

## Residential Lighting Design Guide:

Best practices and lighting designs to help builders comply with California's 2005 Title 24 energy code

# New Residential Lighting Standards in 2005

The California Energy Commission (CEC) has adopted new residential energy standards: *2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. These updates to the Title 24 energy code include comprehensive changes to residential lighting for new and remodeled homes obtaining permits. These standards will significantly reduce lighting energy consumption by requiring the use of new energy-efficient technologies.

The code changes were adopted in response to California's energy crisis in order to reduce energy bills, increase the reliability of energy delivery, and contribute to an improved economic condition for the state. The new code was based on how much energy a

technology can save as well as the technology's reliability, availability, and cost-effectiveness. The code emphasizes energy efficiency measures that save energy during peak periods of power generation, such as hot summer days when air conditioners are running. It incorporates recent publicly funded research and increases the collaboration with California utilities to incorporate results of appropriate market incentive programs for specific technologies.

## **The 2005 standards go into effect October 1, 2005.**

When a builder's permit is applied for *prior to* October 1, 2005, the 2001 code applies; when a permit is applied for *on or after* October 1, 2005, the new 2005 code applies, with no exceptions.

## ***A word from our sponsors***

The upcoming changes represent a significant opportunity for increased energy savings and reduced maintenance in residential lighting. However, these changes also represent new challenges for builders and installation professionals—new technologies and designs that differ from current practice.

The 2005 code revisions were developed through a consensus process, incorporating changes that require minimal disruption to current practice. Given this collaborative approach and the potential for implementation challenges, a consortium representing broad interests developed this design guide for the builder community.

This guide provides a practical "cookbook" approach to lighting code compliance and design, including a broad array of example designs as well as technical and compliance information organized in a step-by-step format. The guide aims to assist in the process of developing compliant, quality lighting designs.

We believe that this guide will greatly help the building community deliver high-performance, energy-efficient lighting systems to homeowners in a cost-effective manner for homebuilders.

California Energy Commission - EPA ENERGY STAR - Pacific Gas and Electric  
Sacramento Municipal Utility District - San Diego Gas & Electric  
Southern California Gas & Electric - Southern California Edison



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# Overview of Title 24 Changes in 2005

	2005 Standards	2001 Standards
Kitchen	High efficacy OR Up to 50% of the total wattage can be low efficacy.  All high-efficacy and low-efficacy lighting must be controlled separately. <i>Switch location requirement removed</i>	General lighting must be high efficacy (fluorescent) and must be controlled by the primary switch at the kitchen entrance.  Additional luminaires used for decorative effects need not meet this requirement.
Bathroom	High efficacy OR Manual-on occupancy sensor	Each bathroom containing a shower or bathtub must have at least one fluorescent luminaire. OR Fluorescent lighting may be installed in a utility room, laundry room, or garage instead of a bathroom AND All other lighting must be fluorescent or equipped with a motion sensor.  If using the alternative option, each additional bathroom must have at least one fluorescent luminaire.
Garage	High efficacy OR Manual-on occupancy sensor	
Laundry Room	High efficacy OR Manual-on occupancy sensor	
Utility Room	High efficacy OR Manual-on occupancy sensor	
All other interior rooms (e.g., living room, dining room, bedrooms, hallways) except closets less than 70 sq. ft.	High efficacy OR Manual-on occupancy sensor OR Dimmer	No requirements
Outdoor lighting attached to buildings	High efficacy OR Controlled by motion sensor + photocontrol	No requirements
Common areas of low-rise residential buildings with 4 or more dwelling units	High efficacy OR Occupancy sensor	No requirements unless used as an alternate for fluorescent bathroom lighting
Residential parking lots and garages for 8 or more vehicles	Must meet nonresidential lighting standards	No requirements

# Overview of Title 24 Changes in 2005

The following is the 2005 Title 24 residential lighting code, quoted directly from the California Energy Commission's *2005 Building Energy Efficiency Standards*, Section 150 ([www.energy.ca.gov/title24](http://www.energy.ca.gov/title24)).

## ***Kitchens***

Section 150 (k) 2: Permanently installed luminaires in kitchens shall be high-efficacy luminaires.

Exception: Up to 50 percent of the total rated wattage of permanently installed luminaires in kitchens may be in luminaires that are not high-efficacy luminaires, provided that these luminaires are controlled by switches separate from those controlling the high-efficacy luminaires. The wattage of high-efficacy luminaires shall be the total nominal rated wattage of the installed high-efficacy lamp(s).

## ***Bathrooms, garages, laundry rooms, and utility rooms***

Section 150 (k) 3: Permanently installed luminaires in bathrooms, garages, laundry rooms, and utility rooms shall be high-efficacy luminaires.

Exception: Permanently installed luminaires that are not high-efficacy shall be allowed provided that they are controlled by an occupant sensor(s) [*sic*] certified to comply with Section 119 (d). Such motion sensors shall not have a control that allows the luminaire to be turned on automatically or that has an override allowing the luminaire to be always on.

## ***Other spaces***

Section 150 (k) 4: Permanently installed luminaires located other than in kitchens, bathrooms, garages, laundry rooms, and utility rooms shall be high-efficacy luminaires.

Exception 1: Permanently installed luminaires that are not high-efficacy luminaires shall be allowed provided they are controlled by a dimmer switch.

Exception 2: Permanently installed luminaires that are not high efficacy shall be allowed provided that they are controlled by an occupant sensor(s) [*sic*] certified to comply with Section 119 (d). Such motion sensors shall not have a control that allows the luminaire to be turned on automatically or that has an override allowing the luminaire to be always on.

Exception 3: Permanently installed luminaires that are not high-efficacy luminaires shall be allowed in closets less than 70 square feet.

## ***Porches and outdoor lighting***

Section 150 (k) 6: Luminaires providing outdoor lighting and permanently mounted to a residential building or to other buildings on the same lot shall be high-efficacy luminaires.

Exception 1: Permanently installed outdoor luminaires that are not high-efficacy shall be allowed provided that they are controlled by a motion sensor(s) [*sic*] with integral photocontrol certified to comply with Section 119 (d).

Exception 2: Permanently installed luminaires in or around swimming pools, water features, or other locations subject to Article 680 of the California Electric Code need not be high-efficacy luminaires.

# How to Use This Guide

This guide is a resource to help builders understand the new 2005 residential lighting requirements and integrate these changes into new home plans. The guide demonstrates ways to meet the new code with multiple lighting design examples on common floor plans.

The code specifically mentions six categories for residential buildings: (1) kitchens, (2) bathrooms, laundry rooms, utility rooms, and garages, (3) other spaces, (4) outdoor spaces, (5) parking lots and garages, and (6) common areas of low-rise buildings. The remainder of this guide will explore these categories in greater depth, with helpful illustrations of ways to meet the 2005 code.

In each section, the code will be dissected into bullet points with reference to the floor plans. The sections will include design tips, technology tips, and caution notes.

*This guide is to aid homebuilders in lighting design. It is not intended to be used in lieu of the actual Title 24 code.*

## Design Tip

Design tips are interwoven throughout this guide to show how new technologies can create aesthetically pleasing lighting designs and also be code compliant.

## Technology Tip

Technical tips are interwoven throughout this guide to help you apply new technologies.

## Caution Note

Caution notes are interwoven throughout this guide to alert you to potential misapplications of technologies or the code.

## Bright ideas

### Create a warm glow

Color temperature is important in homes. Use warm-color fluorescent lamps: typically 2700K/3000K for compact fluorescent lamps (CFLs) and 3000K for linear fluorescent lamps.

### Light output is not always equal

A high-efficacy light fixture may replace a non-high-efficacy light fixture. Be aware that the high-efficacy light fixture may actually produce more lumens, or light output, than the previous low-efficacy fixture.

### Four to one

Most incandescent lamps may be replaced with a CFL that is 1/4–1/3 the wattage. The following list shows common incandescent wattages and their CFL equivalents:

Incandescent	vs.	CFL
40 watt		13 watt
60 watt		18 watt
100 watt		26 watt

### Four-pin not two-pin

There are two configurations of CFLs: four-pin and two-pin. Four-pin units require an electronic ballast (lighter weight, no blinking or humming) while two-pin units require a magnetic ballast, which is not allowed by the new code in most cases.

## Fixture labels for compliance and quality

Now more than ever, it is the responsibility of the builder to fully specify compliant fixtures to the contractor. With the changes in the code, manufacturers are trying to make it easier for builders and contractors to specify compliant fixtures. The following labels may be helpful in specifying high-quality and compliant fixtures. Be aware that Title 24 applies not only to the fixture itself but also to the application and installation. Here is what to look for:

▶ **ENERGY STAR:** The ENERGY STAR label guarantees a minimum standard of quality as well as energy performance. The updated ENERGY STAR standards, also going into effect October 2005, have been written to fit the new Title 24 requirements to help builders specify high-efficacy fixtures. ENERGY STAR fixtures manufactured prior to October 2005 may not be Title 24 2005 compliant. During this transition period, be sure to verify that, regardless of label or manufacturer, fixtures meet the high-efficacy requirements.

▶ **Title 24 Label:** Some fixtures may feature a Title 24 label to help builders and inspectors determine whether a fixture meets the 2005 definition of high efficacy.



▶ **Airtight:** Title 24 requires that recessed fixtures installed in an insulated space be certified airtight in accordance with ASTM E283. If the label on the fixture installed in an insulated space does not specify ASTM E283 testing, additional documentation will be needed to indicate the fixture has been tested and certified in accordance with ASTM E283.

Note: The ASTM E283 certification is a laboratory procedure intended to measure only the leakage of the luminaire housing or, if applicable, of an airtight trim kit, and not that of the installation. For complete airtight compliance, the installation must also be airtight with either sealed gasket(s) or caulking, to ensure all air leaks are sealed between the ceiling and fixture. For more information see the *Residential Compliance Manual*, Chapter 6.10.

## Make sure manufacturers "Stand By Their Can"

Nearly all new high-output CFL downlights should operate for years without any problems. Although concerns have been raised about shortened ballast life due to the elevated temperatures experienced in insulated ceilings, several manufacturers have shown that, with proper fixture design, ballast temperatures can be maintained well within manufacturer guidelines.

However, there is still concern that, in a very competitive market, some manufacturers might attempt to cut costs in a manner that would lead to elevated ballast temperatures, and thus premature ballast failures. **This could be a nightmare scenario for homebuilders.** Even if the ballast

failures occurred within the manufacturer's warranty period, the homebuilder would still be responsible for the costly labor fees associated with replacing failed units. Thus, even a few ballast failures would quickly erode any cost savings from cheaper downlights.

To address this concern some manufacturers are now offering a "parts and labor" warranty. This warranty will minimize the risk to builders by providing replacement components as well as compensation for costs associated with installing these components. We strongly urge builders to specify high-output CFL downlights that carry a parts and labor warranty, ideally for five years or longer.

# Technology Overview

## Understanding the three key energy-efficient lighting technologies

In general, homebuilders will comply with the new Title 24 requirements by installing a mixture of three energy-efficient lighting technologies. This section is intended to familiarize homebuilders with these three technologies. We explain how these systems work, what features to look for when purchasing or specifying them, and which applications are most appropriate for each technology.

The three key energy-efficient lighting technologies for complying with the new code are:

- ▶ **High-efficacy luminaires:** These lighting fixtures are designed and built to operate only energy-efficient light sources, such as fluorescent T8 lamps, compact fluorescent lamps (CFLs), and high intensity discharge (HID) lamps.
- ▶ **Sensors:** Occupancy sensors, vacancy sensors, motion sensors, and daylight sensors are all devices that automatically turn off the lights in response to conditions that they “sense” or “see.”
- ▶ **Dimmers:** Dimmers, which are already common in many residential applications, allow the room occupants to lower the room lighting (and thus the power used) as desired.

Homebuilders who have a solid understanding of these three technologies should have little problem designing and specifying lighting plans that meet the new Title 24 guidelines.

## High-efficacy luminaires

While the formal definition is somewhat complicated (see glossary), high-efficacy luminaires are generally synonymous with energy-efficient fixtures. The code’s requirements for high-efficacy luminaires are that “the lumens per watt for the lamp be above a specified threshold [see chart below] and that electronic ballasts be used in certain applications.” Most ENERGY STAR fixtures will qualify as high-efficacy luminaires, although some lower-efficacy or magnetically ballasted ENERGY STAR products may not be compliant. Each fixture has to qualify with the Title 24 standards on its own merit regardless of what it is labeled.

In general, the following are high-efficacy luminaires:

- ▶ Fluorescent and CFL fixtures with electronic ballasts
- ▶ Fixtures with HID lamps

In general, the following are NOT high-efficacy luminaires:

- ▶ Any fixtures with incandescent sockets (regardless of the installed lamp)
- ▶ Most fluorescent and CFL fixtures with magnetic ballasts



Four-pin CFL  
(high efficacy and code compliant)

### High-Efficacy Lamps

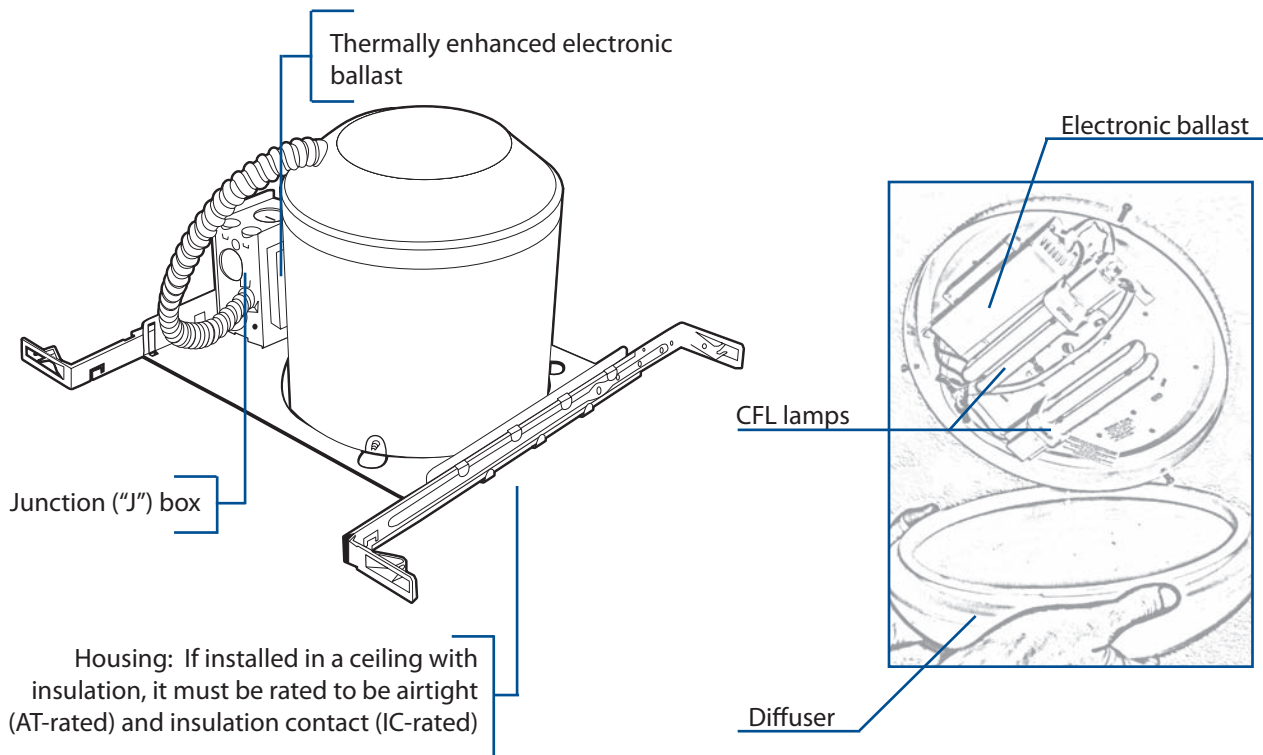
Lamp power	Required lamp efficacy
Less than 15 watts	40 lumens/watt
15–40 watts	50 lumens/watt
More than 40 watts	60 lumens/watt

Note: Ballast wattage is not included when determining lamp efficacy



# High-Efficiency Luminaires

## High-efficiency luminaire anatomy: Recessed cans and surface mounts



### What to specify

- ▶ **Specify the appropriate light output:**  
Replacing incandescent with fluorescent fixtures will often not be a "one-for-one" replacement. In some cases you may install fewer fixtures, while other installations may require more.

*Rule of thumb: You should be able to "lumen match" the incandescent fixtures by specifying fluorescent systems that use one-third or one-fourth as much power.*

- ▶ **Specify the appropriate color:**  
Unlike incandescent lamps, fluorescent lamps come in a wide variety of colors, from "cool white" to "warm white." For most residential applications it is most appropriate to specify a warmer lamp color (CCT = 2700K–3000K), as it gives a warmer feel and more closely matches the look of incandescent lighting.

- ▶ **Specify electronic ballasts:**  
Electronic ballasts, which are mandated in all

high-efficiency luminaires of 13 watts or higher, should improve lighting quality by eliminating the flicker and hum associated with some magnetically ballasted systems.

- ▶ **Specify thermally managed fixtures:**  
Higher CFL wattages can lead to hotter operating temperatures for the electronic ballasts, which if not properly controlled could dramatically shorten ballast life. This is particularly true in ICAT (IC-rated, AT-rated) applications where the heat produced by the downlight is trapped by ceiling insulation. Several lighting manufacturers have developed high-wattage ICAT systems by employing ballasts with higher-rated operating ranges (usually up to 90°C) and by heat-sinking the ballast to the downlight housing. The bottom line is that high-wattage downlights can be an effective choice in insulated ceilings, but only if the products have been properly designed for this application.

# Sensors

## Occupancy/vacancy sensors

With the exception of kitchens, occupancy sensors can be used in lieu of high-efficacy luminaires in most applications throughout the house.

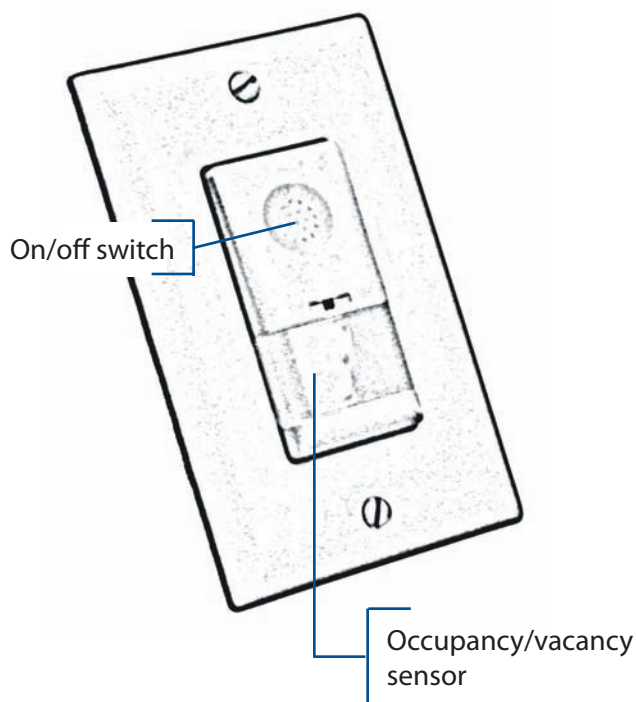
“Vacancy sensor” is a term some manufacturers are using to describe a manual-on, automatic-off occupancy sensor because the primary function of the sensor is to turn the lights off when the room is vacant.

Although the new code does not allow the sensor to turn the lights on automatically when a person enters a space, the sensor may feature a grace period which will allow the lights to automatically turn back on within 30 seconds after they have been automatically turned off. This helps minimize disturbance by allowing a homeowner to activate the lights if they have been turned off due to lack of motion (e.g., during a relaxing bath).

To help ensure the installed sensors will function properly, follow these design tips:

- ▶ Install sensors so they can “view” the space or area that is to be occupied.
- ▶ Avoid using wall box occupancy sensors in three-way applications, which can become overly complicated. Wall box sensors are not recommended for these applications without a thorough understanding of the technology.
- ▶ Feel free to use sensors in bathrooms, toilet rooms, closets, laundry and utility rooms, and garages.
- ▶ Ensure that the sensor’s electrical load requirements are met. For example, if the occupancy sensor has a minimum load rating of 25 watts and the homeowner changes the lamp to a 13-watt CFL, the switch may no longer operate the load.

## Sensor anatomy and what to specify



A compliant sensor must have all of the following features:

- ▶ Must be manual-on/automatic-off (can also be turned off manually)
- ▶ Time delay cannot be greater than 30 minutes
- ▶ Cannot be locked in a permanent “on” state (no “on” override)
- ▶ Outdoor sensors can be automatic-on/off but must also include a photocell that keeps the lights off during daylight hours

Optional features to consider when choosing an occupancy or vacancy sensor:

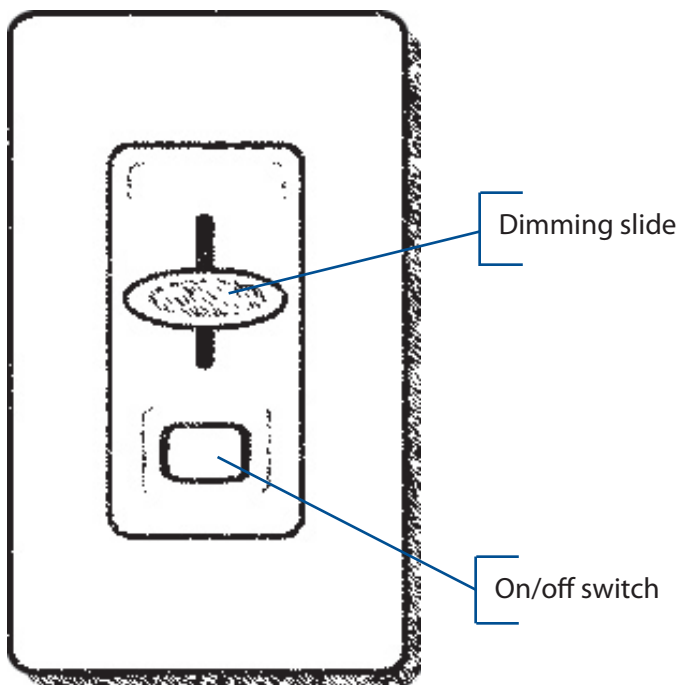
- ▶ Energy-efficient LED nightlight
- ▶ Impact-resistant lens and switch

## Dimmers

Dimmers can be used in lieu of high-efficacy luminaires or sensors in many applications throughout the house. This may often be the least costly code-compliant measure and will increase the lighting quality by allowing residents much greater control over their environments. The following are some considerations when using dimmers:

- ▶ Standard incandescent dimmers will not work with most high-efficacy luminaires or fluorescent luminaires. Dimming is possible with fluorescent luminaires, but they need to have special dimming ballasts and compatible dimmers rated for such use.
- ▶ Compliant applications for dimmers include dining rooms, living rooms, and bedrooms.
- ▶ Failure to correctly match the dimmer with the electrical lighting load of a fixture may result in early equipment failure of the dimmer, transformer, ballast, or lamp.
- ▶ When dimming a low-voltage (e.g., halogen) fixture, additional components are required in the dimmer to avoid overheating the transformer.
- ▶ Check the warranty. Most manufacturers offer a one-year warranty. Verify this is true for the manufacturer you are purchasing from.

## Dimmer anatomy and what to specify



- ▶ **Specify for the correct application:** Specific dimmers are created for line voltage, low voltage and three way applications, for example in a hallway or stairway.
- ▶ **Specify the correct fixture load:** Universal dimmers may not be suitable for every application. It is important to specify a dimmer for a particular fixture load to preserve the life of the dimmer and fixture.
- ▶ **Specify the aesthetic quality:** There are many aesthetic choices in dimmers. Some have a designated on/off toggle that lets homeowners set the light level and remains this way until changed. Other dimmers slide on and off, allowing homeowners to set the light level each time they turn on the lights.

# Kitchens in a Nutshell

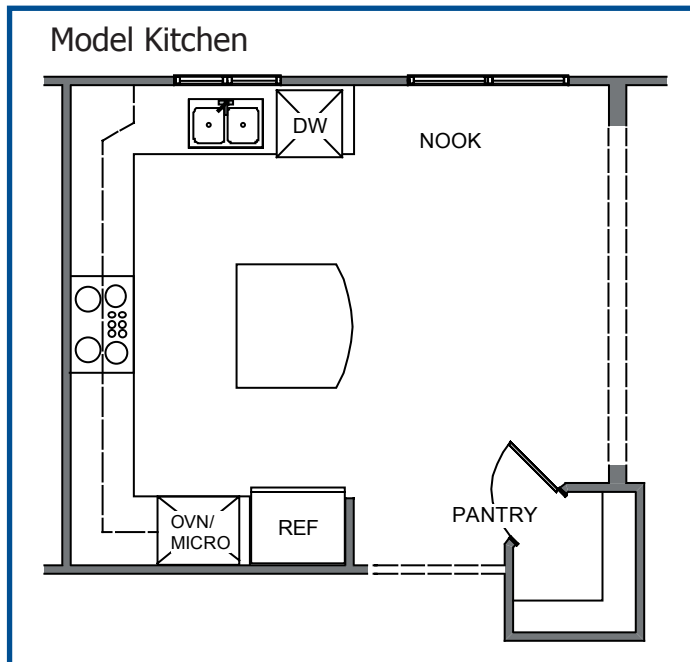
2005 Requirements	<p>High efficacy OR</p> <p>Up to 50% of the total wattage can be low efficacy.</p> <p>All high-efficacy lighting must be controlled separately from low-efficacy lighting.</p> <p><i>Switch location requirement removed</i></p>
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*Each and every permanently installed fixture must be included in the total wattage and must comply with the standards.*

## Additional code explanation:

- ▶ 50% of the kitchen's permanently installed lighting MUST be high efficacy, typically fluorescent; this can include downlights, under-cabinets, over-cabinets, pendants, wall sconces, etc.
- ▶ Permanently installed lighting fixtures include, but are not limited to, those lighting fixtures installed in, on, or hanging from the ceilings or walls. Lighting that is part of an appliance is not regulated by the code.
- ▶ Switching should be designed so the homeowner can automatically turn off 50% of the lighting power, yet retain illumination throughout the entire kitchen, with no overly dark areas.

- ▶ Fluorescent and incandescent light fixtures MUST be controlled separately, while different types of light fixtures may also be controlled separately to correspond with the use.
- ▶ The first switch no longer has to control a fluorescent light fixture.
- ▶ The number of fluorescent light fixtures will vary with each kitchen design. The quantity of light fixtures is not regulated.
- ▶ Nook lighting must be on a separate switch to not be counted as part of the kitchen. Nook lighting is then considered an "other space" and will require a dimmer, manual-on occupancy sensor, or high-efficacy lighting.
- ▶ If a fixture can accept various lamp wattages, its wattage for the sake of code compliance is the highest relamping rated wattage designated by the manufacturer on a permanent, factory-installed Underwriters Laboratory (UL) label (peel-off labels are not permitted).



## Kitchen Definition

As defined by the California Energy Commission, a room or area used for cooking, food storage and preparation, and washing dishes, including associated countertops and cabinets, refrigerator, stove, ovens, and floor area. Adjacent areas are considered kitchen if the lighting for the adjacent areas is on the same switch as the lighting for the kitchen.

# Kitchens: Option #1

## Kitchen lit with multiple lighting systems

Guidelines used for the lighting design shown below:

- ▶ Use 26-watt compact fluorescent recessed cans on 4'–5' centers for even illumination.
- ▶ Supplement recessed cans with fluorescent under-cabinet and/or over-cabinet light fixtures, on separate switches.
- ▶ Use 2700K–3000K color temperatures for fluorescent lamps to ensure a warm, "incandescent" lighting color.

Further code explanation as applied to the lighting plan below:

- ▶ Fluorescent and incandescent light fixtures MUST be controlled separately.
- ▶ The first switch no longer has to control a fluorescent light fixture.
- ▶ Pantries less than 70 sq. ft. have no lighting or control requirements.

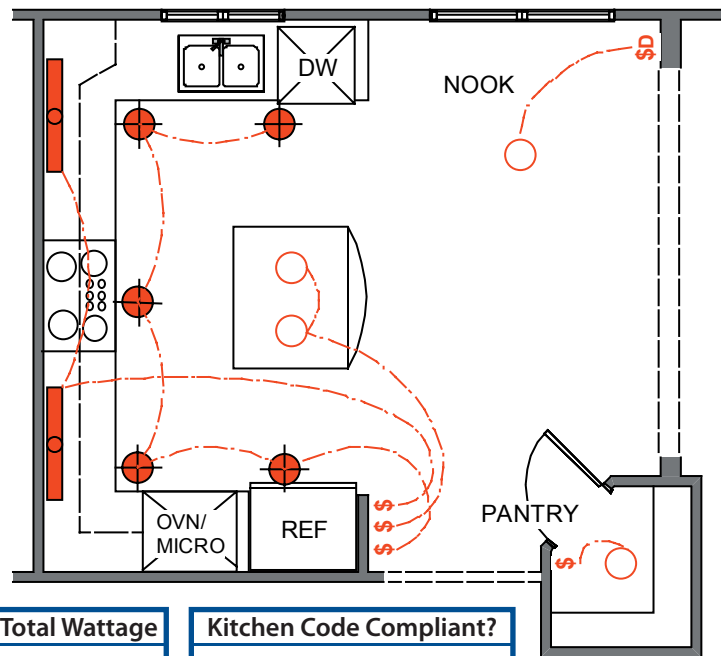
Use aesthetically pleasing light fixtures to reinforce the design of the kitchen and obtain a quality appearance.

Minimize the number of fixtures that extend below the ceiling to help eliminate visual clutter.

### KEY

- ⌘ Switch
- ⌘<sub>D</sub> Dimmer
- Surface- or pendant-mounted incandescent light fixture
- 26-watt CFL recessed can with electronic ballast and white or aluminum reflector and trim
- ▬ Fluorescent under-cabinet and/or over-cabinet light fixture with T8 or T5 lamps and electronic ballast

Note: Applicable fixtures must meet 2005 Title 24 high-efficacy requirements



Kitchen Fixtures	Amount	Wattage	Total Wattage
Fluorescent downlights	5	26 watts	130 watts
Under-cabinet fluorescents	2	25 watts	50 watts
Incandescent pendants	2	60 watts	120 watts

### Kitchen Code Compliant?

Fluorescent = 180 watts

Incandescent = 120 watts

Low efficacy less than half of total wattage = code compliant



# Kitchens: Option #2

## Kitchen lit with linear fluorescents

Guidelines used for the lighting design shown below:

- ▶ Locate linear fluorescents on 6'–8' centers for even illumination, approximately 2' from cabinets.
- ▶ Use 32-watt T8 fluorescent lamps with a 3000K color temperature and a CRI (color rendering index) of 80 or higher for a warm, "incandescent" feel.
- ▶ Recess the linear fixtures to help maintain a higher ceiling height and keep the ceiling uncluttered.
- ▶ Supplement linear fluorescents with fluorescent under-cabinet fixtures on separate switches.

Further code explanation as applied to the lighting plan below:

- ▶ Pantries less than 70 sq. ft. have no lighting or control requirements.
- ▶ Nook lighting on its own switch does not count as kitchen wattage.

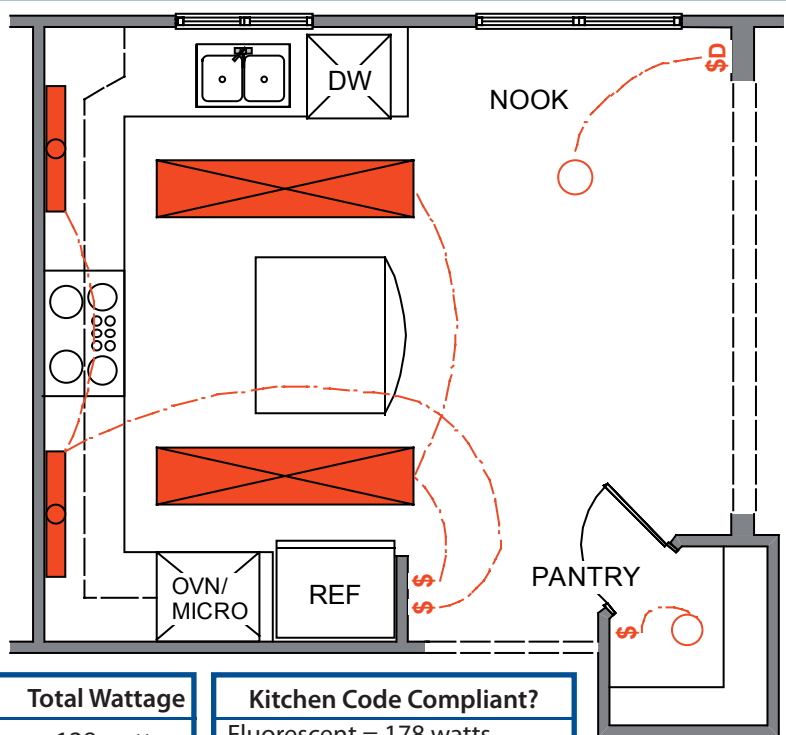
General lighting on the counter should maintain an average of 30 footcandles.

Fluorescent fixtures with electronic ballasts meet the high-efficacy requirements; halogen and incandescent do not.

**KEY**

- \$ Switch
- \$<sub>D</sub> Dimmer
- Surface- or pendant-mounted incandescent light fixture
- ▭ 1' x 4' recessed or surface-mounted fluorescent light fixture with 32-watt T8 lamps and electronic ballast
- ▬ Fluorescent under-cabinet light fixture with T8 or T5 lamps and electronic ballast

*Note: Applicable fixtures must meet 2005 Title 24 high-efficacy requirements*



Kitchen Fixtures	Amount	Wattage	Total Wattage
Surface fluorescents 1' x 4'	2	64 watts	128 watts
Under-cabinet fluorescents	2	25 watts	50 watts

Kitchen Code Compliant?
Fluorescent = 178 watts
Incandescent = 0 watts
Low efficacy less than half total wattage = compliant <input checked="" type="checkbox"/>

# Kitchens: Option #3

## Kitchen lit with recessed fluorescent cans

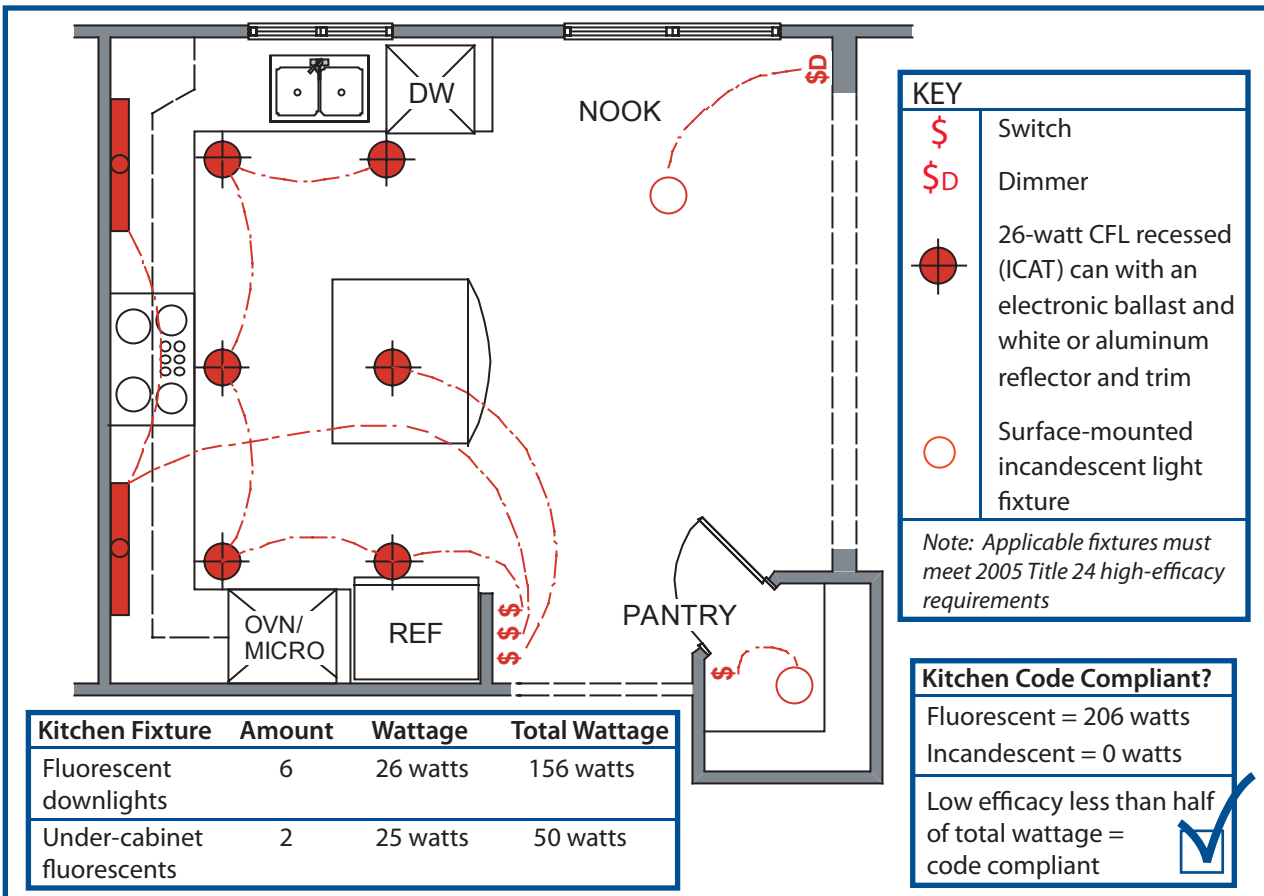
Guidelines used for the lighting design shown below:

- ▶ Use 26-watt compact fluorescent recessed cans on 4'–5' centers for even illumination.
- ▶ Space recessed cans evenly around the sink so that an additional light fixture over the sink is not needed.
- ▶ Supplement recessed cans with high-efficacy under-cabinet light fixtures on separate switches.
- ▶ Locate recessed cans at the edge of the counter to reduce shadows that may be caused by the occupant.
- ▶ Although only one switch is required, provide three for versatility.

Further code explanation as applied to the lighting plan below:

- ▶ Pantries less than 70 sq. ft. have no lighting or control requirements.
- ▶ All recessed cans installed into insulated ceilings are required to be ICAT rated, i.e., rated for insulation contact (IC-rated) and airtight (AT-rated) to prevent conditioned air loss into the attic or ceiling. All air leaks must be sealed with gaskets and caulking between the can housing and ceiling.

Light the countertops more than the walkway. Place the lighting where it is needed.



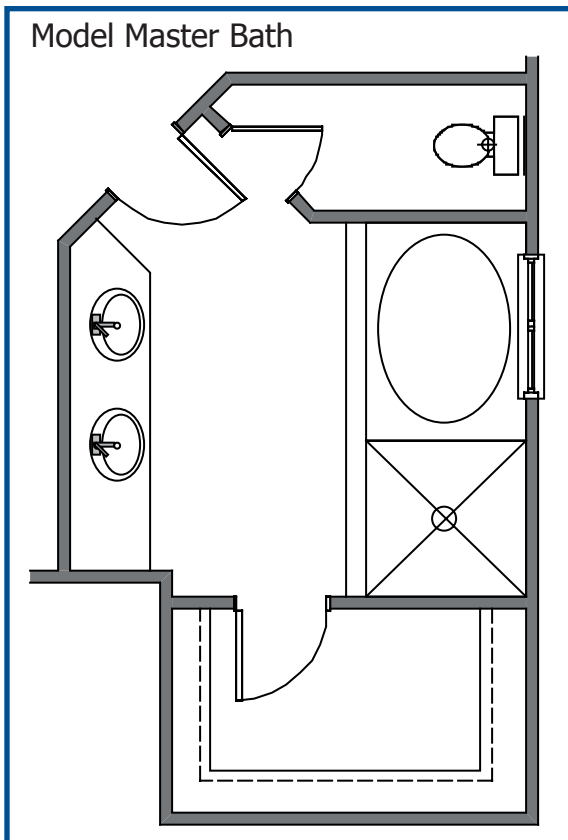
# Bathrooms in a Nutshell

2005 Requirements	Bathroom	High-efficacy OR Manual-on occupancy sensor
	Garage	High-efficacy OR Manual-on occupancy sensor
	Laundry Room & Utility Room	High-efficacy OR Manual-on occupancy sensor

## Code explanation and design suggestions:

- ▶ Fluorescent and incandescent light fixtures MUST be controlled separately.
- ▶ The first switch no longer needs to control a fluorescent light fixture.
- ▶ Occupancy sensors must be manual on/off and automatic off. The maximum time delay to turn off is 30 minutes after the last detected motion. Sensors cannot have an override allowing the light fixture to be continuously on.
- ▶ Using fluorescent light fixtures with regular switches for most of the bathroom helps eliminate any possibility of a homeowner stranded in a dark bathroom due to a lack of motion (e.g., during a relaxing bath).
- ▶ Use 26-watt CFL recessed cans, similar to the kitchen, so the homeowner will not be confused when purchasing replacement parts.
- ▶ The number of fluorescent/incandescent light fixtures will vary with each design. Quantity of light fixtures is not addressed by the code.

*Each and every permanently installed fixture must comply with the standards, by means of being high-efficacy or controlled by a manual-on occupancy sensor.*

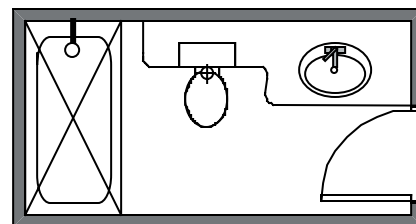


## Bathroom Definition

As defined by CEC, a room containing a shower, tub, toilet, or a sink that is used for personal hygiene.

If a sink used for personal hygiene is in a room other than a bathroom where no doors, walls, or other partitions separate the sink area from the rest of the room, and the lighting for the sink area is switched separately from room area lighting, only the luminaire(s) that are lighting the sink area must meet the bathroom lighting requirements.

## Model Standard Bath





# Bathrooms: Option #1

## Bathroom lit with fluorescent lighting only

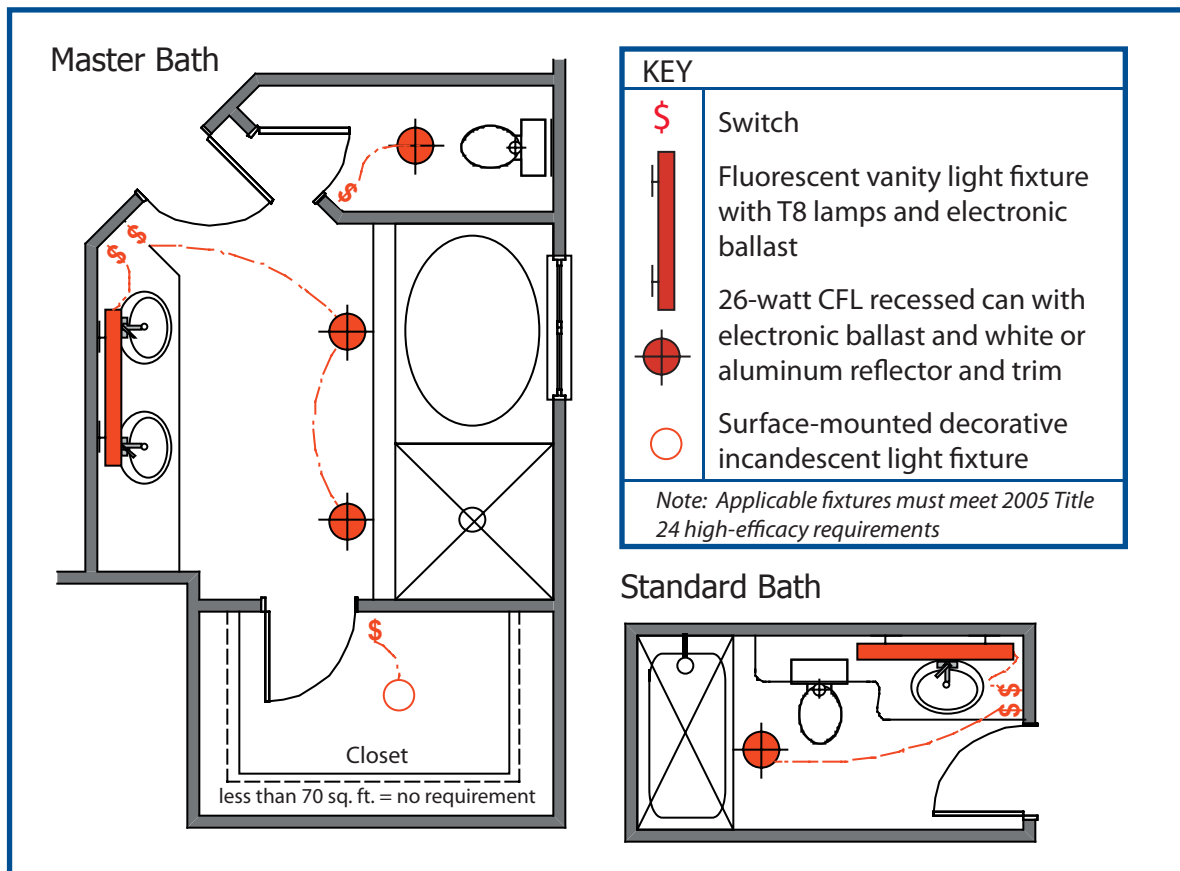
Guidelines used for the lighting design shown below:

- ▶ Use a decorative linear fluorescent light fixture over the mirror.
- ▶ Use 26-watt CFL recessed cans with electronic ballasts (or exhaust fan combination) over the toilet area, tub, and walkways.
- ▶ Provide separate switches for versatility in the lighting environment.
- ▶ Use 2700K or 3000K color temperature lamps for a warm, "incandescent" feel.

General lighting on the counter should maintain an average of 30 footcandles.

Use a color rendering index (CRI) greater than 80 for the light fixture over the mirror.

One switch can be used for this layout instead of two as shown.



# Bathrooms: Option #2

## Bathroom lit with incandescent and fluorescent lighting

Guidelines used for the lighting design shown below:

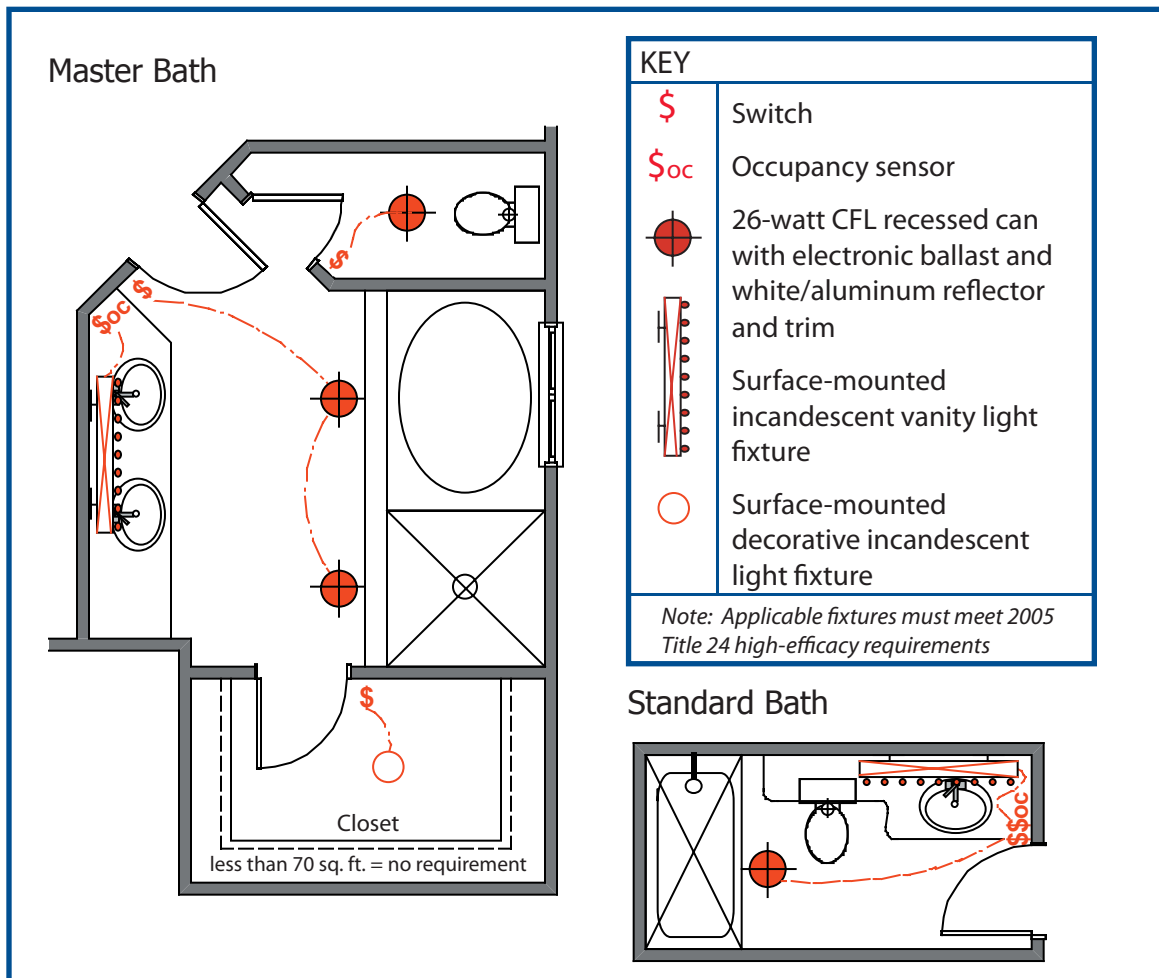
- ▶ Over or alongside the mirror, use incandescent vanity light fixtures controlled with a manual-on, automatic-off occupancy sensor.
- ▶ Use 26-watt CFL recessed cans with electronic ballasts (or exhaust fan combination) over the toilet area, tub, and walkways.

Further code explanation as applied to the lighting plan below:

- ▶ Fluorescent and incandescent light fixtures MUST be controlled separately.
- ▶ The occupancy sensor must be in the direct line of sight of the occupant, not hidden, around the corner, or in another room.

The primary switch no longer needs to control the high-efficiency (fluorescent) light source.

When three-way switching is desired, use fluorescent lighting with a standard three-way switch.



# Bathrooms: Option #3

## Bathroom lit with incandescent lighting only

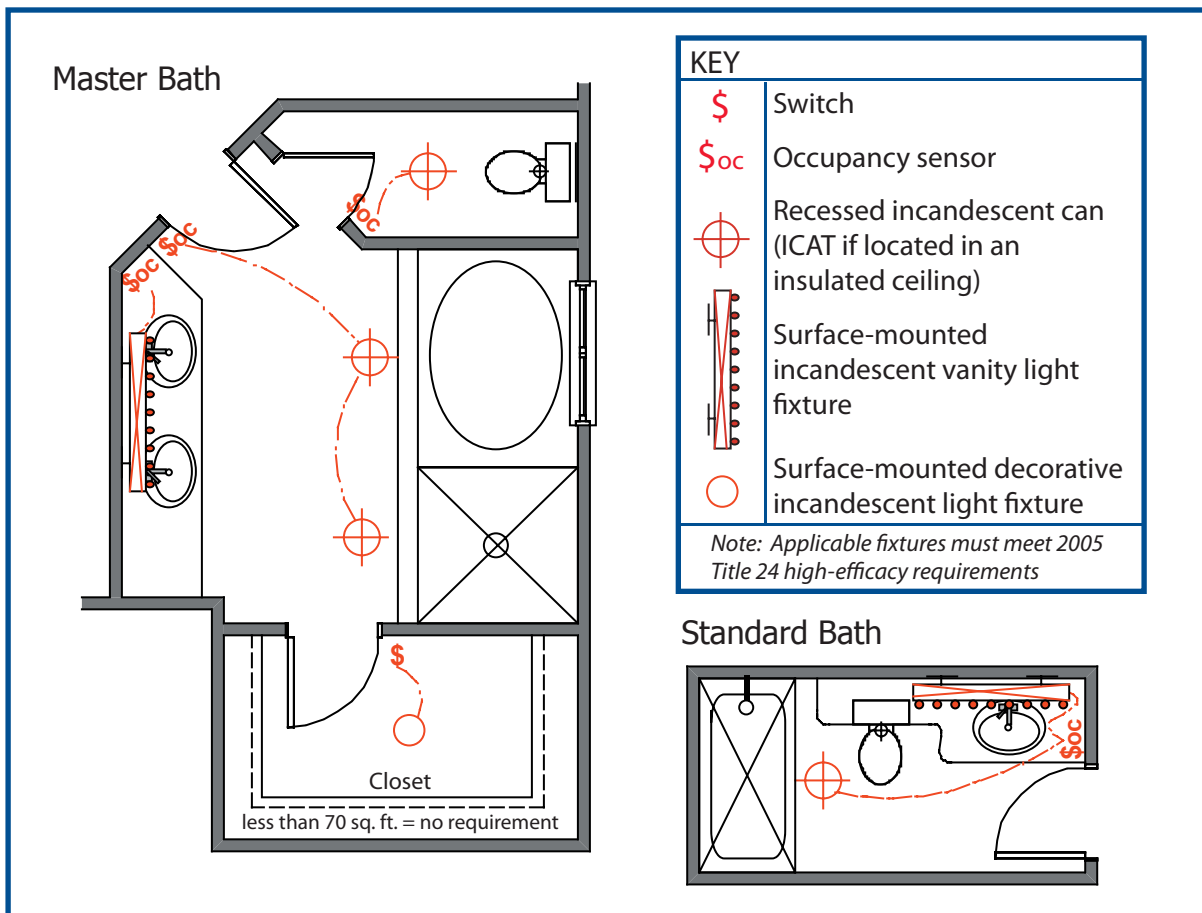
Guidelines used for the lighting design shown below:

- ▶ Use incandescent vanity light fixtures over the mirror or on the sides of the mirror, controlled with a manual-on, automatic-off occupancy sensor.
- ▶ Use incandescent recessed cans or decorative surface-mounted fixtures controlled by occupancy sensors over the toilet area, tub, and walkways.
- ▶ Control all incandescent lighting with one occupancy sensor, as long as the sensor can always “view” or “see” the occupant.

Further code explanation as applied to the lighting plan below:

- ▶ The occupancy sensor must be in the direct line of sight of the occupant, not hidden, around the corner, or in another room.
- ▶ The number of light fixtures will vary with each design and is not addressed in the code.

If the occupancy sensor controls all the light fixtures in the space and turns off the lights prematurely, the occupant could be in total darkness.



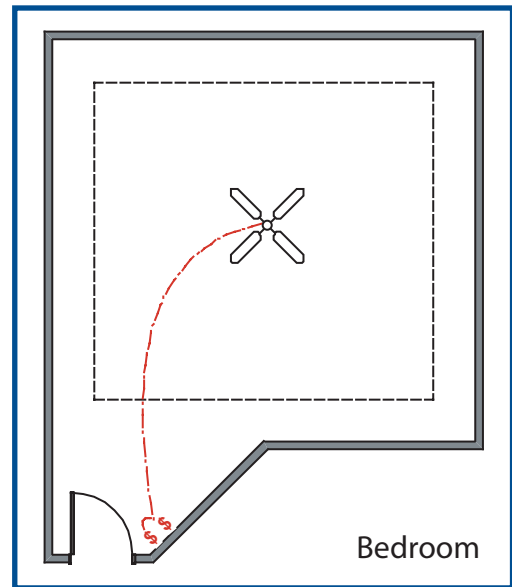
# Other Spaces: Bedrooms & Hallways

2005 Requirements	All other interior rooms (e.g., living room, dining room, bedrooms, hallways,) except closets less than 70 sq. ft.	High efficacy OR Manual-on occupancy sensor OR Dimmer
-------------------	--	---

*Note: Each and every permanently installed lighting fixture must comply with the standards, by means of being high efficacy, controlled by a manual-on occupancy sensor, or controlled by a dimmer.*

## Bedrooms

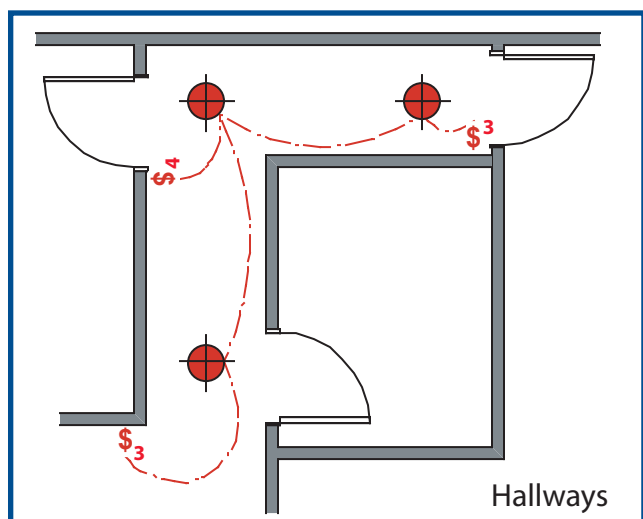
- ▶ Use fluorescent light fixtures with one or more regular switches.  
OR  
Use incandescent light fixtures with dimmers or occupancy sensors.
- ▶ When using ceiling fans with fluorescent light kits, provide one regular switch for the fan and one regular switch for the lights (as shown).
- ▶ When using ceiling fans with incandescent light kits, provide one regular switch for the fan and one dimmer for the light.
- ▶ Switched outlets (half hots) do not require special controls.
- ▶ When installing a switched ceiling box and no fixture, provide two switch wires so homeowners can comply with the 2005 requirements should they install a ceiling fan with a light fixture.



KEY	
\$	Switch
\$ <sub>3</sub>	Switch (three-way switch in hallway)
	26-watt CFL recessed can with electronic ballast and white or aluminum reflector and trim
	Ceiling fan with CFLs and fan motor on separate switches
<i>Note: Applicable fixtures must meet 2005 Title 24 high-efficacy requirements</i>	

## Entry area, foyer, and hallways

- ▶ Use fluorescent light fixtures with regular three-way switching (as shown).  
OR  
Use incandescent light fixtures with three-way dimmers.
- ▶ Choose from three types of incandescent dimmers: line voltage, low-voltage with magnetic transformers, and low-voltage with electronic transformers. Specify the correct dimmer for the incandescent load.



# Living Room, Dining Room & Attic

## Living room

- ▶ Use fluorescent light fixtures with one or more regular switches.  
OR  
Use incandescent light fixtures with dimmers.
- ▶ When using ceiling fans with fluorescent light kits, provide one regular switch for the fan and one regular switch for the light.
- ▶ When using ceiling fans with incandescent light kits, provide one regular switch for the fan and one dimmer for the light.
- ▶ Switched outlets (half hots) do not require special controls.

## Dining room

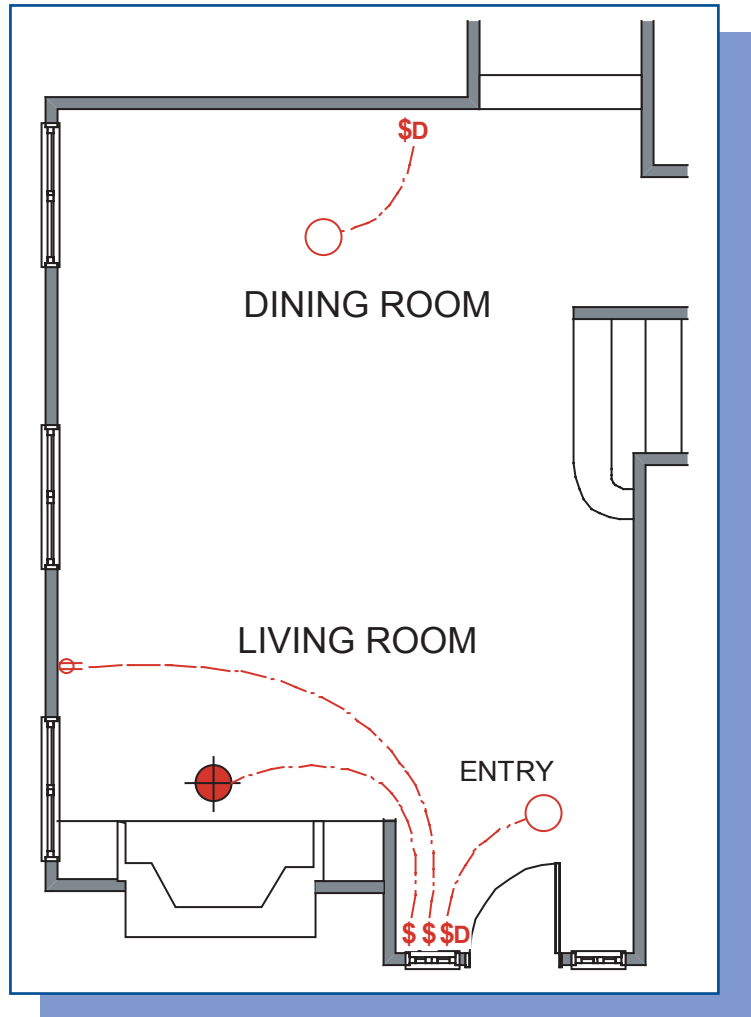
- ▶ For a more decorative option, use incandescent light fixtures with dimmers.

## Enclosed patio

- ▶ An enclosed (unconditioned) patio is considered an "other space." Each fixture must be high efficacy or controlled by a dimmer or occupancy sensor.

## Attic

- ▶ Regardless of the square footage, attics are considered "other spaces" and must use fluorescent light fixtures with a regular switch OR incandescent fixtures with a dimmer or occupancy sensor. The fluorescent option is recommended with a normal switch. The occupancy sensor option is recommended only if the sensor can "see" the entire attic; otherwise it may be a liability if the occupant is left in the dark.



KEY	
\$	Switch
\$D	Dimmer
⊖	Switched (half hot) outlet
⊙	26-watt CFL recessed can (ICAT in insulated ceiling) with electronic ballast and white or aluminum reflector and trim
○	Surface- or pendant-mounted incandescent light fixture
<i>Note: Applicable fixtures must meet 2005 Title 24 high-efficacy requirements</i>	

# Outdoor Lighting

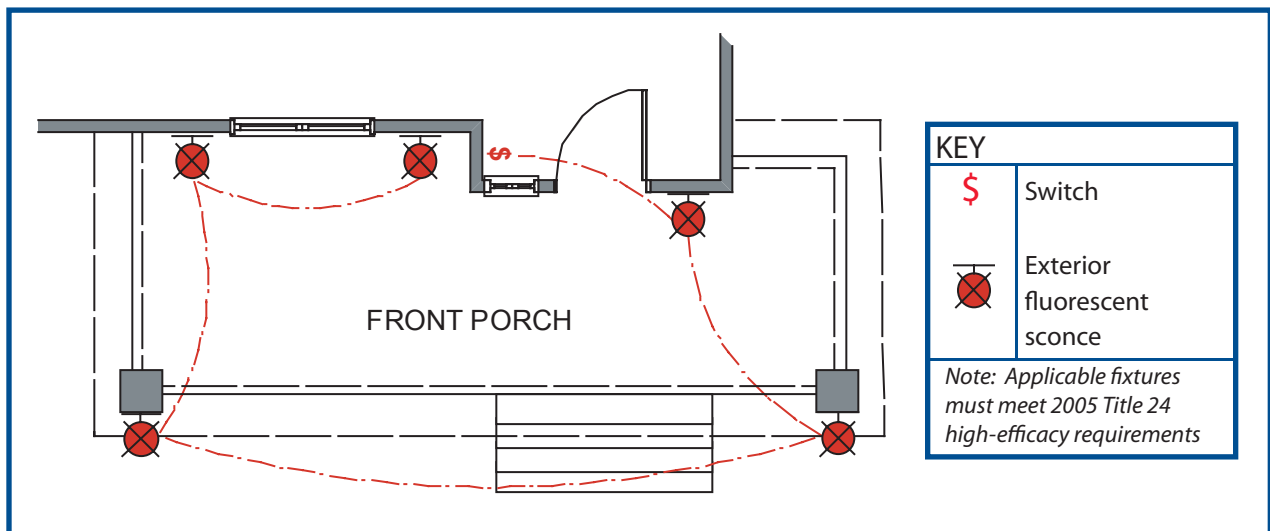
2005 Requirements	Outdoor lighting attached to buildings	High efficacy OR Controlled by motion sensor + photocontrol
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*Note: Each and every permanently installed lighting fixture must comply with the standards.*

Further code explanation as applied to the lighting plan below:

- ▶ This part of the code covers all exterior lighting EXCEPT landscape lighting not attached to the building and residential parking lots or garages for eight or more vehicles.
- ▶ Outdoor motion sensors must have automatic-off operation, but unlike interior occupancy sensors they may have automatic-on operation. In addition, exterior motion sensors must include a photocontrol to keep lights off during daylight hours.
- ▶ In addition to the motion sensor and photocontrol, the homeowner must still be provided with a regular switch to turn the lights on and off manually.
- ▶ Outdoor sensors must comply with the 30-minute shutoff requirement.
- ▶ The sensor must be installed so it views or covers the area that is to be illuminated by the fixture.

Pay attention to the electrical load requirements of the sensor selected. If the sensor rating calls for a minimum load, make sure that this load is met by all fixtures. If the homeowner changes the lamp to a lower wattage, below the minimum load, the switch may no longer operate.



# Outdoor Lighting

Carefully decide which technology to use in different applications because each has different advantages and disadvantages.

## Benefits of high-efficacy outdoor light fixtures:

- ▶ Lights can be left on for an extended period
- ▶ No need to be concerned with the placement of motion sensors
- ▶ No need to worry about motion sensors turning lights on and off at undesired times

## Recommended Uses:

- ▶ Entry porch: freedom to leave lights on for an extended period of time
- ▶ Near bedroom windows: homeowners may be distracted when lights are triggered by a motion sensor as a pet walks by in the middle of the night

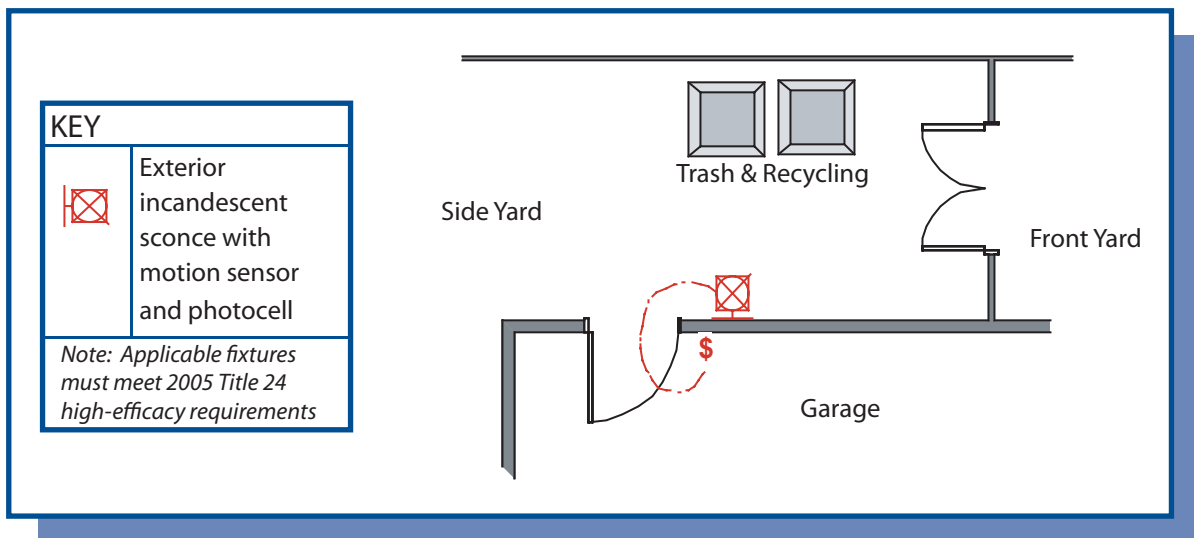
## Benefits of incandescent light fixtures with photocell motion sensors:

- ▶ Lights are not left on unintentionally
- ▶ Lights turn on automatically; no need for a free hand to flip a switch
- ▶ Added home security
- ▶ Can use standard incandescent lamps

## Recommended Uses:

- ▶ Anywhere the light would not be in direct sight of a bedroom: motion sensors may be triggered (on/off) as, for example, a pet walks by in the middle of the night
- ▶ Near the garage and trash can: this transitional space benefits from lights being controlled by motion sensors

Motion sensor coverage should not be too large, or lights will be triggered by street traffic or a neighbor's motion. Most sensors have a sensitivity control to adjust the degree of motion and light that triggers them.



# Multi-Family Applications

2005 Requirements	Common areas of low-rise residential buildings with 4 or more dwelling units	High efficacy OR Occupancy sensor
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*Note: Each and every permanently installed lighting fixture must comply with the standards.*

## Common areas of low-rise residential buildings with four or more dwelling units

### Additional code explanation:

- ▶ Buildings three stories or less are classified as low rise.
- ▶ "Common areas" of low-rise buildings include exercise rooms, hallways, lobbies, corridors, and stairwells.
- ▶ Use high-efficacy lighting (fluorescent, metal halide, or high-pressure sodium), preferably on a photocontrol or time clock.  
OR  
Use any other light source with an occupancy sensor.
- ▶ Occupancy sensors must be in the direct line of sight of the walkway.

Do not use occupancy sensors with HID lamps such as metal halide or high-pressure sodium.

Use passive infrared occupancy sensors located in the direct line of sight of the path/people. Use a set point of 15–30 (30 max) minutes to turn off lights when not in use.

Occupancy sensors should be rated for damp locations when installed under a canopy and wet locations when directly exposed to weather elements.

## Residential parking lots for eight or more vehicles

### Additional code explanation:

- ▶ Lamps rated over 100 watts must have a lamp efficacy of at least 60 lumens per watt OR be controlled by a motion sensor.
- ▶ Fixtures with lamps rated over 175 watts shall be designated as "cutoff," limiting the light emitted upwards. Both "cutoff" and "full-cut-off" fixtures can be used to meet this requirement.
- ▶ Light fixtures must be controlled by a photo-control or an astronomical time switch that turns lights off when daylight is available.
- ▶ The installation must meet the power density limits for nonresidential lighting standards. For more information, see *2005 Building Energy Efficiency Standards*, Section 147.
- ▶ The owner must be able to automatically turn off 50% of the lighting power in a reasonably uniform pattern, so that the entire area retains some illumination (no dark spots).

Uniform lighting helps to eliminate shadows in corners and provide a sense of safety.



**ASTM:** American Society for Testing and Materials.

**ASTM E283:** A standard testing method for measuring the rate of air leakage. As noted in the California Title 24 - 2005 Building Efficiency Standards, Sub-Chapter 7, Section 150, (K), (5): [Recessed luminaires in insulated ceilings] "shall include a label certifying air tight (AT) or similar designation to show air leakage less than 2.0 CFM at 75 Pascals (or 1.57 lbs/ft<sup>2</sup>) when tested in accordance with ASTM E283."

**Bathroom:** As defined by CEC, a room containing a shower, tub, toilet, or a sink that is used for personal hygiene.

**CCT:** Correlated color temperature. See Kelvin.

**CEC:** California Energy Commission.

**CFL:** Compact fluorescent lamp.

**CRI (color rendering index):** A measure of the degree of color shift objects undergo when illuminated by the light source as compared with those same objects when illuminated by a reference source of comparable color temperature. Higher CRI ratings indicate better color rendering. Scale 0–100; 80+ signifies high-quality color rendering.

**Dimmer:** A device used to control the intensity of light emitted from a luminaire by controlling the voltage or current available to it.

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

**Footcandle:** A unit for illuminance (the amount of light that falls on a surface); equal to the number of lumens striking a surface, divided by the area of the surface.

**Half hot:** A switched outlet.

**HID:** High-intensity discharge lamp such as metal halide or high-pressure sodium.

**High efficacy:** As defined by CEC:

- For lamps 15 watts or less—minimum of 40 lumens per watt
- For lamps 15 to 40 watts—minimum of 50 lumens per watt
- For lamps over 40 watts—minimum of 60 lumens per watt

High-efficacy interior lighting is mostly fluorescent; high-efficacy exterior lighting can be fluorescent or HID.

**ICAT:** A luminaire installed in an insulated ceiling meeting the insulation contact *and* airtight rating requirements.

**IESNA:** Illuminating Engineering Society of North America.

**Illuminance:** Light arriving at a surface.

**Kelvin (K):** The unit of temperature used to designate the color temperature of a light source. Temperature: 2700K (warm color index), 3000K, 3500K, 4100K (cooler color index).

**Kitchen:** As defined by CEC, a room or area used for cooking, food storage and preparation, and washing dishes, including associated countertops and cabinets, refrigerator, stove, ovens, and floor area. Adjacent areas are considered kitchen if the lighting for the adjacent areas is on the same switch as the lighting for the kitchen.

**Lamp:** Light bulb.

**Low efficacy:** Opposite of high-efficacy lighting. Typically incandescent, halogen, and mercury vapor.

**LPW:** Lumens per watt (efficacy of a light fixture).

**Lumen:** The unit that quantifies the total amount of light emitted by a source.

**Luminaire:** A complete light fixture consisting of a lamp or lamps and ballast(s) together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply (reflectors, housing, lenses, etc.).

**Maximum rated:** The wattage listed on the label of the light fixture. Fixture with a screw-in base may have a maximum-rated relamping wattage as high as 300 watts.

**Motion sensor:** A switching device used to automatically turn on light fixtures with a sensor that automatically turns off lighting fixtures after 30 minutes (maximum) from when the last motion is detected (for outdoor applications only).

**Nook:** As defined by CEC, an area adjacent to the kitchen *not* on the same switch. This area falls under the "other spaces" code requirements and not under the wattage requirements for the kitchen.

**Occupancy sensor:** A switching device used to manually turn on light fixtures with a sensor that automatically turns off lighting fixtures after thirty minutes (maximum) from when the last motion is detected (for indoor applications only).

**Other rooms:** As defined by CEC these include entry areas, foyers, hallways, living rooms, dining rooms, family rooms, bedrooms, attics, and enclosed patios.

**Photocontrol:** A device used to automatically turn on light fixtures at dusk and automatically turn them off at dawn.

**Relamping wattage:** The maximum allowable wattage specified by the luminaire label.

**Sconce:** A decorative wall light fixture.

**Watt:** The unit of measure for the energy used by a lamp or fixture.

# 2005 Title 24: Inspection & Compliance Guide

## Kitchen

At least 50% of the total wattage is high efficacy:

Fixture Type	High efficacy (y/n)	Relamping wattage	x	Quantity =	High-efficacy wattage	or	Low-efficacy wattage
_____	_____	_____	x	_____ =	_____	or	_____
_____	_____	_____	x	_____ =	_____	or	_____
_____	_____	_____	x	_____ =	_____	or	_____
_____	_____	_____	x	_____ =	_____	or	_____
(Complies if $A \geq B$ )					Total: A: _____		B: _____
						Compliant? YES <input type="checkbox"/>	NO <input type="checkbox"/>

### Additional requirements

Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).

YES  N/A  NO

High-efficacy and low-efficacy fixtures are switched separately.

## Bathroom(s)

All light fixtures are high efficacy.

YES  N/A  NO

Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors.

Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).

High-efficacy and low-efficacy fixtures are switched separately.

## Laundry Room / Utility Room

All light fixtures are high efficacy.

YES  N/A  NO

Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors.

Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).

High-efficacy and low-efficacy fixtures are switched separately.

## Garage

All light fixtures are high efficacy.

YES  N/A  NO

Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors.

Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).

High-efficacy and low-efficacy fixtures are switched separately.

# 2005 Title 24: Inspection & Compliance Guide

<input checked="" type="checkbox"/> <b>Bedroom(s)</b>	YES	N/A	NO
All light fixtures are high efficacy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors OR dimmer switch.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High-efficacy and low-efficacy fixtures are switched separately.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<input checked="" type="checkbox"/> <b>Living Room / Dining Room</b>	YES	N/A	NO
All light fixtures are high efficacy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors OR dimmer switch.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High-efficacy and low-efficacy fixtures are switched separately.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<input checked="" type="checkbox"/> <b>Hallway(s)</b>	YES	N/A	NO
All light fixtures are high efficacy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors OR dimmer switch.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High-efficacy and low-efficacy fixtures are switched separately.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<input checked="" type="checkbox"/> <b>Entry Area / Foyer</b>	YES	N/A	NO
All light fixtures are high efficacy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Incandescent fixtures are switched with manual-on/automatic-off occupancy sensors OR dimmer switch.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recessed fixtures installed in insulated ceilings are rated ICAT and certified ASTM E283 or equivalent. Installation is airtight (caulking, gaskets).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High-efficacy and low-efficacy fixtures are switched separately.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<input checked="" type="checkbox"/> <b>Outdoor Space(s)</b>	YES	N/A	NO
All light fixtures are high efficacy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Incandescent fixtures are controlled by motion sensor with a manual-on/off switch AND photocontrol.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## For more information, contact:

### Title 24 Background & Reference

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California Energy Commission  
[www.energy.ca.gov/title24](http://www.energy.ca.gov/title24)  
916-654-5200

### Residential Lighting Design Guide Sponsors

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#### ENERGY STAR

[www.energystar.gov](http://www.energystar.gov)  
888-STAR-YES

Pacific Gas and Electric  
[www.pge.com](http://www.pge.com)

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

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

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

Southern California Gas Company  
[www.socalgas.com](http://www.socalgas.com)

### Technical Resources

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Advanced Lighting Guidelines  
[www.newbuildings.org/lighting](http://www.newbuildings.org/lighting)

Building Industry Research Alliance  
[www.bira.ws](http://www.bira.ws)

California Association of Building Energy Consultants  
[www.cabec.org/abouttitle24.php](http://www.cabec.org/abouttitle24.php)

California Building Industry Institute  
[www.cbia.org](http://www.cbia.org)

California Lighting Technology Center

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

ConSol  
[www.consol.ws](http://www.consol.ws)

ENERGY STAR  
[www.LightingPlans.com](http://www.LightingPlans.com)

[www.energystar.gov/](http://www.energystar.gov/)  
*(click on "Products" then "Residential Light Fixtures")*

### Manufacturers

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Cooper Lighting  
[www.cooperlighting.com](http://www.cooperlighting.com)

Juno Lighting  
[www.junolighting.com](http://www.junolighting.com)

Leviton  
[www.leviton.com](http://www.leviton.com)

Lithonia Lighting  
[www.lithonia.com](http://www.lithonia.com)

Lutron  
[www.lutron.com](http://www.lutron.com)

Novitas  
[www.novitas.com](http://www.novitas.com)

Philips Lighting  
[www.philips.com](http://www.philips.com)

Progress Lighting  
[www.progresslighting.com](http://www.progresslighting.com)

Seagull Lighting  
[www.seagulllighting.com](http://www.seagulllighting.com)

Thomas Lighting  
[www.thomaslighting.com](http://www.thomaslighting.com)

Watt Stopper  
[www.wattstopper.com](http://www.wattstopper.com)

The California Lighting Technology Center, established through a joint effort of the California Energy Commission and the University of California, Davis, conducts both cooperative and independent activities with lighting manufacturers, with electric utilities, and with the design and engineering professional community. These partnerships are facilitated and supported by state-of-the-art lighting and daylighting applications at CLTC's development and testing facilities, coupled with lighting-efficiency training and educational programs.

The *Residential Lighting Design Guide* was developed by the California Lighting Technology Center, with special thanks to Connie Buchan from Sacramento Municipal Utility District for her contribution to the development of this guide.

For more information and guide updates, visit: [www.cltc.ucdavis.edu](http://www.cltc.ucdavis.edu)

