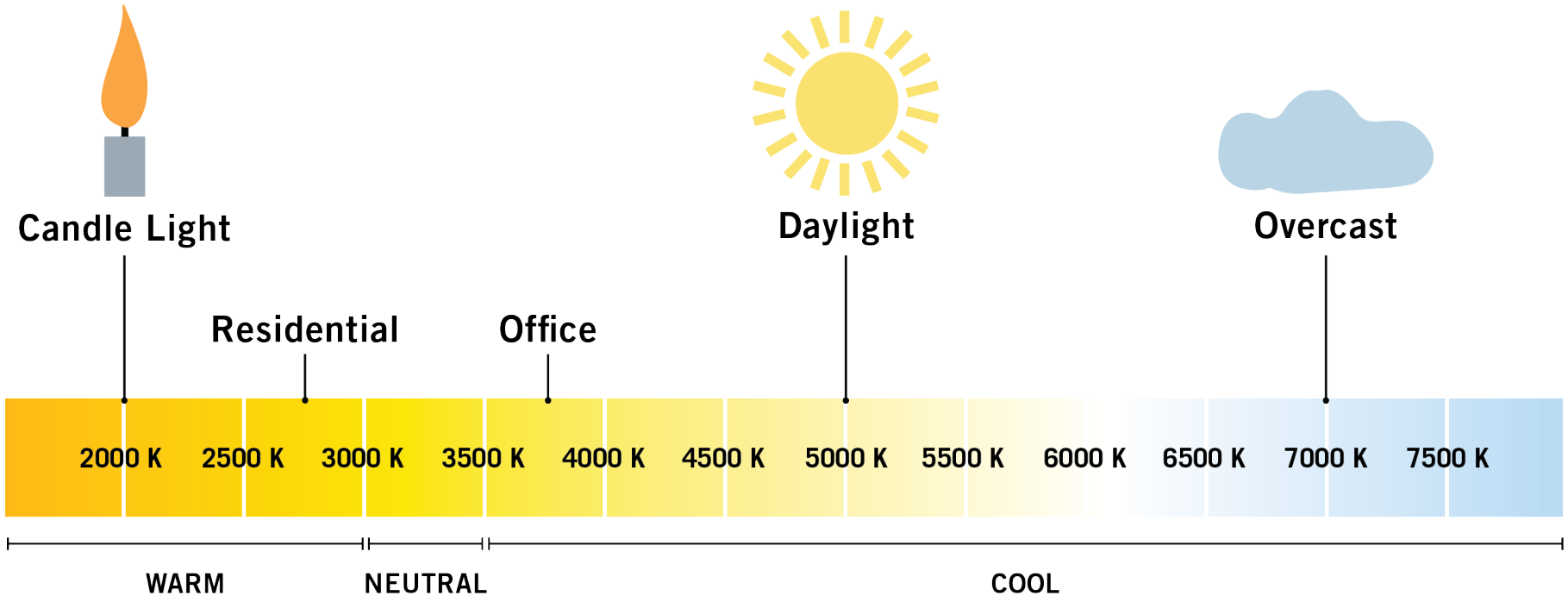
CORRELATED COLOR TEMPERATURE (CCT)

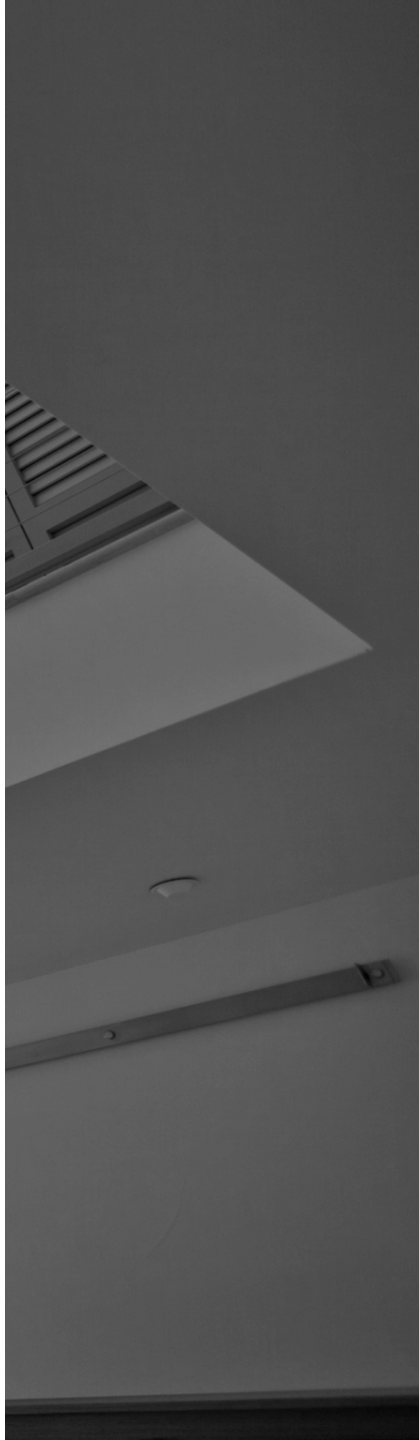
A specification of the color appearance of light emitted by a lamp, relating its color to the color of light from a source when heated to a particular temperature.





CORRELATED COLOR TEMPERATURE (CCT)





COLOR RENDERING INDEX

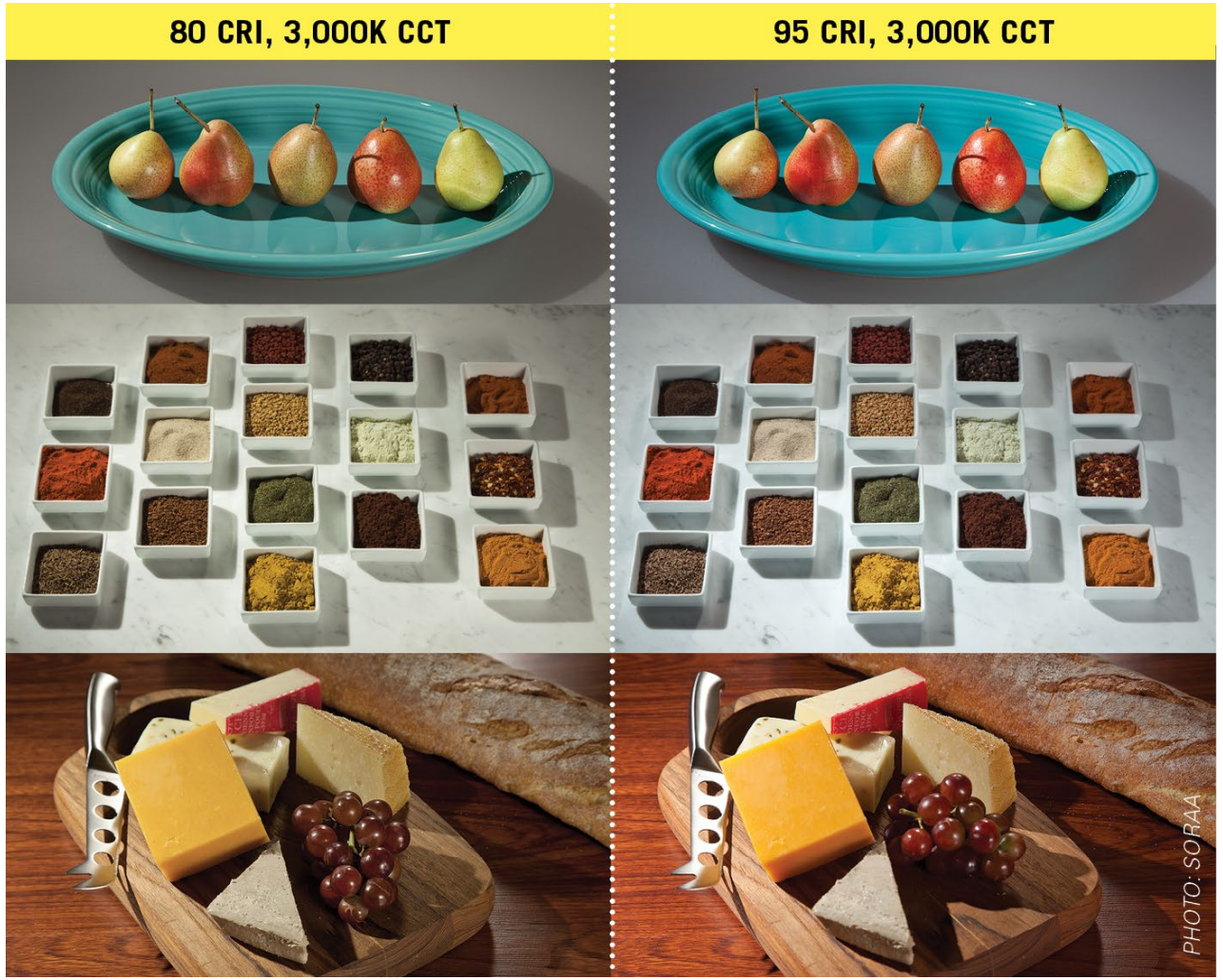
- Color rendering is defined as “Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant” (CIE 17.4–1987)
- It is the only color rendering metric with widespread acceptance
- It is calculated by comparing the color appearance of the test source to a reference source for 8 reflective samples (Score from 1–100)
- All other aspects of the source for a true comparison should be the same

The same nail polish under two different light sources

High CRI Light Source

Low CRI Light Source

COLOR RENDERING INDEX



LIGHTING FACTS LABEL

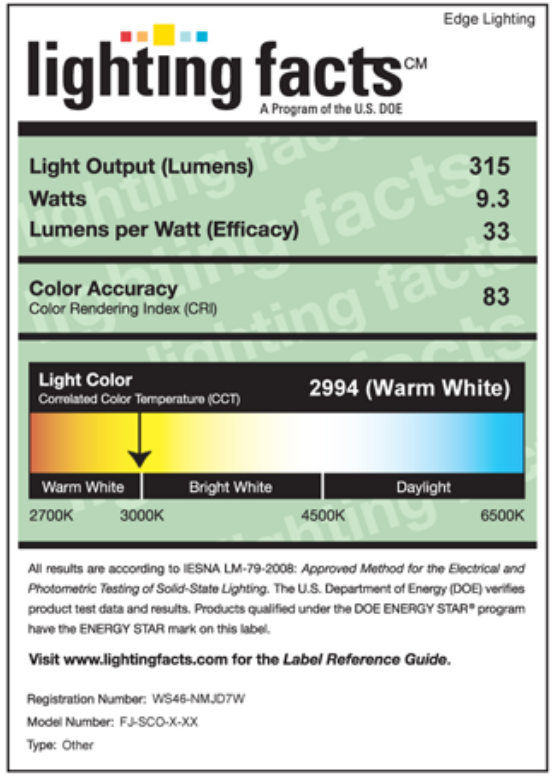
Light Output/Lumens
Measures light output. The higher the number, the more light is emitted.
Reported as "Total Integrated Flux (Lumens)" on LM-79 test report.

Watts
Measures energy required to light the product. The lower the wattage, the less energy used.
Reported as "Input Power (Watts)" on LM-79 report.

Lumens per Watt/Efficacy
Measures efficiency. The higher the number, the more efficient the product.
Reported as "Efficacy" on LM-79 test report.

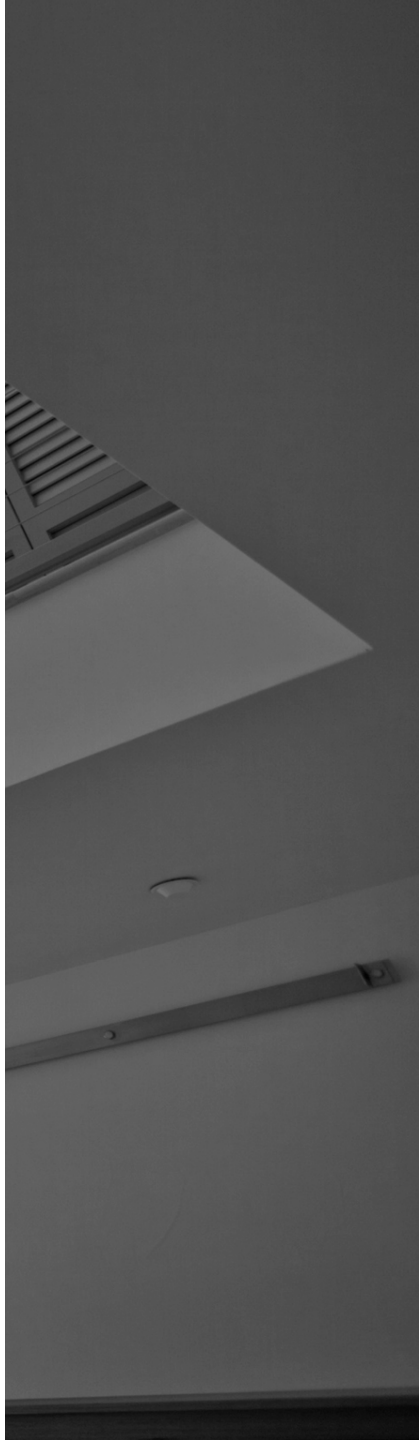
IESNA LM-79-2008
Industry standardized test procedure that measures performance qualities of LED luminaires and integral lamps. It allows for a true comparison of luminaires regardless of the light source.

Brand & Model Number



Color Rendering Index (CRI)
Measures color accuracy.
Color rendition is the effect of the lamp's light spectrum on the color appearance of objects.

Correlated Color Temperature (CCT)
Measures light color.
"Cool" colors have higher Kelvin temperatures (3600–5500K); "Warm" colors have lower color temperatures (2700–3500K).



TECHNOLOGY REQUIREMENTS

TWO STRATEGIES, THREE MAIN TECHNOLOGIES

HIGH EFFICACY LIGHT SOURCES

These light sources are designed and built to operate only high efficacy light sources, as defined by the California Energy Commission. Select sources are automatically considered high efficacy, while others must meet criteria.

SENSORS

Occupancy/vacancy sensors and daylight sensors are all devices that automatically turn lights off (or dim them) in response to conditions that they “sense” or “see.”

DIMMERS

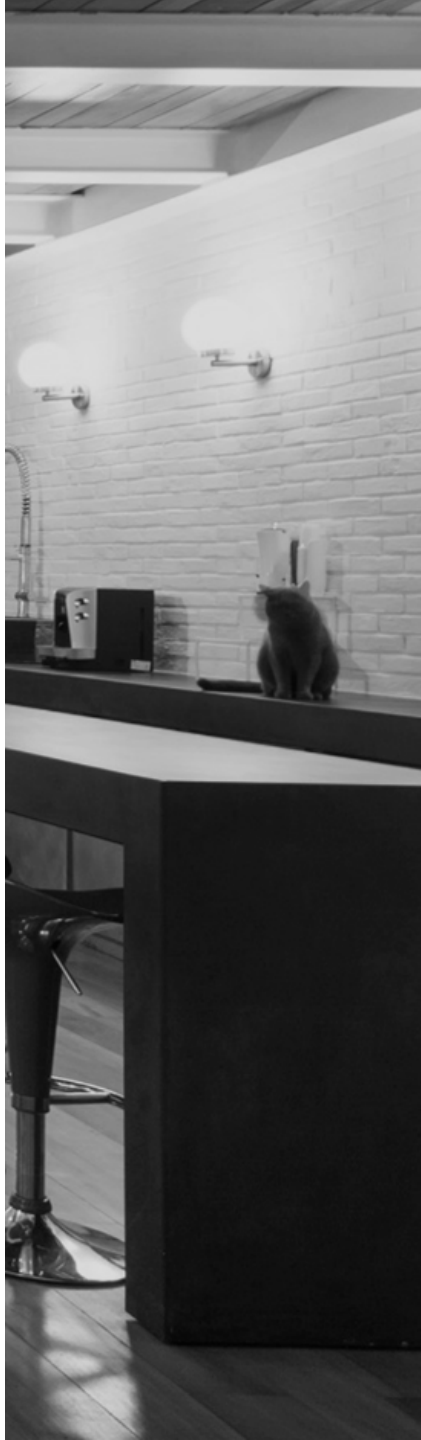
Dimmers, which are already common in many residential applications, allow room occupants to lower lighting levels (and thus energy use) as desired.

LIGHT SOURCES

LUMINAIRE REQUIREMENTS

- Luminaire Efficacy
- Screw based Luminaires
- Recessed Downlight Luminaires
- Light sources in Enclosed or Recessed Luminaires
- Blank Electrical Boxes

Section 150(k)1



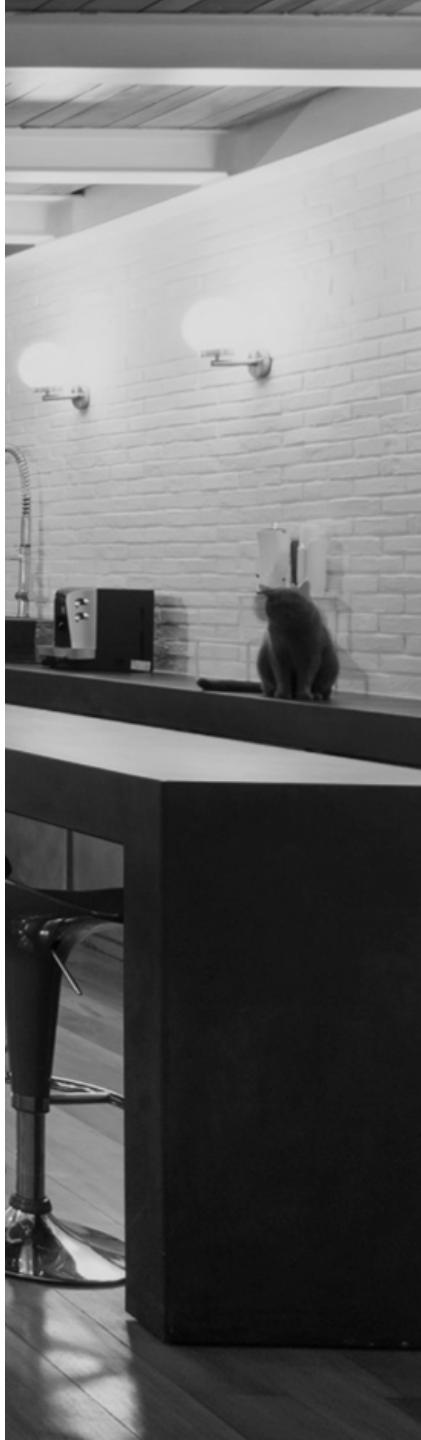
HIGH EFFICACY LIGHTING

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

Light sources in this column, other than those installed in ceiling recessed downlight luminaires, are classified as high luminous efficacy and are not required to comply with Reference Joint Appendix JA8.	**Light sources in this column are required to comply with Reference Joint Appendix JA8 and shall be certified and marked as required by JA8.**
1. LED light sources installed outdoors. 2. Inseparable Solid State Lighting (SSL) luminaires containing colored light sources that are installed to provide decorative lighting. 3. Pin-based linear fluorescent or compact fluorescent light sources using electronic ballasts. 4. High intensity discharge (HID) light sources including pulse start metal halide and high pressure sodium light sources. 5. Luminaires with hardwired high frequency generator and induction lamp. 6. Ceiling Fan Light Kits subject to federal appliance regulations.	7. All light sources installed in ceiling recessed downlight luminaires. ***Note:*** *Ceiling recessed downlight luminaires shall not have screw base sockets regardless of lamp type as specified in Section 150.0(k)1C.* 8. Any light source not otherwise listed in this table.

New!

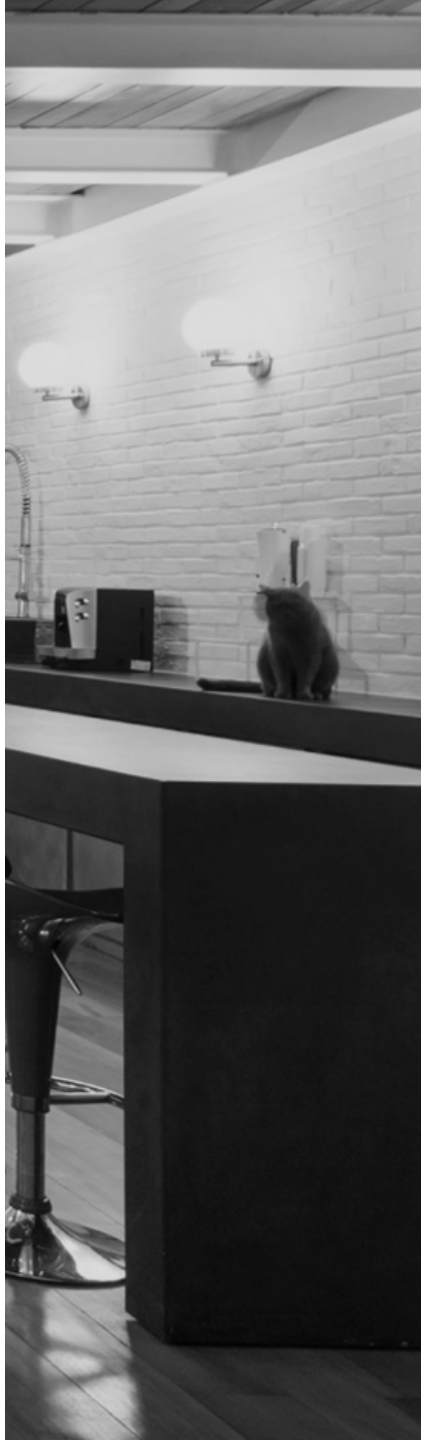
Section 150(k)1A



HIGH EFFICACY LIGHTING

Light Sources that are ***always*** considered 'high efficacy' by the Energy Code:

1. LED light sources installed outdoors
2. Inseparable SSL luminaires containing colored light sources that are installed to provide decorative lighting
3. Pin-based linear or compact fluorescent light sources paired with electronic ballasts
4. Pulse-start metal halide
5. High pressure sodium
6. Luminaires with hardwired high frequency generator and induction lamp
7. Ceiling fan light kits subject to federal appliance regulations



Section 150(k)1A

HIGH EFFICACY LIGHTING

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

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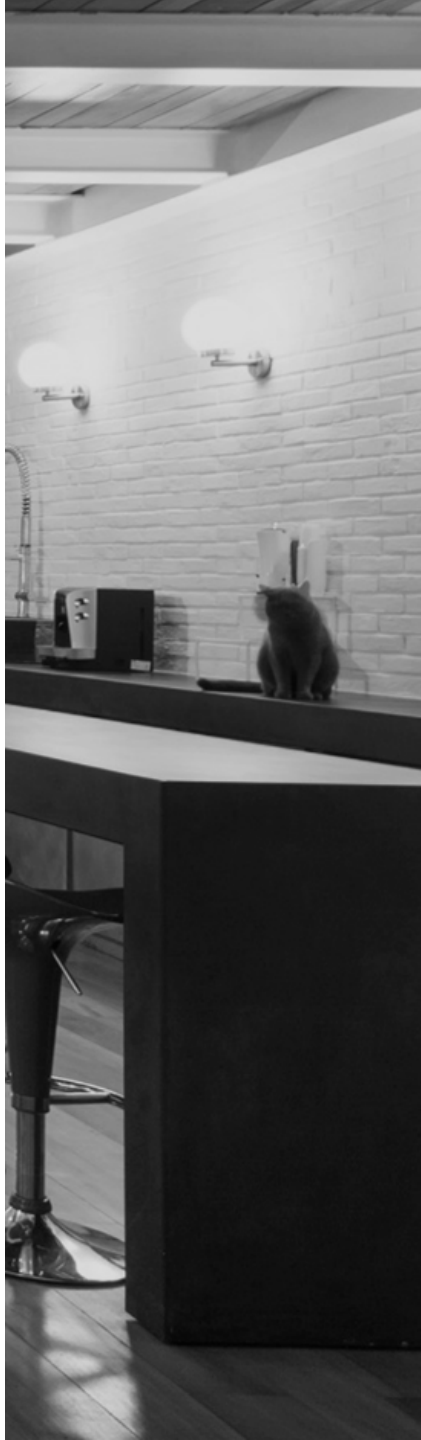
Section 150(k)1A



HIGH EFFICACY LIGHTING

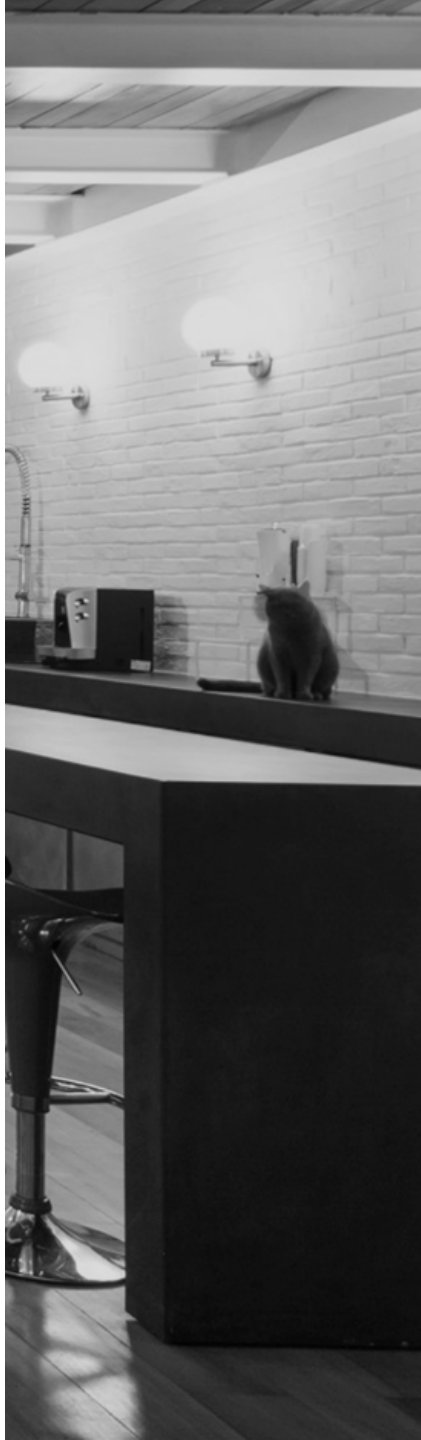
Light Sources that are considered ‘high efficacy’ by the Energy Code when they comply with ***JA8 requirements***:

1. All light sources in ceiling recessed downlight luminaires.
   - Note that ceiling recessed downlight luminaires shall not have screwbases regardless of lamp type
2. Any light source not otherwise listed in Table 150.0-A and certified to the Commission as complying with JA8

Photo: Frederick Ramond

Photo: Juno Lighting

Photo: Designer’s Fountain



HIGH EFFICACY LIGHTING – JA8

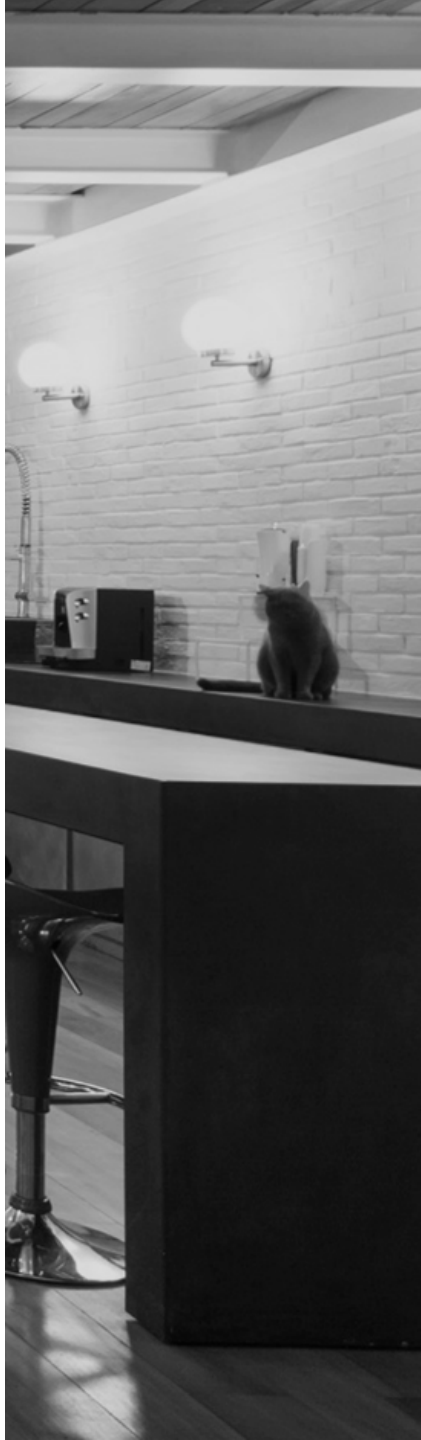
- High efficacy products include any luminaire that contains a JA8-compliant lamp or other approved light source **(Section 150.0(k) and Joint Appendix JA8)**
- Manufacturers must test their products at an accredited test laboratory and submit the results to the California Energy Commission to gain JA8 certification
- Must be certified and marked as either **JA8-2022** or **JA8-2022-E**
- Products certified to JA8-2016/JA8-2016-E do not need to be retested/certified to remain compliant with JA8-2019/JA8-2019-E.

2016 & 2019 markings a*lso valid for 2022 code cycle.

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

Specification	Requirement
Initial Efficacy	≥ 80 lm/W for state regulated LED lamps, 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 lamps; or ≥ 90 for all else
R1–8; R9	R1–R8 ≥ 72 for state regulated LED lamps; or R9 ≥ 50 for all else
Minimum Dimming Level	≤ 10% light output
Flicker	< 30% for frequencies of 200 Hz or below, at 100% and 20% light output

Section 150(k)1A



EXCEPTIONS TO HIGH EFFICACY REQUIREMENTS

LIGHTING INTEGRAL TO EXHAUST FANS, KITCHEN RANGE HOODS, BATH VANITY MIRRORS AND GARAGE DOOR OPENERS

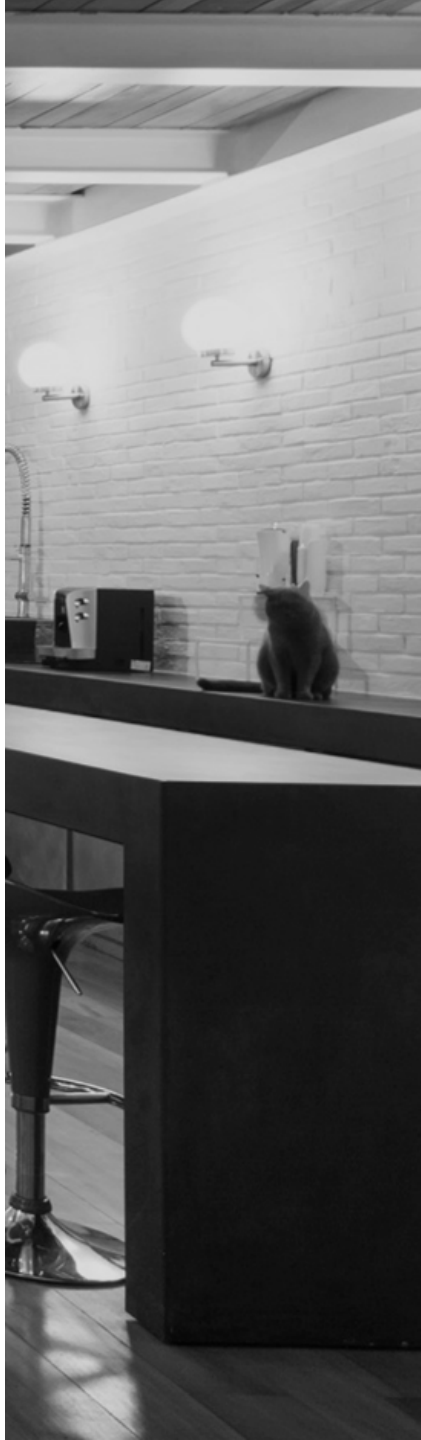
- Exempt if 5 W or less

NAVIGATION LIGHTING SUCH AS NIGHT LIGHTS, STEP LIGHTS, AND PATH LIGHTS

- Exempt if 5 W or less

LIGHTING INTERNAL TO DRAWERS, CABINETRY AND LINEN CLOSETS

- Exempt if 45 lm/W or greater



BLANK ELECTRICAL BOXES

APPLIES TO THE ENTIRE RESIDENCE:

- **What does 'blank electrical box' mean?**

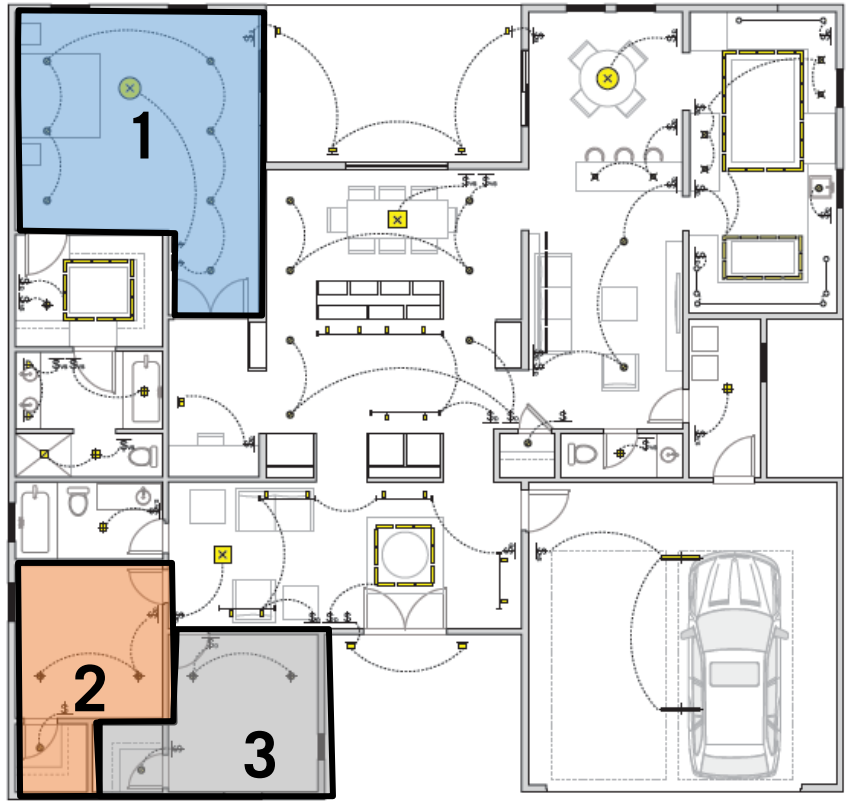
  Electrical box that does not contain a luminaire or other device

  AND

  Higher than 5 feet above the finished floor

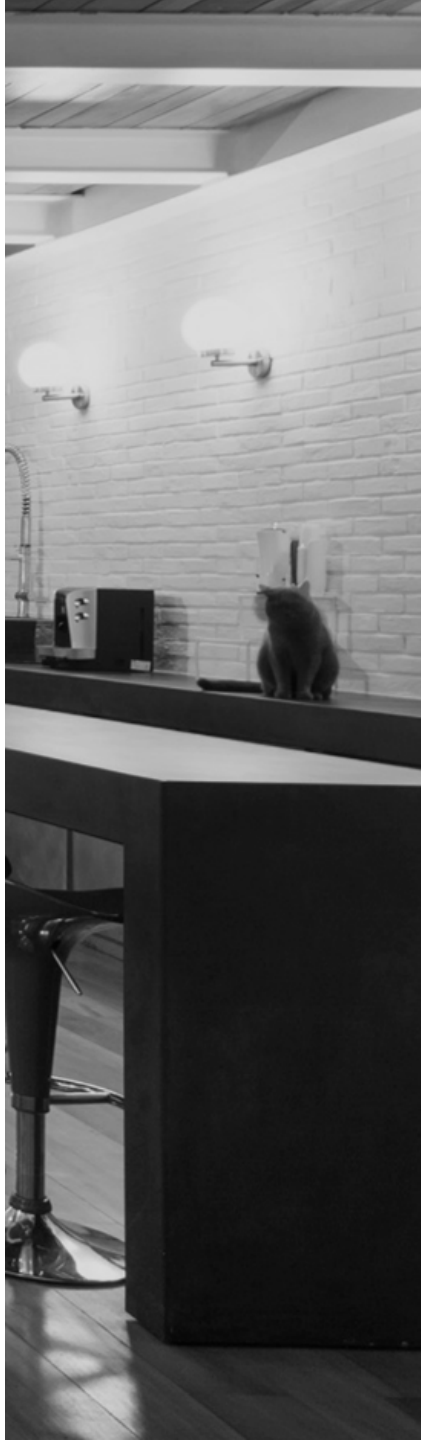
- **Number of blank electrical boxes shall be no greater than the number of bedrooms in the residence.**

- *How many blank electrical boxes is this residence allowed?*
  - *3 Bedrooms =*
    Up to 3 blank electrical boxes!



Additionally: *Blank electrical boxes must be controlled by dimmer, vacancy sensor control or fan speed control.*

Section 150(k)1B



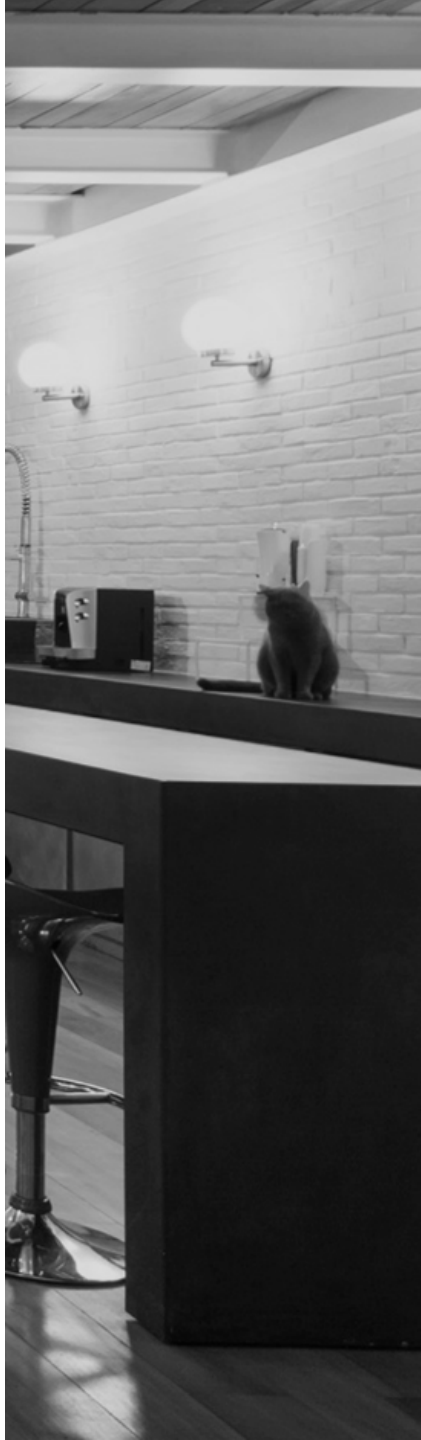
RECESSED DOWNLIGHT LUMINAIRES IN CEILINGS

MUST BE:

- Not containing of screw base sockets (E26)
- Approved for insulation contact (IC) by UL or equivalent laboratory
- Labeled certifying airtight (AT) according to ASTM E283
  - Air leakage is less than 2.0 CFM at 75 Pascals
  - Does not apply to exhaust fans **with integral light**
- Sealed with gasket or caulking between housing and ceiling and must have all air leak paths through luminaire assembly or ceiling opening sealed, or be installed per manufacturer's instructions to maintain airtightness
- **Meet the clearance and installation requirements of California Electrical Code Section 410.116 for recessed luminaires.**

EXCEPTION:
Recessed luminaires marked for use in fire-rated installations and recessed luminaires installed in non-insulated ceilings.

Section 150(k)1C

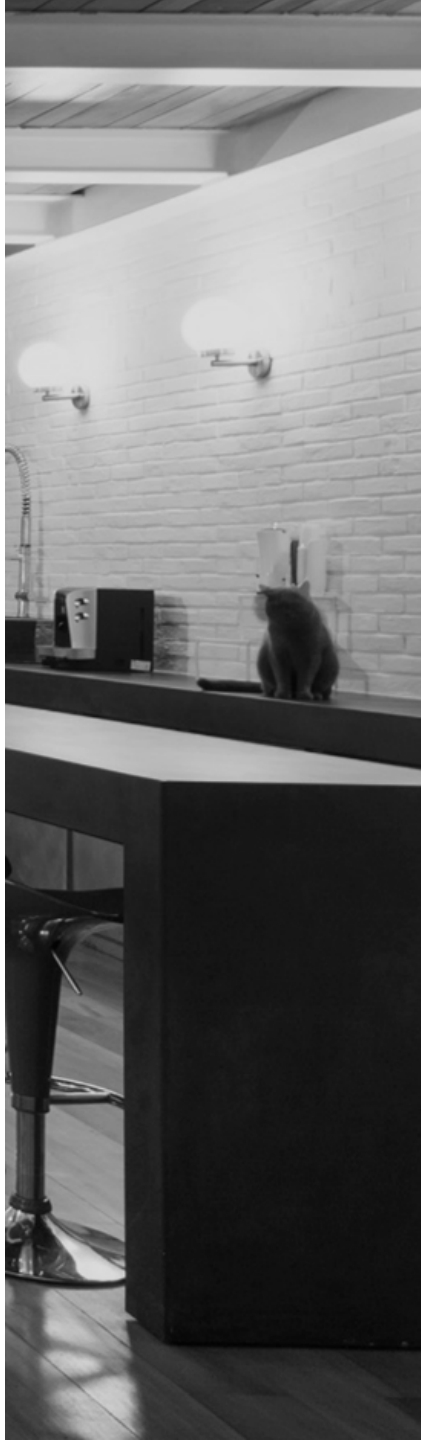


ALTERATIONS OF RECESSED DOWNLIGHT LUMINAIRES IN CEILINGS

For alterations, clarifying language has been added addressing existing screw base sockets.

- 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.

Section 150.2(b)1J



SCREW BASED LUMINAIRES

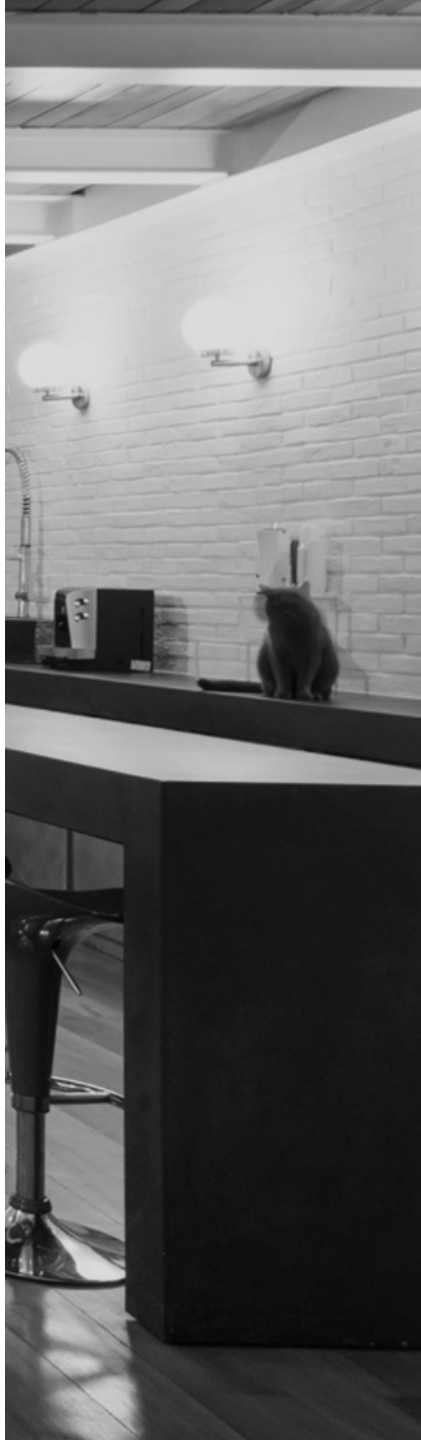
APPLICABLE TO:

- Any screw base luminaires

MUST:

- Contain lamps that comply with JA8

Photo: Fredrick Ramond



Section 150(k)1G

LIGHT SOURCES IN ENCLOSED OR RECESSED LUMINAIRES

- Light sources not compliant with the JA8 elevated temperature requirements shall not be installed in enclosed luminaires
- **Enclosed luminaires** are luminaires which contain enclosed lamp compartments where ventilation openings are less than 3 square inches per lamp in the lamp compartment as defined by UL 1598
- *What are some examples of enclosed luminaires?*

Photo: Capital

Photo: Kichler

Photo: Amazon

Section 150(k)1H

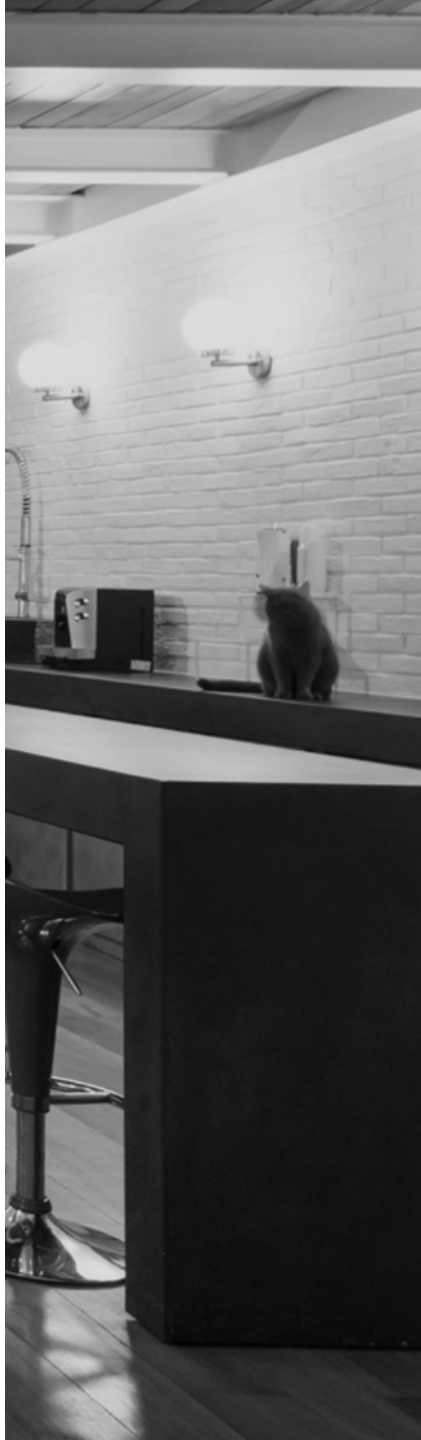


Photo: Tech Lighting

INDOOR LIGHTING CONTROLS

Photo: Tech Lighting

ON/OFF LIGHTING CONTROLS

- Lighting shall have readily accessible, wall-mounted controls that allow the light to be manually turned ON and OFF

Exception: Ceiling fans with integrated lighting can be controlled by a remote control.

Photo: Hunter

Section 150(k)2C

LIGHTING CONTROL REQUIREMENTS

- Comply with Section 110.9
- The dimmer shall:
  - Reduce power consumption by a minimum of 65 percent at its lowest level,
  - Include an OFF position which produces a zero lumen output,
  - Reduce flicker through dimming range to be no greater than 30 percent flicker,
  - For 3-way, do not override level set by dimmer and all switches should turn light off

Photo: Lutron

Section 110.9(b)3

LIGHTING CONTROL REQUIREMENTS

VACANCY SENSOR REQUIREMENTS

- Must be manual-ON/automatic-OFF (can also be turned off manually)
- A maximum time out of 20 minutes
- Provide a visible status signal indicating that the device operates properly, or that it has failed
- Cannot be locked in a permanent "on" state (no "on" override)

OPTIONAL FEATURES TO CONSIDER

- Energy-efficiency LED night-light
- Impact-resistant lens and switch

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

Section 110.9(b)4

SWITCHING DEVICES & CONTROL REQUIREMENTS

- All forward phase dimmers used with LED light sources must comply with NEMA SSL 7A*
- Controls shall be readily accessible
- Shall have the capability of manually switching lighting ON and OFF
- Shall be installed according to manufacturer's instructions
- Shall not bypass any dimmer or vacancy sensor functionality installed to comply with §150(k)2 requirements
- Energy Management Control Systems (EMCS) can be used to comply with §150(k)2 requirements assuming it provides the same functionality and is certified

Photo: Lutron

**NEMA SSL 7A is an industry standard that provides compatibility requirements for dimmers and LED light sources*

Sections 150(k)2A, 150(k)2C, 150(k)2D, 150k(2)E, 150(k)2G

AUTOMATIC OFF REQUIREMENTS

Occupancy OR vacancy sensors are required to control *at least one luminaire* in the following space types:

- Bathrooms
- Garages
- Laundry rooms
- Utility rooms
- Walk in closets

Lighting internal to drawers & cabinets with opaque fronts/doors shall have controls that turn the lights off when the drawer/door is closed.

Sections 150(k)2E

DIMMING CONTROL REQUIREMENTS

Dimming controls required for habitable spaces (i.e., living rooms, dining rooms, kitchens, bedrooms)

EXCEPTIONS:

- Circuit with controlled lighting power less than 20 W or controlled by an occupancy/vacancy sensor
- Navigation lighting (night lights, step lights, path lights less than 5 watts
- Lighting internal to drawers/doors with opaque front/doors or with automatic off controls

Photo: Lutron

Sections 150(k)2F

INDEPENDENT CONTROLS

- Integrated lighting of exhaust fans shall be controlled independently from the fans
- The following shall be controlled separately from ceiling-installed lighting:
    - Undercabinet lighting
    - Undershelf lighting
    - Interior lighting of display cabinets
    - Switched outlets

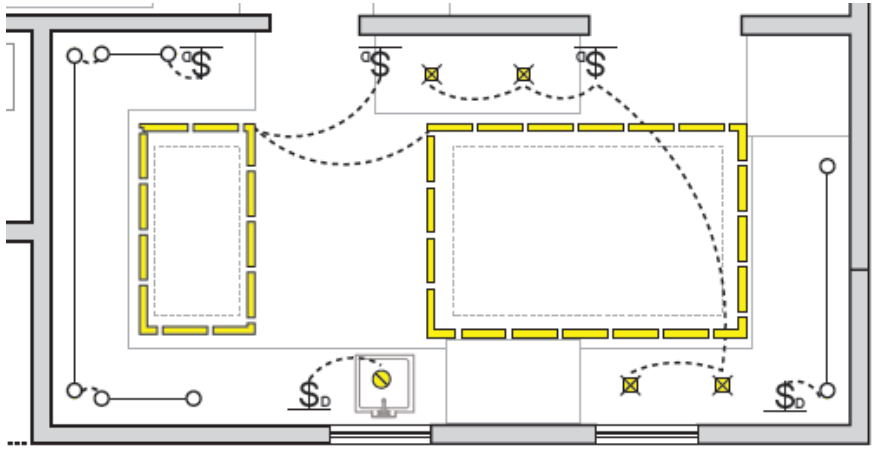
Photo: Broan

Section 150(k)2G

EXERCISE YOUR INDOOR LIGHTING KNOWLEDGE!

Is this design compliant?

1. All high efficacy?
2. Manual on/off controls?
3. If JA8 listed, is it controlled by a dimmer or vacancy sensor?
4. Undercabinet lighting switched separately?



Symbol	Luminaire Type	Lamp	Quantity	CRI	CCT	Watts	Total Watts	Efficacy (lm/W)
KITCHEN								
⟷	**LED undercabinet**	Dedicated LED	21'	94	2,150 K	1.4 W/ft.	29.4	84
▬▬	**LED tape light**	Dedicated LED	41'	90	2,200 K	4 W/ft.	164	230
⊠	**Pendant**	Dedicated LED	4	90	2,700 K	15	60	60
⊘	**Recessed downlight**	Dedicated LED	1	90	2,700 K	13	13	54

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

OUTDOOR LIGHTING

OUTDOOR LIGHT SOURCE REQUIREMENTS

Must meet the requirements in Table 150.0-A

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

Light sources in this column, other than those installed in ceiling recessed downlight luminaires, are classified as high luminous efficacy and are not required to comply with Reference Joint Appendix JA8.	Light sources in this column are required to comply with Reference Joint Appendix JA8 and shall be certified and marked as required by JA8.
1. LED light sources installed outdoors. 2. Inseparable Solid State Lighting (SSL) luminaires containing colored light sources that are installed to provide decorative lighting. 3. Pin-based linear fluorescent or compact fluorescent light sources using electronic ballasts. 4. High intensity discharge (HID) light sources including pulse start metal halide and high pressure sodium light sources. 5. Luminaires with hardwired high frequency generator and induction lamp. 6. Ceiling Fan Light Kits subject to federal appliance regulations.	7. All light sources installed in ceiling recessed downlight luminaires. ***Note:*** *Ceiling recessed downlight luminaires shall not have screw base sockets regardless of lamp type as specified in Section 150.0(k)1C.* 8. Any light source not otherwise listed in this table.

Section 150.0(k)3

OUTDOOR CONTROL REQUIREMENTS

Lighting for single family homes and lighting mounted to any building on the lot must be controlled by:

Manual ON/OFF control switch that permits the automatic actions of one of the following combinations AND paired with one of the following combinations:

1. Photocell and motion sensor
2. Photocell and automatic time switch controls
3. Astronomical time clock
4. EMCS with features:
    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

Photo: RAB Electric Lighting

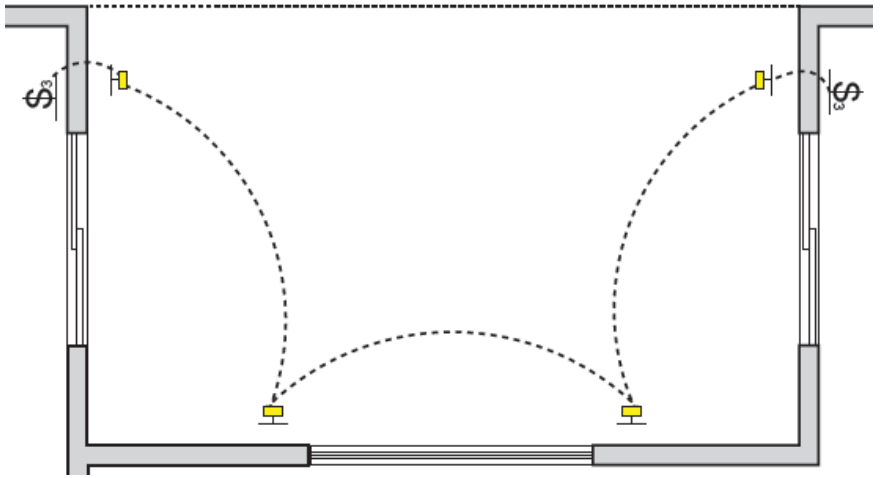
Photo: Tork

Section 150.0(k)3A

EXERCISE YOUR OUTDOOR LIGHTING KNOWLEDGE!

Is this design compliant?

1. All high efficacy?
2. Manual ON/OFF controls?
3. Does it meet one of the following control strategy requirements?
    1. Photocell/motion sensor,
    2. Automatic time switch, ***or***
    3. Astronomical time clock



Symbol	Luminaire Type	Lamp	Quantity	CRI	CCT	Watts	Total Watts	Efficacy (lm/W)
PATIO								
⊢	**Outdoor wall sconce (with photocell and motion sensor)**	Dedicated LED	4	90	2,700 K	13	52	64

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


8

INTERNALLY ILLUMINATED ADDRESS SIGNS

INTERNALLY ILLUMINATED ADDRESS SIGNS

Consume no more than 5 watts of power

OR

Comply with the nonresidential sign lighting requirements in §140.8:

- Cannot exceed 12 watts per square foot of internal illumination
- Cannot exceed 2.3 watts per square foot of external illumination

OR…

Section 150.0(k)4

INTERNALLY ILLUMINATED ADDRESS SIGNS

Alternatives when equipped only with one or more of the light sources:

- High-pressure sodium
- Select metal halide lamps
- Select neon or cold cathode lamps
- Fluorescent lamps with a minimum 80 CRI OR paired with electronic ballasts
- Compact fluorescent lamps with no screw-base sockets
- LEDs

Sections 150.0(k)4, 140.8(a), 140.8(b)

Photo: CLTC, UC Davis

RESIDENTIAL GARAGES AND PARKING LOTS

Photo: CLTC, UC Davis

PARKING LOTS AND GARAGES

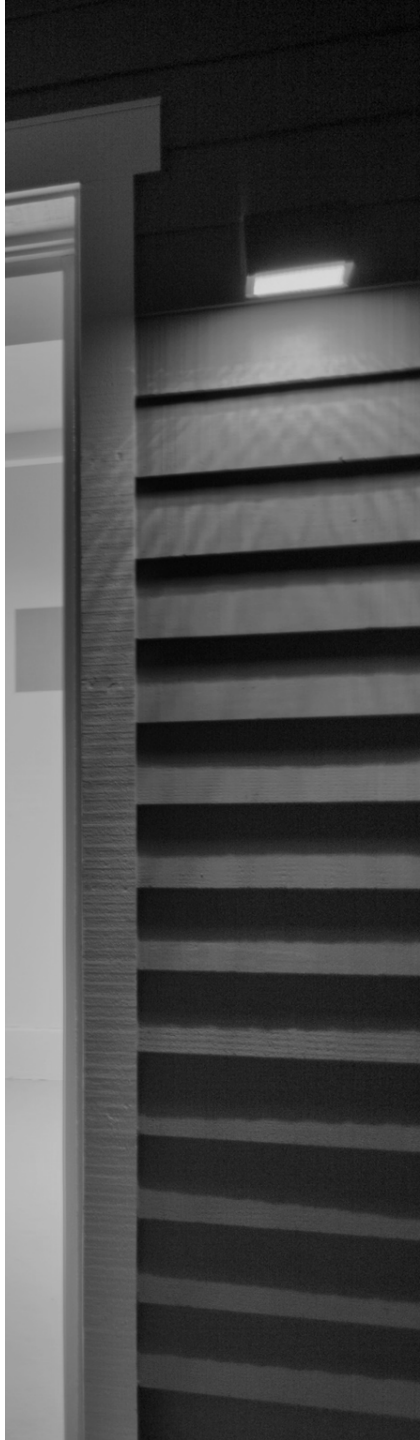
RESIDENTIAL LOTS AND GARAGES

- Residential standards apply to parking lots, carports and parking garages (attached and detached from dwelling unit) for **seven or fewer vehicles** per site
- Parking lots and carports must meet the residential **outdoor** lighting requirements or the nonresidential requirements
- Parking garages must meet the residential **indoor** lighting requirements:
    - High efficacy **and**
    - Controlled by a vacancy sensor

NONRESIDENTIAL LOTS AND GARAGES

- Nonresidential standards apply to parking lots, carports and parking garages (attached and detached from dwelling unit) **for eight or more vehicles**
- Must meet the power density limits for nonresidential lighting standards
- Luminaires must be controlled by a photo control or time switch that turns lights off when daylight is present
- New construction or major alterations are required to comply with Backlight, Uplight, Glare ratings per IES TM-15-11
- Pole mounted luminaire > 40 watts and < 24 feet must include motion sensors that reduce lighting levels on vacancy.
- Other conditions apply, see sections: 110.9, 130.0, 130.2, 130.4, 140.7 & 141.0

Section 160.5/170.2



MULTI-FAMILY RESIDENTIAL BUILDINGS

LOW-RISE MULTIFAMILY COMMON AREAS

A multifamily complex consists of four or more dwelling units. A low-rise is considered a building with three or fewer stories.

If the building has more than three stories, the common areas must comply with the nonresidential code.

Section 160.5/170.2

LOW-RISE MULTI-FAMILY COMMON AREAS

Where common areas constitute more than 20 percent of the floor space:

- Lighting must comply with the non-residential standards
- Lighting in corridors and stairwells **must** be controlled by occupancy sensors that reduce lighting power by at least 50 percent

Where common areas are less than or equal to 20 percent of the floor space:

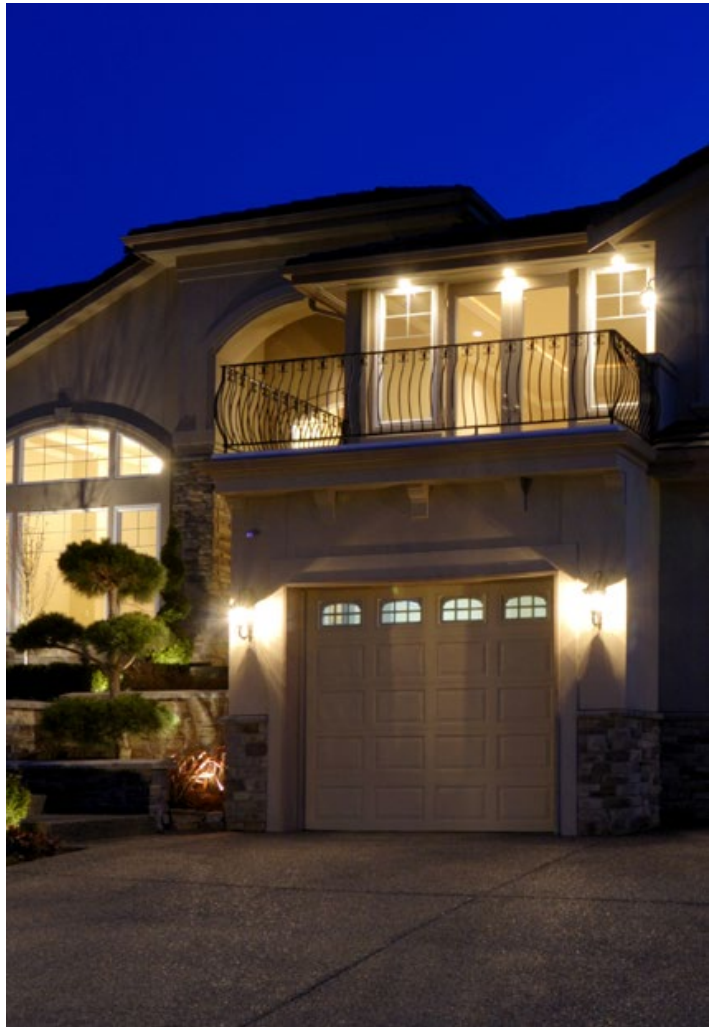
- All hardwired lighting must comply with Table 160.5-A **and** controlled by an occupancy sensor

MULTIFAMILY OUTDOOR CONTROL REQUIREMENTS

Low-rise multifamily residential buildings, outdoor for private patios, balconies, entrances and porches must meet these requirements:

Manual ON/OFF switch paired with one of the following combinations:

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



Section 160.5(a)3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RESOURCES

WWW.ENERGY.CA.GOV/NEWSROOM/BLUEPRINT-NEWSLETTER

Blueprint is the California Energy Commission's quarterly e-newsletter that delves into the Building Energy Efficiency Standards and provides examples of projects. The newsletter provides updates, answers to frequently asked questions, clarifications to requirements, announcements, and educational resources and training.

Expand All

- **Compiled Blueprints** +
- **Issue 126, April - June 2019** +
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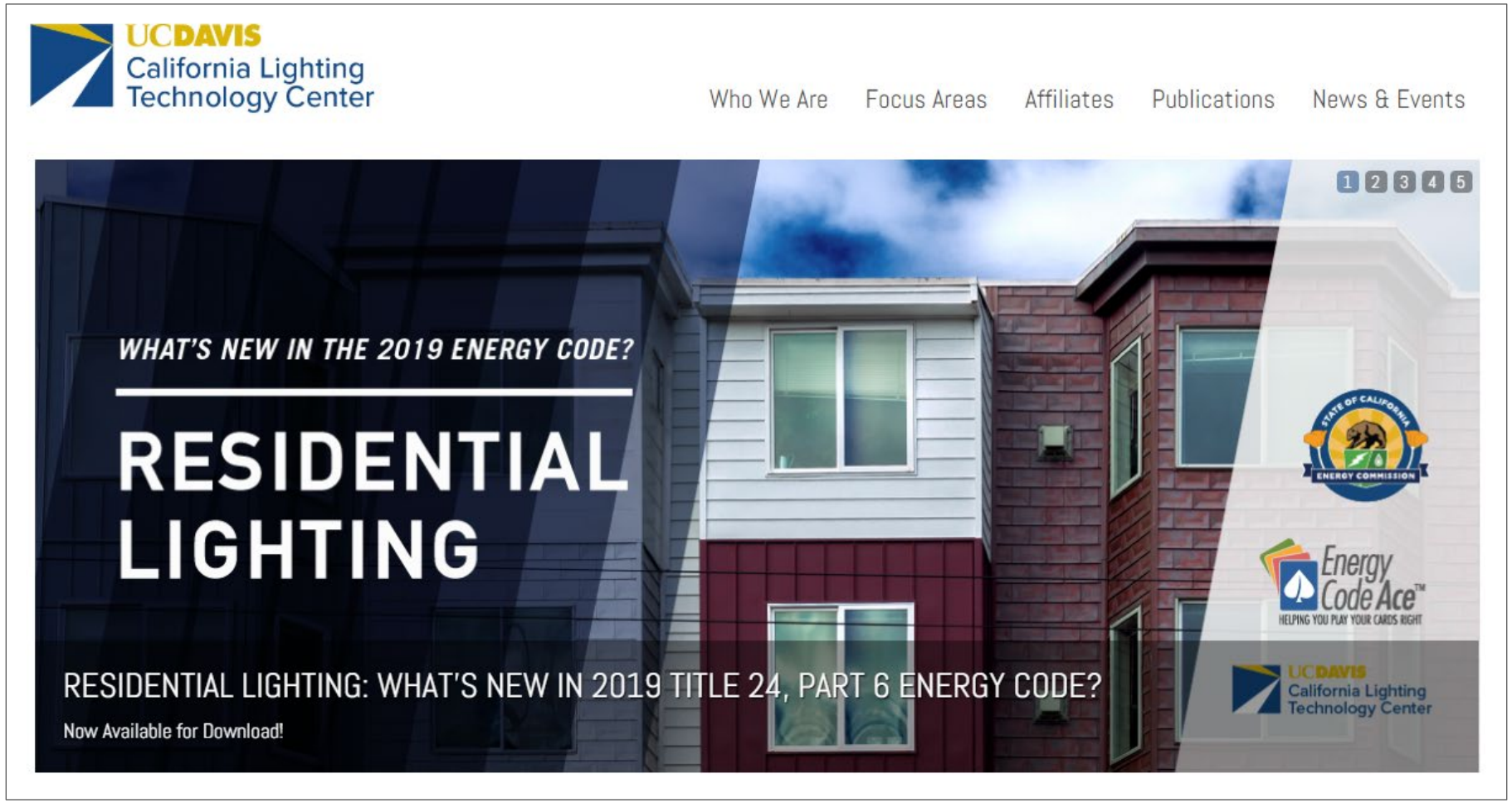

WHEN IN DOUBT...

The California Energy Commission provides contacts for energy efficiency programs related to the Energy Code:

Home > Programs and Topics > All Topics > Energy Efficiency > **Energy Efficiency Program Contact Information**

Energy Efficiency Program Contact Information

Contact information for hotlines and call centers supporting the California Energy Commission's energy efficiency programs.

Energy Standards (Title 24) Hotline

916-654-5106
800-772-3300, toll-free in California
Title24@energy.ca.gov

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