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**ASSIST** *recommends...*

# A Homeowner's Guide to Residential Under-cabinet Lighting: Getting Good Lighting for Your Kitchen Counters

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Lighting  
Research Center



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## Contents

<b>What is Under-cabinet Lighting?</b> .....	<b>4</b>
<b>Types of Under-cabinet Lighting</b> .....	<b>4</b>
Incandescent Lamps.....	5
Fluorescent Lamps .....	5
LEDs (light-emitting diodes).....	6
<b>Under-cabinet Lighting Performance</b> .....	<b>7</b>
Table Definitions .....	7
<b>Selecting and Installing Your Under-cabinet Lighting</b> .....	<b>8</b>
Getting the Best Lighting for Kitchen Counters .....	9
Incandescent Puck Lighting.....	10
Incandescent Linear Lighting.....	11
Light strips .....	11
Linear fixtures .....	12
Fluorescent Linear Lighting .....	12
Compact Fluorescent Puck Lighting .....	13
LED Puck Lighting .....	14
LED Linear Lighting .....	15
<b>Designing Your Under-cabinet Lighting</b> .....	<b>15</b>
Countertops .....	15
Lighting Color.....	16
Brightness and Glare .....	17
Dimming Capability .....	17
Fixture Fit.....	18
Fixture Lenses .....	18
<b>Codes, Safety, Standards, and Compliance</b> .....	<b>18</b>
California Energy Standards – Title 24 .....	18
ENERGY STAR® .....	18
Underwriters Laboratories .....	19
Disposal .....	19
<b>Glossary</b> .....	<b>19</b>
<b>Resources</b> .....	<b>20</b>
<b>About ASSIST</b> .....	<b>20</b>

## What is Under-cabinet Lighting?

Under-cabinet lighting is often added to kitchen and pantry cabinets to provide task lighting on the countertops that is complementary to the general lighting of the room. The underside of cabinets provides an ideal location for task lighting because the light source is near the task and can be easily concealed to avoid glare. Under-cabinet lighting also can reduce shadows cast by the cabinets from the overhead lighting. Illumination on the backsplash creates a bright surface that enhances the appearance of the kitchen. In some instances, under-cabinet lighting also doubles as a night light, especially if the light is dimmable or if the fixture has a low light level for this purpose.



A kitchen with energy-efficient lighting.

## Types of Under-cabinet Lighting

Under-cabinet lighting can be purchased at home improvement centers and specialty lighting showrooms, as well as from online distributors. The fixtures available from these suppliers may use one of three types of bulbs, also called lamps: incandescent, fluorescent, or LED. The type of lamp influences the performance of the fixture, including the amount of light, the light's color, the life of the lamp or fixture, and its energy use. The type of lamp also often dictates the style of the fixture.



A variety of under-cabinet lighting fixtures.

### ***Incandescent Lamps***

Incandescent lamps are the most common light source found in homes. Incandescent lamps come in a variety of styles for under-cabinet lighting, such as “bi-pin,” “wedge,” and “festoon.” They are available in different wattages and correlated color temperatures (CCT), referring to the color appearance of white light (for example, a yellowish-white vs. a bluish-white). They provide a warm, glowing light, though some types of incandescent, including halogen and xenon, are popular because they have a higher CCT. These lamps are a “cooler” white or less yellow in appearance.



Bi-pin Lamp & Puck Light

Wedge Lamp & Linear Fixture

Festoon Lamp & Light Strip

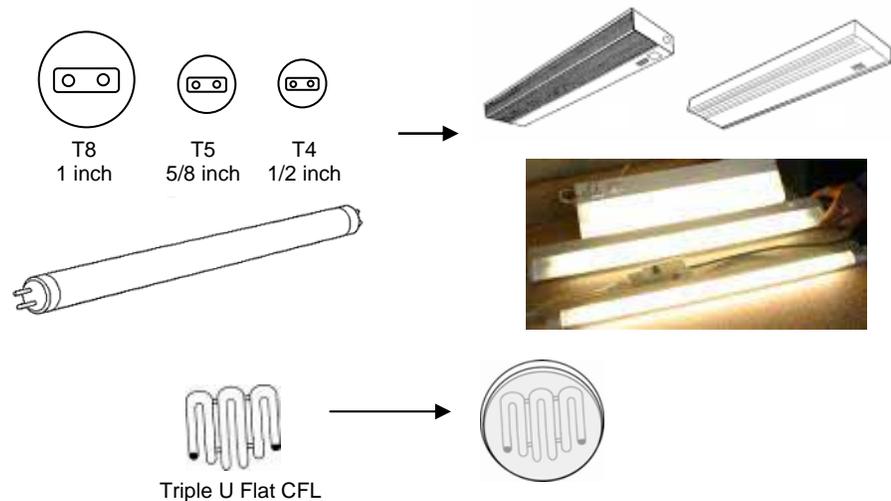
Incandescent lamps are readily available, inexpensive, and easy to replace when one burns out. However, they typically have the shortest life (2 years on average at 3 hours per day) and highest energy use for equal light output of the three types of lamp available. Xenon lamps tend to have the longest life in this category, 7 years on average at 3 hours per day.

### ***Fluorescent Lamps***

Under-cabinet fluorescent lighting is available with linear fluorescent lamps or compact fluorescent lamps (CFLs). Linear fluorescent lamps are the most popular type of fluorescent lighting for under-cabinet fixtures because they are thin, allowing them to be concealed behind the cabinet trim. CFLs are used typically in round fixtures, though some linear CFL fixtures are available.

Newer fluorescent lamps have many improvements over older designs, including choice of light color (from warm to cool), good color rendering, instant-on, no flickering, and no buzzing or humming.

The most common linear fluorescent lamps for under-cabinet lighting are T8, T5, and T4, referring to the diameter size of the lamp (8/8 in., 5/8 in., and, 4/8 in., respectively), and range in length from 1 ft. to 4 ft. Longer lengths use higher wattage lamps. However, a fluorescent lamp's efficacy (the amount of light, or lumens, emitted per watt of electrical power) improves as the lamp wattage increases. The higher the wattage, the more efficacious the lamp.



Fluorescent lamps have the advantages of high efficacy (a high rate of light output per watt of electrical power), long life (7 years on average at 3 hours per day), and bright, uniform lighting. Fluorescent under-cabinet fixtures are sold as both plug-in types or as fixtures to be hard-wired. The disadvantage of fluorescent fixtures for under-cabinet lighting, however, is that some linear designs may not be small enough or narrow enough to be concealed without modifying the cabinet with trim molding to shield the fixture.

### **LEDs (light-emitting diodes)**

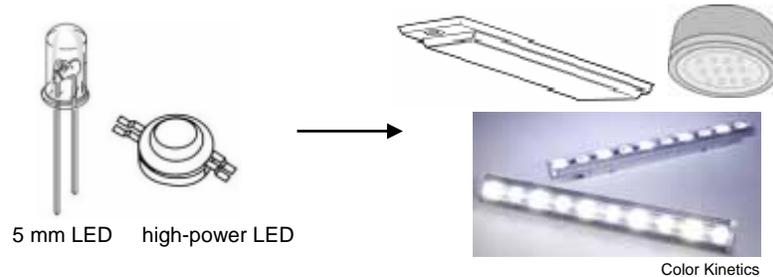
White LEDs have become popular for a variety of task lighting uses because of their low energy use. LED fixtures may use one of several types of LED, including small 5 millimeter (mm) LEDs, which use 1/10 W of energy, or larger high-power LEDs of 1/2 W or 1 W. While some LEDs may be quite small, they still require other components that enable their proper operation, making the size of an LED fixture about the same as other fixtures used for under-cabinet lighting.

LEDs are also popular for their long life. Properly designed LED fixtures can last longer than 10 years. Unlike incandescent and fluorescent lamps, LED lamps typically do not burn out. Rather, they get dimmer over time to a point where they do not produce enough light to see by, even though they are still operating. This light output depreciation also occurs in fluorescent and incandescent lamps, but the rate is different for each type.

White LEDs are generally a bluer-white in color appearance than incandescent lamps, though warm-white LEDs that mimic incandescent are becoming more common. White LEDs are generally available in the same color range as fluorescent lamps. While their operating life is long and they use less energy than

incandescent (and less than fluorescent in some cases), their initial purchase price is currently much higher.

One consideration for LEDs is heat. Though LEDs are generally thought of as cool compared to incandescent lamps (which put out approximately 90% of their energy as heat), LEDs still produce heat and are susceptible to high temperatures. Under high temperatures, LEDs will have a shorter life and will fade more quickly.



## Under-cabinet Lighting Performance

All under-cabinet lighting fixtures do not perform the same, as illustrated by the table on the next page. Performance can vary widely depending on the type of lamp and the design of the fixture. Performance can also differ by the place of purchase. Specialty lighting retailers and manufacturer distribution representatives may offer specification-grade products that provide better quality but for a higher price. These may be available only through electricians and contractors.

The table lists estimates of the amount of power, in watts, needed for each type of under-cabinet lighting in order to provide an appropriate light level on a kitchen counter measuring 24 in. to 28 in. wide. In turn, the estimated wattages were used to calculate purchase, installation, lamp replacement, and energy costs for each type of lighting.

### **Table Definitions**

**Power per cabinet.** The wattage (W) of the fixture needed for one 24-in. to 28-in. wide cabinet in order to provide sufficient light on the counter for critical visual tasks. The Illuminating Engineering Society of North America (IESNA) recommends an appropriate range of light levels for critical tasks. In the kitchen, these could be cooking, chopping, or other activities requiring an attention to detail.

**Initial purchase cost.** The cost to purchase a lighting fixture varies greatly by the types of light source and supplier. The table gives an estimate of the purchase cost based on retail prices.

**Initial installation cost.** The installation cost considers the labor cost and incidental costs of small hardware to install the fixtures to existing electrical outlets. The calculations assume an average rate of \$56 per hour for a qualified electrician.

**Annual lamp replacement cost.** The cost noted here is the average expense to replace lamps per year considering an average daily use of 3 hours.

**Annual energy cost.** This is the expected yearly electricity bill cost to operate the lighting, considering an average daily use of 3 hours at 10 cents per kilowatt hour (kWh).

**Lamp replacement frequency.** The average number of years the lamps are expected to last before needing replacement.

Under-cabinet Lighting Fixture Performance and Cost							
Estimates are for a 24-in to 28-in wide cabinet and provide an average of 350 lx on the counter							
light source	fixture type and number	power per cabinet (W)	initial purchase cost (\$)	initial installation cost (\$)	annual lamp replacement cost (\$/yr)	annual energy cost (\$/yr)	lamp replacement frequency (years)
Incandescent	halogen pucks (2)	39 W	\$ 22	\$ 42	\$ 2.40	\$ 4.30	2
	xenon pucks (3)	59 W	\$ 30	\$ 56	\$ 1.50	\$ 6.50	7
	xenon linear (1)	102 W	\$ 60	\$ 56	\$ 2.50	\$ 11.20	7
	xenon strip (1)	162 W	\$ 189	\$ 112	\$ 9.80	\$ 17.70	7
Linear fluorescent	T4 (1)	13 W	\$ 16	\$ 56	\$ 0.80	\$ 1.40	7
	T5 (1)	14 W	\$ 29	\$ 56	\$ 0.70	\$ 1.60	7
	T8 (1)	29 W	\$ 47	\$ 56	\$ 0.70	\$ 3.20	7
Compact fluorescent	triple U flat (2)	15 W	\$ 18	\$ 42	\$ 2.80	\$ 1.60	7
LED*	5 mm linear (1)	19 W	\$ 183	\$ 56	\$ 20.00	\$ 2.10	9**
	5 mm pucks (2)	8 W	\$ 79	\$ 42	\$ 8.60	\$ 0.90	9**
	high-power linear (1)	42 W	\$ 147	\$ 56	\$ 3.20	\$ 4.60	>10**

\*Because LED lighting is a relatively new technology, performance and cost are changing on a regular basis. Check for updates to this table at [www.lrc.rpi.edu/programs/solidstate/assist/recommends.asp](http://www.lrc.rpi.edu/programs/solidstate/assist/recommends.asp).

\*\*Rated life of the LED source only, not given as a fixture. The actual rated life for the fixture may be less.

## Selecting and Installing Your Under-cabinet Lighting

Under-cabinet lighting should be considered the workhorse of the kitchen, but it is too often underestimated in relation to the benefits it can provide. It should be smooth, uniform illumination for a variety of tasks and purposes ranging from reading the faded handwriting on an old recipe, to mincing and dicing meats and vegetables, to simply displaying a colorful blown glass decanter or a piece of kitchen art. With good under-cabinet lighting, colors of food are vibrant and textures are enhanced. As the social center of the home, kitchens are often the primary location for family activities and parties. Adjustable light levels allow for a transition from a bright, clear visual environment, to a lively setting, to one that is quiet and relaxed when the day's activities are over.

The variety of under-cabinet lighting fixtures available can make it hard to choose what is best. This section discusses how to get the best lighting for kitchen counters, describes the most common types of fixtures available for each type of lighting technology, illustrates the lighting quality each can achieve, and recommends best practices for installation.

For more information about how to select LED under-cabinet lighting and the issues to consider, see *ASSIST recommends . . . How to Select Residential LED Under-cabinet Lighting*.

### **Getting the Best Lighting for Kitchen Counters**

There are two main criteria for good task lighting: the amount of light falling on the work surface, called *illuminance level*, and the evenness of the lighting, called *uniformity*.

The illuminance of a kitchen counter is measured using an imaginary square grid laid out on the horizontal surface of the counter. Measurements are taken at each spot on the grid and then averaged to determine the average illuminance of the work surface.

The recommended average illuminance level for kitchen counters where activities such as cooking, chopping, and other detailed or critical tasks occur is 500 *lux*, a unit of measure for illuminance. For general lighting of a counter and tasks such as reading a recipe, 300 lux is recommended. Because ambient overhead lighting also contributes to the illuminance level on the counter, an under-cabinet fixture should provide at least 300 lux to meet the recommended light level for critical tasks.

Uniformity is a measure of the evenness of the lighting. Uniform lighting is easier to work under because the surface has a constant illumination, rather than “pools” or “spots” of light and dark areas. Uniformity problems may be created by the fixture spacing or the design of the fixture itself. Irregular light patterns will hinder performing tasks, detract from the counter and backsplash design, and create an unattractive overall appearance.

Uniformity is measured as a ratio of the average illuminance on the imaginary grid to the minimum illuminance on the grid. The lower the uniformity number, the more even the lighting. Most lighting designers recommend a uniformity of 5 to 1 (5:1) or less.



Each cabinet features an LED fixture. The fixture on the right provides poor uniformity and distribution, creating a central pool of light on the counter, poor lighting on the backsplash, and dark areas on the counter.

Illuminance and uniformity levels are listed for the products photographed below. These products were purchased on the open market and are representative of those available to homeowners.

### ***Incandescent Puck Lighting***



Puck lights, so named because they look like a hockey puck, are round or oval fixtures good for cabinet and display lighting. They are low-profile (less than 2 in. depth) and can be concealed under cabinets easily. The fixture housing comes in several colors (generally black, white, or metallic finish) to match different décors. Some puck lights can be mounted in different positions to aim the light either straight down or at the backsplash. In addition to surface mounting, some fixtures can be recessed into cabinets.

Incandescent puck lights typically use one 20–25 W bi-pin lamp. Because of the nature of their design, puck lights can create scallops, spots, or pools of light, rather than even illumination across the counter, especially when spaced far apart from each other.

In general, one puck light is needed for every 8–12 in. of cabinet length. This spacing will provide the best uniformity and distribution of light and avoid any dark areas under the cabinets.



Two xenon puck lights spaced 16 in. on center  
Average illuminance: 238 lux  
Minimum illuminance: 49 lux  
Meets recommendation for critical tasks? No  
Uniformity on counter: 5:1



Three xenon puck lights spaced 8 in. on center  
Average illuminance: 339 lux  
Minimum illuminance: 70 lux  
Meets recommendation for critical tasks?: Yes  
Uniformity on counter: 5:1

### ***Incandescent Linear Lighting***

Incandescent linear lighting comes in two forms: as a light strip or as a linear fixture or light bar. They can be normal voltage (120 volt) or low voltage (12 volt).



#### **Light strips**

Light strips use 5, 6, or 10 W festoon lamps and may have 20 W halogen MR11 lamps added as well. Light strips are quite narrow (less than 1 in.) and have a height of less than 1 in. They are sold by the foot and can be cut to length during installation. The space between lamp sockets can be anywhere from 2 in. to 6 in., though a spacing of 2–3 in. between sockets is best for under-cabinet lighting. Some light strips include reflectors for each socket, which help direct the light down toward the counter, rather than up toward the cabinet. Reflectors reduce wasted light and help put the light where it is needed.

To illuminate countertops evenly, cut the light strip to fit the full length of the cabinet. For a low voltage system, allow room at one end of the run for an integral electronic transformer; alternatively, the transformer can be located in a remote location, such as the top of a cabinet. Flexible or straight connectors can link the light strip from one cabinet to the next, depending on the cabinet layout. If the counter space will be used to perform a variety of tasks, use frosted festoon lamps. These will provide more uniform lighting. If the counter will be used as a display space, use clear festoon lamps, which provide accent and sparkle.



Low voltage halogen frosted festoon lamp light strip  
Average illuminance: 117 lux  
Minimum illuminance: 60 lux  
Meets recommendation for critical tasks?: No  
Uniformity on counter: 2:1

### Linear fixtures



Linear incandescent fixtures or light bars typically use 18–35 W xenon lamps or 20–25 W halogen lamps. The lamps may be shielded behind a lens to create a uniform illumination across the length of the fixture, similar to those used with fluorescent lamps. Or they may look like individual puck lights installed side by side into one fixture. As an alternative to dimming, some fixtures have two light level settings, high and low.

As shown in the images below, the 18 in. xenon fixture produces a more uniform distribution of light than the 12 in. halogen fixture. Fixtures should be sized according to the length of the cabinet. Mounting should be at the front edge of the cabinet; if the fixture is lensed, the lens should face the backsplash.

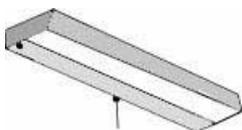


18 in. xenon linear fixture  
Average illuminance: 204 lux  
Minimum illuminance: 72 lux  
Meets recommendation for critical tasks? No  
Uniformity on counter: 3:1



12 in. halogen two puck light bar  
Average illuminance: 322 lux  
Minimum illuminance: 90 lux  
Meets recommendation for critical tasks?: Yes  
Uniformity on counter: 4:1

### Fluorescent Linear Lighting



Linear fluorescent under-cabinet fixtures are available in a multitude of lengths and depths. A limited selection is available at home improvement centers, while more lengths can be found through online distributors or special order. The lenses or housing may be adjustable to different aiming positions. As an alternative to dimming, some fixtures have two light level settings, high and low.

Some manufacturers make a product in a “standard quality” and a “premium quality.” The primary difference between these two is the light output and cost. The premium product will have the same design and same type of lamp (e.g., T5) as the standard product, but it will produce more light on the work surface. As a result, the premium product will be more expensive to purchase. Consider your lighting needs and kitchen décor when selecting a product grade.

For linear fixtures, a slim profile not greater than 1 in. high x 4 in. wide is recommended to conceal the fixture behind the cabinet trim molding. For the most uniform lighting, use fixtures of the same length for the entire kitchen. Select the longest length that will fit in the shortest-length cabinet and then use multiple fixtures of the same length to cover the cabinet. If the entire length of the cabinet cannot be covered by fixtures mounted end to end, try to cover at least 2/3 of the cabinet with each fixture spaced at even distances over the entire length of the cabinet.



14 watt T5 linear fixture  
Average illuminance: 405 lux  
Minimum illuminance: 128 lux  
Meets recommendation for critical tasks? Yes  
Uniformity on counter: 3:1



16 watt T4 linear fixture  
Average illuminance: 408 lux  
Minimum illuminance: 140 lux  
Meets recommendation for critical tasks?: Yes  
Uniformity on counter: 3:1

### **Compact Fluorescent Puck Lighting**

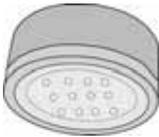


CFL under-cabinet fixtures typically use 9 W replaceable lamps. These fixtures produce more light than an incandescent puck light and also use less energy. The fixtures are usually linkable and can be plugged in or hard-wired. Based on the light distribution shown in the photo below, fixtures can be spaced 16 inches on center, so one fixture would suffice for a 12–18 in. cabinet, two for a 27–30 in. cabinet, etc. Mounting toward the front of the cabinet is recommended to cover as much of the front edge of the countertop as possible, while still lighting the backsplash uniformly.



Two CFL puck lights mounted 16 in. apart  
Average illuminance: 429 lux  
Minimum illuminance: 152 lux  
Meets recommendation for critical tasks?: Yes  
Uniformity on counter: 3:1

### **LED Puck Lighting**



These fixtures use several LED lamps, either 5 mm or high-power, inside one puck light fixture. In most cases, the LED lamps cannot be replaced if one burns out; the entire puck light has to be replaced. However, a well-designed LED puck light may last 20 years or longer.

The recommended installation for LED puck lights is the same as for incandescent puck lights. The selection of LED puck lights should be carefully considered, however, because they may not provide the same amount of light as incandescent puck lights. Unfortunately, most product packaging will not state the light output of the fixture. Check home improvement centers and lighting showrooms that have displays where you can compare the lighting of incandescent and LED puck lights.



Two LED puck lights mounted 16 in. on center  
Average illuminance: 151 lux  
Minimum illuminance: 58 lux  
Meets recommendation for critical tasks?: No  
Uniformity on counter: 3:1

## LED Linear Lighting



LED linear fixtures use either clusters of many 5 mm lamps or several high-power lamps equally spaced 1–4 in. apart. Like LED puck lights, the LEDs cannot be replaced if one burns out; the entire fixture has to be replaced. Lamp failure is generally not an issue with LED fixtures, however.

Fixtures should be sized as closely as possible to the length of the cabinet. As in most cases, mounting toward the front edge of the cabinet is recommended. If the fixture is lensed, the lens should face the backsplash. Some fixtures have adjustable switching to provide higher or lower light levels.

Because heat is an issue for LEDs and can affect the overall life and light output of the fixture, LED fixtures should not be mounted flush with the cabinet. Mounting brackets can be used to create a small gap between the fixture and cabinet where air can circulate, allowing heat to escape. This will ensure a longer life but will increase the overall height of the fixture.

The photos below show two similar LED linear fixtures from different manufacturers. Both products are labeled by the manufacturer as “warm white” yet there is an obvious difference in color. The term “warm white” is not standardized, so the best option is to check the product packaging for a color temperature (CCT). See “Lighting Color” on p. 13 for more information.



24 in. high-power LED “warm white” fixture  
Average illuminance: 119 lux  
Minimum illuminance: 37 lux  
Meets recommendation for critical tasks? No  
Uniformity on counter: 3:1



24 in. 5 mm LED “warm white” fixture  
Average illuminance: 153 lux  
Minimum illuminance: 7 lux  
Meets recommendation for critical tasks?: No  
Uniformity on counter: 22:1

## Designing Your Under-cabinet Lighting

Here are a few issues to consider when designing your under-cabinet lighting:

### Countertops

Countertops with a matte finish will produce a smoother lighting effect than those that are glossy, greatly reducing reflections. Light-colored surfaces will have a higher reflectance, resulting in a brighter appearance, than dark-colored surfaces.

For glossy surfaces, reflections can be minimized by using a fixture that includes a lens over the light source, rather than having a bare bulb. Dark-colored counters and backsplashes may require fixtures that produce more lumens.



Dark glossy counter with reflections



Dark matte counter with smooth illumination



Light matte counter with smooth illumination.

### **Lighting Color**

Since people are working at the counter, colors and textures of foods and surfaces need to be well enhanced. The appropriate correlated color temperature (CCT), or color appearance, depends on the décor and personal preference. For wood tones, warm-colored tiles, copper-toned metal backsplashes or warm-toned walls, warm CCTs in the 2700 to 3500 kelvin (K) range are appropriate. For decorative glass tiles, glass shelves, cool-toned tiles or gray-toned metal colors, cool CCTs in the 3500 to 5000 K range are appropriate. Some manufacturers also label their product packaging with the CCT. If the products are not labeled, look for in-store displays where you can see the color of the lighting first-hand.

When trying to match lamps for the same color, it is best to choose lamps from the same manufacturer. Because CCT is not the primary determinant of a lamp's color, two lamps with the same CCT will not necessarily be the same color.



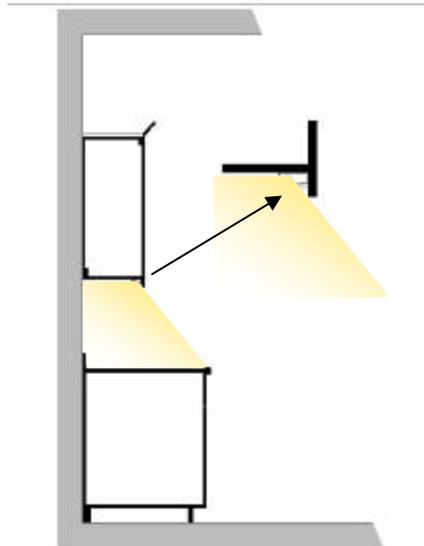
Warm CCT of 3000 K (left) and cool CCT of 6500 K (right).



White light colors appear different for fluorescent (left) and incandescent (right) lighting.

### ***Brightness and Glare***

Under-cabinet lighting should not be glaring to anyone, especially someone in a seated position elsewhere in the room. Fixtures mounted under the cabinets should be well shielded; if the cabinet does not provide enough of a recess to conceal the fixture, a piece of trim molding approximately 1 in. wide should be added to the bottom of the cabinet. Installation toward the front of the cabinet or shelf with the light source facing the back is generally recommended. This produces the most even light distribution on both the countertop and the backsplash. This location is also useful in reducing the potential for direct view of the light source, typically resulting in the least glare.



*Above:* Forward mounting of fixtures, facing backsplash.

*Left:* Schematic of cabinet mounting and detail.

### ***Dimming Capability***

The ability to control the brightness of the under-cabinet lighting adds greatly to its value. The tasks being carried out and their difficulty will dictate the light level required. People of different ages with different visual needs performing various tasks will use this space, so flexibility could offer benefits. Incandescent and LED lighting can be dimmed easily, but having this feature may add to the fixture cost. Dimming fluorescent lighting is costlier than dimming incandescent lighting because of the type of dimming components required.

### ***Fixture Fit***

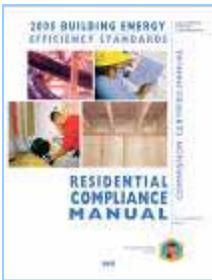
For linear under-cabinet lighting, matching the length of the fixture as closely as possible to the size of the cabinet or shelf will result in the best uniformity and minimize dark spots and shadows between the fixtures. Being able to connect fixtures as close together as possible between cabinets, whether by routing through the cabinet stiles to enable snapping fixtures together, or by using interconnect cords as unobtrusively as possible, will also result in fewer shadows.

### ***Fixture Lenses***

Lenses help diffuse the light provided by the fixture and produce a more uniform appearance on the counter. In the case of halogen or xenon fixtures especially, a lens will help minimize reflections on the countertop. Lenses will also reduce the light intensity to a degree. Lenses can reduce the multiple shadows cast by fixtures with many light sources, especially ones with high-power LEDs.

## **Codes, Safety, Standards, and Compliance**

### ***California Energy Standards – Title 24***



In October 2005, California adopted new energy standards that include comprehensive changes to residential and non-residential lighting. Known as Title 24, the code applies to not only the efficacy of the lighting installation, but also to the fixture itself. Some fixtures may feature a "T24 – 2005" label to help identify whether a fixture is compliant with the code's efficacy requirements.

For kitchens, Title 24 requires that at least 50% of the permanently installed lighting be high efficacy, generally fluorescent, and that no more than 50% of the total lighting wattage be low efficacy, or incandescent. For example, a kitchen with permanently installed lighting fixtures totaling 300 watts cannot have more than 150 watts from incandescent fixtures. High-efficacy lighting and low-efficacy lighting must be controlled by separate switches.

Although Title 24 applies only to California homes, the regulations are the most prominent guidelines for residential energy savings. For more about designing your lighting based on Title 24, download the "Residential Lighting Design Guide" free at: <http://cltc.ucdavis.edu/title-24-residential-lighting-design-guide>.

### ***ENERGY STAR®***



ENERGY STAR, a government program run by the U.S. Department of Energy and the U.S. Environmental Protection Agency, labels residential lighting products for their performance reliability, energy savings, and aesthetic appeal. Purchasing an ENERGY STAR-qualified lighting product can help ensure a minimum standard of reliability and energy efficiency. ENERGY STAR's program requirements for residential light fixtures were updated in October 2005 to fit the new California Title 24 regulations.

At the time of this publication, ENERGY STAR had 25 qualified under-cabinet fixtures, all using linear fluorescent lamps. ENERGY STAR presently is amending the program requirements for residential lighting fixtures to include the labeling of LED fixtures.

### **Underwriters Laboratories**



The Underwriters Laboratories (UL) tests products for safety and writes standards for product safety. Manufacturers may voluntarily submit a product for safety testing and certification. A product that has passed the UL's safety evaluation will have a UL mark on the packaging.

### **Disposal**



Many types of lamps, most notably fluorescent lamps, contain small amounts of hazardous materials. Mercury is the most common, but some lamps also contain lead. Mercury exposure in large amounts or over a long period can cause kidney, nerve, and brain damage in adults, children, and fetuses. In some cases, mercury from municipal landfills can leach into the groundwater and sources of drinking water. Lamps that go to municipal incinerators can release up to 90% of the mercury they contain if the incinerator does not have emission controls.

State and federal governments regulate the disposal of mercury-containing lamps. Except in a few states and municipalities, residents and homeowners disposing of only a few linear fluorescent or compact fluorescent lamps can generally put these out with their regular trash; however, many towns and cities offer hazardous waste recycling programs at recycling centers and transfer stations, as well as annual hazardous waste recycling events. Check with your state and municipal governments for more information on disposal regulations and opportunities. Those disposing of many lamps need to contact a local lamp recycling company or their local hazardous waste recycling plant. For more information, visit [www.lamprecycle.org](http://www.lamprecycle.org).

While mercury and other hazardous materials are a concern, this does not mean you should avoid fluorescent lamps. Fluorescent lamps provide many benefits, including energy and cost savings, less maintenance, and longer life. The lower energy use of fluorescent lamps reduces power plant emissions, a far greater contributor to environmental mercury. With proper disposal, fluorescent lamps are a great choice for lighting.

If you are renovating an older kitchen and have older under-cabinet fixtures to dispose, these may also require special hazardous-waste disposal. Older fluorescent lamp ballasts contain polychlorinated biphenyls, or PCBs, and their use in ballast capacitors was banned in the United States beginning January 1, 1979. Newer ballasts are labeled "No PCBs." Ballasts with PCBs must be disposed of in accordance with state and federal guidelines. The use and disposal of PCBs is regulated by the U.S. Environmental Protection Agency under the Toxic Substances and Control Act.

## **Glossary**

**Correlated color temperature (CCT).** The general indication of the color appearance of a white lamp, measured in kelvin (K). Lamps, such as incandescent, with a warm or yellowish-white color appearance have a CCT in the 2800–3200 K range. Lamps that are more neutral white, such as some fluorescent lamps, have a CCT in the 4000 K range. Cooler or bluer lamps, such as some LEDs, have a CCT of 5000 K or higher. CCT is a matter of personal preference.

**Efficacy.** A measure of the amount of light output, or lumens, per watt of electrical power, expressed as lumens per watt (lm/W or LPW). Higher efficacy numbers indicate greater energy efficiency.

**Fixture.** The complete lighting system, including lamp, housing, electrical cord, and other components.

**Illuminance.** The amount of light falling on a work surface or an object. The Illuminating Engineering Society of North America recommends illuminance levels for different types of lighting applications and tasks. Illuminance is measured in units of lux.

**Lamp.** An industry term for a light bulb.

**LED.** Light-emitting diode, a semiconductor that converts electricity into light.

**Lumen.** A unit of measurement (lm) for the rate at which a lamp or fixture produces light. More lumens equals more light output from the lamp or fixture.

**Lux.** A unit of measurement for illuminance.

**Stile.** A vertical member of a door or frame. In cabinets, it is the vertical piece that extends from the top and bottom of cabinets and is considered an obstruction when attempting to install continuous lighting.

**Uniformity.** Referring to the evenness of lighting on a work surface, uniformity is typically defined as the ratio of the average measured illuminance to the minimum measured illuminance. Lighting designers recommend a uniformity of 5 or less.

## Resources

ENERGY STAR. *Residential light fixtures product list*. Available at [www.energystar.gov](http://www.energystar.gov).

Leslie RP, Conway KM. 1996. *The Lighting Pattern Book for Homes*. New York: McGraw-Hill.

## About ASSIST

ASSIST was established in 2002 by the Lighting Research Center at Rensselaer Polytechnic Institute to advance the effective use of energy-efficient solid-state lighting and speed its market acceptance. ASSIST's goal is to identify and reduce major technical hurdles and help LED technology gain widespread use in lighting applications that can benefit from this rapidly advancing light source.